State of California
California Regional Water Quality Control Board, Los Angeles Region

Amendment
to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties
to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

adopted on November 5, 2009

Administrative Record
Volume 3 of 4

Transmittals to 3 Peer Reviewers

California Regional Water Quality Control Board

Los Angeles Region

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Arnold Schwarzenegge
Governor

August 20, 2009

Jorg E. Drewes, Ph.D., Associate Professor *via e-mail: jdrewes@mines.edu*
Director, Advanced Water Technology Center
Environmental Science and Engineering Division
Colorado School of Mines
1500 Illinois Street
Golden, Colorado 80401-1887

SUBJECT: External Peer Review of Technical Memoranda #3 and #4 in support of an amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Dr. Drewes:

At the direction of Gerald W. Bowes, Manager of the Cal/EPA Scientific Peer Review Program, we are hereby initiating an external peer review process. Please find, attached to this letter, a letter dated August 6, 2009 to Gerald W. Bowes with the following attachments:

1. 'Plain English' summary of the *Basin Plan* amendment
2. Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems (OWDSs), drafts dated July 31, 2009 and August 5, 2009 respectively.
3. List of Participants in Tech Memos #3 and #4.
4. Technical Staff Report (Overview – draft dated July 31, 2009), in support of an Amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-Site Wastewater Disposal Systems in the Malibu Civic Center Area, plus Tech Memos #3 and #4.[1]
   a. Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation,** by Elizabeth Erickson, P.G. – draft dated July 31, 2009.
   b. Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life,** by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E. – draft dated August 5, 2009.

[1] Other tech memos and materials related to this proposed regulatory action, may be accessed and downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml.

Please note that the overview in Attachment 4 above includes a summary of all five tech memos. As this extra material is provided as background, we ask that you limit the peer review to tech memos #3 and #4 (which are included in attachment 4, following the overview). Also, it is important to note that we are not requesting peer review of the TMDLs (Total Maximum Daily Loads) that are related to this proposed prohibition, as these TMDLs have already been peer reviewed, or modeled on TMDLs that had already received peer review(s).

Your review must follow the guidance provided in Attachment 2 referenced above (Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems). Furthermore, your review must address the topics listed in Attachment 2, as expertise allows, in the order given.

We ask that you complete your review of Tech Memo #4 no later than September 3, 2009. Also, we ask that you delay your review of Tech Memo #3, as we intend to provide raw data in supporting this memoranda within the next two weeks. We shall notify you as soon as this additional information is ready and ask you to initiate your review of Tech Memo #3, which we anticipate will be no later than September 10, 2009. We shall need the results of your peer review of Tech Memo #3 no later than October 8, 2009.

Would you please notify me immediately if you require additional background, documents, or hard copies to initiate your review? Also, if we need to provide overnight delivery of documents, please advise me of the address to which the documents should be delivered.

Should you need to contact me, you may reach me me at (213) 576-6618 or wphillips@waterboards.ca.gov.

Sincerely,

/s/

Wendy Phillips
Chief, Groundwater Permitting and Landfills Section

cc: Dr.Gerald W. Bowes, Cal/EPA Scientific Peer Review Program
Tracy Egoscue, Los Angeles Regional Water Quality Control Board
Deborah Smith, Los Angeles Regional Water Quality Control Board
Dr. Rebecca Chou, Los Angeles Regional Water Quality Control Board
Elizabeth Erickson, Los Angeles Regional Water Quality Control Board
Toni Callaway, Los Angeles Regional Water Quality Control Board

California Regional Water Quality Control Board

Los Angeles Region

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

inda S. Adams
Agency Secretary

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Arnold Schwarzenegger
Governor

August 28, 2009

Robert Arnold, Ph.D., Professor
Department of Chemical and Environmental Engineering
University of Arizona
Tucson, AZ 85721

via e-mail: rga@engr.arizona.edu

SUBJECT: External Peer Review of Technical Memoranda #3 and #4 in support of an amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Dr. Arnold:

At the direction of Gerald W. Bowes, Manager of the Cal/EPA Scientific Peer Review Program, we are hereby initiating an external peer review process. Please find, attached to this letter, a letter dated August 6, 2009 to Gerald W. Bowes with the following attachments:

1. 'Plain English' summary of the *Basin Plan* amendment

2. Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems (OWDSs), drafts dated July 31, 2009 and August 5, 2009 respectively.

3. List of Participants in Tech Memos #3 and #4.

4. Technical Staff Report (Overview – draft dated July 31, 2009), in support of an Amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-Site Wastewater Disposal Systems in the Malibu Civic Center Area, plus Tech Memos #3 and #4. [1]

    a. Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation,** by Elizabeth Erickson, P.G. – draft dated July 31, 2009.

    b. Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life,** by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E. – draft dated August 5, 2009.

[1] Other tech memos and materials related to this proposed regulatory action, may be accessed and downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml.

Please note that the overview in Attachment 4 above includes a summary of all five tech memos. As this extra material is provided as background, we ask that you limit the peer review to tech memos #3 and #4 (which are included in attachment 4, following the overview). Also, it is important to note that we are not requesting peer review of the TMDLs (Total Maximum Daily Loads) that are related to this proposed prohibition, as these TMDLs have already been peer reviewed, or modeled on TMDLs that had already received peer review(s).

Your review must follow the guidance provided in Attachment 2 referenced above (Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems). Furthermore, your review must address the topics listed in Attachment 2, **as expertise allows, in the order given.**

We ask that you complete your review of Tech Memo #4 no later than noon on Thursday, September 10, 2009. Also, we ask that you delay your review of Tech Memo #3, as we intend to provide raw data in supporting this memoranda within the next two weeks. We shall notify you as soon as this additional information is ready and ask you to initiate your review of Tech Memo #3, which we anticipate will be no later than September 10, 2009. We shall need the results of your peer review of Tech Memo #3 no later than October 8, 2009.

Would you please notify me immediately if you require additional background, documents, or hard copies to initiate your review? Also, if we need to provide overnight delivery of documents, please advise me of the address to which the documents should be delivered.

Should you need to contact me, you may reach me at (213) 576-6618 or wphillips@waterboards.ca.gov.

Sincerely,

/s/

Wendy Phillips
Chief, Groundwater Permitting and Landfills Section

cc: Dr.Gerald W. Bowes, Cal/EPA Scientific Peer Review Program
Elizabeth Erickson, Los Angeles Regional Water Quality Control Board
Toni Callaway, Los Angeles Regional Water Quality Control Board

California Regional Water Quality Control Board

Los Angeles Region

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Arnold Schwarzenegger
Governor

September 3, 2009

Professor JoAnn Silverstein joann.silverstein@colorado.edu
Department of Civil, Environmental, and Architectural Engineering
University of Colorado, Boulder
428 UCB, Engineering Center, Room OT 441
Boulder, Colorado 80309-0428

SUBJECT: External Peer Review of Technical Memoranda #3 and #4 in support of an amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Dr. Silverstein:

We understand that Dr. Gerald W. Bowes, Manager of the Cal/EPA Scientific Peer Review Program, has tentatively approved your review of two of our agency's documents. At his direction, we are hereby initiating an external peer review process. Please find, attached to this letter, a letter dated August 6, 2009 to Gerald W. Bowes with the following attachments:

1. 'Plain English' summary of the *Basin Plan* amendment

2. Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems (OWDSs), drafts dated July 31, 2009 and August 5, 2009 respectively.

3. List of Participants in Tech Memos #3 and #4.

4. Technical Staff Report (Overview – draft dated July 31, 2009), in support of an Amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-Site Wastewater Disposal Systems in the Malibu Civic Center Area, plus Tech Memos #3 and #4. [1]

   a. Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation,** by Elizabeth Erickson, P.G. – draft dated July 31, 2009.

   b. Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life,** by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E. – draft dated August 5, 2009.

[1] Other tech memos and materials related to this proposed regulatory action, may be accessed and downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml.

Please note that the overview in Attachment 4 above includes a summary of all five tech memos. As this extra material is provided as background, we ask that you limit the peer review to tech memos #3 and #4 (which are included in attachment 4, following the overview). Also, it is important to note that we are not requesting peer review of the TMDLs (Total Maximum Daily Loads) that are related to this proposed prohibition, as these TMDLs have already been peer reviewed, or modeled on TMDLs that had already received peer review(s).

Your review must follow the guidance provided in Attachment 2 referenced above (Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems). Furthermore, your review must address the topics listed in Attachment 2, as expertise allows, **in the order given.**

Due to our time constraints, we need to receive your comments on Tech Memo #4 no later than noon on Thursday, September 10, 2009. I want to emphasize that you may not be able to accomplish review of Tech Memo #4 on such short notice, and we will accept your decision on that.

Also, we ask that you delay your review of Tech Memo #3, as we intend to provide raw data in supporting this memoranda within the next two weeks. We shall notify you as soon as this additional information is ready and ask you to initiate your review of Tech Memo #3, which we anticipate will be no later than September 10, 2009. We shall need the results of your peer review of Tech Memo #3 no later than October 8, 2009.

Would you please notify me immediately if you require additional background, documents, or hard copies to initiate your review? Also, if we need to provide overnight delivery of documents, please advise me of the address to which the documents should be delivered.

Should you need to contact me, you may reach me at (213) 576-6618 or wphillips@waterboards.ca.gov. As I shall be away from the office next week, please contact Dr. Rebecca Chou in my absence. She may be reached at (213) 620-6156 or rchou@waterboards.ca.gov .

Sincerely,

/s/

Wendy Phillips
Chief, Groundwater Permitting and Landfills Section

cc: Dr.Gerald W. Bowes, Cal/EPA Scientific Peer Review Program
Dr. Rebecca Chou, P.E., Los Angeles Regional Water Quality Control Board
Elizabeth Erickson, Los Angeles Regional Water Quality Control Board
Toni Callaway, Los Angeles Regional Water Quality Control Board

California Regional Water Quality Control Board
Los Angeles Region

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Agency Secretary

Arnold Schwarzenegger
Governor

August 6, 2009

Gerald W. Bowes, Ph.D.
Manager, Cal/EPA Scientific Peer Review Program
Office of Research, Planning and Performance
State Water Resources Control Board
1001 I Street, Sacramento, CA 95814

SUBJECT: Request for External Peer Review of Technical Memoranda #3 and #4 in support of an amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Dr. Bowes:

Pursuant to the *California Health and Safety Code,* section 57004, amendments to basin plans are subject to peer review. We are hereby requesting external peer review of two technical memoranda (tech memos) that were prepared by Regional Water Quality Control Board for the Los Angeles Region in support of a proposed amendment to the *Basin Plan* to prohibit discharges from on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area. These tech memos are:

Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation**, by Elizabeth Erickson, P.G.

Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life**, by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E.

Drafts of the above two tech memos are available for peer review and are included in attachment 4. For background, we have included, also in attachment 4, our overview[1] of all five technical memoranda that comprise the evidence supporting our proposed prohibition (*Basin Plan*

[1] Please note that this overview includes a summary of all five tech memos. As this extra material is provided as background, we ask that you limit the peer review to tech memos #3 and #4 (which are included in attachment 4, following the overview). Also, it is important to note that we are not requesting peer review of the TMDLs (Total Maximum Daily Loads) that are related to this proposed prohibition, as these TMDLs have already been peer reviewed, or modeled on TMDLs that had already received peer review(s).

amendment). You may also read and download these documents, along with other documents related to this regulatory action, at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml.

A 'plain English' version, along with our proposed Basin Plan amendment language (in a draft resolution, proposed for adoption on October 1, 2009), is included as attachment 1. A description of scientific issues to be addressed is included as attachment 2. A list of Regional Board staff who participated in the development of tech memos #3 and #4 is included in attachment 3.

As we have scheduled this proposed regulatory action for public hearing on October 1, 2009, we hope that you will be able to accommodate our request to expedite the review of tech memos #3 and #4, and complete this effort by September 3, 2009. Should you have any questions regarding these studies and the development of the proposed prohibition, please contact me at (213) 576-6618 or wphillips@waterboards.ca.gov.

Sincerely,

Wendy Phillips
Chief, Groundwater Permitting and Landfills Section

cc: Rik Rasmussen, State Water Resources Control Board
Jeff Ogata, State Water Resources Control Board
Todd Thompson, State Water Resources Control Board
Tracy Egoscue, Los Angeles Regional Water Quality Control Board
Deborah Smith, Los Angeles Regional Water Quality Control Board

Attachments:

1. 'Plain English' summary of the *Basin Plan* amendment

2. Scientific Issues to be addressed by peer review for Technical Memoranda #3 and #4 of the proposed Prohibition on On-Site Wastewater Disposal Systems (OWDSs), drafts dated July 31, 2009 and August 5, 2009 respectively.

3. List of Participants in Tech Memos #3 and #4.

4. Technical Staff Report (Overview – draft dated July 31, 2009), in support of an Amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-Site Wastewater Disposal Systems in the Malibu Civic Center Area, plus Tech Memos #3 and #4 – draft dated July 31, 2009.[2]

   a. Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation**, by Elizabeth Erickson, P.G. – draft dated July 31, 2009.

   b. Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life**, by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E. – draft dated August 5, 2009.

[2] Other tech memos and materials related to this proposed regulatory action, may be accessed and downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml.

This page intentionally left blank.

Attachment 1
'Plain English' Summary of the *Basin Plan* Amendment

Draft Technical Staff Report *(dated July 31, 2009)*

Evidence in support of an Amendment to the Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties to incorporate a Prohibition on On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Introduction

Staff at the Regional Water Quality Control Board (Regional Board) has presented evidence in support of a prohibition on subsurface disposal systems in the Malibu Civic Center area. The Malibu Civic Center area (shown in Figure 1 of attachment 4) includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Types of subsurface disposal systems that would be prohibited range from passive systems with conventional septic tanks to active systems that more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would apply to systems that serve individual properties (residential, commercial, industrial, and public properties) as well as groups of those properties. Collectively throughout this report, these disposal systems are referred to as on-site wastewater disposal systems, or OWDSs.

The prohibition would be in the form of an amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan).* To effect the amendment, staff is proposing that the board adopt the attached resolution, at a public hearing scheduled for October 1, 2009.

Background

The Malibu Civic Center area supports a population of about 1,000 residents and is the core of the City's business, cultural, and commercial activities. The area, which includes the renowned Surfrider Beach, attracts a high volume of visitors.

Without community sewers and wastewater treatment infrastructure, residents, businesses, and public facilities in the City of Malibu use thousands of on-site disposal systems to discharge their sewage to the subsurface and underlying groundwater. In several areas of the City, unfavorable hydrogeologic conditions coupled with high flows of wastewaters have raised concerns about reliance on this wastewater disposal strategy. In one of those areas of concern, the Malibu Civic Center area, intensive land use activities by almost 400 dischargers result in the release of wastewaters to the subsurface at a rate that Regional Board staff estimates to be as high as 255,000 gallons per day (gpd).

In a series of tech memos, staff presents evidence showing that OWDSs in the area have released pollutants that impair the beneficial uses of the following water resources:

- Malibu Lagoon – a valuable fresh/saltwater habitat for rare, threatened and endangered species. Nitrogen loads from OWDSs, transported in groundwater that recharges the lagoon, accelerates eutrophication (a process that depletes oxygen dissolved in water and stimulates aquatic growth – i.e. the formation of excessive amounts of algae).

- Malibu Civic Center area beaches – Together with Malibu Lagoon and Malibu Creek, the beaches along the Civic Center area are popular among residents for contact (e.g. sun-bathing, bird-watching, hiking, picnicking) and non-contact recreation (e.g. swimming, surfing, wading). They are also a destination for visitors. However, due, in part, to pathogens released from OWDSs, these waters consistently fail to meet public health standards for water contact recreation, and the renowned Surfrider Beach has a 'beach bummer' reputation among surfers and the media.

- Groundwater – Although groundwater in the area is not an existing source of drinking water to the community, groundwater was the community's source of drinking water until the 1960s. Groundwater production in the area gradually ceased as a newly formed special district – Los Angeles County Waterworks District No. 29, Malibu – started delivering imported water to the area in the early 1960s. As a future resource – and also in the event of a disruption of deliveries of imported water, groundwater is an important local resource that the community may need to use in the future. The Regional Board recognized this beneficial use, in designating groundwater as a potential source of drinking water in the *Basin Plan*. However, pathogens released to groundwater from OWDSs impair the use of potential use of groundwater as a source of drinking water.

TMDLs

In order to restore beneficial uses, the Regional Board and/or US Environmental Protection Agency, has taken past actions, through *Basin Plan* amendments, to establish Total Maximum Daily Loads (TMDLs), including:

a. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities.

The TMDL specifies a load allocation for on-site wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

b. **Malibu Creek and Lagoon Bacteria TMDL:** The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, on-site wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for on-site wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

c. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for on-site wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including on-site wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

These TMDLs completed peer review prior to adoption, or were closely modeled on TMDLs that had already completed the peer review process.

Summary of Evidence in support of the Prohibition

Staff investigations focused in five areas and are presented in five technical memoranda that comprise this staff report and that meet the requirements of the California Water Code, sections 13280 and 13281 for determination that discharges of OWDSs in the Malibu Civic Center area result in violation of water quality objectives, will impair present or future beneficial uses of

water, will cause pollution, nuisance, or contamination, or will unreasonably degrade the quality of any water of the state.

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.

For the privilege of discharging wastewater to a water of the state (including both surface water and groundwater), dischargers must comply with waste discharge requirements (WDRs) that are specified in Orders issued by the Regional Board. The WDRs generally incorporate monitoring and reporting programs that rely on self-monitoring by dischargers. The reports of self-monitoring are used by the Regional Board to determine compliance and to ensure that the quality of the water into which wastes are discharged is not degraded and that beneficial uses, such as drinking water and swimming (body contact recreation) are protected.

In the Malibu Civic Center area, the Regional Board regulates 21 discharges, all of which are from commercial, industrial, or public facilities. In a review of the compliance records for these discharges, each discharger had a record of violations. Among the most serious violations are repeated failures to achieve effluent limits specified in WDRs; in particular, limits for pathogens and nutrients (species of nitrogen and phosphorus) that are identified as pollutants in nearby waters that the Regional Board and EPA have designated as impaired under Clean Water Act section 303(d). Also, several dischargers 'failed to submit' monitoring reports, and compliance with technical requirements in their WDRs could not be determined.

Staff concludes that dischargers have poor records of compliance with Orders issued by Regional Board, and that discharges are, in general, not meeting requirements prescribed to protect water quality and beneficial uses.

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water.

To evaluate impacts from OWDSs on groundwater as a potential source of drinking water, staff identified 47 groundwater wells, all of which were designed and constructed for monitoring the quality of groundwater, and compiled data pathogens and nitrogen. To examine the extent of impairment of this groundwater for drinking water, staff compiled all available analytical results of sampling for pathogen indicators and nitrogen species during the period July 2002 through May 2009 and compared these results with drinking water standards for these pollutants. As summarized in graphs and tables for each well:

- ***Pathogens in Groundwater do not meet the Drinking Water Standard:*** Forty-four wells, or 94% of the 47 wells, had fecal coliform during at least one sampling period. Of the 671 fecal coliform samples collected from the 47 wells during the review

period, 360 samples (54%) tested positive and exceeded the maximum contaminant level (MCL) of less than 1.1 MPN/100ml (Most Probable Number per 100 milliliters).

- ***Nitrogen in Groundwater does not meet the Drinking Water Standard:*** Fourteen wells, or 30% of the 47 wells, had nitrate plus nitrite at levels above the MCL of 10 mg/L (as nitrogen). Of the 671 samples collected from the 47 wells during the review period, 100 (15%) were above the MCL. Although there is no drinking water standard for ammonia, staff also reviewed analytical data for ammonia in view of the likelihood that the ammonia species of nitrogen will nitrify. These results indicate that, when concentrations of ammonia (converted to nitrogen) are added to concentrations of nitrate and nitrite, 163 samples or 24% were above the MCL. Twenty-four wells, or 51% of the 47 wells, had levels above the MCL of 10 mg/L.

As indicated by coliform results, pathogens are present in groundwater at levels that elevate the risk of infectious disease should this groundwater be used for potable purposes. As indicated by the nitrogen results, species of nitrogen are present in groundwater at levels that can cause health problems in humans should this groundwater be used for potable purposes. Infants and fetuses are particularly sensitive and can develop methemoglobinemia (blue-baby syndrome) from ingestion of water with nitrate at levels that deplete oxygen in the blood stream.

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation.

To examine the hydraulic connection of discharges from OWDSs through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters migrate to surface waters and that, consistent with data supporting the designations of impairments, the levels of pathogens do not meet standards protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center area versus comparable beaches with sewers.

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to beneficial use of water contact recreation.

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.

As noted above, beneficial uses of Malibu Lagoon are impaired by excessive nutrient levels in the lagoon, depleting dissolved oxygen in the water and stimulating aquatic growth (algae). As

established in the nutrient TMDL, nitrogen from OWDSs in hydraulic connection with the lagoon are subject to a load allocation of six pounds per day.

To quantify current nitrogen loads from OWDSs in the Malibu Civic Center area to the lagoon, staff compiled an inventory of 38 commercial dischargers and 349 residential dischargers. Using real data where available and reasonable assumptions (based on published literature and best professional judgment) for data gaps, staff calculated that the dischargers release about 255,000 gpd through OWDSs and estimated nitrogen loading factors. Applying these nitrogen loading factors to update an existing numerical model designed and calibrated by Questa 2005 for an earlier investigation, staff estimates that nitrogen loads released from OWDSs and transmitted via groundwaters to Malibu Lagoon total 29 pounds per day (lb/day). As a check, staff used the same flows and loading factors to a 'spreadsheet' model which characterized wastewater transport by hydrogeologic sector. Based on the 'spreadsheet' model, staff estimates that wastewaters transport 36 lb/day into Malibu Lagoon.

Staff's estimates of 29 lb/day to 36 lb/day from the numeric and 'spreadsheet' models are greater than two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies, and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

- Commercial Flows: The third-party models used significantly lower assumptions for commercial wastewater flows.
- Nitrogen Concentrations – Residential: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are about one-half of what staff determined is a reasonable assumption.
- Nitrogen Concentration – Commercial: Staff determined that the average nitrogen concentration of commercial wastewater discharges has decreased since 2004, as OWTSs with greater treatment capabilities has been brought on-line. However, this declining trend in this subset of OWTSs is not great enough to meet the TMDL goal.

Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the load allocation of 6 lb/day for OWDSs established in a TMDL. Accordingly, staff concludes that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 29 lb/day to 36 lb/day as wells as third-party estimates from 17 lb/day to 32 lb/day, all of which fail to meet targets established to restore water quality and protect beneficial uses in Malibu Lagoon.

Technical Memorandum No. 5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.

Intensive land use activities on many properties in the Malibu Civic Center area generate wastewater flows at rates that exceed the capacity of OWDSs to transmit the wastewaters into the subsurface. While some dischargers are limited by treatment equipment that has inadequate capacity and/or treatment capabilities, many dischargers do not have adequate disposal capacity on their properties to transmit the wastewaters into the subsurface. Their disposal rates can be constrained not only by lack of space, or area, for on-site disposal fields, but by hydrogeologic constraints as well, such as a high water table or tight soils. Consequently, in order to avoid failure of the OWDSs, a significant number of large dischargers resort to hauling liquid sewage and sludge to communities that have infrastructure to accept their liquid wastes.

To quantify reliance on the practice of hauling, staff reviewed reports of self-monitoring, which include summaries of off-site hauling, submitted by ten large commercial dischargers. In 2008, these ten dischargers, whose activities generated a total of approximately 28 million gallons of wastewater (77,000 gpd), hauled almost 2 million gallons (5,500 gpd), or about 7%, of their raw sewage to off-site disposal facilities. Furthermore, staff quantified trends from 2004 through 2008, which indicate that these ten dischargers have cumulatively increased their rate of wastewater generation by 15% and their rate of hauling by 29%. (Staff was not unable use existing data from dischargers to analyze seasonal hauling trends – e.g. hauling trends during the wet season, and also during warm summer holidays when populations have high peaks.)

Recommendation

Based on the evidence above, staff has proposed action by the Regional Board that will immediately halt new discharges of wastewater in the Malibu Civic Center area, and mandate a five-year time schedule for existing dischargers to cease, during which time the city, or an existing or newly formed utility or water authority would construct a regional compliance project to meet the five-year time schedule (see the Environmental Staff Report for details).

The resolution setting forth these actions, including the language for the proposed amendment to the *Basin Plan*, is attached. Critical portions are re-stated below:

This action was supported by technical evidence that concluded:

i. *Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance.*

ii. *Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water.*

iii. *Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation.*

iv. *Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.*

v. *Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.*

[Re Time Schedule]
....the City is hereby directed to submit quarterly written reports to the Executive Officer, summarizing the strategy and progress toward meeting the five-year prohibition deadline. In the quarterly progress reports, the City shall document progress, to the satisfaction of the Executive Officer, toward the following interim and final deadlines:

April 1, 2010: Completion of 25% of a master facilities plan for possible projects to comply with the prohibition, including initiation of a strong public participation program.

October 1, 2010: Completion of 50% of a master facilities plan and initiation of environmental review, with strong, on-going public participation. Concurrently, initiation of preliminary engineering and a feasibility study for possible projects to comply with the prohibition.

April 1, 2011: Substantial completion of a master facilities plan, preliminary engineering and a feasibility study, and engagement of the public in selection of a project to comply with the prohibition.

October 1, 2011: Completion of a master facilities plan, preliminary engineering and a feasibility study, and selection of a project to comply with the prohibition.

October 1, 2012: Completion of final design for selected project.

October 1, 2013: Completion of 50% of construction of selected project.

October 1, 2014: Completion of project to comply with prohibition, including successful startup of facilities, residential and commercial connections to the project facilities, and cease discharge from OWDSs.

This page intentionally left blank.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Resolution No. R4-2009-xx

Amendment to the
Water Quality Control Plan for the Coastal Watersheds
of Ventura and Los Angeles Counties
to Prohibit On-site Wastewater Disposal Systems
in the Malibu Civic Center Area

WHEREAS, the California Regional Water Quality Control Board, Los Angeles Region (hereinafter Regional Board), finds that:

1. In the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (hereafter *Basin Plan*), the Regional Board designated beneficial uses and established water quality objectives for the following water resources in the Civic Center area of the City of Malibu:

   Groundwater: Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

   Malibu Lagoon: Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

   Malibu Creek: Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

   Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach: Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.

2. In a 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses were formally identified for the following water resources:

   Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
   Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
   Malibu Beach: impaired by Indicator Bacteria.
   Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
   Carbon Beach: impaired by Indicator Bacteria.

D R A F T J U L Y 3 1 2 0 0 9

DRAFT JULY 31 2009

3. To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

   i. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for on-site wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

   ii. **Malibu Creek and Lagoon Bacteria TMDL**: The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, on-site wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for on-site wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

   iii. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for on-site wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including on-site wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

4. Pursuant to Water Code Section 13243, the Regional Board may, in its *Basin Plan*, specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted. During a public meeting on December 14, 1998, the Regional Board directed the Executive Officer to prepare a prohibition for consideration by the Regional Board. During a public meeting on November 13, 2008, the Regional Board discussed the need for a firm time schedule to address water quality problems in the Malibu Civic Center area and again directed staff to prepare a prohibition for Board consideration.

5. In accordance with the California Water Code, sections 13280 and 13281, Regional Board staff presented technical evidence, in a public hearing on October 1, 2009, demonstrating that discharges of wastewater in the Civic Center area fail to meet water quality objectives established in the *Basin Plan* and contribute to impairments of existing or potential beneficial uses of water resources. The evidence, as presented in a Technical Staff Report, includes the following conclusions:

   i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance.

   ii. Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water.

   iii. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation.

   iv. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.

   v. Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

6. A peer review was conducted, pursuant to California Health and Safety Code section 57004.

DRAFT JULY 31 2009

7. No authorized public agency has offered satisfactory assurance that discharge systems are appropriately designed, located, sized, spaced, constructed, and maintained, such that they are adequate to protect the quality of water for beneficial uses in the Malibu Civic Center area, pursuant to the CWC section 13282.

8. Pursuant to the California Water Code, section 13283, the State Water Resources Control Board (State Board) shall include a preliminary review of possible alternatives necessary to achieve protection of water quality and present and future beneficial uses of water, and prevention of nuisance, pollution, and contamination, including, but not limited to, community collection and waste disposal systems which utilize subsurface disposal, and possible combinations of individual disposal systems, community collection and disposal systems which utilize subsurface disposal, and convention treatment systems. The Regional Board has conducted a preliminary review of possible alternatives, as documented in the staff report.

9. The basin planning process has been certified as functionally equivalent to the California Environmental Quality Act (CEQA), including preparation of an initial study, negative declaration, and environmental impact report (14 CCR, section 15251(g)). As this amendment is part of the basin planning process, staff has prepared an Environmental Staff Report, which is considered a substitute to an initial study, negative declaration, and/or environmental impact report. This Environmental Staff Report satisfies the substantive requirements of the California Code of Regulations, title 23, section 3777(a), and includes a project description, environmental checklist, reasonable alternatives, and mitigation measures.

THEREFORE, be it resolved that:

1. The Regional Board finds substantial evidence that discharges from septic systems in the Malibu Civic Center area fail to meet water quality objectives and impair both existing and potential beneficial uses of water, as documented in the Final Technical Staff Report, dated October 1, 2009. Pursuant to section 13240 of the California Water Code, the Regional Board hereby amends the *Basin Plan* to include a prohibition on discharges from individual/group septic/disposal systems in the Civic Center area. This amendment, as set forth in Attachment A, will:

   - Prohibit all new discharges.
   - Prohibit discharges from existing systems within five years from the date of adoption by the Regional Board of this *Basin Plan* amendment.
   - A specific discharge may be permitted for a "zero-discharge" project if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle

DRAFT JULY 31 2009

any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the *Basin Plan.*

2. The Regional Board adopts and certifies the Final Environmental Staff Report, including the environmental checklist, dated October 1, 2009.

3. The Regional Board directs the Executive Officer to submit these regulatory actions to the State Board and Office of Administrative Law for review and approval.

4. This prohibition is not intended to prevent repairs and maintenance to existing septic/disposal systems, provided that repairs and maintenance do not expand the capacity of the systems and increase flows of wastewaters.

5. On behalf of dischargers in the Civic Center area, the City is hereby directed to submit quarterly written reports to the Executive Officer, summarizing the strategy and progress toward meeting the five-year prohibition deadline. In the quarterly progress reports, the City shall document progress, to the satisfaction of the Executive Officer, toward the following interim and final deadlines:

   April 1, 2010: Completion of 25% of a master facilities plan for possible projects to comply with the prohibition, including initiation of a strong public participation program.

   October 1, 2010: Completion of 50% of a master facilities plan and initiation of environmental review, with strong, on-going public participation. Concurrently, initiation of preliminary engineering and a feasibility study for possible projects to comply with the prohibition.

   April 1, 2011: Substantial completion of a master facilities plan, preliminary engineering and a feasibility study, and engagement of the public in selection of a project to comply with the prohibition.

   October 1, 2011: Completion of a master facilities plan, preliminary engineering and a feasibility study, and selection of a project to comply with the prohibition.

   October 1, 2012: Completion of final design for selected project.

   October 1, 2013: Completion of 50% of construction of selected project.

   October 1, 2014: Completion of project to comply with prohibition, including successful startup of facilities, residential and commercial connections to the project facilities, and cease discharge from OWDSs.

DRAFT JULY 31 2009

The first progress report is due December 31, 2009, and subsequent quarterly progress reports are due on March 31st, June 30th, September 30th, and December 31st of the following years.

The City may, upon approval from the Executive Officer, transfer this responsibility to another public agency.

I, Tracy J. Egoscue, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of a resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on October 1, 2009.

_____

Tracy J. Egoscue
Executive Officer

DRAFT JULY 31 2009

Resolution No. R4-2009-xx

Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties
to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Attachment A: Language to be inserted into the *Basin Plan*

The *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties* (*Basin Plan*) contains a section entitled "Septic Systems" in Chapter 4. This amendment to the *Basin Plan* revises the section entitled "Septic Systems," as indicated by italicized, underlined text for additions, and text strikeouts for deletions.

Septic Systems

~~The California Water Code, Chapter 4, Article 5, sets forth criteria for regulating individual disposal systems (i.e., residential septic tanks). Prior to the 1950s, the Regional Board placed certain types of septic tank systems under individual WDRs. In the 1950s, the regional Board delegates local health or public works departments jurisdiction to permit and regulate septic tank disposal systems, typically for single family dwellings. However, the Regional Board could exercise jurisdiction over multiple dwelling units, some non- domestic septic tank systems, and large developments in certain problem areas, as well as in any situation where systems are creating or have the potential to create a water quality problem.~~

Malibu Civic Center Area

On October 1, 2009, the Regional Board amended the Basin Plan *to prohibit on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area (figure 4-xx), pursuant to section 13280 of the California Water Code. Effective immediately:*

- *All new on-site wastewater disposal system discharges are prohibited.*
- *All wastewater discharges from existing on-site wastewater disposal systems are prohibited five yers from the date of adoption by the Region Board of this Basin Plan amendment.*
- *A specific wastewater discharge may be permitted if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the Basin Plan.*

DRAFT JULY 31 2009

This action was supported by technical evidence that concluded:

i. *Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance.*

ii. *Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water.*

iii. *Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation.*

iv. *Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.*

v. *Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.*

The prohibition is not intended to prevent repairs and maintenance to existing septic/disposal systems, provided that repairs and maintenance do not expand the capacity of the systems and increase flows of wastewaters.

Oxnard Forebay Septic Prohibition

On August 9, 1999, the Regional Board amended the Basin Plan to include a prohibition on septic systems in the Oxford Forebay (figure 4-xx), pursuant to Section 13280 of the California Water Code. The prohibition applies to both future and existing septic systems in the Oxford Forebay. As of August 9, 1999, new septic systems in the Oxford Forebay were prohibited. By January 1, 2008, discharges from existing septic systems must cease. This action was taken in view of:

- The conclusion that discharges of wastewaters from residential and commercial facilities to groundwater underlying the Oxford Forebay do not meet water quality objectives specified in the Basin Plan, and are impairing the present and future beneficial uses of underlying resources of ground water.

DRAFT JULY 31 2009

- The need to ensure long-term protection of ground water underlying both the Oxford Forebay and the Oxford Plain. Alternatives to replace these supplies of local water, or to treat the water before beneficial use, would be costly and would violate the requirement to protect the water for beneficial uses.

The prohibition is not intended to prevent repairs to existing septic systems in the Oxford Forebay prior to [a date five year from Regional Board adoption of the amendment], provided that the purpose of such repairs is not to increase capacity.

Other Areas

In other areas, where ground water constitutes an important source of drinking water, the Regional Board has adopted general WDRs (Order 91-94) for certain private residential subsurface sewage disposal systems. A lot with size less then 1 acre in not eligible for these general WDRs; for those lots between one and less than five acres in size, the General WDRs require either a hyrdogeologic study or mitigation measures. WDRs are not required for lot sizes greater than five acres.

DRAFT JULY 31 2009

This page intentionally left blank.

Attachment 2

Description of Scientific Issues to be addressed by Peer Review

The statute mandate for external scientific peer review (Health and Safety Code Section 57004) states that the reviewer's responsibility is to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. We request that you make this determination for each of the following issues that constitute the scientific basis of the proposed regulatory action.

For Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation,** by Elizabeth Erickson, P.G.:

a. The interpretation of existing literature identifying factors that increase the risk of human enterococcus, human pathogens and human viruses at the beach.

b. The interpretation of the 1983 EPA marine health criteria for health risk as opposed to illness rate.

c. Unexplored or missing evidence that might link or refute a link between groundwater pathogens and beach pathogens in the Malibu Civic Center area, other than a multi-year and seasonal groundwater or epidemiology study.

d. The application of correlation coefficients and normal and rank interval statistical methods to the results of the investigation.

For Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life,** by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E.

a. The approach used to compile an inventory of wastewater discharges from OWDSs in the Malibu Civic Center area, which staff estimates to total 255,000 gallons per day.

b. The methodology used to calculate loads of nitrogen from wastewaters discharged from OWDSs in the Malibu Civic Center area; specifically, staff's interpretation of published literature and assumptions used to calculate nitrogen loads released from OWDSs for those discharges where real data were not available.

c. Staff's characterization of groundwater flow regimes in the Malibu Civic Center area into five hydrogeologic sectors, and staff's application of the nitrogen loads (calculated from #2 above) into a 'spreadsheet' model that estimates attenuation of nitrogen loads released

from OWDSs and transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon) for each hydrogeologic sector.

d. Staff's use of the updated nitrogen loads released from OWDSs (calculated from #2 above) to adjust (update) estimates of nitrogen transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon), using a relationship already established by a groundwater flow and transport model (which is already accepted by stakeholders in the community).

Finally, reviewers are not limited to addressing only the specific issues presented above, and we request the scope of the peer review response include the following overarching questions:

(a) In reading Tech Memos #3 and #4, are there any additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

(b) Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices?

Reviewers should also note that some proposed actions may rely significantly on professional judgment where available scientific data are not as extensive as desired to support the statue requirement for absolute scientific rigor. In these situations, the proposed course of action is favored over no action.

The preceding guidance will ensure that reviewers have the opportunity to comment on all aspects of the scientific basis of the proposed Board action. At the same time, reviewers also should recognize that the Board has a legal obligation to consider and respond to all feedback on the scientific portions of the proposed rule. Because of this obligation, reviewers are encouraged to focus feedback on the scientific issues that are relevant to the central regulatory elements being proposed.

Attachment 3 – List of Participants

Technical Staff at the Los Angeles Regional Water Quality Control Board:

Wendy Phillips, P.G., C.E.G, C.H.G., Chief, Groundwater Permitting and Landfills Section

Dr. Rebecca Chou, P.E., Chief, Groundwater Permitting Unit

Elizabeth Erickson, P.G., Engineering Geologist, Groundwater Permitting Unit

Toni Callaway, P.G., Engineering Geologist, Groundwater Permitting Unit

Orlando Gonzalez, Water Resources Control Engineer, Groundwater Permitting Unit

Dr. C.P. Lai, P.E., TMDL Unit

Jenny Newman, Chief, TMDL Unit

This page intentionally left blank.

Attachments 4, 4.a, and 4.b

3. Technical Staff Report (Overview – draft dated July 31, 2009), in support of an Amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-Site Wastewater Disposal Systems in the Malibu Civic Center Area, plus Tech Memos #3 and #4:[1]

   a. Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation**, by Elizabeth Erickson, P.G. (draft dated July 31, 2009)

   b. Technical Memorandum #4: **Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life**, by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E. (draft dated August 4, 2009)

[1] Other tech memos and materials related to this proposed regulatory action, may be accessed and downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml.

State of California
California Regional Water Quality Control Board, Los Angeles Region

DRAFT

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

JULY 31 2009

July 31, 2009

Table of Content

Page Numbers

Technical Staff Report Overview.....1-10
Wendy Phillips

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.....T1-1 to T1-5
Rebecca Chou

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water
David Koo.....T2-1 to T2-7

Attachment 2-1 Data Tables for 47 Individual Wells.....T2-8 to T2-51
Attachment 2-2 Graphs for 47 Individual Well.....T2-52 to T2-95

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Body Contact Recreation.....T3-1 to T3-47
Elizabeth Erickson

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.....T4-1 to T4-33
Toni Callaway and Orlando Gonzalez

Attachment 4-1 Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loading from WODS to the Lagoon..T4-34 to T4-43
C. P. Lai

Technical Memorandum #5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.....T5-1 to T5-22
Dionisia Rodriguez and Ryan Thacher

DRAFT JULY 31 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* to incorporate a Prohibition on On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Staff Report Overview

by
Wendy Phillips,* P.G., C.H.G., C.E.G.
Chief, Groundwater Permitting and Landfill Section

In addition to her current colleagues in the Groundwater Permitting Unit, the author expresses appreciation for TMDL contributions from Jenny Newman, CP Lai and Eric Wu, post-production contributions from Rosie Villar, Enrique Casas, Jeff Ogata, Rodney Nelson, and Joe Luera, and contributions from past colleagues Rick Viergutz, Hugh Marley, Morton Price, and Dennis Dickerson.

DRAFT JULY 31 2009

Technical Staff Report Overview

by
Wendy Phillips, P.G., C.H.G., C.E.G.
Chief, Groundwater Permitting and Landfill Section

DRAFT JULY 31 2009

Introduction

The purpose of this Technical Staff Report is to present evidence in support of an amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan),* to prohibit subsurface disposal systems in the Malibu Civic Center area. The Malibu Civic Center area, shown in Figure 1, includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Types of subsurface disposal systems that would be prohibited by the amendment to the *Basin Plan* range from passive systems with conventional septic tanks to active systems that more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would apply to systems that serve individual properties (residential, commercial, industrial, and public properties) as well as groups of those properties. Collectively throughout this report, these disposal systems are referred to as on-site wastewater disposal systems, or OWDSs.

Environmental Setting

Background

The Malibu Civic Center area supports a population of about 1,000 residents and is the core of the City's business, cultural, and commercial activities. The area, which includes the renowned Surfrider Beach, attracts a high volume of visitors.

Without community sewers and wastewater treatment infrastructure, residents, businesses, and public facilities in the City of Malibu use thousands of on-site disposal systems to discharge their sewage to the subsurface and underlying groundwater. In several areas of the City, unfavorable hydrogeologic conditions coupled with high flows of wastewaters have raised concerns about reliance on this wastewater disposal strategy. In one of those areas of concern, the Malibu Civic Center area, intensive land use activities by almost 400 dischargers result in the release of wastewaters to the subsurface at a rate that Regional Board staff estimates to be as high as 255,000 gallons per day (gpd).

Water Resources

Surface waters in the Malibu Civic Center area include Malibu Creek, Malibu Lagoon – a fresh/saltwater habitat for rare, threatened, and endangered species, and ocean beaches, which are heavily used by the resident population as well as visitors. Groundwater in the area is a historic and potential source of drinking water. In the *Basin Plan*, the Regional Board has formally designated these plus other beneficial uses for the water resources in the area as follows:

Malibu Lagoon: Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

Malibu Creek: Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach: Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.

Groundwater: Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

Also in the *Basin Plan,* the Regional Board has established water quality objectives to protect the beneficial uses identified above.

Impairments to Beneficial Uses of Water Resources

In a 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses are formally identified for the following water resources:

Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
Malibu Beach: impaired by Indicator Bacteria.
Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
Carbon Beach: impaired by Indicator Bacteria.

To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

a. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for on-site wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

b. **Malibu Creek and Lagoon Bacteria TMDL:** The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric

DRAFT JULY 31 2009

mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, on-site wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for on-site wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

c. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for on-site wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including on-site wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

DRAFT JULY 31 2009

Summary of Evidence

Staff investigations focused in five areas and are presented in five technical memoranda that comprise this staff report, and that meet the requirements of the California Water Code, sections 13280 and 13281 for determination that discharges of OWDSs in the Malibu Civic Center area result in violation of water quality objectives, will impair present or future beneficial uses of water, will cause pollution, nuisance, or contamination, or will unreasonably degrade the quality of any water of the state.

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.

For the privilege of discharging wastewater to a water of the state (including both surface water and groundwater), dischargers must comply with waste discharge requirements (WDRs) that are specified in Orders issued by the Regional Board. The WDRs generally incorporate monitoring and reporting programs that rely on self-monitoring by dischargers. The reports of self-

monitoring are used by the Regional Board to determine compliance and to ensure that the quality of the water into which wastes are discharged is not degraded and that beneficial uses, such as drinking water and swimming (body contact recreation) are protected.

In the Malibu Civic Center area, the Regional Board regulates 21 discharges, all of which are from commercial, industrial, or public facilities. In a review of the compliance records for 20[1] of the 21 discharges, each dischargers had a record of violations. Among the most serious violations are repeated failures to achieve effluent limits specified in WDRs; in particular, limits for pathogens and nutrients (species of nitrogen and phosphorus) that are identified as pollutants in nearby waters that the Regional Board and EPA have designated as impaired under Clean Water Act section 303(d). Also, several dischargers 'failed to submit' monitoring reports, and compliance with technical requirements in their WDRs could not be determined.

Among the minor violations included in Table 1-1 are tardy submittal of reports of self-monitoring required by the WDRs and improper certifications of those monitoring reports – e.g. a perjury statement executed by a party not authorized to certify the accuracy of the results on behalf of the discharger, and/or modifications to the language of the perjury statement that is specified in a WDR.

Staff concludes that dischargers have poor records of compliance with Orders issued by Regional Board, and that discharges are, in general, not meeting requirements prescribed to protect water quality and beneficial uses.

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water.

Although groundwater in the Malibu Valley Groundwater Basin is not an existing source of drinking water to the community, groundwater was the community's source of drinking water until the 1960s. Groundwater production in the area gradually ceased as a newly formed special district – Los Angeles County Waterworks District No. 29, Malibu – started delivering imported water to the Malibu area and Topanga Canyon in the early 1960s. As a future resource – and also in the event of a disruption of deliveries of imported water, groundwater is an important local resource that the community may need to use in the future. The Regional Board recognized this beneficial use, in designating groundwater as a potential source of drinking water in the *Basin Plan.*

To evaluate impacts from OWDSs on groundwater as a potential source of drinking water, staff identified 47 groundwater wells, all of which were designed and constructed for monitoring the quality of groundwater, and compiled data pathogens and nitrogen. To examine the extent of impairment of this groundwater for drinking water, staff compiled all available analytical results of sampling for pathogen indicators and nitrogen species during the period July 2002 through May 2009 and compared these results with drinking water standards for these pollutants. As summarized in graphs and tables for each well:

[1] One discharger, Malibu Lumber, did not commence discharge until April 2009, subsequent to the staff's evaluation of compliance records. Since commencement of the discharge, this discharger has been in violation of its WDR.

DRAFT JULY 31 2009

- ***Pathogens in Groundwater do not meet the Drinking Water Standard:*** Forty-four wells, or 94% of the 47 wells, had fecal coliform during at least one sampling period. Of the 671 fecal coliform samples collected from the 47 wells during the review period, 360 samples (54%) tested positive and exceeded the maximum contaminant level (MCL) of less than 1.1 MPN/100ml (Most Probable Number per 100 milliliters).

- ***Nitrogen in Groundwater does not meet the Drinking Water Standard:*** Fourteen wells, or 30% of the 47 wells, had nitrate plus nitrite at levels above the MCL of 10 mg/L (as nitrogen). Of the 671 samples collected from the 47 wells during the review period, 100 (15%) were above the MCL. Although there is no drinking water standard for ammonia, staff also reviewed analytical data for ammonia in view of the likelihood that the ammonia species of nitrogen will nitrify. These results indicate that, when concentrations of ammonia (converted to nitrogen) are added to concentrations of nitrate and nitrite, 163 samples or 24% were above the MCL. Twenty-four wells, or 51% of the 47 wells, had levels above the MCL of 10 mg/L.

As indicated by coliform results, pathogens are present in groundwater at levels that elevate the risk of infectious disease should this groundwater be used for potable purposes. As indicated by the nitrogen results, species of nitrogen are present in groundwater at levels that can cause health problems in humans should this groundwater be used for potable purposes. Infants and fetuses are particularly sensitive and can develop methemoglobinemia (blue-baby syndrome) from ingestion of water with nitrate at levels that deplete oxygen in the blood stream.

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation.

Malibu Creek, Lagoon, and nearby beaches are popular not only within the local community but as a destination for visitors as well. In the *Basin Plan,* the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, consistently failing to meet standards set to protect swimmers and surfers from infectious disease resulting from direct exposure to or incidental ingestion of polluted waters during recreation. Repeated failures to meet standards for standards have resulted in a 'beach bummer' reputation for the renowned Surfrider Beach.

To examine the hydraulic connection of discharges from OWDSs through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters migrate to surface waters and that, consistent with data supporting the designations of impairments, the levels of pathogens do not meet standards protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center area versus comparable beaches with sewers.

DRAFT JULY 31 2009

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to beneficial use of water contact recreation. 5

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.

Malibu Lagoon supports a valuable wetland ecosystem and nearby plant communities such as the the coastal salt marsh and the coastal strand, and also serves as refuge for migrating birds (with over 200 observed species). These beneficial uses are impaired by excessive nutrients levels in the lagoon, depleting dissolved oxygen in the water and stimulating aquatic growth (algae). As established in the nutrient TMDL[2] adopted by the US EPA on March 21, 2003 for Malibu Lagoon, nitrogen from OWDSs in hydraulic connection with the lagoon are subject to a load allocation of six pounds per day.

To quantify current nitrogen loads from OWDSs in the Malibu Civic Center area to the lagoon, staff compiled an inventory of 38 commercial dischargers and 349 residential dischargers. Using real data where available and reasonable assumptions (based on published literature and best professional judgment) for data gaps, staff calculated that the dischargers release about 255,000 gpd through OWDSs and estimated nitrogen loading factors. Applying these nitrogen loading factors to update an existing numerical model designed and calibrated by Questa 2005 for an earlier investigation, staff estimates that nitrogen loads released from OWDSs and transmitted via groundwaters to Malibu Lagoon total 29 pounds per day (lb/day). As a check, staff used the same flows and loading factors to a 'spreadsheet' model which characterized wastewater transport by hydrogeologic sector. Based on the 'spreadsheet' model, staff estimates that wastewaters transport 36 lb/day into Malibu Lagoon.

Staff's estimates of 29 lb/day to 36 lb/day from the numeric and 'spreadsheet' models are greater than two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies, and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

- Commercial Flows: The third-party models used significantly lower assumptions for commercial wastewater flows.
- Nitrogen Concentrations – Residential: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are about one-half of what staff determined is a reasonable assumption.
- Nitrogen Concentration – Commercial: Staff determined that the average nitrogen concentration of commercial wastewater discharges has decreased since 2004, as OWTSs

[2] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003), the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential land use activities. The TMDL specifies a load allocation for on-site wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

DRAFT JULY 31 2009

with greater treatment capabilities has been brought on-line. However, this declining trend in this subset of OWTSs is not great enough to meet the TMDL goal.

Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the load allocation of 6 lb/day for OWDSs established in a TMDL. Accordingly, staff concludes that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 29 lb/day to 36 lb/day as wells as third-party estimates from 17 lb/day to 32 lb/day, all of which fail to meet targets established to restore water quality and protect beneficial uses in Malibu Lagoon.

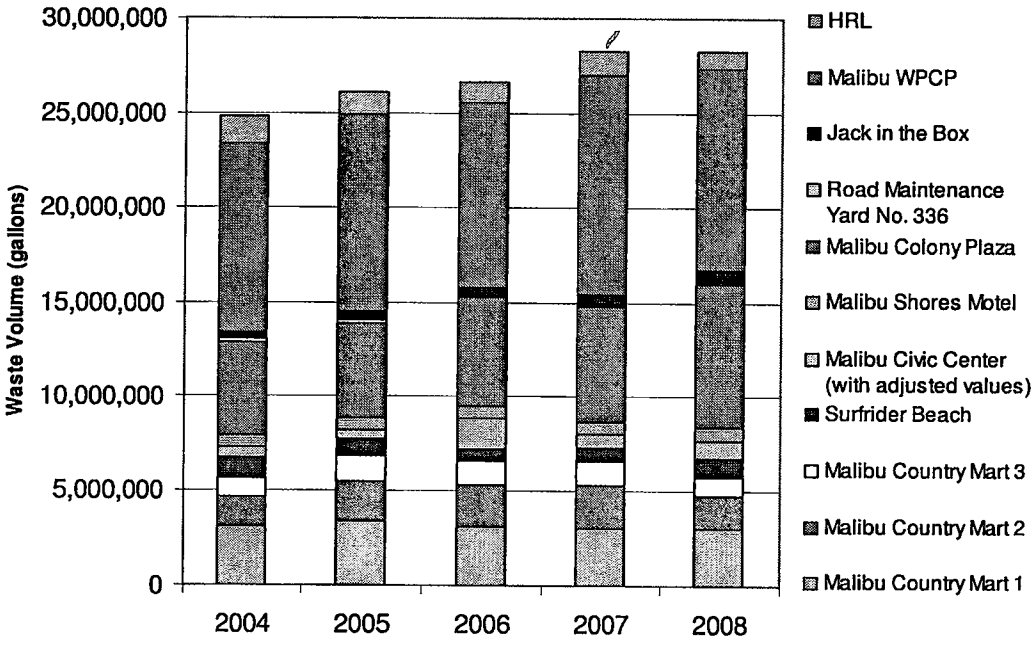
Technical Memorandum No. 5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.

Intensive land use activities on many properties in the Malibu Civic Center area generate wastewater flows at rates that exceed the capacity of OWDSs to transmit the wastewaters into the subsurface. While some dischargers are limited by treatment equipment that has inadequate capacity and/or treatment capabilities, many dischargers do not have adequate disposal capacity on their properties to transmit the wastewaters into the subsurface. Their disposal rates can be constrained not only by lack of space, or area, for on-site disposal fields, but by hydrogeologic constraints as well, such as a high water table or tight soils. Consequently, in order to avoid failure of the OWDSs, a significant number of large dischargers resort to hauling liquid sewage and sludge to communities that have infrastructure to accept their liquid wastes.

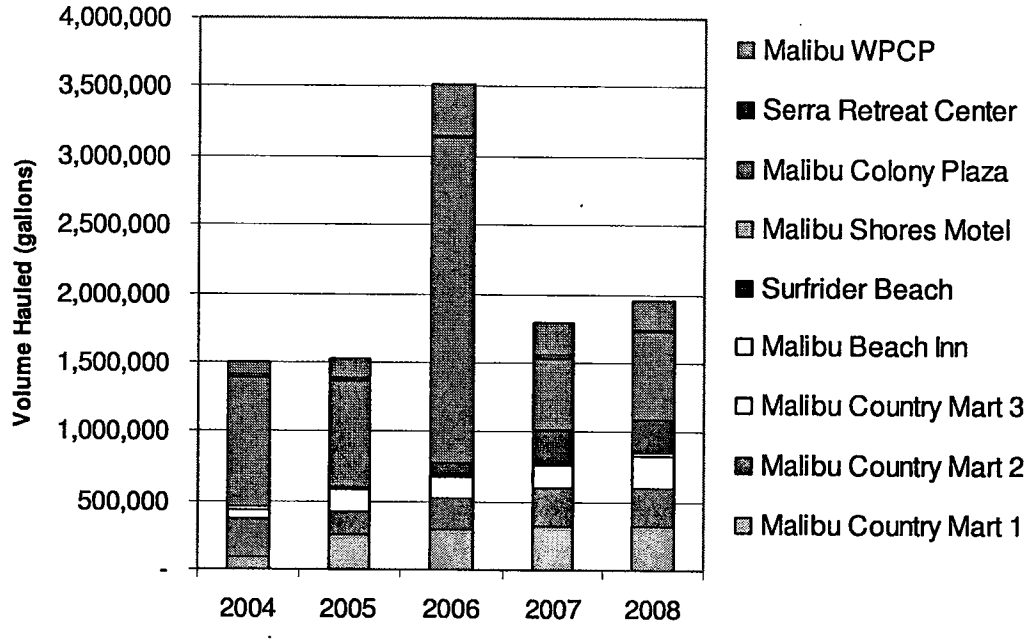
To quantify reliance on the practice of hauling, staff reviewed reports of self-monitoring, which include summaries of off-site hauling, submitted by ten large commercial dischargers. In 2008, these ten dischargers, whose activities generated a total of approximately 28 million gallons of wastewater (77,000 gpd), hauled almost 2 million gallons (5,500 gpd), or about 7%, of their raw sewage to off-site disposal facilities. Furthermore, staff quantified trends from 2004 through 2008, which indicate that these ten dischargers have cumulatively increased their rate of wastewater generation by 15% and their rate of hauling by 29%. (Staff was not unable use existing data from dischargers to analyze seasonal hauling trends – e.g. hauling trends during the wet season, and also during warm summer holidays when populations have high peaks.)

DRAFT JULY 31 2009

Combined Annual Waste Flows for Select Dischargers



Combined Annual Septic Waste Hauling for Select Dischargers



DRAFT JULY 31 2009

Staff also considered the carbon footprint of hauling practices, which generally use large diesel-powered tanker trucks that have to travel between 60 and 180 miles round trip to transport sewage. Staff estimates that hauling by these vehicles releases over 250 tons of carbon dioxide each year. Eliminating the need for sewage waste hauling would contribute toward the goals of California's Global Warming Solution Act by decreasing greenhouse gas emissions. Also, elimination of excessive hauling can help reduce public nuisances, such as traffic, noise, and odor resulting from these practices.

Conclusions

Discharges of wastewaters to the subsurface through OWDSs have degraded water resources and impaired existing and potential beneficial uses of these waters, as determined by the following conclusions from the technical memoranda.

i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) and Time Schedule Orders (TSOs) have poor records of compliance.

ii. Discharges of wastewaters contain elevated levels of pathogens and nitrogen that impair the underlying groundwater as a potential source of drinking water.

iii. Discharges of wastewaters to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds contain levels of pathogens that elevate risks of infectious disease for water contact recreation.

iv. Discharges of wastewaters that flow through groundwater and recharge Malibu Lagoon transport a nitrogen load significantly in excess of the allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.

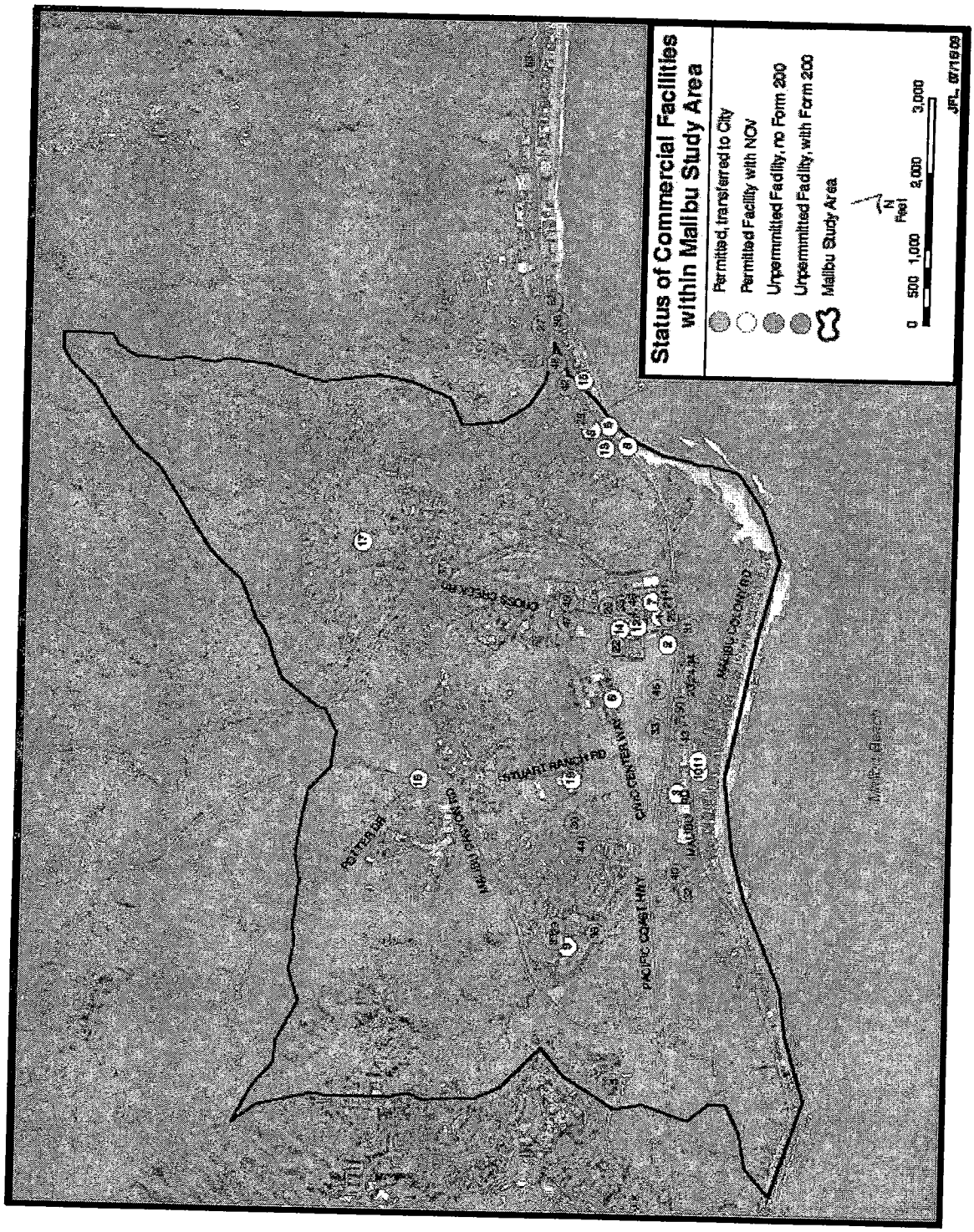
v. Generation of wastewater flows in the Civic Center area has been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

Recommendation

Staff recommends that the Regional Board adopt Resolution R4-2009-xx to immediately prohibit all future discharges of wastewaters and to prohibit existing discharges of wastewater within five years of the Regional Board's adoption, i.e. by October 1, 2014.

DRAFT JULY 31 2009

Figure 1: Malibu Civic Center Area



DRAFT JULY 31 2009

This page intentionally left blank.

State of California
California Regional Water Quality Control Board, Los Angeles Region

DRAFT JULY 31 2009

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit on On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #3: *Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment for Water Contact Recreation*

By
Elizabeth Erickson,* Registered Geologist
Groundwater Permitting Unit

** The author would like to thank Regional Board staff, Joe Luera and interns Albert Chu, Shentong Lu, Shannon Liou, Justin Tang, Tessa Nielsen, Holly MacGillivray, Thomas Palmieri, Ryan Thatcher and Yifei Tong for their assistance in preparing map, tables and graphs.*

Technical Memorandum #3: ***Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment for Water Contact Recreation***

By
Elizabeth Erickson, Registered Geologist
Groundwater Permitting Unit

DRAFT JULY 31 2009

1. Purpose

The purpose of the study is (a) to measure the discharge of enterococcus, a fecal-indicator-bacteria for human pathogens, from septic systems (On-site Wastewater Disposal Systems or OWDS) in the Malibu Civic Center onto adjacent surface waters and beaches, and (b) to determine human health impacts of septic system wastewater disposal on beach users.

2. Study Design and Data

The study design is (a) to examine the distribution of bacteria in groundwater beneath the Malibu Civic Center area, (b) to use beach studies to determine likely fate and transport paths and (c) to use epidemiology studies to estimate health impacts.

Fecal-indicator-bacteria are identified in septic discharge, in leachfields/seepage pits, in groundwater, in streams and beaches and, through rainfall records and frequency distributions, related to groundwater discharge. On-site Wastewater Disposal System performance data from reporting permitted commercial facilities, groundwater monitoring data and beach monitoring data at the Malibu Civic Center are studied for the presence of enterococcus bacteria, which can originate in the human gut, have been used as indicators of human pathogens, and are the basis of a marine recreational criteria for the protection of human health.

The Los Angeles Regional Water Quality Control Board (Regional Board) was tasked with permitting about 40 commercial facilities in the study area after the year 2000 when the State Water Resource Control Board (SWRCB) eliminated waivers for septic systems. Twenty one permitted facilities were transferred to the City of Malibu for oversight under Memorandum of Understanding signed in 2004. Twenty permitted commercial facilities are under Regional Board's oversight. Notices of Violation (NOV) were issued in the spring of 2009 to 20 facilities for non-compliance with WDR and Time Schedule Orders including failure to submit monitoring reports. Of the permitted septic systems which provided monitoring information, four provided end-of-pipe measures and ten submitted groundwater monitoring results. End-of-pipe discharge reports from permitted systems describe effluent as it enters the leachfield/seepage pit. Enterococcus densities were also examined in groundwater monitoring wells surrounding the leachfields which receive septic system effluent.

The City of Malibu measures groundwater quality periodically throughout the Malibu Valley basin which receives the effluent from the septic systems in the Civic Center. The ground water monitoring of 20 wells in the Malibu Civic Center area was completed by the City of Malibu in 2004 and summarized by Stone Environmental, Inc. (Stone) in 2004, but water level and water quality monitoring information collected since that date has not been submitted to the Regional Board and is not included in this analysis.

State and local agencies and nonprofit organizations measure enterococcus in the surface waters and on the beaches adjacent to the Malibu Civic Center area and these records were examined. As an example, beach data was collected as part of the Coordinated Shoreline Monitoring Plan for Santa Monica Bay beaches and the result of a multi-jurisdictional collaborative effort, involving representatives from (a) municipalities and public agencies responsible for the implementation of the Santa Monica Bay Beaches Bacteria Total Maximum Daily Loads (TMDLs), (b) the Regional Board, and (c) the environmental advocacy groups. The "Santa Monica Bay Beaches Bacteria Total Maximum Daily Load Coordinated Site Monitoring Plan, April 7, 2004" (CSMP) went into effect on April 28, 2004 and can be found at http://ladpw.org/wmd/npdes/beachplan.cfm . All sampling procedures are standardized, including morning sampling in ankle-deep water at fixed points with testing in State certified laboratories.

The CSMP monitoring sites were selected to sample the wave wash of 55 miles of shoreline encircling Santa Monica Bay. The sites include major drains that have measurable flow to the beach at the wave wash during the wet weather and beaches that are used for wading and swimming. Each subwatershed was represented by at least one sampling site. Where a storm drain of freshwater outlet is absent, the midpoint of the beach is used. Based on observations of the Santa Monica Bay Restoration Commission staff and Regional Board staff, only the monitoring sites at Santa Monica Canyon and Ballona Creek have flow to the beach wave wash during dry weather throughout August, September, October and November of each sample year.

Among the beach monitoring information collected, the study focused on records for June through August in 2005, May through October in 2006, April through October in 2007, and May through October in 2008, on a total of 58 beaches, 36 of which receive freshwater drainage (with MS-4 stormwater permits) and 22 of which do not. The beaches stretch from El Pescador Beach in the northwest to Redondo Beach in the southeast. Winter data was not evaluated as septic discharge through groundwater to the beach is anticipated to be smaller in contrast to stormwater bacteria discharge to the beaches after rain events.

The sample sites were sorted according to characteristics, such as watershed size, land-use, fecal-indicator-bacteria concentrations, septic system presence, wave strength and beach visitor population. A full array of site characteristics were found to be represented: sewage or septic system waste treatments, adjacent groundwater levels of enterococcus levels above 1 MPN/100mL, watershed sizes ranging from 813 acres to 81,980 acres, urban acres ranging from 128 acres to 68,700 acres, and wave action identified from surf web-sites ranging from none to persistent. Some beaches had adjacent lagoons, tidally influenced pools, stormwater containments and low flow diversions.

Two epidemiology studies, one by the U.S. Environmental Protection Agency (EPA) used in the development of the existing marine recreational swimming criteria based on enterococcus densities, and a recent study from Wisconsin (Borchardt, 2003) correlating health impacts on children to septic system density, were used to estimate the human health effects of a septic system disposal for the Malibu Civic Center

Attachment 3-1 contains a discussion of the statistical analysis completed as part of this study. Attachment 3-2 contains an expanded reference list.

DRAFT JULY 31 2009

Groundwater Discharge

This study examines correlations between bacteria distributions in groundwater basin, surface waters and on many beaches with different characteristics. A different study design would be necessary to confirm causation. For the purposes of this study, groundwater discharge is defined as any flow which passes through the beach face or subsurface to enter the wave zone. It may be comprised of varying volumes of (a) stormwater or urban runoff which has entered the groundwater upgradient from the beach and discharges at the beach, (b) septic effluent which enters the groundwater as a discrete plume or with mixing and discharges at the beach, (c) groundwater which has resided for longer than a season in the aquifer and discharges at the beach. In every beach studied, except Ballona Creek and Santa Monica Canyon beaches, freshwater entering the wave zone must pass through the sand of the beach face during some of the summer months.

When septic beaches are compared with sewered beaches during dry weather, septic beaches may receive groundwater discharge of septic effluent, urban flows, and groundwater, while sewered beaches are limited to a mix of urban and groundwater flows.

Peer Review

A peer review of a portion of this work was conducted between June 8, 2009, and the public release of this document. An early technical review resulted in recommendations from the reviewers (a) to enhance the confidence of the conclusions using statistics, (b) to recommend additional studies to confirm and extend the results shown here, and (c) to emphasize the complexity of the subsurface hydraulic and microbiological environment between septic discharge and the ocean which have limited a simple characterization of a relationship between human illness from marine recreational swimming and coastal septic use. In response to these comments, additional statistical results were completed and the qualitative conclusions were made on human health risks. The external technical reviewers were Dr. Mark Gold (Heal the Bay), Mr. Steve Weisberg and Dr. John Griffith (Southern California Coastal Water Research Project or SCCWRP), Dr. Alexandria Boehm (Stanford University) and Dr. John Izbicki (US Geological Survey), all of whom have completed research on pathogens on beaches.

Dr. C.Y. Jeng (Department of Toxic Substances Control) provided helpful discussions on statistics.

Integration with Ongoing Studies

An epidemiology study of Surfrider Beach by SCCWRP is planned for the summer of 2009. Groundwater assessment is planned for a seven-day period in July 2009 by Dr. John Izbicki. While providing critical and important information, these two studies are limited in their ability to deny a causal relationship between septic systems and bacteria because (a) groundwater and epidemiology are not examined over an extended period of time and (b) groundwater identification of bacteria transport is repeatedly confounded by time, tide and effluent pathway dependent variations (Boehm et. al., 2004). Descriptions of the ongoing studies are available from the Regional Board.

DRAFT JULY 31 2009

3. Results

Bacteria in Groundwater

Enterococcus bacteria are found being discharged from OWDS, in the adjacent leachfields/seepage pits, throughout the groundwater basin, and in the subsurface adjacent to Malibu Creek, Lagoon and the Civic Center Beaches.

End-of-pipe bacteria measurements were reported for four permitted sites in the Malibu Civic Center. Half of the measures show enterococcus bacteria concentrations larger than or equal to total or fecal coliform measures[1]. The data show the typical wide variation in measures of water samples examined for this study.

All four reporting sites had disinfection so the end-of-pipe measures show events which are present during the failure of chlorine, ultraviolet or ozone treatment. Technical memorandum #1 quantifies the frequency of these failures as does the permit violations notices discussed above.

Table 1: End-of-Pipe Effluent Bacteria Densities MPN/100mL reported for permitted Malibu Civic Center Commercial Facilities with Disinfection. Highlighted measures are enterococcus values in human waste which exceed fecal and/or total bacteria counts or are above 35 Most Probable Number (MPN)/100 mL (geometric mean standard for beneficial use of body contract recreation (REC-1)).

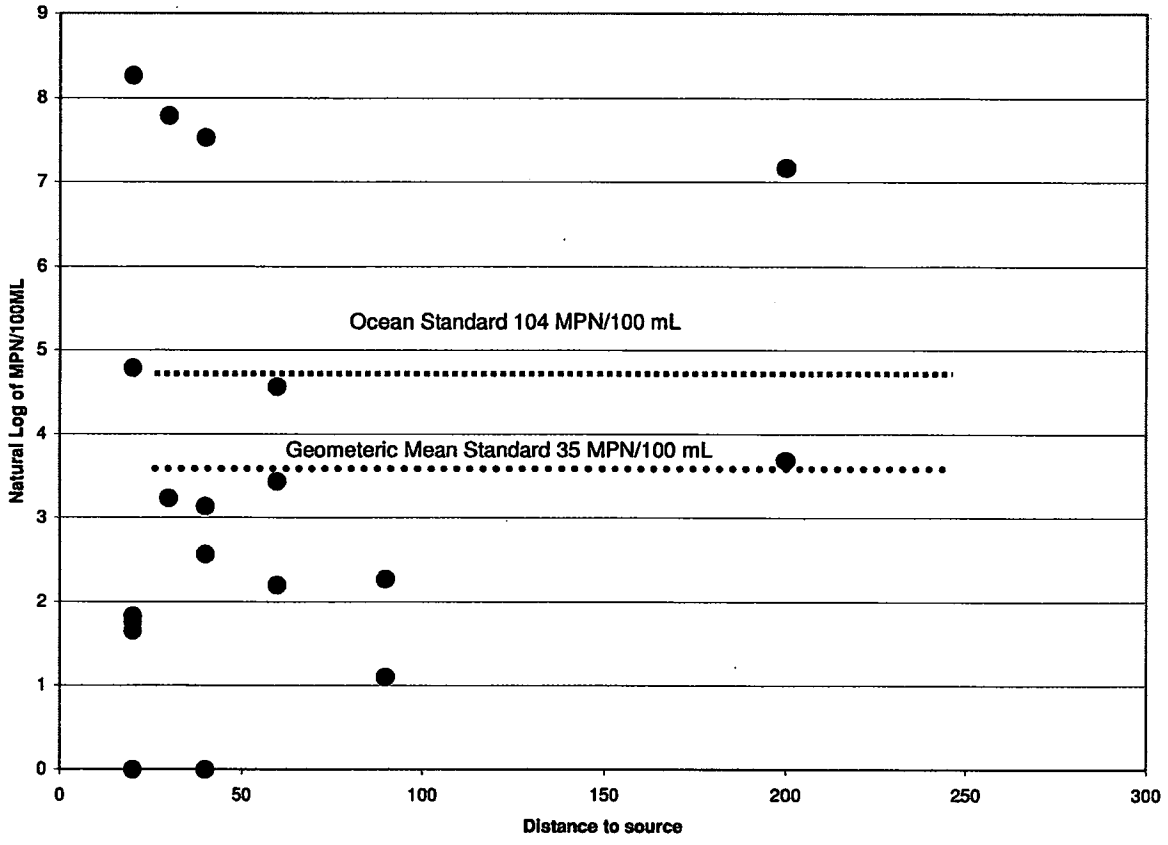
Site	Total	Fecal	Enterococcus
Malibu Creek Preservation	1,600	350	46
	1,600	140	110
Malibu Beach Inn	Not measured	2	2
	Not measured	2	2
Malibu Colony Plaza	105	2	2
	4,000	2	2
	1,600	1,600	2,419
	1,600	1,600	2,419
Fire Station 88	1,600	1,600	2,419
	9,000	Not available	90,000
	24,000	24,000	24,000
	30,000	2,400	50,000
	240,000	Not available	240,000
	300,000	50,000	1,600,000

[1] All bacteria measures, even from the same waste stream, are highly variable. Enterococcus bacteria in end-of-pipe measures correlate with fecal (R^2 = .88) and total (R^2=.84) bacteria in those same samples.

DRAFT JULY 31 2009

An examination of maximum enterococcus densities in groundwater monitoring wells adjacent to nine permitted Advanced On-site Wastewater Disposal Systems in the Malibu Civic Center found that the groundwater bacteria densities are present at elevated levels and decrease from 10,000,000 MPN/mL to zero with distance from the subsurface discharge point to the monitoring well (Figure1).

Figure 1: Natural Log of Enterococcus in Groundwater Wells versus distance from the end-of-pipe in feet in the Malibu Civic Center (outliers at 200 feet distance are attributed to bacteria transport through fractures to the Malibu Administration Center, possibly from residential septic systems)



Elevated bacteria levels were found throughout the Malibu Valley groundwater basin which underlies the Malibu Civic Center area as reported in 2004 by Stone Environmental in "Final Report- Risk Assessment of Decentralized Wastewater Disposal Systems in High Priority Areas in the City of Malibu CA."(Figures 2a, 2b and 3). Large densities are seen adjacent to the receiving waters. Fifteen out of 20 wells in Stone 2004 Study and 16 out of 27 permit monitoring wells contained maximum enterococcus exceeding water quality objective of 104 MPN/100ml for beneficial use of REC-1, i.e., 31 out 47 wells (76% wells) have exceedance.

DRAFT JULY 31 2009

Figure 2a: Chart of Maximum Enterococcus MPN/100 mL for 20 groundwater wells in the Civic Center area from Stone 2004 Study (well locations are shown in Figure 3).

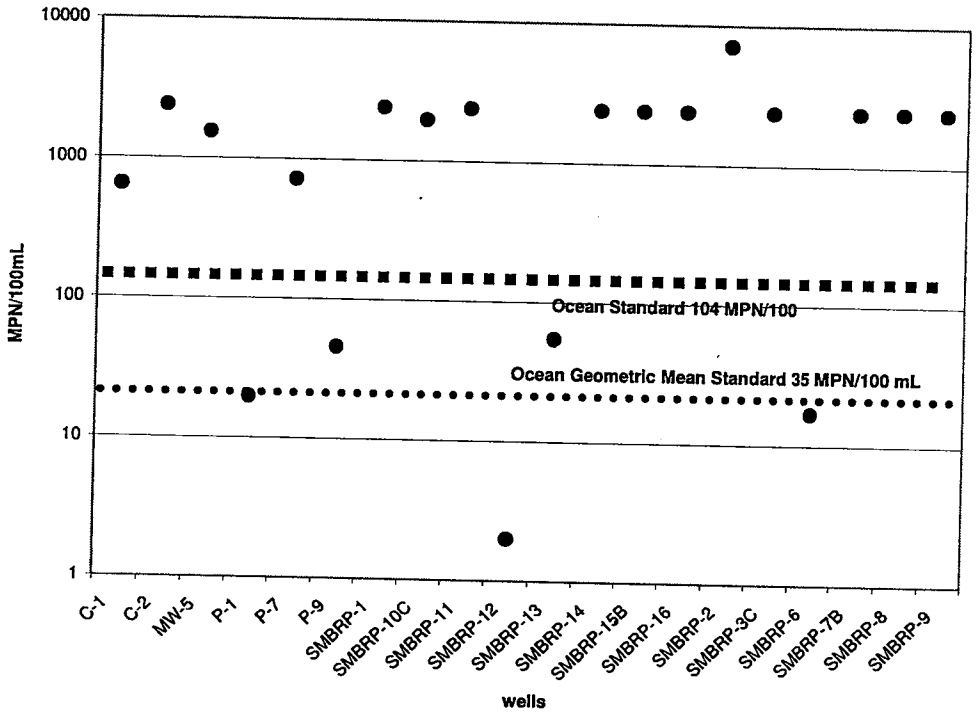
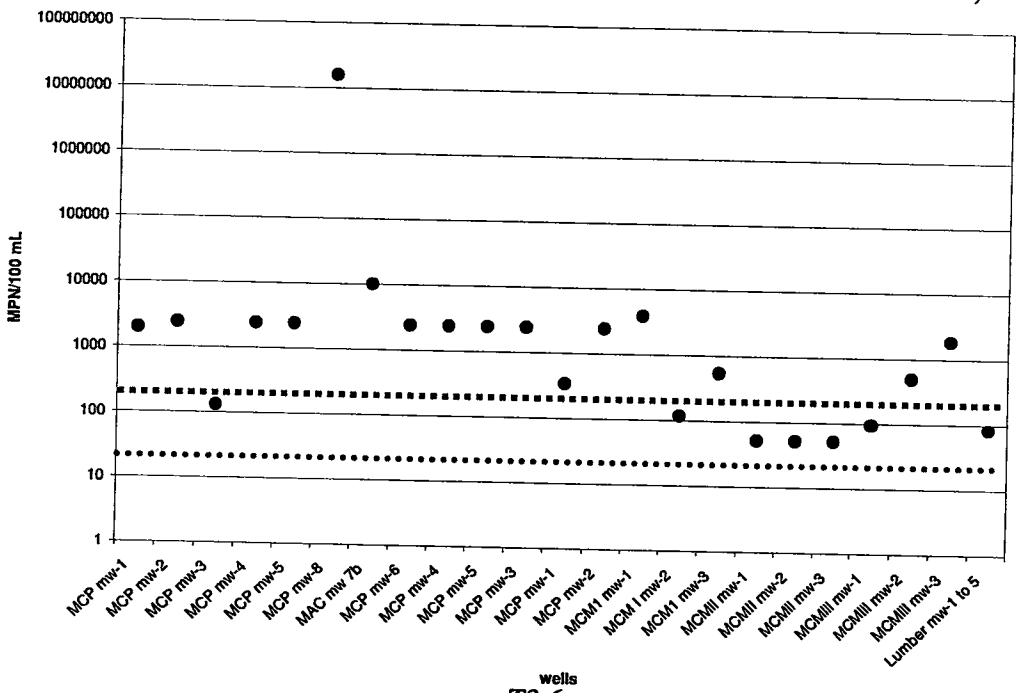
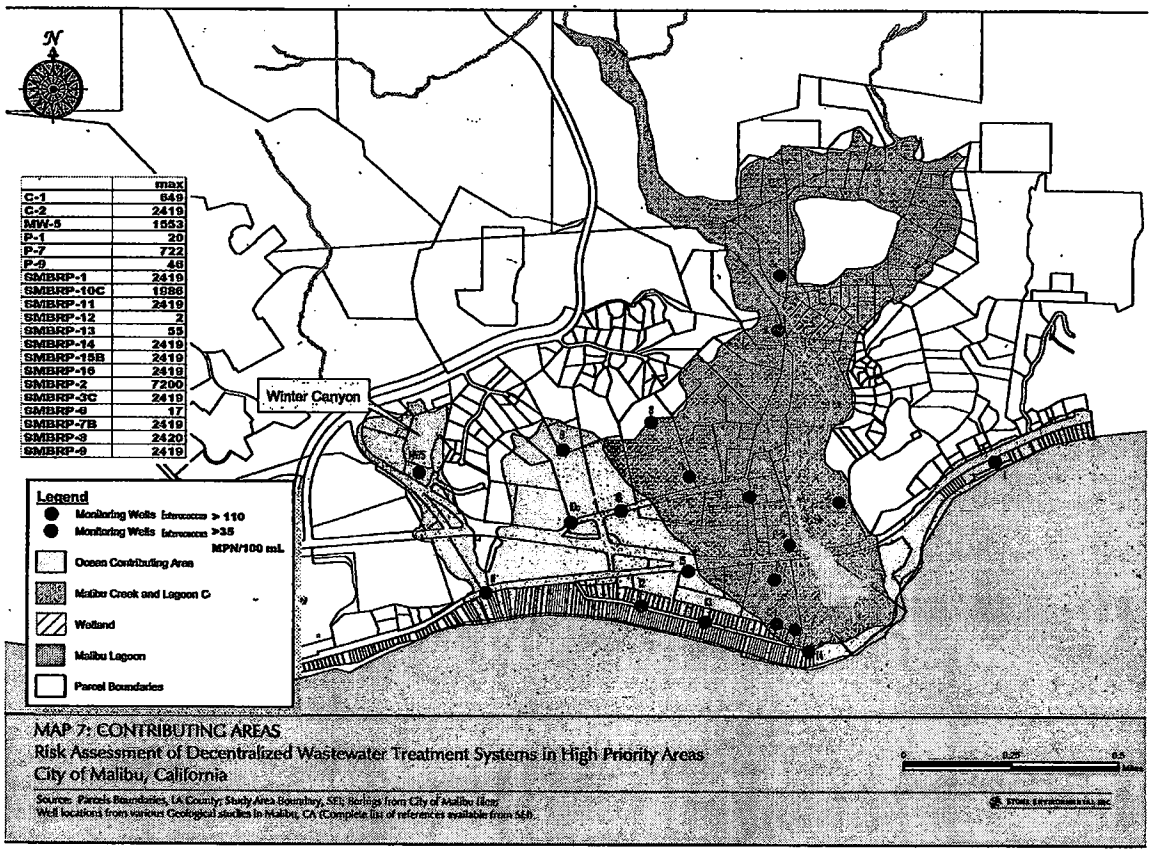


Figure 2b: Chart of Maximum Enterococcus MPN/100 mL for 27 permit monitoring wells in the Civic Center area (well locations are shown in Figure 1 of Technical memorandum #2).



DRAFT JULY 31 2009

Figure 3 after Stone 2004 shows the maximum enterococcus measures in wells in the Civic Center area. (Densities above 104 MPN/100 mL are the darkest spots).

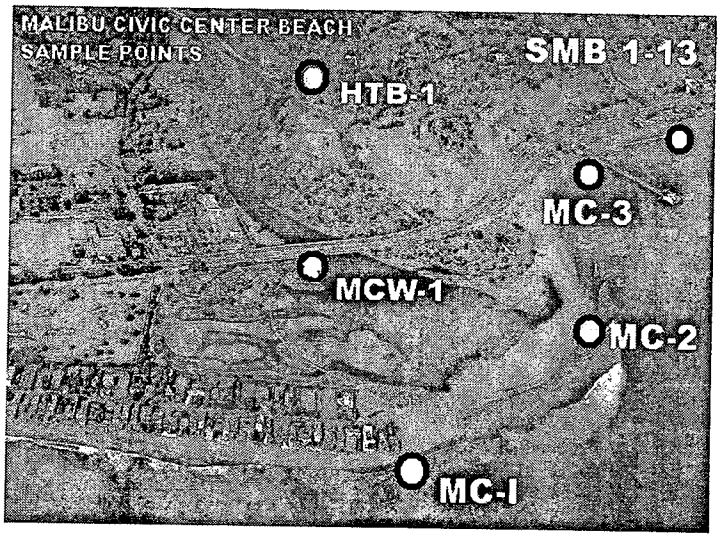


Bacteria in Surface Water

Summer levels of the fecal-indicator-bacteria enterococcus are not as high in the water entering Malibu Lagoon from the Malibu Creek watershed (see Figure 4), as they are downstream of the Malibu Civic Center area. The contrast can be seen in Figure 5 showing enterococcus at Lower Malibu Creek sampling station HTB-1 and Lagoon sampling station MCW-1. Some bacteria in surface water flows in the Malibu Civic Center may enter the surface water with summer groundwater discharge from the Malibu Civic Center area and result in higher enterococcus in the Lagoon. Further, the bacteria in the lagoon surface water must enter the groundwater beneath Surfrider Beach again before discharging into the wave zone at MC-2 as seen on the Figure 4 below.

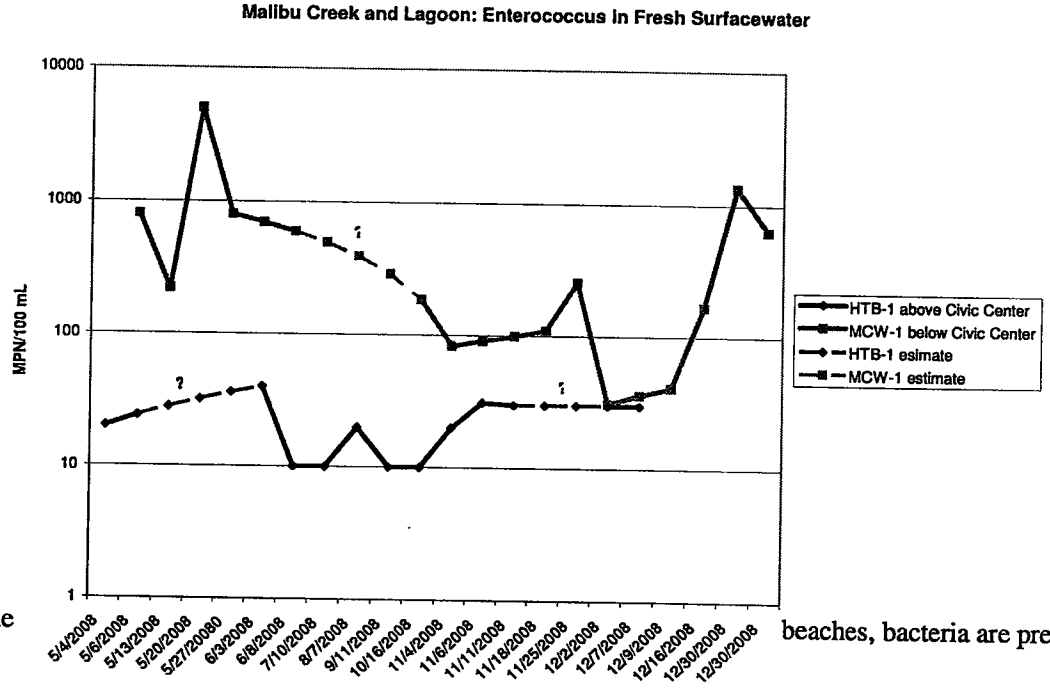
DRAFT JULY 31 2009

Figure 4: Malibu Civic Center Surface water and Beach Sampling Points. (HTB-1 where surface water from Malibu Creek watershed enters the lagoon, MCW-1 where Malibu Creek enters Malibu Lagoon after receiving groundwater discharge from the Malibu Civic Center. Also see are beach sampling points MC-1 at the Beach adjacent to Malibu Colony, MC-2 at the breach point of Malibu Lagoon on Surfrider Beach, MC-3 at the beach adjacent to Malibu Pier and SMB-1-13 at Carbon Canyon Beach where Sweetwater Canyon discharges.)



The Malibu Creek and Lagoon TMDL also evaluated the bacteria levels in surface water and set loads for total bacteria which are less than the loads measured in 2004.

Figure 5: Enterococcus in Surface water at Malibu Civic Center



On the beaches, bacteria are present

DRAFT JULY 31 2009

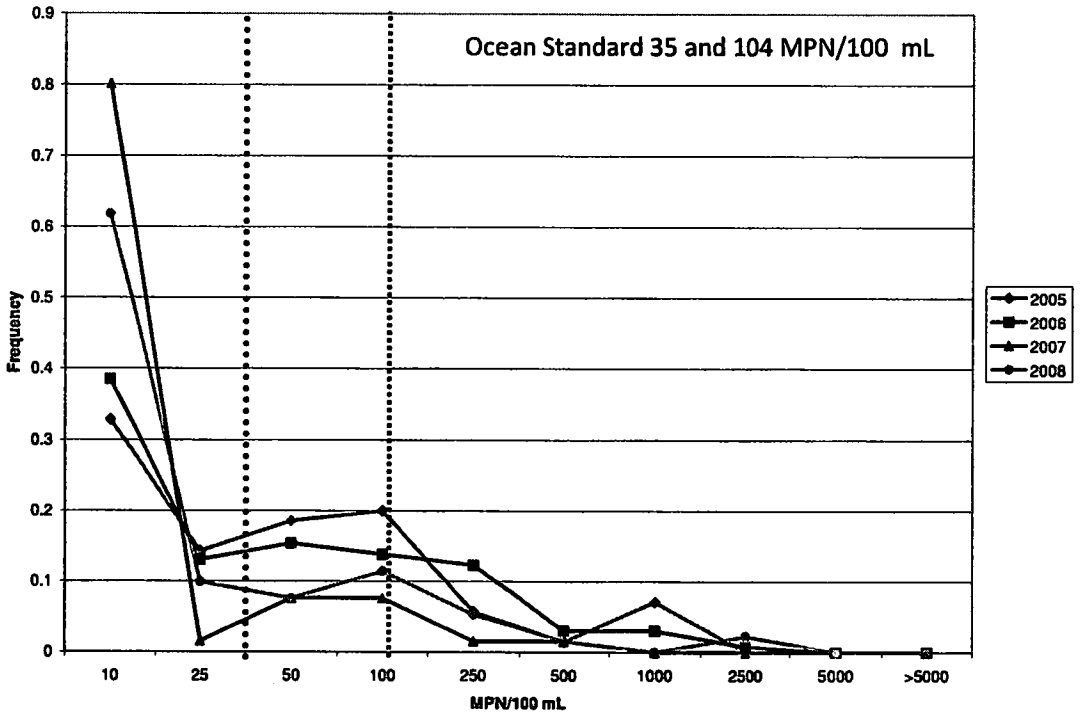
at levels above water quality objectives at Malibu Colony (MC-1), Surfrider Beach (MC-2), and Malibu Pier (MC-3). The pollution on beaches has been quantified in the 2003 303(d) list, Heal the Bay's beach quality grades, and the Regional Board's Santa Monica Bay Bacteria TMDLs. Further, the Regional Board issued a Notice of Violation (NOV) for bacteria at the Malibu Civic Center beaches in March 2008. It identified violations of the waste discharge requirements established in Board Order No. 01-182, as amended by Order No. R4-2006-0074 and Order No. R4-2007-0042, Board directions which constitute the Los Angeles MS-4 Permit controlling urban runoff and stormwater discharge. The NOV identified 493 days and 836 instances in the City of Malibu during the summer of 2007 when water contact recreation objectives were exceeded. Of these exceedances, seventy single sample violations occurred adjacent to the Malibu Civic Center.

Enterococcus on Malibu Civic Center Beaches and all Santa Monica Bay Beaches

The enterococcus measures recorded on beaches at the Malibu Civic Center area over the summers 2005 to 2008 were sorted by interval frequency and plotted against the percentage of the total number of measurements. The method was chosen to minimize the impact of varying sample sizes and simplify large variations in the measures.

The Civic Center beaches were found to have enterococcus frequency distributions with correlation coefficients which demonstrate that the distribution of bacteria frequencies is consistent at a beach, and not a function of external events such as swimmer shedding, the inappropriate disposal of a diaper or beach use by a homeless person.

Figure 6. Surfrider Beach MC-2 Enterococcus Interval Frequency for May-October Summer Single Measures (Correlation coefficients of the frequency distribution ranges from .82 to .99: see discussion in Attachment 3-1)



T3-9

DRAFT JULY 31 2009

Figure 7. Malibu Colony MC-1 Enterococcus Interval Frequency for May-October Summer Single Measures

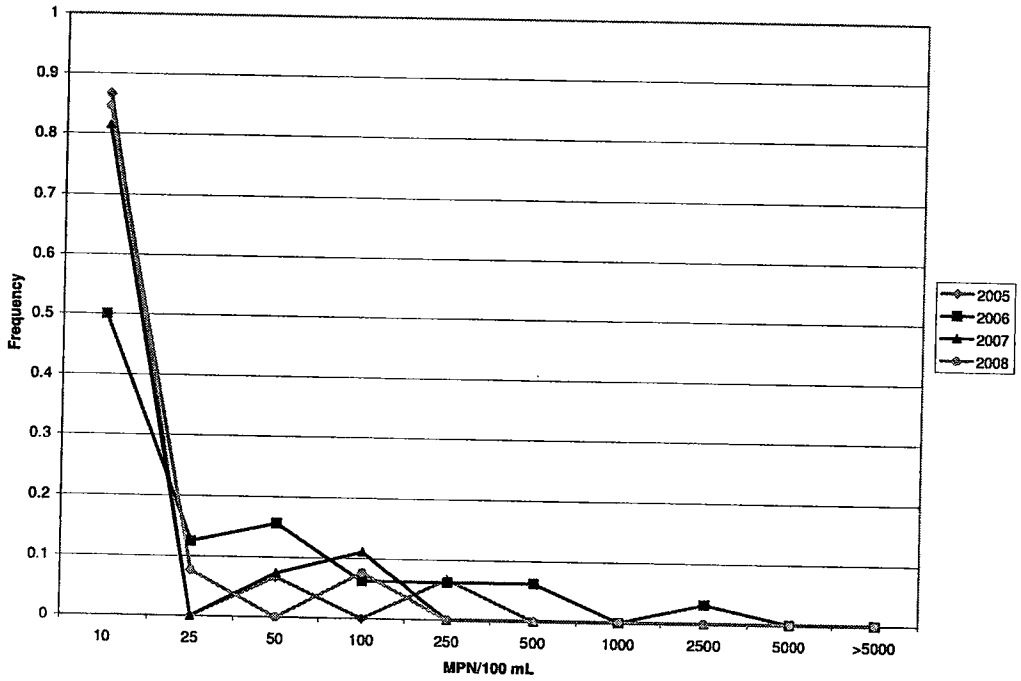
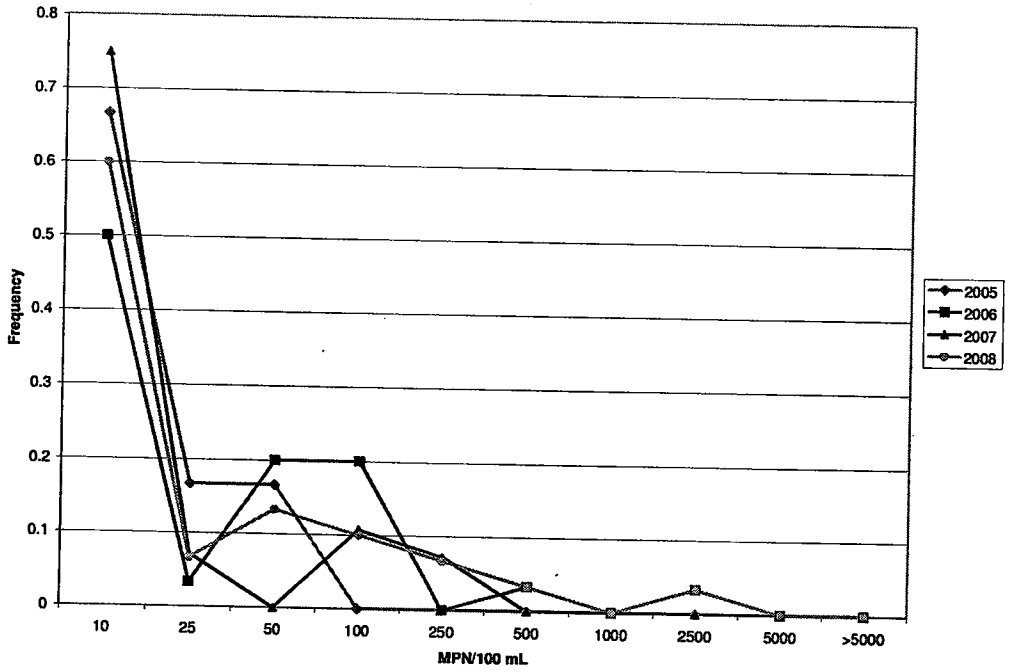


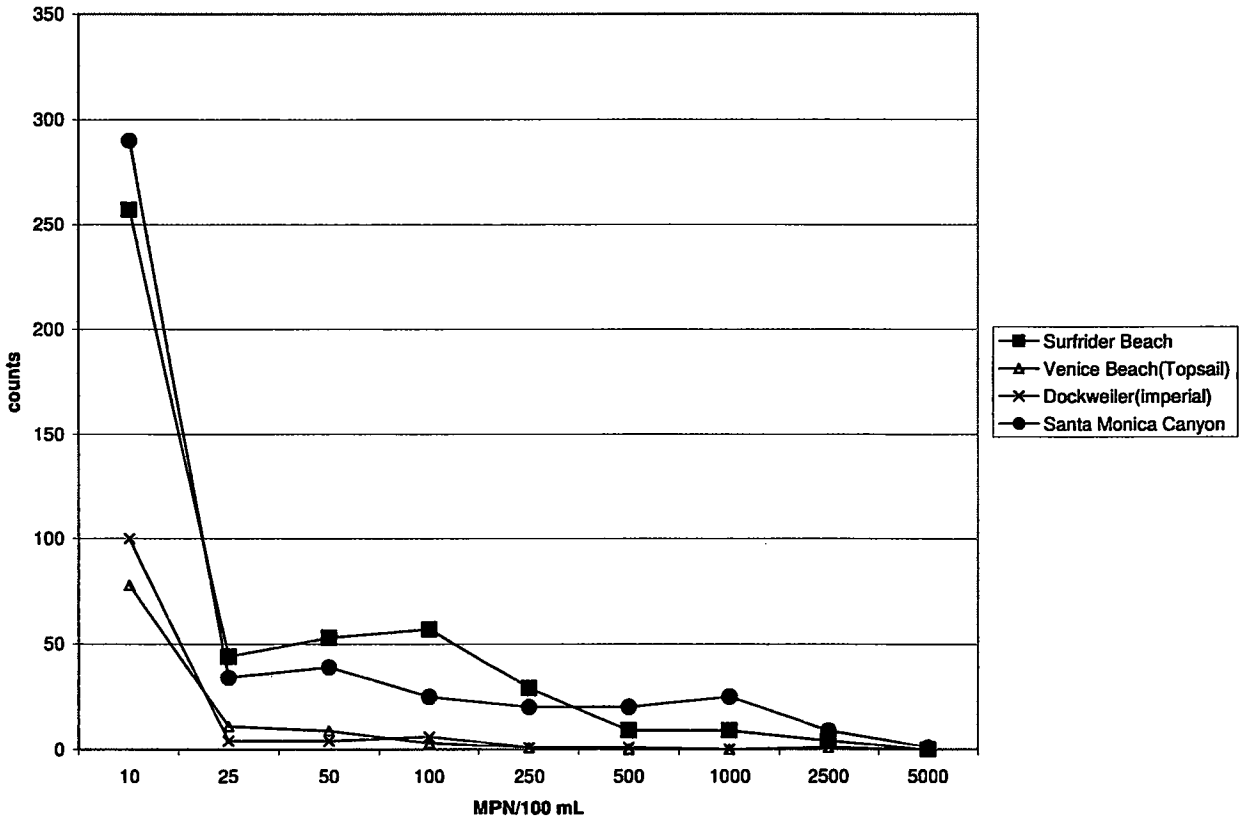
Figure 8. Malibu Pier MC-3 Enterococcus Interval Frequency for May-October Single Measures



DRAFT JULY 31 2009

The enterococcus interval frequency distribution at the Malibu Civic Center beaches (septic beaches) are both similar and distinct from those found for other individual beaches, as in this comparison of the septic Surfrider Beach and Santa Monica Canyon, Venice Beach at Topsail and Dockweiler Beach at Imperial, all of which are sewered. All four beaches are near to a freshwater discharge point for a large watershed area and have heavy public use. In this particular graph, values below 10 MPN/100 mL were not included and counts are displayed instead of frequency.

Figure 9. Surfrider, Santa Monica Canyon, Venice and Dockweiler Beaches Enterococcus Interval Counts for May-October Summer Single Measures for 2005-2008 without values <10 MPN/100mL



DRAFT JULY 31 2009

The Malibu Civic Center beaches were found to have enterococcus frequency distributions similar to those for all Santa Monica Bay Beaches in that they had the most measures at 10 MPN/100 mL and some additional measures above 1,000 MPN/100 mL. Figures 10-13 and Tables 4-7 of all Santa Monica Bay beaches for 2005 through 2008 show that these general characteristics are present for all the studied beaches.

Figure 10. 34 Santa Monica Bay Beaches 2005 (All MS-4 beaches without direct ocean discharge to waves) Enterococcus Interval Frequency for June-August Single Measures

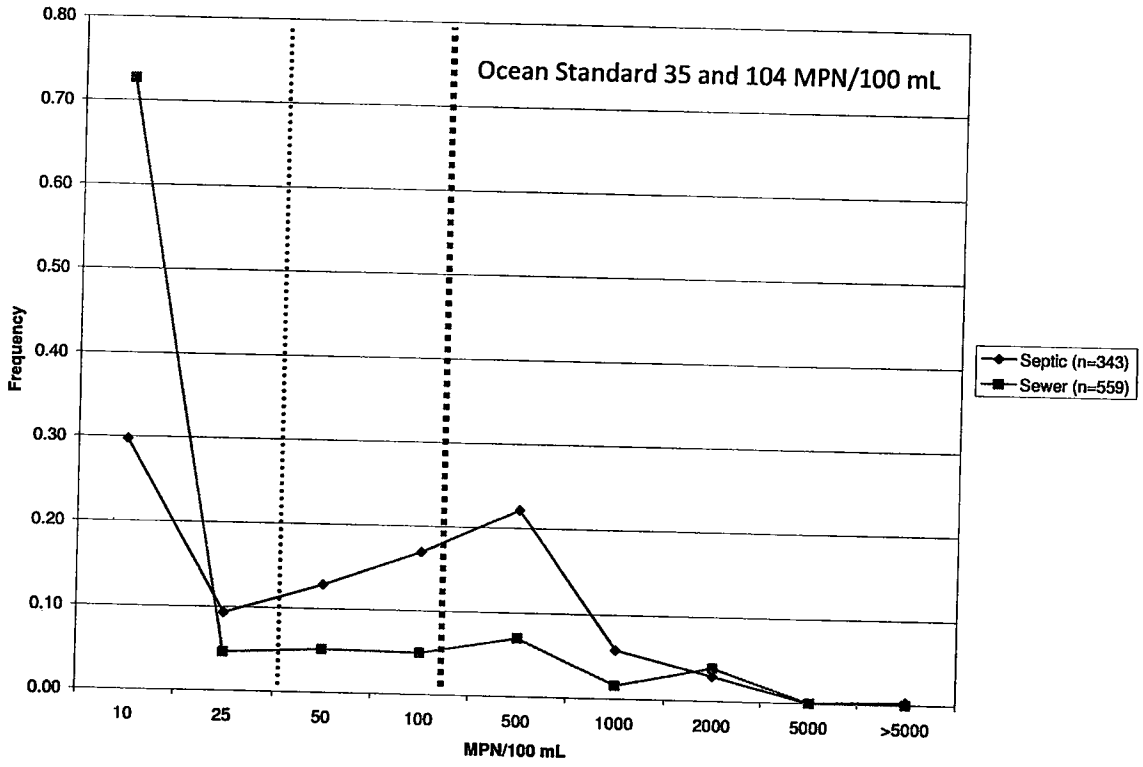


Table 4: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2005.

In MPN/100mL	all beaches in 2005			
Enterococcus	Septic (n=466)	% total days reported at septic sites	Sewer (n=859)	% total days reported at sewer sites
Days above 35	206	44%	207	24%
Days above 104	108	23%	126	15%

DRAFT JULY 31 2009

Figure 11. 34 Santa Monica Bay Beaches 2006 (All MS-4 beaches without direct ocean discharge to waves) 1nterococcus Interval Frequency for May-October Single Measures

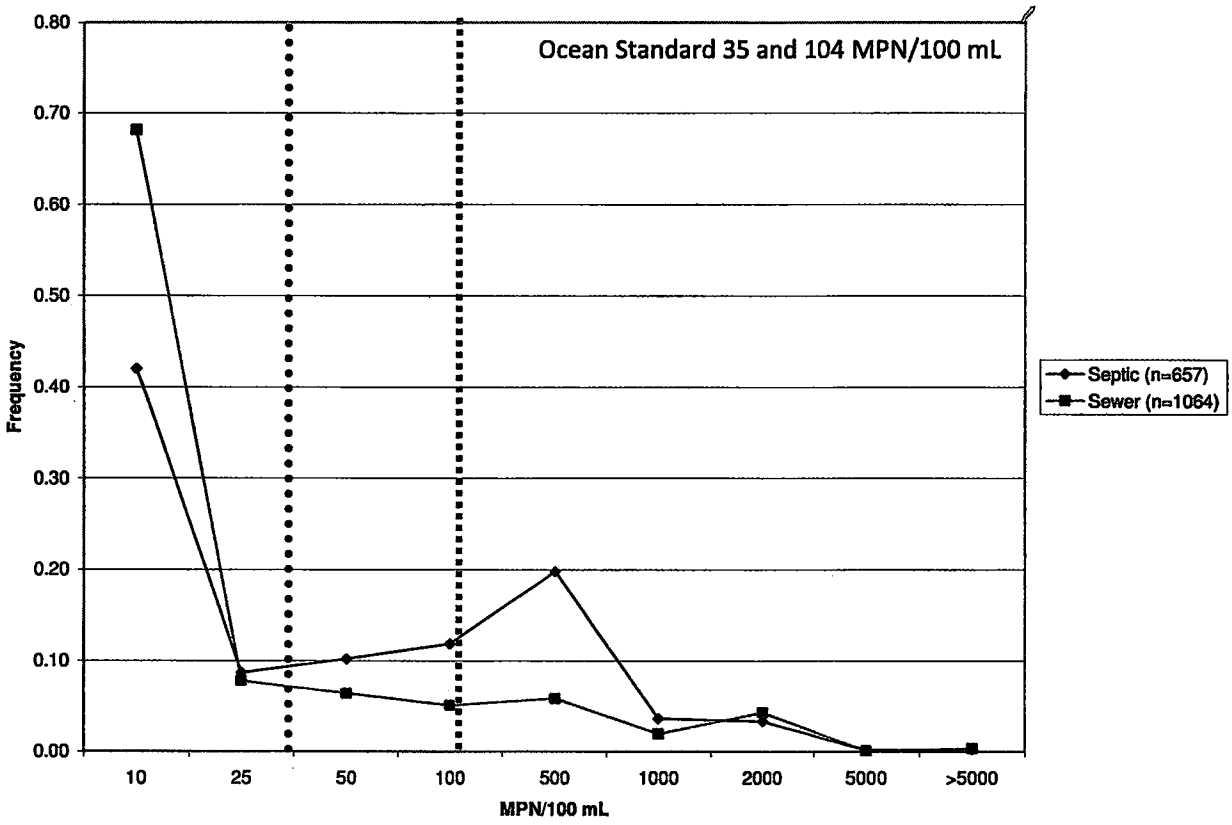


Table 5: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2006. Sewered beaches were tested about one and a half times as often, in this year, as septic beaches, yet more days were recorded when enterococcus densities on septic beaches were higher than the Ocean single sample and geometric mean objectives.

In MPN/100mL	all beaches in 2006			
Enterococcus	Septic (n=903)	% total days reported at septic sites	Sewer (n=1669)	% total days reported at sewer sites
Days above 35	326	36%	295	18%
Days above 104	183	20%	156	9%

T3-13

DRAFT JULY 31 2009

Figure 12. 34 Santa Monica Bay Beaches 2007 (All MS-4 beaches without direct ocean discharge to waves) Enterococcus Interval Frequency for May-October Single Measures

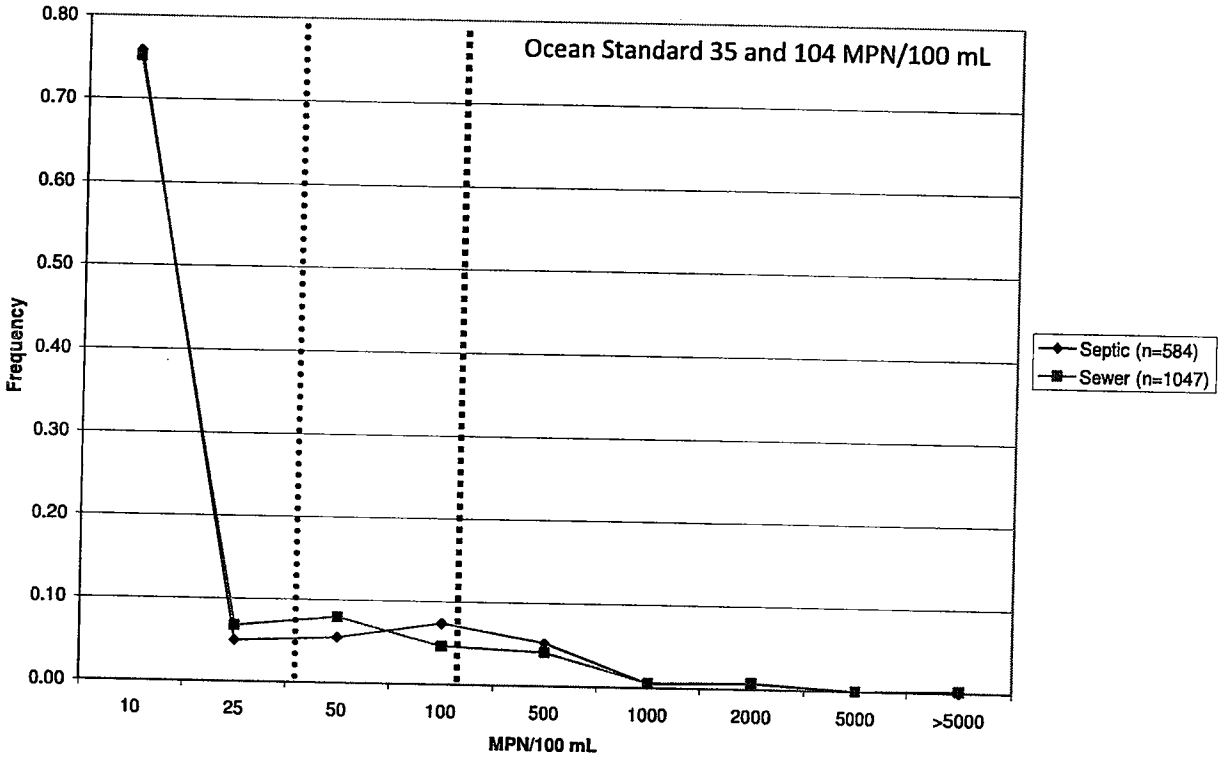


Table 6: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2007. Sewered beaches were tested about twice as often, in this year, as septic beaches, and both had the same frequency of exceedances.

In MPN/100mL	all beaches in 2007			
Enterococcus	Septic (n=816)	% total days reported at septic sites	Sewer (n=1705)	% total days reported at sewer sites
Days above 35	106	13%	215	13%
Days above 104	38	5%	79	5%

DRAFT JULY 31 2009

Figure 13. 34 Santa Monica Bay Beaches 2008 (All MS-4 beaches without direct ocean discharge to waves) Enterococcus Interval Frequency for May-October Single Measures

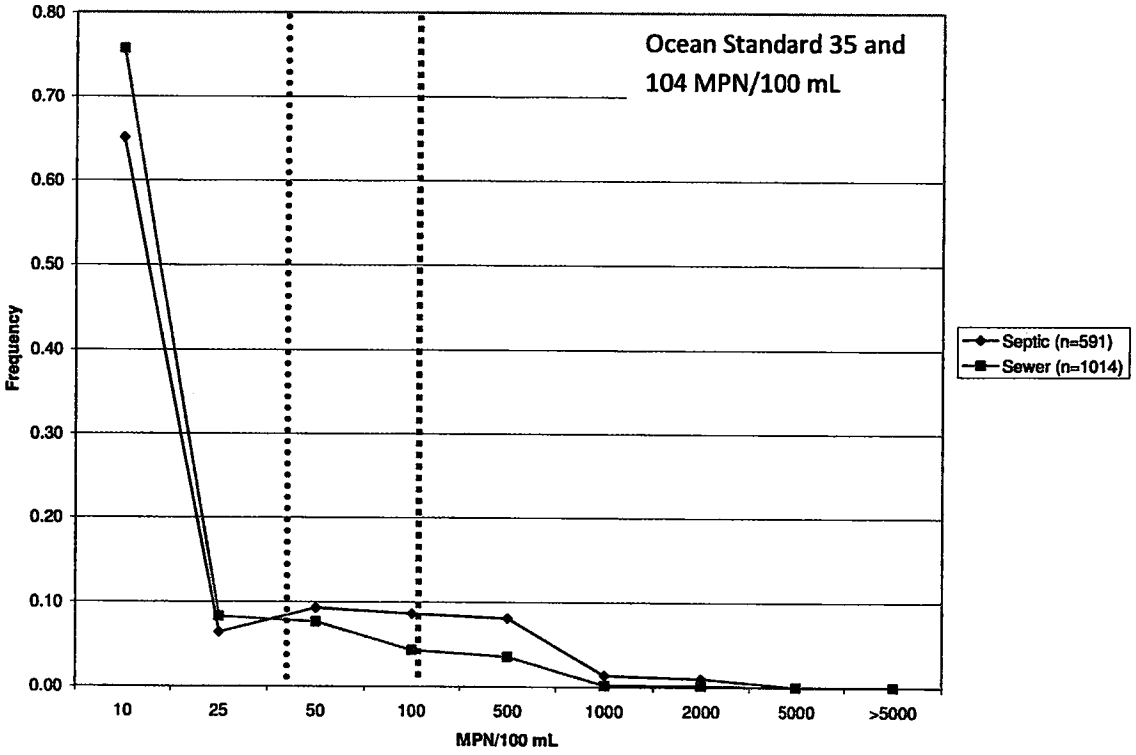


Table 7: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2008.

In MPN/100mL	all beaches in 2008			
Enterococcus	Septic (n=813)	% total days reported at septic sites	Sewer (n=1644)	% total days reported at sewer sites
Days above 35	145	18%	176	11%
Days above 104	59	7%	54	3%

This general comparison between Civic Center Beaches and all Santa Monica Bay beaches is consistent with the hypothesis that the mechanism(s) supplying enterococcus bacteria to beaches during the summer months does not operate uniformly every year. Further, the mechanism which supplies enterococcus bacteria to the beaches at levels of 10 MPN/100 mL, and to a lesser extent at levels above 1,000 MPN, must operate on all beaches regardless of the year or the method of waste treatment in the adjacent area.

Statistic analysis is performed for the same data sets of 2005-2008 using Gehan Test (a non-parametric Statistical Program) from USEPA ProUCL Statistical Program. All results confirmed hypothesis that

DRAFT JULY 31 2009

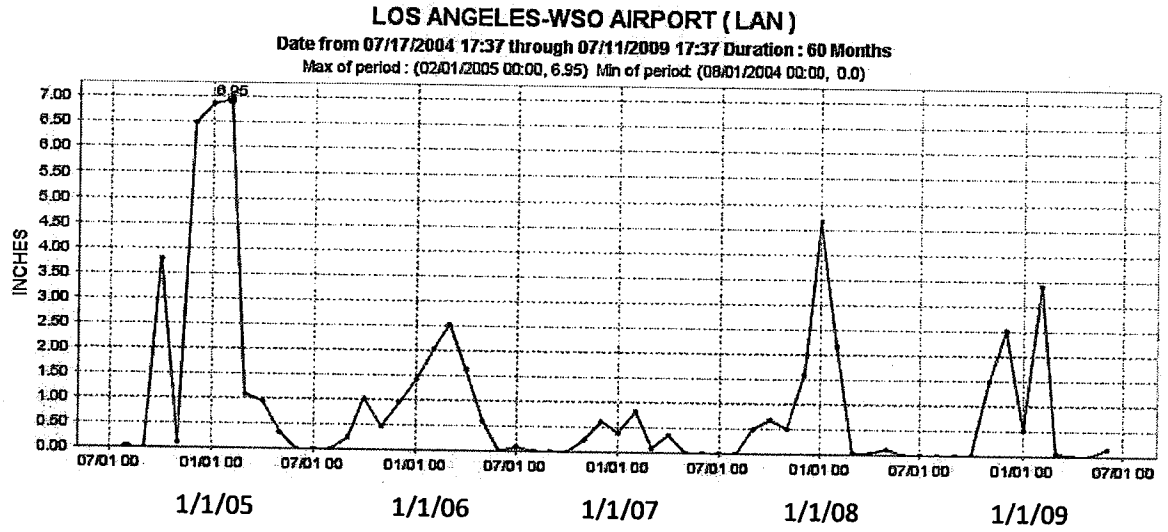
enterococcus concentrations at septic beaches are greater than sewered beaches with 95% confidence level except 2007 data. Gehan Test results are included in Attachment 3-1. *Rainfall and Bacteria*

Examination of all Santa Monica Bay beaches over four years provides evidence that bacteria are transported by groundwater to the beach face. Because bacteria must be transported by the groundwater between the septic systems and surface receiving waters and groundwater gradients increase after rain, a correlation between the number of enterococcus measures per site and the rainfall is expected at beaches where groundwater movement of the bacteria takes place.

Rainfall and Enterococcus

The highest monthly volume of rain fell in 2005 (wet year), among the years evaluated here, when 6.95 inches were recorded. The lowest was reported in 2007 (dry year) when less than one inch was recorded. However, the average annual rain fall in this area is 12 inches per year, significantly larger than the rain received in this study's "wet" year of 2005. Rain gauge reports from Los Angeles International Airport reported by the Department of Water Resources confirm annual variations in precipitation by year and are shown in Figure 14.

Figure 14. Rain gauge information for Los Angeles International Airport (elev.100 feet)



Septic beaches are more distinct from sewered beaches in summers preceeded by rainy winters. The relative frequency of bacteria densities above 35 MPN/100mL on the beaches during the summer are seen to decrease between 2005 and 2007 in Tables 4 through 6. The rainfall also decreases during this period as shown in Figure 14.

Non parametric statistical tools were applied to the enterococcus beach data sets using Gehan Test from EPA's ProUCL statistical program. Using Form 1 Test, the Null Hypothesis is "Septic Beach

DRAFT JULY 31 2009

Mean/Median Less Than or Equal to Sewer Beach Mean/Median;" and the Alternative Hypothesis is "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median". The result of the Gehan Test for 2005, 2006 and 2008 shows that the Null Hypothesis is rejected by a low P-value with an alpha value of 0.05 (a confidence level of 95%) , which rejects the Null Hypothesis and supports the Alternative Hypothesis "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median".

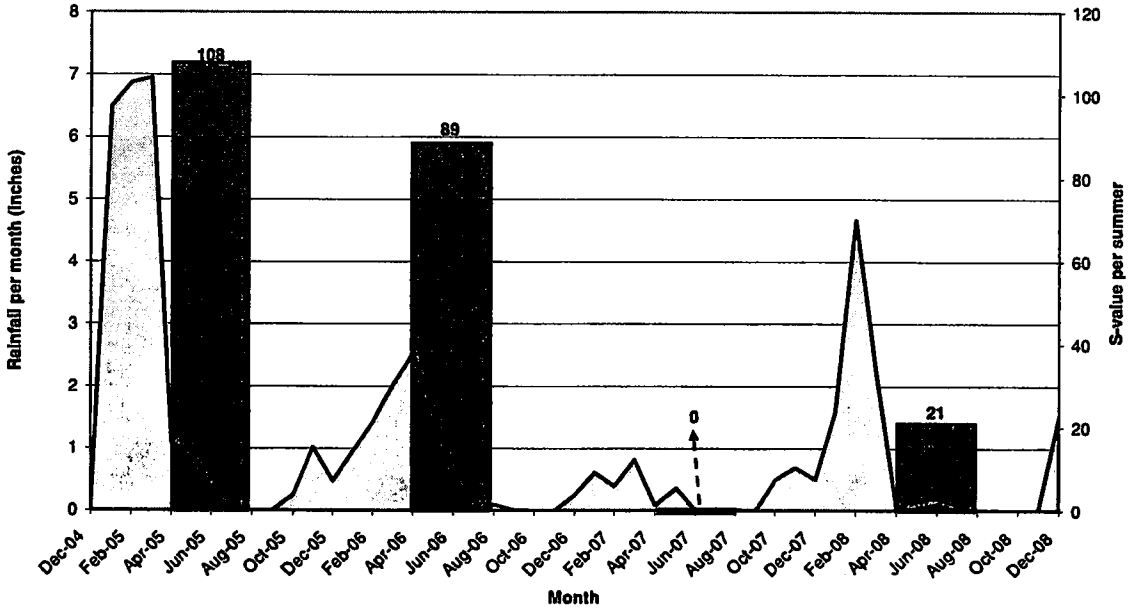
The statistical assessment of the 2007 enterococcus data is not consistent with the statistical results for 2005, 2006, and 2008. The same results were also obtained with an alpha value of 0.01 (a confidence level of 99%); enterococcus concentrations at septic beaches are higher than concentrations at sewered beaches statistically. Form 2 Test is also performed using the Gehan Test to verify the above conclusions.

The "Substantial Difference" (S) is used to estimate the difference in enterococcus concentration between septic and sewered beaches and is shown in Figure 15. The rainfall was low in 2007, as is the S value. The S increases as the winter rains increase in 2008.

Because septic or sewered beach have no stormwater discharge for June to September, these observations document a supply and transport mechansim. Ground water discharge with elevated enterococcocus densities after wet winters is affecting septic beaches to a greater extent than is occuring on sewered beaches. In the summer of 2008, the frequency of enterococcus densities above 35 MPN/100mL does not increase to the 2006 summer levels, despite increasing rainfall in the winter of 2007-2008, nor does the S value increase to 2006 levels. This observation is attributed to short term rain events in February 2008 when discharge was via stormwater and not groundwater recharge..

Figure 15.

Santa Monica Bay: Los Angeles International Airport Monthly Rainfall and Dimensionless Measure of Significance for the Contrast between Summer-Month Septic and Sewered Beach Enterococcus-Interval-Frequency-Distributions vs. Months



T3-17

DRAFT JULY 31 2009

* For a discussion of the S value see Attachment 3-1 on statistics.

The number of violations of the Ocean Plan enterococcus objectives, as reported in the 2008 Notice of Violation sent to MS-4 Stormwater dischargers based on the Santa Monica Bay Dry Weather Bacteria Total Maximum Daily Loads, is higher at Civic Center Beach than at beaches with shared physical characteristics. The exception is Santa Monica Pier. It had fewer geometric mean enterococcus exceedances than Malibu Pier and even single sample enterococcus is less likely to be a human-fecal-indicator as summarized in Table 8. In general, septic beaches have higher exceedance of water quality objectives than sewered beaches when similar individual beach data sets are compared.

Table 8: Failure to meet Ocean Standards at Civic Center Beaches and paired beaches

Fecal Indicator Bacteria Violations for Civic Center Beach	Paired Beach	Single Total	Single Fecal	Single Enter	30 day Mean Enter	Objective not achieved	Total Days objective not achieved
Surfrider (MC-2)		7	25	9	8	132	62
	Santa Monica Canyon(2-7)	0	1	8	0	10	10
	Venice beach Topsail (2-9)	0	0	0	0	0	0
	Dockweiler Imperial (2-13)	1	0	0	0	1	1
Malibu Colony (MC-1)		0	1	0	13	19	14
	Will Rogers east of Sunset (2-3)			3	3		
	Santa Monica Beach at strand (3-9)			0	0		
	Hermosa Beach at 26th (5-4)			1	1		
Malibu Pier (MC-3)		0	0	3	16	20	19
	Santa Monica Pier (3-3)	4	96	15	13	424	236
	Redondo Beach Pier (6-2)			2	2		
	Hermosa Beach Pier (5-5)			1	1		

DRAFT JULY 31 2009

Human Health Risk from Enterococcus on Civic Center Beaches

A specific measure of the human health risk with enterococcus density is based on an epidemiology study (Cabelli, V.J, 1983 EPA health criteria for enterococcus density in marine recreational waters) which correlates fecal-indicator-bacteria enterococcus, a bacteria species found in the human gut, and increased rates of gastrointestinal illness (flu symptoms) among swimmers who immersed their heads. Some of the beaches studied had identifiable sources of treated or untreated human waste entering the marine environment in the vicinity of the beaches, and some did not. All had urban runoff, storm flow and human visitors during the study period.

The swimming-associated gastroenteritis examined in the study is acute, is of short duration and children have the highest attack rates. The symptoms quantified were fever, vomiting, diarrhea, stomachache, and nausea. EPA proposed human rotavirus and/or the parvo-like viruses as etiologic agents. The researchers find "..the etiologic agent(s) for the observed GI [Gastrointestinal] symptomatology is present in sewage in large numbers, that it is highly infective and/or that it survives sewage treatment, disinfection, and/or transport better than the indicator [enterococcus] (page 44)."

EPA counted the immersed-head swimming and non-swimming populations, their highly credible gastrointestinal illness rates and the enterococcus density in the chest-depth water. They found a linear relationship between the swimming associated rate for gastrointestinal symptoms for 1,000 people and enterococcus bacteria density, a relationship depicted for frequency interval in Table 9.

Table 9. Enterococcus Densities and Illnesses among Swimmers

1983 EPA Health Effects Criteria for Marine Recreational Waters (Figure 9, page 43)						
MPN/100 mL	10	50	100	250	500	1,000
Number of illnesses per 1,000 swimmers	9	23	30	40	46	53

Where enterococcus densities are measured and EPA's other assumptions apply, the risk of illnesses per 1,000 swimmers can be estimated using this relationship. If the interval frequencies of enterococcus densities are calculated for a beach over a summer, then that interval frequency (F) at the Santa Monica Bay beaches times the number of illnesses corresponding to the average MPN/100 mL of the interval (N), from the EPA study quantifies the risk (R) as estimated in the number of illnesses in 100 summer days if 1,000 swimmers swim each day.

F (Frequency for range of MPN/100mL) **X** **N** (Number of illness for average MPN/100ML) = **R** (Risk or number of illnesses).

EPA's criteria have been applied to enterococcus bacteria delivered in stormwater flow across a beach into the Santa Monica Bay, similar to the river influent cases in New York. It has also been applied where no surface flow exists between the influent drain or river and the beach monitoring site, like the case in

DRAFT JULY 31 2009

Boston Harbor, where increased enterococcus densities are related to transport of bacteria from the Ocean or through the beach subsurface.

Since the EPA criteria were developed, some authors (Yamahara, 2008) have questioned its application where an ocean outfall of untreated or partially treated sewage is not present. The EPA study is used here because the illness rates were also based on beaches with no identifiable source of human sewage.

Human viruses, have been found in Malibu Lagoon and Ballona Creek as described in Dr. Mark Gold's 1994 thesis. The source of the viruses are identified as urban flows/stormwater and septic discharge. An elevated risk that enterococcus bacteria indicate human fecal pathogens and viruses could be inferred to exist at beaches adjacent to septic systems, receiving surface flows which discharge directly into the wave wash, and adjacent to discharging ground water in which human enterococcus is identified and attributed to septic discharge. Table 10 below is based on 2006 data and combines the EPA risk as defined solely by enterococcus frequencies and illnesses among swimmers and an estimated additional risk factor that the enterococcus measured on the beach is associated with human fecal pathogens or human viruses. Selected beaches are ranked by the presence of (a) year-round overland flow across the beach of storm/urban flow like Ballona Creek where human viruses were identified , (b) septic systems within 300 feet of the tributary channel or the beach like Malibu Lagoon where the viruses were found, or (c) groundwater concentrations of enterococcus above 1 MPN/ 100 mL within 300 feet of the tributary or channel adjacent and related to leach field discharge of human waste. A ranking of 'High' means that all of these factors are present, a ranking of "Moderate" means that two of these factors are present, and a ranking of "Low" means that one of these factors is present. "None" means that none of these factors are present.

The beaches adjacent to the Malibu Civic Center show the highest combined risk based on possible illness related to enterococcus levels and an increased likelihood of the presence of human fecal pathogens and viruses.

Table 10: Combined Measures of Risk for Human Health- individual Santa Monica Beaches (2006).

Site	1983 EPA health risk (Additional illnesses)	Additional risk factors for human enterococcus*	
SMB 1-12	43	High	Marie Canyon Stormdrain on Puerco Beach
SMB 1-07	27	High	Ramirez Canyon at Paradise Cove Pier
SMB MC-02	22	High	Breach of Malibu Lagoon/Malibu Beach
SMB MC-03	20	High	Malibu Pier on Carbon Beach
SMB MC-01	19	High	Malibu Point on Malibu State beach
SMB 1-10	24	Mod	Solstice Creek at Dan Blocker Beach
SMB 1-18	21	Mod	Topanga Canyon on Topanga State Beach
SMB 2-07	17	Mod	Santa Monica Canyon ##
SMB BC-01	13	Mod	Ballona Creek##
SMB 1-08	27	Low	Escondido Creek
SMB 1-09	19	Low	Latigo Canyon
SMB 3-03	18	None	Santa Monica Pier Stormdrain/Beach##
SMB 5-02	17	None	28th Street Drain, Manhattan Beach##
SMB 3-04	12	None	Pico-Kenter Storm Drain##

*risk factors are (a) groundwater enterococcus levels above 1 MPN/100mL, (b) adjacent septic systems, and (c) surface flow across the beach face. ## sewered beaches. Enterococcus levels were not found to correlate with

DRAFT JULY 31 2009

increasing watershed size among MS-4 beaches and were not found to correlate with other possible sources of human enterococcus such as beach attendance or with possible elevated rates of enterococcus preservation such as low wave strength (Yamahara 2007).

Risk at Septic Beaches compared to Risk at Sewered Beaches

A comparison of estimated illness risk for 13 septic and 21 sewered beaches[2], using only the EPA criteria and the MS-4 interval frequency curves for the wettest summer of 2005 results in a risk of 22 illnesses among swimmers for all septic beaches and a risk of 16 swimmer illnesses for all sewered beaches for 100 days with 1000 swimmers at all beaches or 10,000 swimmers at all Santa Monica Bay beaches over 10 days.

For 2006, 22 illness are predicted for 13 septic beaches for every 1000 summer swimmers and 16 for 21 sewered beaches for every 1000 swimmers. While the illness risk for 2007 is the same, the risk of illness in the wet year of 2008 is 15 for septic beaches and 13 for sewered beaches.

This risk calculation assumes that human viruses are equally likely to be indicated by enterococcus at all beaches. More human illnesses are expected at septic beaches because the supply of human fecal material is larger, as described above based on 2005 to 2008 data.

Waste Discharge Treatment and Human Health Risk

About 300 Malibu Colony residences can be counted from aerial photo interpretations after 1955 on US Geological Survey topographic maps at a beach bar with 6,000 feet of ocean front. The width of the developed area of the Colony is estimated at 500 feet for a total area of 3,000,000 square feet. Because 43,560 square feet constitutes an acre, the septic density for Malibu Colony is about 4 septic systems per acre.

Septic systems have been shown to discharge to the surface in the vicinity of the leachfields/seepage pits and this process has been linked to increased illness in children. As a result, increased septic system density is also related to an elevated human health risk. In M.A. Borchardt et.al., "Septic System Density and Infectious Diarrhea in a Defined Population of Children" in May 2003 (*Environmental Health Perspectives* Vol. 111, No. 5), an 8% increase in the risk of viral diarrhea illness was associated with an additional septic holding tank per 640 acres and a 20% increase in bacterial diarrhea was related to an additional septic holding tank in 40 acres. For reference, the density of septic systems in Malibu Colony is much higher, about 4 per acre. The author states "consumption of well water was not a likely transmission route of bacterial infection from nearby septic systems in this study, because bacterial pathogens were not isolated from the wells of case households, although contamination may have been sporadic."

In contrast, a high level of effectiveness of sewage treatment in centralized treatment plants has been developed through best management practices (Allen 1949), the National Pollution Discharge Elimination

---

[2] For the purposes of this study, the following site definitions were made: MS-4 Septic (13)1-06, 1-07, 1-08, 1-09, 1-10, 1-11, 1-12, 1-13, 1-18, 4-01, MC-01, MC-02,MC-03; MS-4 Sewer (21) 2-01, 2-02, 2-06, 2-07, 2-10, 2-11, 2-13, 2-15, 3-01, 3-02, 3-03, 3-04, 3-05, 3-06, 3-07, 3-08, 5-02, 5-03,6-01,6-05,BC-01; Non MS-4 Septic (9)1-01,1-02,1-03,1-04,1-05,1-14,1-15,1-16,1-17; Non MS-4 Sewer (15) 2-03,2-04,2-05,2-08,2-09,2-12,2-14,3-09,5-05,5-04,5-05,6-02,6-03,6-04,6-06

DRAFT JULY 31 2009

System and the State of California's Title 22 regulation. State and Federal regulations now require that when treated sewage is discharged in large quantities (above 50,000) gallons per day, viruses must be 99.9% deactivated by ultra violet or chlorine disinfection before possible human contact is allowed. Even advanced on-site wastewater disposal systems in the Malibu Civic Center area have high failure rate of disinfection as shown in Table 1.

4. Discussion of Historic and Recent Studies

Historic Studies relating Malibu Civic Center Septic Systems to Human Health Risk and Beach Pathogens

Existing technical studies (summarized in Table 11) link septic systems at the Malibu Civic Center area to beach bacteria and are discussed below:

On February 5, 1970, Los Angeles County Health (now California Department of Public Health or CADPH) provided a letter to the Regional Board stating that serious potential hazards to human health were expected to result from septic systems. CADPH has repeatedly closed Surfrider Beach at the Malibu Civic Center due to high bacteria concentrations.

On July 8, 1987, Los Angles County Public Works held a public meeting to discuss a Draft Environmental Impact Report for a centralized waste water treatment plant and sewer for Malibu to address human health risk caused by septic system pathogens. The City of Malibu subsequently incorporated and a group of citizens brought a lawsuit to block the formation of assessment districts. The legal settlement required the new City of Malibu to provide sufficient oversight of on-site waste water treatment facilities such that they would meet Regional Board requirements.

The 1994 Ph.D. thesis of Dr. Mark Gold "What are the health risks of swimming in the Santa Monica Bay?" identified human viruses in Malibu Lagoon and identified a source of the contamination as adjacent septic systems.

On December 12, 2002, the Regional Board adopted a Resolution amending the Santa Monica Beach bacteria TMDL to the Basin Plan. The staff report found that bacteria loads from septic systems contribute to beach pathogens.

On August 30, 2004, the Stone report found that bacteria in the groundwater may enter receiving water where septic systems are found within 6 month groundwater travel time of the Ocean or Malibu Creek.

The September 17, 2004, Memorandum of Understanding between the City of Malibu and the Regional Board stated that "ordinances shall be drafted by staff, and recommended for adoption within the six-month-time-of-travel zone, as identified in the Risk Assessment Report (Stone), to provide advanced treatment and disinfection. The six-month time-of-travel zone shall include all areas contributing to Malibu Creek and Lagoon, and beaches between Sweetwater Canyon outfall and Winter Canyon outfall. OWTS located outside of the six-month-travel-time zone that cannot demonstrate compliance through inspection or that are identified as impacting groundwater by any other means shall provide adequate vertical separation and/or advanced treatment with disinfection." As of the date of this document, the City of Malibu has not provided documentation that systems within the six-month-time-of-travel zone have

DRAFT JULY 31 2009

been upgraded to prevent bacteria discharge to the subsurface or include disinfection, nor has an ordinance to this effect been passed by the City of Malibu.

On Dec. 13, 2004, the Regional Board adopted a Resolution amending the Malibu Creek and Lagoon Bacteria TMDL to the basin plan. The staff report references a surface water model prepared by Tetra Tech which quantifies bacteria loads provided by septic systems in the Malibu Civic Center.

Numerous studies have been completed to describe the ecosystem, hydrology, land use, possible mechanisms of waste water treatment, and costs to support of policy decisions about bacteria and human health risk in the Malibu Civic Center (Ambrose et. al. 2008; Bing Yen and Associates, 2001; Crawford Multari and Clark Associates, 1997, 2006, 2007; Ensitu Engineering, 2008; Gold, 1994; Jones and Stokes, 2008; REGIONAL BOARD, 1972, 1998, 1990, 2002, 2004b, 2008, 2008b; Lucero, 2008; Warshall, 1992; Questa, 2003; RMC, 2008; SMBRP, 1999, 2001; UCLA, 2000; URS Greiner, 1999; EPA, 2003; Stone, 2004a, 2004b, 2004c; Trim, 1994; Thorsen, 2008; and Van Beveren, 2008a, 2008b, 2008c).

Table 11: Historic Findings of Human Health Risk related to Malibu Septic System Use.

Date	Source	Summary
Feb 5, 1970	LA County Flood letter to Regional Board	Future septic systems will pollute groundwater in Malibu Creek with nutrients
Feb 5, 1970	LA County Health (now CA DPH) to Regional Board	Serious potential hazard to health from septic systems
Feb 11, 1970	CA DWR to Regional Board	Malibu Valley needs an area wide Water Quality plan
Apr. 8, 1970	Public Hearing SWRCB	Discontinue septics, continue Regional Board surveillance
Jan. 21, 1971	CA DPH Status Ocean and streams in Malibu	Local ocean and freshwater bacteria exceed shell fish collection in areas of development
Mar. 12, 1971	Regional Board EO to LA County Supervisors	Sewer for Malibu must be provided
May 31, 1972	Regional Board Resolution 72-4	Waste Discharge Requirements only allowed if a timetable is established to provide future connections to LA County sewer
Apr. 10, 1985	CA DPH to LA County Supervisors	Staff report and recommendation to authorize Sewer districts
July 8, 1987-Nov. 30 1988	LA Public Works Public Meeting and Malibu Citizens Committee public meetings	Draft Environmental Impact Report for Sewer, discussion of Malibu incorporating, discuss alternatives for centralized system with wetland treatment
Jan. 18, 1989	LA County Supervisors hearing	STEP WWTP system construction approved

DRAFT JULY 31 2009

1992	Warshall et. al. report finalized	Septic systems in Malibu described. Pathogen removal quantified. Author states that systems require extensive management and recommends centralized system in some areas like Civic center
1994	Thesis Dr. Mark Gold	Three studies between 1990 and 1992 show high fecal-indicator-bacteria frequencies at ankle-depth wave wash and human viruses in runoff from three storm drains in Santa Monica Bay.
Dec. 14, 1998	Regional Board Resolution 98-023	Directs Report of Waste Discharge for all septics and ACL to City of Malibu
Aug 12, 1999	Regional Board Resolution 99-13	El Rio Septic staff report: Poorly maintained septics linked to nitrogen contamination in groundwater
1999	Dames and Moore study	Salt tracer, no pathogens found in wells within 200 feet, but tidal reversal confound results
1999	URS Greiner study	Salt Tracer found at 20 feet in wells, but pathogens not seen in short period test.
Dec. 12, 2002	Regional Board Resolution	Santa Monica Bay bacteria Total Maximum Daily Load: beach pathogens attributed to loads from septic systems
March 21, 2003	EPA Malibu Creek Nutrient TMDL	Total Maximum Daily Load sets loads and numeric targets for total Nitrogen
2003	Questa study	Groundwater discharge to receiving water, quantified including volume from septic system discharge.
Aug 30, 2004	Stone study	Bacteria may enter receiving water where septic systems are found within 6 month travel time
Dec. 13, 2004	Regional Board Resolution	Malibu Creek and Lagoon TMDL: Tetra Tech surface water model sets loads for bacteria from septic systems
March 2006	Richard Viergutz, M.S. Thesis	Discharge of sewage-polluted groundwater into Malibu Creek and Lagoon resulting from groundwater surface interactions

Recent Studies relating Septic Systems to Beach pathogens

Research completed over the last ten years has expanded the understanding of beach bacteria sources and mechanisms of transport. For example, it has been demonstrated that the fecal-indicator-bacteria enterococcus is present on all California beaches, a contamination that is related to both human and non-human sources (Yamahara, 2007) and can be associated with septic system effluent (Boehm et. al., 2004; De Sieyes et. al , 2008). Enterococcus can be transported, stored and, under some conditions, grown in the beach environment. Groundwater transport of bacteria occurs and has been related to nitrogen levels from on-site wastewater treatment systems.

In 2003, Mark Borchardt and others reported in Environmental Health Perspectives, Vol. 111, No. 5 that the density of septic systems correlated with increased rates of infectious diarrhea in children in central Wisconsin. Fecal enterococcus bacteria were one of the indicators used to denote the presence of human pathogens. Borchardt found that viral diarrhea increased by 8% for every additional holding tank in 640 acres and bacterial diarrhea increase by 22% for every additional holding tank in 40 acres. While household wells were sampled for bacterial, risks relate to surface contact with pathogens near septic systems.

DRAFT JULY 31 2009

In 2004, Alexandria Boehm and others reported in Environmental Science and Technology Vol. 38, No. 13 that groundwater discharge of microbial pollution moved from a shallow beach aquifer on to the beach face at Huntington Beach. While fecal-indicator-bacteria were found in only one groundwater sample, column studies show that the transport of enterococcus is not inhibited by sand collected in the field. In addition, radon isotopes characteristic of groundwater linked 38% of the enterococcus variation to groundwater discharge.

In 2007, Kevin Yamahara and others reported in Environmental Science and Technology, Vol. 41, No. 12, that 91% of sampled California coastal beaches had enterococcus. The presence of a source, such as a river, wave shelter and surrounding anthropogenic land use correlated with a significant portion of the population variation. An enterococcus gene study identified a human fecal source in a nearby storm drain.

In 2008, Nicholas De Sieyes and others reported in the Journal of Limnology and Oceanography Vol. 53, No. 4, that fresh nutrient-rich groundwater discharges in fortnightly pulsing into the ocean across a beach. While fecal indicator bacteria and human gene analysis found in monitoring wells were attributed to pollution from adjacent septic systems, the concentrations of these pathogens did not increase with nutrients.

In 2009, Kevin Yamahara and others reported in Applied and Environmental Microbiology, Vol. 75, No. 6, that enterococcus bacteria, related to human enteric disease from swimming in marine waters, can replicate in beach sand with repeated wetting.

In 2009, the American Association for the Advancement of Science summarized studies on Methicillin Resistant Staphylococcus Aureus bacteria (MSRB) found in ocean water and on beaches in Florida in 2009. The bacterial infections are resistant to anti-biotics and are more commonly found in hospitals, but are now known to be transmitted to the beach through contact with infected individuals and, according to one report, through municipal effluent. The ability of the bacteria to travel via sewage has not been quantified.

Other studies have been completed within the last twenty years to characterize pathogen sources and the mechanisms of transport since 1970 when concerns about a human health impact were first discussed for the Malibu Civic Center Area (Bloch, A.B. et. al., 1990; Boehm, A et.al., 2004; Borchardt, M.A. et. al., 2003; Chu A.K. and Sander, B.F., 2008; Cuyk. S.V. et. al. 2004., De Sieyes, N.R., Yamahara, K.M., Layton, B.A., Joyce, E.H., & Boehm, A.B. 2008; Goyal, S.M., & Gerba, C.P. August 1979; Ground Water Monitoring and Assessment Program. May 1999; Noble, R.T, & Fuhrman, J.A.,1996;Schaub, S.A., & Sorber, C.A. May 1977; Schijven, J.F. & Hassanizadeh, S.M. 2002; Stramer, S.L., & Cliver, D.O. 1984;Tiefenthaler, L.L, Stein, E.D., & Lyon, G.S. January 2008; United States Environmental Protection Agency. August 2002;Vaughn, J.M., Landry E.F., Baranosky, L.J., Beckwith, C.A., Dahl, M.C., & Delihas, N.C. July 1978;Yates, M.V., Gerba, C.P., & Kelley, L.M. April 1985;Yates, M.V., Yates, S.R., Warrick, A.W., & Gerba C.P. September 1986;Yamahara, K.M., Layton, B.A., Santoro, A.E., & Boehm, A.B. 2007;Yamahara, K.M., Walters, S.P., & Boehm, A.B. January 6, 2009).

These studies have shown that the beach is a more complex microbiological environment than was previously understood. Familiar fecal-indicator-bacteria like enterococcus have been found in animal and bird (Boehm et. al., 2004; De Sieyes et. al , 2008) feces. Enterococcus has been grown in the laboratory setting from unseeded ocean water samples (Yamahara, 2009) and found in a freshwater environment free

DRAFT JULY 31 2009

from human impact (Tiefenthaler, 2008). Enterococcus has also been shown to persist for later discharge in the beach sand and occur in higher concentrations in organic beach debris (San Diego Regional Board-Newport Bay Total Maximum Daily Loads; Yamahara, 2007).

Anthropogenic enterococcus has been identified in marine water in sheltered urban beaches (Yamahara, 2007) and in nitrogen-rich water (De Sieyes, 2008; Boehm, 2004) attributed to septic discharge from septic systems through the groundwater into the Ocean. Radon rich water associated with groundwater discharge has been related to groundwater discharge of enterococcus on a beach in an urban setting (Boehm et. al., 2004; De Sieyes et. al , 2008).

Recent work also shows that the beach is a more complex hydrologic environment than the steady state condition than had been previously modeled (Stone 2005 Malibu Risk Assessment). Tidal and seasonal (neap and spring) freshwater transport rates have both been reported as higher (Boehm et. al., 2004; De Sieyes et. al , 2008) while ground transport rates during low tide are reported to be higher (Izbicki, 2009). Bacteria have been shown to move unimpeded through field sand samples (Yamahara, 2007). Other workers used sand column studies to show bacteria and virus retention and remobilization was related to the movement of organic material. Sand filtration studies for sewage treatment plants describe 'breakthrough' or bacterial transport for both small (viruses) and large particles (bacteria) in the dynamic condition of 'backwashing' or sand re-packing which takes place in a sand filter and on a beach.

Studies of groundwater do not report bacteria in concentrations consistent with the bacteria measurements taken on the adjacent beach (Boehm, 2004; De Sieyes, 2008). Hydrological mounding beneath the septic areas may affect water table gradients otherwise dependent on tides and freshwater subsurface movement and may result in unpredicted flow paths and either limit or enhance septic discharge (Izbicki, 2009). Similarly, bacteria and viruses have recently been shown to adhere and remain viable in organic material (Yamahara, 2007; Azadpour-Keeley, 2003; Noble, 1996; Schaub, 1997, Schijven, 2002; Stramer, 1984) until remobilized. Other mechanisms which may result in the preservation of enterococcus include elevated nitrogen and/or oxygen levels (Vaughn, 2008; Azadpour-Keeley, 2003; Yates, 1985, 1986) in the subsurface or on the beach face. Further, the subsurface septic plumes have been found to stay intact during subsurface movement (Groundwater Monitoring and Assessment Program: Baxter, Minnesota, 1999).

Possible Sources and Transport Mechanisms for Bacteria in the Malibu Civic Center.

Figure 15 shows the Malibu Civic Center with planned development (Questa, 2003), and the line of the cross section shown in Figure 16. The cross section shows possible paths of transport for the bacteria discharged into septic leachfields/seepage pits to Malibu Creek, Malibu Lagoon and the ocean. Note in the cross section that bacteria leaving septic systems in Malibu Colony or adjacent to Legacy Park have the shortest travel times and fewest opportunities for subsurface physical detention, chemical attack or biological predation.

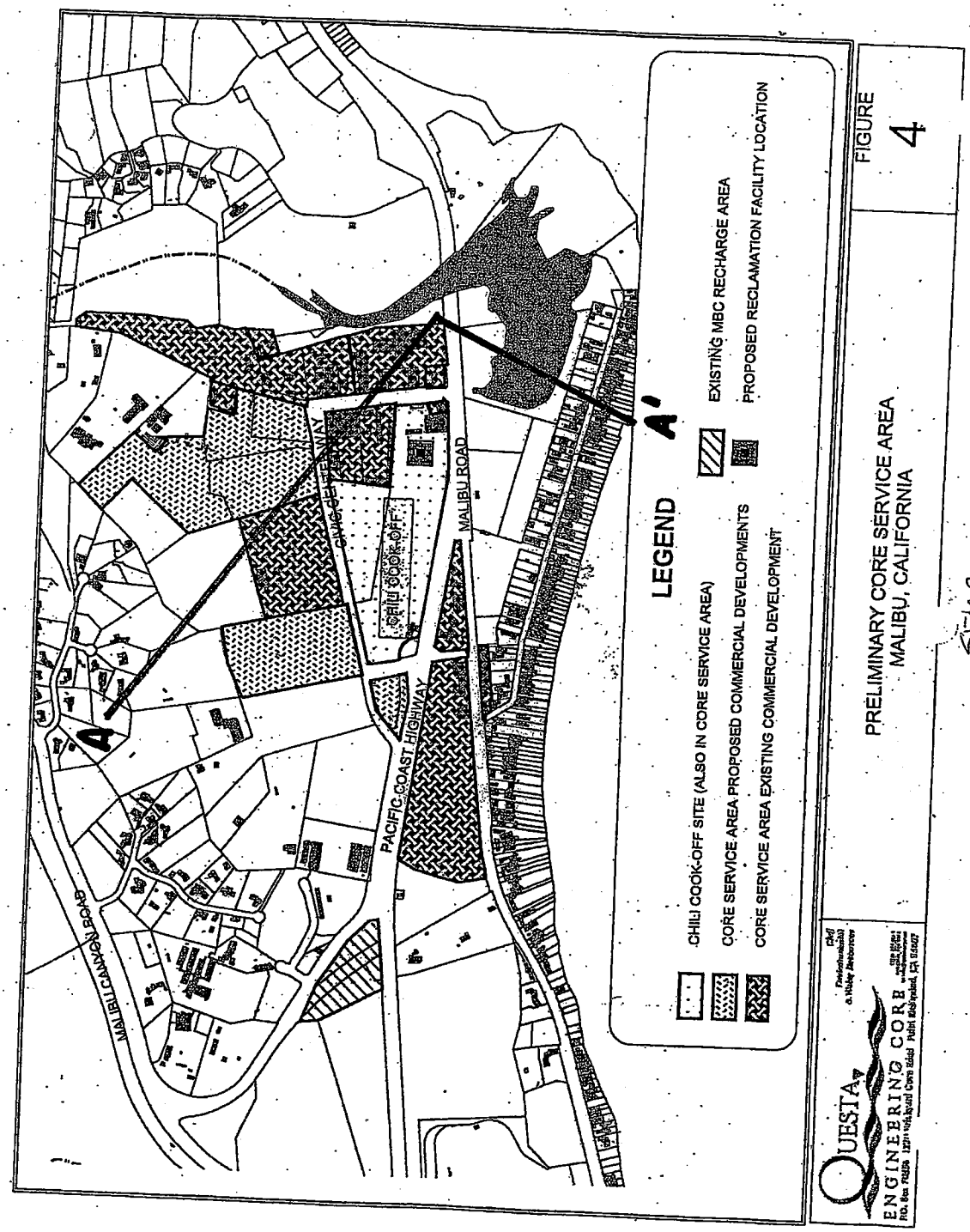
The movement of bacteria from the Civic Center area north of Pacific Coast Highway via subsurface transport to Surfrider Beach under summer conditions would require preservation or growth of enterococcus and movement through the beach barrier with remobilization in marine water (see Figure 16 [cross section]). Human fecal enterococcus must survive physical, chemical and biological destruction in the subsurface before their discharge, enterococcus from higher elevations within the watershed must

DRAFT JULY 31 2009

travel further and both light and distance are known to cause de-activation of both viruses and bacteria (Azadpour-Keeley, 2003;Yates, 1985, 1986).

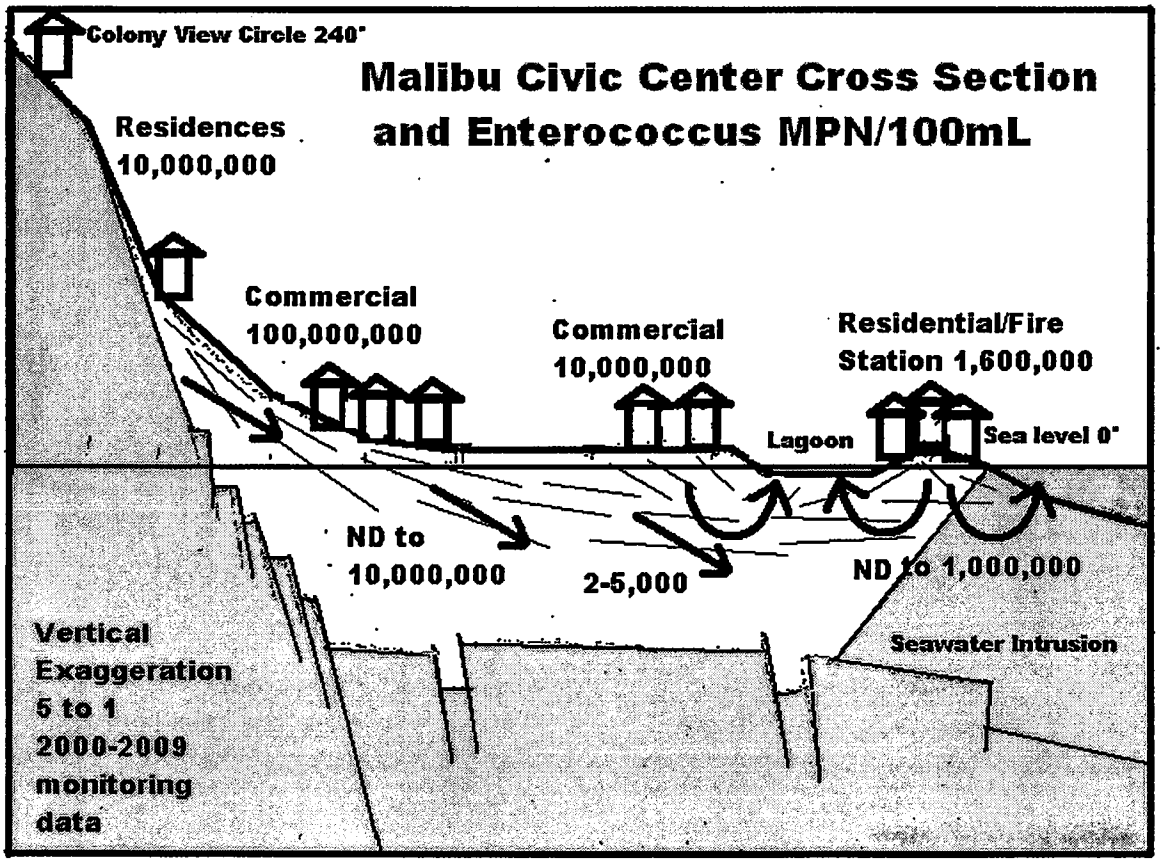
DRAFT JULY 31 2009

Figure 16. Planned development in the Malibu Civic Center from Questa 2003 and cross section line



DRAFT JULY 31 2009

Figure 17. Cross Section A to A' showing facility and groundwater bacteria and flow paths



5. Conclusion

Malibu Creek, Lagoon, and nearby beaches are popular not only within the local community but as a destination for visitors as well. In the Basin Plan, the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, and consistently have failed to meet standards set to protect ingestion of waters by swimmers and surfers. Repeated failures to meet standards set to protect public health has resulted in a 'beach bummer' reputation for Surfrider Beach.

To examine the hydraulic connection of discharges from OWDSs through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters migrate to surface waters and that, consistent with data supporting the designations of impairments, the levels of pathogens do not meet standards

DRAFT JULY 31 2009

protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center area versus comparable beaches with sewers.

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to the beneficial use of water contact recreation.

DRAFT JULY 31 2009

ATTACHMENT 3-1: STATISTICS

Statistical Significance

The application of statistical tools to the beach bacteria data sets revealed that standard tests have a high potential to produce misleading results. Additional statistical tests were used to confirm a significant difference between enterococcus interval frequency distributions for septic and sewered beaches in 2005, 2006 and 2007 for non-MS-4 beaches not including beaches with direct discharge to beach wave wash.

The examination of enterococcus on beaches requires the manipulation of very large data sets. As an example, 7,081 measures were collected from beaches receiving MS-4 discharge in the summers of 2005 through 2008. The measures were not all normally distributed and were dominated by densities at or below 10 Most Probable Number (MPN)/100 mL (considered to be non-detect), with the presence of occasional measures above 24,000 MPN/100mL. The majority of the bacteria measures in the beach data sets had low and high enterococcus densities which together constitute a log normal distribution, but with interval frequencies between 50 and 1,000 MPN/100 mL which were not consistent with a log normal distribution.

Statistics which rely on normal distributions may produce false positive measures of significance for the beach bacteria populations. Many single beach samples assembled through weekly sampling over 4 summers did not have sufficiently large populations to allow statistical assessment with such tests. For example, an attempt to compare Surfrider and Manhattan (40th Street) beaches during the summer of 2007 was not successful because of the distribution of the measures for Manhattan Beach (9 measures below 10 MPN/100 mL, one of 24,000 MPN/100mL and 5 of 10 MPN/100mL). The resulting sample distribution was not normally distributed nor was the natural log of the sample distribution normally distributed. A comparison of the data with the larger sample at Surfrider Beach varied with the interval to which the statistical test was applied.

Where data sets are large, normal distributions can be created through repeated sampling. However, the largest data sets also had very large measurements and many small measurements, suggesting that populations were not the result of sample bias. As an example, annual populations for all sewered and septic beaches which had high correlation coefficients for large and small intervals, but not for the interval between 50 and 1,000 MPN/100 mL.

If normality was assumed and Student's t-tests and Correlation Coefficient were applied, the results were repeatedly inconsistent. Some data sets which Student's t-test showed to have intervals from different populations were also found to have high Correlation Coefficients. Where a correlation was suspected and the data sets were plotted, the typical result was that a single very high or numerous very low values produced a large correlation coefficient (R^2) erroneously indicating that the correlation is good. Where the sample sets were distinct, did not correlate, and were suspected to be samples from different populations, the Student t-test (p) or the Student's t-test of the natural log (ln p) were measured. Small measures of p or ln p indicated that some populations were distinct with values above .05 considered significant (less than 1 chance in 20) .The typical result was that a Student t-test finding that the populations to be distinct was highly dependent on the size of the sample (and the number of values below 25 MPN/100mL) or the presence of a few measures above 1000 MPN/100 mL.

DRAFT JULY 31 2009

The statistic package Minitab was used to apply the Chi-square test. When the chi square correlation was made on truncated populations of all beaches with some values below 10 MPN/100 ML removed, the results ($p<.05$) indicated that septic and sewered beaches did not belong to the same population. However, the removal of about half of the population was of concern.

Non parametric statistical tools were applied to the same data sets. When all septic and sewered beaches for the year 2005 - 2008 were contrasted using the non-parametric Quartile Hypothesis Test, the Wilcoxon-Mann-Whitney (WMW)Test and Gehan Test from EPA's ProUCL statistical program, the Quartile Test results recommend using the WMW Test. However, the WMW Test is only applicable for data set with less than 40% non-detect level of 10 MPN/100mL. Therefore, the Gehan Test is the most appropriate Test for this study. The Gehan test looks at all intervals and emphasizes the mean/median interval. The results are summarized in Tables 1 through 4.

The Null Hypothesis is termed "Septic Beach Mean/Median Less Than or Equal to Sewer Beach Mean/Median;" and the Alternative Hypothesis is "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median" using Gehan Form 1 Test.

The result of the Gehan Test for 2005, 2006 and 2008 shows that the Null Hypothesis is rejected by a low P-value with an alpha value of 0.05 (a confidence level of 95%) , which rejects the Null Hypothesis and supports the Alternative Hypothesis "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median". The 2007 data is not consistent with the results of 2005, 2006, and 2008 due to low groundwater discharge to beaches after dry winter. The same results were also obtained with an alpha value of 0.01 (a confidence level of 99%) that enterococcus concentration at septic beaches is higher than concentration at sewered beaches statistically.

DRAFT JULY 31 2009

Table 1 - 2005 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	358	754
Number of Non-Detect Data	113	482
Number of Detect Data	245	272
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	31.56%	63.93%
Minimum Detected	20	20
Maximum Detected	9208	4200
Mean of Detected Data	261.7	368.9
Median of Detected Data	87	99
SD of Detected Data	661.3	591.3

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	9.461
Critical z (0.95)	1.645
P-Value	1.52E-21

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

DRAFT JULY 31 2009

Table 2 - 2006 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	685	1377
Number of Non-Detect Data	293	921
Number of Detect Data	392	456
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	42.77%	66.88%
Minimum Detected	20	20
Maximum Detected	24192	48010
Mean of Detected Data	324.9	532.3
Median of Detected Data	86.5	42
SD of Detected Data	1320	2701

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	11.74
Critical z (0.95)	1.645
P-Value	4.17E-32

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

DRAFT JULY 31 2009

Table 3 - 2007 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	731	1364
Number of Non-Detect Data	574	1023
Number of Detect Data	157	341
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	78.52%	75.00%
Minimum Detected	10	20
Maximum Detected	2000	24192
Mean of Detected Data	127.5	260
Median of Detected Data	52	41
SD of Detected Data	281	1713

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	-1.226
Critical z (0.95)	1.645
P-Value	0.89

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site <= Background
P-Value >= alpha (0.05)

DRAFT JULY 31 2009

Table 4 - 2008 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	734	1315
Number of Non-Detect Data	514	979
Number of Detect Data	220	336
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	70.03%	74.45%
Minimum Detected	20	20
Maximum Detected	2000	2000
Mean of Detected Data	146.8	90.55
Median of Detected Data	53	31
SD of Detected Data	290.3	226.3

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test Value	3.45
Critical z (0.95)	1.645
P-Value	2.81E-04

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

DRAFT JULY 31 2009

An additional measurement of significance using the Gehan test can be achieved by adding an investigation value (i.e. enterococcus concentration) to the mean/median before assessing the Null hypothesis to demonstrate the magnitude of difference using Gehan Form 2 Test. The larger this value, called substantial difference, S, the greater the difference between the populations, i.e., the greater an S, the greater an enterococcus concentration for septic beaches versus sewered beaches. Definitions from EPA's ProUCl program are detailed follow.

> Δ (delta): The true difference between the mean concentration of X in one sample and the mean of X in a second sample. Delta is an unknown parameter which describes the true state of nature. Hypotheses about its value are evaluated using statistical hypothesis tests. In principle, we can select any specific value for Δ and then test if the observed difference is as large as Δ or not with a given confidence and power.
>
> S (substantial difference): A difference in mean concentrations that is sufficiently large to warrant additional interest based on health or ecological information. S is the investigation level. If Δ exceeds S, the difference in concentrations is judged to be sufficiently large to be of concern, for the purpose of the analysis. A hypothesis test uses measurements from the site and from background to determine if Δ exceeds S.

In the study cases, the S value was calculated to determine the significance of the contrast between sewered and septic beaches for the summers of 2005, 2006, 2007 and 2008. The resulting S values show that septic beaches were most distinct from sewered beaches in 2005 after wet winter and not distinct in 2007 after dry winter. A substantial difference exists between septic and sewered beaches for every year except 2007.

Year	2005	2006	2007	2008
S value MPN/100 mL	108	89	0	21

The Gehan calculation with S factor calculation for the 2005 - 2008 are shown in Tables 5 - 8.

DRAFT JULY 31 2009

Table 5 – 2005 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	108
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	358	754
Number of Non-Detect Data	113	482
Number of Detect Data	245	272
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	31.56%	63.93%
Minimum Detected	20	20
Maximum Detected	9208	4200
Mean of Detected Data	261.7	368.9
Median of Detected Data	87	99
SD of Detected Data	661.3	591.3

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 108

Gehan z Test Value	-1.631
Critical z (0.95)	-1.645
P-Value	0.0514

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 108.00
P-Value >= alpha (0.05)

DRAFT JULY 31 2009

Table 6 – 2006 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	89
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	685	1377
Number of Non-Detect Data	293	921
Number of Detect Data	392	456
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	42.77%	66.88%
Minimum Detected	20	20
Maximum Detected	24192	48010
Mean of Detected Data	324.9	532.3
Median of Detected Data	86.5	42
SD of Detected Data	1320	2701

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 89

Gehan z Test Value	-1.353
Critical z (0.95)	-1.645
P-Value	0.088

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 89.00
P-Value >= alpha (0.05)

DRAFT JULY 31 2009

Table 7 – 2007 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	731	1364
Number of Non-Detect Data	574	1023
Number of Detect Data	157	341
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	78.52%	75.00%
Minimum Detected	10	20
Maximum Detected	2000	24192
Mean of Detected Data	127.5	260
Median of Detected Data	52	41
SD of Detected Data	281	1713

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 0

Gehan z Test Value	-1.226
Critical z (0.95)	-1.645
P-Value	0.11

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 0.00
P-Value >= alpha (0.05)

DRAFT JULY 31 2009

Table 8 – 2008 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	21
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	734	1315
Number of Non-Detect Data	514	979
Number of Detect Data	220	336
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	70.03%	74.45%
Minimum Detected	20	20
Maximum Detected	2000	2000
Mean of Detected Data	146.8	90.55
Median of Detected Data	53	31
SD of Detected Data	290.3	226.3

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 21

Gehan z Test Value	-0.305
Critical z (0.95)	-1.645
P-Value	0.38

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 21.00
P-Value >= alpha (0.05)

DRAFT JULY 31 2009

ATTACHEMENT 3-2: REFERENCES

Ambrose, Richard. May 14, 2008. Ecological Goals. Malibu Legacy Park Project prepared by Richard F. Ambrose in association with RMC Water and Environment

Allen, L.A., Brooks, E., Williams, & I.L. November 1949. Effect of Treatment at the Sewage Works on the Numbers and Types of Bacteria in Sewage. Prepared for The Journal of Hygiene by L.A. Allen, E. Brooks, & I.L. Williams.

Azadpour-Keeley, A., Faulkner, B.R., & Chen, J.S. April 2003. Movement and Longevity of Viruses in the Subsurface. Prepared for United States Environment Protection Agency by A. Azadpour-Keeley, B.R. Faulkner, and J.S Chen

Bales, R.C., Gerba, C.P., Grondin, G.H., & Jensen, S.L. 1989. Bacteriophage Transport in Sandy Soil and Fractured Tuff. Prepared for Applied and Environmental Microbiology by R.C. Bales, C.P. Gerba, G.H. Grondin, & S.L. Jensen.

Bing Yen & Associates, Inc. January 5, 2001. Report of Malibu Civic Center Groundwater Evaluation. Prepared for City of Malibu by Bing Yen & Associates, Camarillo CA.

Bloch, A.B., Stramer, S.L., Smith, D., Margolis, H.S., Fields, H.A., McKinley, T.W. Gerba, C.P., Maynard, J.E., & Sikes, R.K. April 1990. Recovery of Hepatitis A Virus from Water Supply Responsible for a Common Source Outbreak of Hepatitis A. Prepared for American Journal of Public Health by A.B. Bloch, S.L. Stramer, D. Smith, H.S. Margolis, H.A. Fields, T.W. McKinley, C.P, Gerba, J.E. Maynard, & R.K. Sikes.

Boehm, A.B., Shellenbarger, G.G., & Paytan, A. 2004. Groundwater Discharge: Potential Association with Fecal Indicator Bacteria in the Surf Zone. Prepared for Environmental Science & Technology by A.B Boehm, G.G. Shellenbarger, & A. Paytan.

Borchardt, M.A., Bertz, P.D., Spencer, S.K.,& Battigelli, D.A. 2003. Incidence of Enteric Viruses in Groundwater from Household Wells in Wisconsin. Prepared for Applied and Environmental Microbiology by M.A. Borchardt, P.D. Bertz, S.K. Spencer, & D.A. Battigelli.

Borchardt, M.A., Chyou, P.H., DeVries, E.O., & Belongia, E.A. May 2003. Septic System Density and Infectious Diarrhea in a Defined Population of Children. Prepared for Environmental Health Perspectives by M.A, Borchardt, P.H. Chyou, E.O. DeVries,& E.A. Belongia.

Cabelli, V.J. August 1983. Health Effects Criteria for Marine Recreational Waters. Prepared for Health Effect Research Laboratory Office of Research and Development by V.J. Cabelli.

CDM. August 10, 2006. Technical Memorandum Task 10, TMDL Implementation Analysis.

CDM. February 27, 2007. Integrated Total Maximum Daily Load Implementation Plan for the Malibu Creek Watershed. Prepared for Los Angeles County Department of Public Works by CDM, Irvine CA.

DRAFT JULY 31 2009

Chu, A.K., & Sanders, B.F. August 2008. Data Requirements for Load Estimation in Well-Mixed Tidal Channels. Prepared for Journal of Environmental Engineering by A.K. Chu, & B.F Sanders.

City of Malibu. November 5, 2002. Ordinance No. 242. City Council of the City of Malibu.

City of Marco Island. City of Marco Island Position Paper Septic Tank Replacement Program. Prepared by the City of Malibu for the City of Malibu.

Crawford, Multari & Clark Associates. July 1997. Draft, City of Malibu, Civic Center Specific Plan. Prepared for City of Malibu by Crawford, Multari & Clark Associates, San Luis Obispo CA.

Cuyk, S.V., Siergrist, R.L., Lowe, K., & Harvey, R.W. 2004. Vadose Zone Processes and Chemical Transport. Prepared for Journal of Environmental Quality by S.V Cuyk, R.L. Siergrist, K. Lowe, & R.W. Harvey.

De Sieyes, N.R., Yamahara, K.M., Layton, B.A., Joyce, E.H., & Boehm, A.B. 2008. Submarine Discharge of Nutrient-Enriched Fresh Groundwater at Stinson Beach, California is enhanced during Neap Tides. Prepared for Limnol Oceanography by N.R. de Sieyes, K.M. Yamahara, B.A. Layton, E.H. Joyce, & A.B. Boehm.

Ensitu Engineering Inc. June 30, 2008. Advanced On-site Wastewater Treatment System Design, California Department of Health Services Engineering Report. Prepared for Malibu Lumber by Ensitu Engineering Inc, Morro Bay CA.

Ensitu Engineering Inc. August 13, 2008. Malibu Lumber Wastewater Flow Calculations Commercial Development without Restaurant Use. Letter addressed to Brett Thornton, prepared by Ensitu Engineering, Morro Bay CA.

Ensitu Engineering Inc. 2008. Advanced On-site Wastewater Treatment System Design, City of Malibu Engineering Report. Prepared for Malibu Lumber by Ensitu Engineering Inc., Morro Bay CA.

Gold, M.A. 1994. What are the health risks of swimming in the Santa Monica Bay?: An examination of the issues surrounding the public health debate. Prepared for University of California, Los Angeles by M.A. Gold.

Goyal, S.M., & Gerba, C.P. August 1979. Comparative Adsorption of Human Enteroviruses, Simian Rotavirus, and Select Bacteriophages to Soils. Prepared for Applied and Environmental Microbiology by S.M. Goyal, & C.P. Gerba.

Gronewold, A.D.,& Wolpert, R.L. April 7, 2008. Modeling the Relationship between Most Probable Number (MPN) and Colony – Forming Unit (CFU) Estimates of Fecal Coliform Concentration. Elsevier.

Ground Water Monitoring and Assessment Program. May 1999. Effect of Septic Systems on Ground Water Quality – Baxter, Minnesota. Prepared for Ground Water Monitoring and Assessment Program by Ground Water Monitoring and Assessment Program

DRAFT JULY 31 2009

James, Kirsten. November 19, 2008. Comments on Tentative Waste Discharge Requirements, Water Reclamation Requirements and Monitoring and Reporting Program for Malibu Lumber. Heal The Bay, Santa Monica CA.

Jones & Stokes. 2008. Malibu Legacy Park Project, Draft Environmental Impact Report. Prepared for City of Malibu by Jones & Stokes, Los Angeles CA.

REGIONAL BOARD. 1972. Resolution No. 72-4, Policy Statement Relative to Sewage Disposal in the Malibu Area. California Regional Water Quality Control Board, Los Angeles Region.

LARWCB. December 14, 1998. Resolution No. 98-023 Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 1990. Regional Water Quality Control Board's Interim Policy on the Use of Septic Tanks. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2002. Santa Monica Bay Beaches Wet Weather Bacteria TMDL, Item #5 Regional Board Workshop, June 27, 2002. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2004b. Total Maximum Daily Loads for Bacteria, Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2008. 520th Regular Board Meeting, Item 16, Consideration of Termination of Memorandum of Understanding for On-site Wastewater Treatment Systems for the City of Malibu. California Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2008b. 521st Regular Board Meeting, Item 18, Revised Order, Waste Discharge Requirements/Water Reclamation Requirements and Monitoring and Reporting Program for City of Malibu's Malibu Lumber at City of Santa Monica's Legacy Park. California Regional Water Quality Control Board, Los Angeles Region.

Lucero, Gene. 2008. Submittal of Comments to Tentative Waste Discharge Requirements and Water Reclamation Requirements for Malibu Lumber LLC. Latham & Watkins, LLP.

National Center for Environment Research. 2003. Final Report: Fate for Pathogens in Storm Water Runoff. Prepared for National Center for Environment Research by National Center for Environment Research.

Nicosia, L.A., Rose, J.B., Stark, L., & Stewart, M.T. 2001. Ground Water Quality. Prepared for Journal of Environment Quality by L.A Nicosia, J.B Rose, L. Stark, and M.T. Stewart.

Noble, R.T, & Fuhrman, J.A. October 25, 1996. Virus Decay and Its Causes in Coastal Waters. Prepared for Applied and Environmental Microbiology by R.T. Noble, & J.A. Fuhrman.

Office of Water. October 2006. Occurrence and Monitoring Document for the Final Ground Water Rule. Prepared for Office of Water by the Office of Water.

DRAFT JULY 31 2009

Peter Warshall & Associates and Philip Williams & Associates. 1992. Malibu Wastewater Management Study, A Human Ecology of the New City. Prepared for City of Malibu by Philip Williams and Associates, San Francisco CA and Peter Warshall & Associates, Tucson AZ.

Pradhan, S., Hoover, M.T., Clark, G.H., Gumpertz, M., Wollum, A.G., Cobb, C., & Strock, J. February 2008. Septic Tank Additive Impacts on Microbial Populations. Prepared for Journal of Environmental Health by S. Pradhan, M.T. Hoover, G.H. Clark, M. Gumpertz, A.G. Wollum, C. Cobb, & J. Strock

Questa Engineering Corporation. July 7, 2003. Preliminary Conceptual Plan for Wastewater Reclamation in the Civic Center Area, Malibu, California. Prepared for City of Malibu by Questa Engineering, Santa Barbara CA.

RMC Water and Environment. August 15, 2008. Irrigation of Legacy Park with Treated Effluent from Lumber Yard Development. Technical Memorandum prepared by RMC Water and Environment.

RMC Water and Environment. May 14, 2008. Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon. Prepared by RMC Water and Environment for City of Malibu, Legacy Park.

Rong, Y. November 3, 1997. Pitfalls in Statistics for Environmental Sampling Evaluation. Prepared for Environmental Geosciences by Yue Rong.

Santa Monica Bay Restoration Project. 1999. Malibu Creek Watershed Restoration Activities Draft. Malibu Creek Watershed Executive Advisory Council.

Santa Monica Bay Restoration Project. January 2001. Improving Septic System Management in the Santa Monica Bay Watershed. Santa Monica Bay Restoration Project, Septic System Task Force.

Schaub, S.A., & Sorber, C.A. May 1977. Virus and Bacteria Removal from Wastewater by Rapid Infiltration Through Soil. Prepared for Applied and Environmental Microbiology by S.A. Schaub, & C.A. Sorber.

Schijven, J.F. & Hassanizadeh, S.M. 2002. Virus Removal by Soil Passage at Field Scale and Groundwater Protection of Sandy Aquifers. Prepared for Water Science and Technology by J.F Schijven & S.M Hassanizadeh .

Stone Environmental, Inc. 2004. Final Report- Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu CA. Prepared for Santa Monica Bay Restoration Commission by Stone Environmental, Montpelier VT.

Stone Environmental, Inc. April 9, 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates, Inc by Stone Environmental, Montpelier VT.

Stone Environmental, Inc. May 6, 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates, Inc by Stone Environmental, Montpelier VT.

Stramer, S.L., & Cliver, D.O. 1984. Septage Treatments to Reduce the Numbers of Bacteria and Polioviruses. Prepared for Applied and Environmental Microbiology by S.L. Stramer,& D.O. Cliver.

DRAFT JULY 31 2009

Tiefenthaler, L.L, Stein, E.D., & Lyon, G.S. January 2008. Fecal Indicator Bacteria Levels During Dry Weather form Southern California Reference Streams. Prepared for Southern California Coastal Water Research Project by L.L. Tiefenthaler, E.D. Stein, & G.S. Lyon.

Tim, Heather. November 1994. Review of Monitoring and Response Protocol for the Malibu Creek Watershed. Santa Monica Bay Restoration Project.

Thorsen, Jim. 2008. Letter in Response to the Los Angeles Regional Water Quality Control Board's Letter Regarding Notification of Incomplete Application for Waste Discharge Requirements for Malibu Lumber. City of Malibu, CA.

United States Environmental Protection Agency. January 2001. Linkage between Water Quality Targets and Pollutant Sources. Prepared for United States Environmental Protection Agency by United States Protection Agency.

United States Environmental Protection Agency. August 2002. Predicting Attenuation of Viruses During Percolation in Soils. Prepared for United States Environmental Protection Agency by United States Protection Agency.

University of California, Los Angeles. May 200. Lower Malibu Creek and Lagoon Resource Enhancement and Management. Final Report to the California State Coastal Conservancy by UCLA.

URS Greiner Woodward Clyde. 1999. Final Report, Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems. Prepared for City of Malibu by URS Greiner Woodward Clyde, Santa Ana CA.

US Environmental Protection Agency. January 10, 2003. Total Maximum Daily Loads for Nutrient, Malibu Creek Watershed, Public Review Draft. US Environmental Protection Agency, Region 9.

Van Beveren & Butelo Inc. 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared for Malibu Lumber, LLC by Van Beveren & Butelo Inc

Van Beveren & Butelo Inc. February 20, 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. June 27, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. August 11, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. October 13, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Vaughn, J.M., Landry E.F., Baranosky, L.J., Beckwith, C.A., Dahl, M.C., & Delihas, N.C. July 1978. Survey of Human Virus Occurrence in Wastewater-Recharged Groundwater on Long Island. Prepared for Applied and Environmental Microbiology by J.M. Vaughn, E.F. Landry, L.J. Baranosky, C.A. Beckwith, M.C. Dahl, & N.C. Delihas.

DRAFT JULY 31 2009

Viergutz, Richard, 2006, Discharge of Sewage-Polluted Groundwater into Malibu Creek and Lagoon Resulting from Groundwater Surface Interactions: MS Thesis, California State University, Los Angeles

Yates, M.V., Gerba, C.P., & Kelley, L.M. April 1985. Virus Persistence in Groundwater. Prepared for Applied and Environmental Microbiology by M.V. Yates, C.P. Gerba, & L.M. Kelley.

Yates, M.V., Yates, S.R., Warrick, A.W., & Gerba C.P. September 1986. Use of Geostatistics to Predict Virus Decay Rates for Determination of Septic Tank Setback Distances. Prepared for Applied and Environmental Microbiology by M.V. Yates, S.R. Yates, A.W. Warrick, and C.P. Gerba.

Yamahara, K.M., Layton, B.A., Santoro, A.E., & Boehm, A.B. 2007. Beach Sands along the California Coast are Diffuse Sources of Fecal Bacteria to Coastal Waters. Prepared for Environmental Sciences & Technology by K.M. Yamahara, B.A. Layton, A.E Santoro, & A.B. Boehm.

Yamahara, K.M., Walters, S.P., & Boehm, A.B. January 6, 2009. Growth of Enterococci in Unaltered, Unseeded Beach Sands Subjected to Tidal Wetting. Prepared for Applied and Environmental Microbiology by K.M. Yamahara, S.P Walters, & A.B. Boehm.

DRAFT JULY 31 2009

This page intentionally left blank.

State of California
California Regional Water Quality Control Board, Los Angeles Region

DRAFT AUG 5 2009

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway,* P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

** The authors would like to thank Regional Board staff, Joe Luera and intern Gina Ho for their assistance in preparing map and tables.*

Technical Memorandum #4:

Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway, P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

DRAFT AUG 5 2009

1. Purpose

Aquatic life in Malibu Lagoon is impaired by eutrophication resulting from excessive nitrogen loads. One of the sources of nitrogen loading is from discharges of wastewaters through on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area.

The purpose of this evaluation was to quantify cumulative nitrogen loads from OWDSs to Malibu Lagoon and compare the result with targets established through the TMDL for restoration of Malibu Lagoon.

2. Method

a. Malibu Civic Center Area Description and Data Collection

The City of Malibu does not provide regional sewage collection or treatment. Most wastewater generated in Malibu is treated by on-site wastewater disposal systems (OWDS) is the terminology used to describe wastewater discharged from both septic and advanced treatment systems. The Malibu Civic Center area for this evaluation corresponds to the lower two miles of the Malibu Creek watershed, which discharges to the Malibu Lagoon and the ocean, and was divided into 5 sectors as shown in Map 1. The Malibu Civic Center area includes the Malibu Valley, Winter Canyon, and the surrounding hills and the beaches located immediately north and south of the Lagoon.

The main commercial area in the Malibu Valley has historically been referred to as the Malibu Civic Center area. Both Los Angeles County and the City of Malibu have administrative offices there. Commercial development is concentrated along Pacific Coast Highway, Malibu Road, and Cross Creek Road adjacent to Malibu Creek just above the Malibu Lagoon.

Malibu Civic Center area has high groundwater and is also subject to flooding and tidal fluctuations. Shallow groundwater located in the Cross Creek area closest to Malibu Lagoon

rises and drops in response to daily tides (Figure 1) and provides direct evidence of communication with Malibu Lagoon and the ocean.

Each Waste Discharge Requirements (WDR) includes a monitoring and reporting program that requires quarterly submission of self-monitoring data. These data include mass loading from wastewater discharged at commercial properties located in the Malibu Civic Center area. The subsequent evaluation of such data incorporates information from monitoring reports submitted to the Regional Board from the 4th quarter 2004 to the 2nd quarter 2009. The time interval for data inclusion is post release of the Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", in 2004 (2004 Stone Report).

This evaluation of nitrogen loading from the subsurface discharge of sewage incorporates information from Regional Board records. WDRs have been issued to most of the larger commercial dischargers in the area; and for these sites, a Monitoring and Reporting Program (MRP) is issued with every permit. For smaller businesses and private residents, we have used inventory listed in 2004 Stone Report.

Staff identified all of the commercial and residential properties located in the Malibu Civic Center area. The inventory consists of 349 residential properties and 38 commercial properties. When it was available, real data on wastewater volumes and total nitrogen (TN) concentrations from self-monitoring reports were used for this evaluation. When actual data were not available, conservation assumptions, based on information from published literature, were used to calculate nitrogen mass loading from all wastewater discharged in the Malibu Civic Center area. Results from the summation of the wastewater TN load are used to model attenuation of the nitrogen load as it moves from the point of discharge to groundwater and from groundwater as it flows to the Lagoon.

Commercial Sites - Several sources were used for the inventory of commercial properties located in the Malibu Civic Center area. The Regional Board's databases for permitted and un-permitted commercial facilities were the primary sources of information (Table 1). Other sources of information were the 2004 Stone Report, the City of Malibu, and the (2002) Malibu Survey by S. Groner & Associates. Wastewater discharge volumes from commercial properties located in the Malibu Civic Center area were extracted from the self- monitoring reports submitted for those facilities which are permitted. For the un-permitted commercial properties, additional information regarding business activities, population served, and the OWTS was utilized to estimate discharge volumes and wastewater strength.

Residential Sites – An inventory of residential properties located in the Malibu Civic Center area was listed in the 2004 Stone Report and used for its assessment of nitrogen loads contributed by residential properties in the Malibu Civic Center area[1]. This inventory was originally extracted from the City of Malibu Assessor's data of 2002. Information is posted in the Assessor's web-page by Assessor Identification Number (AIN). The number of bedrooms

[1] Stone Environmental, Inc., "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California," 2004.

DRAFT AUG 5 2009

and bathrooms at each residence was used to estimate the wastewater discharge volume for each home. Calculations for the total nitrogen load discharged at residential property in the Malibu Civic Center area used the estimated wastewater discharge volumes. The residential property inventory sorted by sector location is listed in Table 2.

Geographic Sectors – Earlier evaluations approached the assessment of nitrogen loading by estimating the percentage of the groundwater flow from the entire lower Malibu Creek watershed, which discharges to the Lagoon versus the Pacific Ocean. Staff evaluation of nitrogen loading to the Lagoon used a different approach. All sectors of the entire watershed do not have an equal flow contribution to impairment of the Lagoon. Therefore, we divided the Malibu Civic Center area into geographic sectors to evaluate groundwater flow and nitrogen load contribution to evaluate impairment of the Lagoon from OWDS discharges. Initially, the area surrounding Malibu Lagoon was divided into five geographic sectors on the basis of surface topography (Map 1). Surface geographic features marking boundaries for the sectors are the gently sloping Valley floor, Malibu Creek, Pacific Coast Highway (PCH), and the Pacific Ocean. After considering flow gradients, subsurface hydrologic, and geologic conditions, two of the sectors were further divided on the basis of estimated flow contribution to the Lagoon. Each sector has a unique flow contribution to the Lagoon.

b. Total Nitrogen Loading from On-site Wastewater Treatment Systems

Slightly different approaches had to be taken to calculate total nitrogen loads from wastewater discharged at commercial and residential sites. Because the Regional Board issues permits or WDRs for wastewater discharges from commercial sites, there has been much more information on file for commercial properties. Historically, permitting of residential wastewater discharges has been delegated to local agencies.

i. Commercial Wastewater

We calculated the nitrogen loading from the commercial facilities dividing the commercial facilities into three groups. One group includes permitted facilities with advanced wastewater treatment, effluent volume limits, and discharge volume limits. At these permitted facilities, a Discharger is required to measure wastewater volumes, total nitrogen concentrations at "end of pipe," and submit this information to the Regional Board per the MRP issued with the WDR. Staff was able to use actual data from these sites to calculate the nitrogen loads. The second group includes smaller permitted commercial facilities where monitoring of wastewater discharge volume is required, but not effluent monitoring, because these facilities discharge domestic-type wastewater. In these cases, staff estimated nitrogen loading by using the provided flow information and published information on total nitrogen concentrations for domestic wastewater from similar types of businesses. The third group includes all un-permitted commercial facilities. In these cases, staff conducted drive-by inspections and collected information from several other sources regarding the OWTS, the business activity, and the population served in order to estimate wastewater flow, nitrogen concentration, and nitrogen loading from these commercial sites. A list of commercial facility is provided (See Table 1).

DRAFT AUG 5 2009

General Characterization of Wastewater Strength

Biological Oxygen Demand (BOD) - The 5-day BOD (BOD_5, 5-day, 20°C) value is considered the best single strength measure of wastewater and/or polluted surface water containing degradable wastes. Thereafter, in this technical memorandum the term BOD refers to BOD_5, 5-day, 20°C. BOD includes both carbonaceous and nitrogenous loading. The strength of wastewater is commonly expressed in terms of BOD, suspended solids, and chemical oxygen demand (COD). COD is commonly used to measure the amount of oxygen consumed under specific conditions in the oxidation of organic and inorganic material in both sewage and industrial waste. Both BOD and COD greatly impact the amount of dissolved oxygen in receiving water and determine the waste assimilative capacity of that surface water, an example being the Malibu Lagoon.

There are several chemical, physical, and biological parameters which provide information on water quality and organic pollution. These parameters are total and fecal coliform density, pH, nitrite, nitrate, Kjeldahl nitrogen which includes, ammonia nitrogen, and organic nitrogen, phosphates, chlorides, turbidity, suspended solids, temperature, grease fats and oils. BOD is commonly used for the characterization of domestic wastewater and the sizing and design of wastewater treatment systems. In this study, BOD is used to estimate total nitrogen when total nitrogen data is unavailable.

Total Nitrogen Concentration Milligrams per Liter (mg/L) - Total nitrogen concentration in milligrams per liter (mg/L) measured at "end of pipe" (e.o.p.) was used for load calculations when this information was available. Staff also used previous analyses of samples taken directly from the septic tanks. There is considerable information in Regional Board files on the septic tank composition for commercial sites in the Malibu Civic Center area.

Where neither e.o.p nor septic tank effluent analyses was available, staff based the estimation of total nitrogen on typical total nitrogen (TN) concentrations seen in the published literature on domestic wastewater composition. BOD values for commercial wastewater are more widely available than total nitrogen values and total nitrogen can be estimated as a proportion of BOD. Most wastewater engineering textbooks have tables showing the concentration of various elements in typical untreated domestic wastewater. Review of this information yields a percentage proportion or TN/BOD ratio[2] of 21% between total nitrogen (TN) and BOD. Another widely used textbook on wastewater engineering shows TN/BOD ratios ranging from 18% to 21%.[3] An average TN/BOD ratio of 20% was used to estimate the total nitrogen load at selected commercial sites.

In the nitrogen load spreadsheet, either a total nitrogen value from "end of pipe" or an estimated total nitrogen value derived from the TN/BOD ratio in the above tables was used for the nitrogen load spreadsheet, where no "end of pipe" total nitrogen value was available.

[2] Table 4-14, on page 181 in Crites and Tchobanoglous, "Small and Decentralized Wastewater Management Systems," 1998.
[3] Table 3-16, page 109, Metcalf & Eddy, Inc. "Wastewater Engineering Treatment, Disposal and Reuse," 3rd Edition, 1991.

DRAFT AUG 5 2009

Assumptions Made for Commercial Nitrogen Loading Calculations

Most of the larger commercial wastewater discharges have been permitted. There are 38 commercial sites located in the Malibu Civic Center area, 25 of which have been permitted. Total nitrogen concentrations measured at "end of pipe" and wastewater discharges volumes are available and were used for nitrogen loading calculations for these sites. When wastewater effluent analysis was not available, estimation of the total nitrogen load (TN) was based on published information for similar businesses or typical nitrogen concentrations for domestic wastewater. The total nitrogen load spreadsheet developed as Table 2 has two key assumptions: 1) BOD value based on the type of business, and 2) a total nitrogen load based on the average TN/BOD ratio found in the above popular wastewater textbooks. The volume of wastewater discharged is known for most commercial properties in the Malibu Civic Center area, but an estimate of wastewater volume had to be made for 10 of the smaller unpermitted commercial sites. Basic assumptions are listed below:

TN/BOD Ratio - Most of the larger commercial discharges in the Malibu Civic Center area, such as Malibu Colony Plaza, Malibu Creek Plaza, and the three Malibu Country Mart shopping centers, were permitted by the Regional Water Quality Control Board, and as a result we have analysis of septic tank samples, or "end of pipe" effluent where advanced OWTS have been installed. For shopping centers with a high proportion of restaurants and stand alone restaurants, we chose a very high BOD of 800 mg/L and a TN of 160 mg/L, but the septic tanks at the Malibu Country Mart shopping centers have to be pumped each week, and frequent pumping reduces both septic tank solids and the BOD and TN values, so ½ of the TN value was used.

For commercial dischargers such as small offices where we have no data, we choose a low BOD of 220 mg/L, and estimated the TN to be 40 mg/L.

For wastewater generated commercial facilities, such as schools, mid-range to high-range effluent strength and nitrogen concentrations were assumed. Depending on soil profile and groundwater separation, estimated total nitrogen was reduced to values ranging from 75 mg/L to 45 mg/L for these sites.

Flow Rate - For the purpose of calculating nutrient load due to wastewater discharges from OWDS, we have used actual flow data from monitoring reports for commercial facilities permitted by the Regional Water Quality Control Board. As stated previously, the septic discharge volume or flows for residential and smaller un-permitted commercial properties were estimated. For the residential properties, the flow estimate was based on the number of bathrooms.

Some of the smaller commercial properties remain unpermitted because the City of Malibu agreed to assume responsibility for any non-food preparation commercial properties discharging less than 2,000 gpd. For most of the smaller unpermitted commercial properties under the jurisdiction of the City of Malibu, Regional Board staff assumed a

DRAFT AUG 5 2009

flow of 400 gpd. Many of the smaller commercial properties were not included in previous Malibu inventories and surveys.

2001 Tetra Tech[4] and 2003 U.S. Environmental Protection Agency [5] studies on Total Mass Daily Loads generated in the Malibu Civic Center area used total commercial wastewater flow of 75,000 gallons per day (gpd). Since 2001, the inventory on commercial properties located in the City of Malibu has increased. Current total wastewater volume generated by the commercial properties located in the Malibu Civic Center area is 128,469 gpd. This reflects a greater than 100% increase in the wastewater discharge volume estimated for commercial properties in the Malibu Civic Center area made by in earlier nitrogen loading studies, e.g. 2004 Stone Report, 2005 Questa Report, and 2001 Tetra Tech Report.

The Regional Board staff estimate of the wastewater discharge volume associated with residential OWDS located in the Malibu Civic Center area is 126,300 gpd. This volume was, virtually identical to the residential volume in the 2004 Stone Report. Our estimation of the commercial wastewater discharge volume is greater than commercial discharge volume estimate of 62,166 gpd in the 2004 Stone Report. This Regional Board staff assessment of total nitrogen load does not include non-septic or OWDS nitrogen load contributions.[6]

Formula Used for Calculation of Commercial Nitrogen Loading

Calculations of nitrogen loading from commercial properties were made with the equation shown below.[7]

Equation (4-4):

Mass Load, lb/d = (concentration, mg/L)(flow rate Mgal/d) [(8.345* lb/Mgal x mg/L)]

The above formula has two variables, including: 1) concentration of total nitrogen (TN) in milligrams per liter (mg/L), and 2) flow rate in million gallons per day (Mgal/d). (8.345* is a unit conversion factor)

For the permitted commercial properties, staff used reported average wastewater discharge volumes and total nitrogen values compiled from quarterly monitoring reports for the loading calculations. This evaluation includes more "end of pipe" nitrogen concentrations for our total nitrogen load calculations. Using reported or estimated using wastewater discharge volumes and total nitrogen concentrations, wastewater flow was multiplied by the nitrogen concentration to obtain the nitrogen loading rate.

[4] Tetra Tech, Inc., 2001, "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.
[5] U.S. Environmental Protection Agency, 2003, "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.
[6] HRL industrial wastewater nitrogen load of .31 lbs/d; TN load from use of treated wastewater for landscape irrigation on Pepperdine University Campus; TN load carried by Malibu Creek from upper watershed; and the TN load from the Malibu Colony private golf course.
[7] Page 196, Crites and Tchobanoglous, "Small and Decentralized Wastewater Management Systems," 1998.

DRAFT AUG 5 2009

For unpermitted commercial facilities, flow and nitrogen concentration in the wastewater discharge for each business was estimated based on the information searched about the business activities and number of people working or type of business.

ii. Residential Wastewater

A different approach was needed to determine nitrogen mass loading from residential areas. Both discharge volume and nitrogen concentration of the residential domestic wastewater had to be estimated. Wastewater flow was based on the total number of houses and the bedrooms and bathrooms in each house. Residential property located in the Malibu Civic Center area was listed by Assessor Identification Number (AIN) from 2004 Stone Report. With AIN numbers, staff found the address and the number of rooms and baths for each residence posted on the County Assessor's web-page.

Staff assigned houses per their address into the five sectors. Addresses were viewed with aerial photo location guides to insure their section location. Once houses were grouped by sector, the total flow from each sector was calculated by multiplying the total number of homes by 100 gpd produced per bathroom. The next step was to estimate the nitrogen concentration in the domestic wastewater. Staff consulted published literature on wastewater to estimate the nitrogen load. The research indicated that typical untreated domestic wastewater has a range of total nitrogen concentrations. Review of standard engineering literature found nitrogen concentrations of 20 mg/L, 40 mg/L and 85 mg/L, defining domestic wastewater strength[8] as weak, medium or strong. Staff chose a nitrogen concentration of 45 mg/L for calculating the nitrogen load from residential sites. The residential property inventory was sorted by sector location is listed in Table 2.

Assumptions for Residential Flow and Total Nitrogen Concentration

Assumptions made to determine the flow and nitrogen loading from each residence in the absence of wastewater meter and sampling and analytic data of each discharge are listed below.

100 Gallons per Day per Bathroom - Regional Board staff estimated the flow by making the assumption that at least there is one user per bathroom (personal private bathroom) at home with a total water use per person of 100 gallons per day. The 100 gallons per person is widely used number for design and estimation purpose of wastewater flow[8].

45 mg/L for Domestic Wastewater - The nitrogen level in the domestic wastewater depends on the wastewater strength or organic load type discharged to OWDS. Waste strength is determined by considering food preparation practices, type of food prepared and consumed (e.g. high protein foods have higher nitrogen content), the use of garbage disposal units, left-over food handling and disposal practices, etc. The sewage generated by affluent neighborhoods has higher strength, measured by BOD and higher total nitrogen

[8]Table 2-9, page 27, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition , 1991

DRAFT AUG 5 2009

concentrations. Domestic wastewater with levels of TN as high as 80 mg/L, are associated with residential affluence.[9] Considering affluence and other factors, Regional Board staff selected a septic tank influent value of 60 mg/L of nitrogen, a concentration exactly mid-range of nitrogen concentration values assigned to untreated domestic wastewater, which ranges between low (20 mg/L) medium (40 mg/L) and high (85 mg/L) strength.

Another source of nitrogen reduction occurs within a septic tank, especially when the septic tank is oversized for the wastewater volume and the retention time is several days. This nitrogen load reduction is called "in-tank denitrification" and it can reduce a large percentage of total nitrogen from the effluent. Also, ammonia nitrogen can be incorporated into microbial or plant biomass in the septic tank systems as well as in the subsurface effluent disposal zone given certain environmental conditions. In general, this is not considered a major mechanism for nitrogen removal from septic tanks, but the total nitrogen concentration in residential effluent in the Malibu Civic Center area was further reduced from 60 mg/L to 45 mg/L before calculating the total nitrogen load from residential OWTS. The value of 45 mg/L TN concentration reflects OWDS treatment and removal. Table 14-7,[10] indicates that the total nitrogen concentration in the septic tank effluent ranges from 25 mg/L to 60 mg/L. A nitrogen concentration of 45 mg/L for OWDS treated wastewater is mid-range of typical domestic wastewater strengths.

Formula Used for Calculation of Residential Nitrogen Loading

The same basic formula is used to calculate mass load of nitrogen from residential wastewater, but with no data or metering of the discharge volume, residential flow volume was estimated using, the number of bathrooms is multiplied by 100 gpd. Flow volume is converted to million gallons per day by multiplying (10^{-6}). Nitrogen load is calculated by multiplying flow volume by the effluent nitrogen concentration of 45mg/L and unit conversion values. The conversion factor of 8.345 is the result of carrying the conversion for the different units to pounds per day of nitrogen. The formula shown below shows the complete calculations described:

$$\frac{No.\ of}{Bathrooms} \times 100\,gpd \times 3.7854\frac{L}{gal} \times \frac{Total}{Nitrogen}\frac{mg}{L} \times 2.205x10^{-6}\frac{lb}{mg} = Nitrogen\frac{lb}{day}$$

iii. Summary of Total Nitrogen Loading from Commercial and Residential Sites

Staff's inventory of commercial wastewater flows in the Malibu Civic Center area consists of 25 permitted sites and 13 unpermitted sites. The total wastewater discharge volume released from these commercial properties is 128, 469 gallons per day (gpd). The total nitrogen load carried to groundwater by these wastewater discharges is 42.53 lbs/day or 15,422 lbs/year.

[9] **Rich Stowell, personal communication, Notes from State Board Training Academy training course "Wastewater Engineering 2, Volume 1, The Advanced Class," 2009.**

[10] Table 14-7, page 1040, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

DRAFT AUG 5 2009

Total residential flow is 126,300 gpd and the total nitrogen load from residential sites is 47.429 lbs/day or 17,311 lbs/year.

Total nitrogen loading from commercial and residential wastewater is summarized in Table 1. Total flow of 255,000 gpd and total nitrogen loading of 89.7 lbs/day are used for both spreadsheet and numerical models to estimate the mass loading to Malibu Lagoon.

DRAFT AUG 5 2009

c. Modeling to Estimate Nitrogen Load to Malibu Lagoon

i. Numerical Model

Using an updated total nitrogen release of 89.7 lbs/d in the numerical fate and transport model, the estimation of wastewater derived nitrogen load transported by groundwater flow to the Lagoon is 28.7 lbs/day. When the estimated total nitrogen load is greater, the numerical model indicates load to the Lagoon is greater. Details of the numerical modeling approach to estimate mass loading to the Lagoon, using updated total nitrogen load, and older load assessments were prepared by Dr. C.P. Lai, and are appended to this Technical Memorandum #4 as Attachment 4-1.

ii. Spreadsheet Model by Flow Reduction via Geographic Sectors and Soil Reduction

Flow Reduction Factor

Flow portioning reduces the TN load reaching the Lagoon. Factors governing flow contribution include: wastewater discharge locations, surface topography, and groundwater contours, which control the direction of groundwater flow. Different proportions of the total wastewater discharged in each reach the Lagoon.

Sector I - consists of the Winter Canyon drainage and the bedrock highlands that extend above the western side of the Malibu Valley. Sector 1 corresponds to the Winter Canyon and West Alluvium areas described in the 2004 Stone Report. Exclusive of Pepperdine University, there are nine commercial wastewater discharges located in this sector. The wastewater discharged from the commercial facilities in Sector 1 is a mixture of treated and untreated wastewater and the total discharge volume is 51,737 gpd. There are 61 homes in Sector 1, discharging an estimated 17, 800 gpd of wastewater.

The highland area is bisected by Malibu Canyon Road and includes 61 homes and a portion of the Pepperdine University campus. Winter Canyon is not eroded to the depth of the Malibu Valley and thickness of the alluvium is less. Sector I is subdivided into two sub-sectors with significant differences in contribution to the Lagoon. The greatest volume of wastewater from Sector I is discharged in the Winter Canyon drainage, but the Winter Canyon flow is assumed to have a relatively low contribution (1%) to Malibu Lagoon. Most of the wastewater discharged in Winter Canyon is assumed to discharge to Malibu Beach.

Section I is divided into the Winter Canyon drainage and drainage from highland area southeast toward Malibu Valley. The division is based on topography. Wastewater in this sub-sector is discharged from mostly single family homes, private schools, nurseries, and the HRL facility. Flow is directed by topography southeast to the western edge of Malibu Valley and east toward Malibu Creek Canyon.

Regional Board staff assumed that the maximum contribution to the Lagoon from this sub-sector is 45% of the total flow. The fractured bedrock highlands outside of the Winter Canyon drainage have a thin veneer of soil. It has been assumed in some previous studies that all wastewater from septic discharges to this highland area flows into the alluvial sediments on the west-side of Malibu Valley. Where flow through the relatively impermeable alluvium is slow and travel times to the Lagoon of 30 years to 50 years. A portion of the wastewater flow from this highland sub-sector does enter the alluvium, as evidenced by the relatively high nitrogen concentrations and high bacteria found in the monitoring wells located near the Valley walls (e.g. monitoring wells located at the Mira Mar Properties on Stuart Ranch Road and behind the County Administration Center on Civic Center Way). Monitoring wells used for the Stone risk assessment study were all located in the alluvium of the Malibu Valley and none of the groundwater table contours extend to the bedrock highlands, which represent over 50% of the Malibu Civic Center area.

Groundwater takes the path of least resistance. It can be logically assumed that some portion of the septic wastewater will percolate down into the fractured bedrock, until it reaches the water table. Low permeability sediments are not recharged at high rates; flow is restricted. There should be sufficient hydrostatic head for groundwater flow through the highly fractured bedrock underlying the Valley. Unconfined, this groundwater will rise to potentiometric surface.

Malibu Water Company records and geologic reports[11] indicate that the deep and shallow alluvial aquifers in the Malibu Valley are recharged by groundwater in the fractured bedrock exposed in the surrounding highlands. All unconfined groundwater in the Malibu Civic Center area rises to the same potentiometric surface, a surface that slopes from the bedrock highlands to sea level. Groundwater in the bedrock highlands derived from rainfall, infiltration from septic discharges, and irrigation preferentially would not flow into relatively impermeable alluvial layers of silt and clay when high permeability sands, gravels, and fractured bedrock underlying the Malibu Valley provide a relative super highway for groundwater flow. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. There are no confining layers in this relatively coarse alluvium. These sediments have high conductivities and travel times of 400 feet a day (ft/d).

Sector II – Sector II consists of area along the west side of Malibu Creek including the residential area surrounding Serra Retreat and the surrounding highlands, which drain to

[11] Old records for the Malibu Water Company, owned and operated by the Adamson Family, are kept in storage at Mariposa Land Company, LLC, offices on Cross Creek Rd.

DRAFT AUG 5 2009

this area. In the Stone Environmental report, Sector II corresponds to the Malibu Tributary, Serra Retreat, North Alluvium, and East Alluvium areas. There is only one commercial facility located in Sector II; that is Serra Retreat with a relatively low wastewater discharge of 720 gpd. There are 83 homes located in this sector with an estimated wastewater discharge volume of 31,100 gpd.

Percolate from septic systems following topography flows toward Malibu Creek. Most of Malibu Water Company's water supply wells were located in this area. It was implied in previous nitrogen load studies that flow from the wastewater discharged into the thin alluvium draped over the bedrock highlands in this sector was confined to this thin soil layer until it reaches the alluvial sediments in the Valley. Alluvium adjacent to Malibu Creek on the east-side of Malibu Valley has very high conductivities, 400 ft/d, and travel times of less than one year for the alluvium in this area of the Malibu Valley were estimated in the (2004) Stone report[11]. Regional Board staff estimated that as much as 95% of the total wastewater flow from this sector reaches the Lagoon.

Sector III – Sector III consists of the relatively flat, gently sloping floor of Malibu Valley located north of Pacific Coast Highway. Sector III is generally described as the Malibu Civic Center area and most of the commercial development is located here. Many of these commercial facilities are located close to Malibu Creek and the Lagoon where the alluvial sediments have high conductivity. Travel time to Malibu Creek and the Lagoon for wastewater discharged in this area can be less than one day. Staff estimates 95% of the wastewater flow from this area reaches Malibu Creek and Lagoon. An exception to this high percentage of total flow is the wastewater discharged from two commercial properties located near the western edge of Malibu Valley. The (2004) Stone report found travel times to the Lagoon from this area can be as much as 50 years[12]. The Racquet Club and Miramar Properties are located in this area. It is estimated that only 20% of the wastewater discharged at these two sites reaches the Lagoon.

Only two homes with an estimated wastewater of 800 gpd are located in Sector III. There are 16 commercial facilities located in Sector III. An estimated 49,438 gpd, consisting of wastewater from both septic and advanced wastewater treatment systems, is discharged in Sector III.

Sector IV – Sector IV consists of commercial facilities located south of Pacific Coast Highway along Malibu Road and 180 homes located in Malibu Colony and Amarillo Beach. All of the wastewater generated at Malibu Colony Plaza, which encompasses all of the commercial facilities located between Malibu Road and Pacific Coast Highway, is pumped under Pacific Coast Highway to Winter Canyon for treatment and disposal and assigned to Sector 1. Most of the wastewater from commercial development in this sector is collected and treated in Winter Canyon. Only five commercial properties located in Sector IV are not connected to the Malibu Colony Plaza wastewater collection system. The collective, wastewater discharge from these commercial properties is only 2,140 gpd.

[12] Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", 2004.

DRAFT AUG 5 2009

There are 180 homes located in Sector IV. Wastewater, from the five commercial properties and most of the homes (107), discharges directly to the ocean and beaches north of Malibu Lagoon. A portion of the nutrient and bacteria load discharged to the beach can be transported with sediments toward the Lagoon by the prevailing long-shore movement of northwest to southeast. Once transported toward the Lagoon, it can enter the Lagoon through tidal inflow. The U.S. Environmental Protection Agency estimated that tidal inflow contributed only 1% of the nutrient load in Malibu Lagoon. Staff estimates that 1% of the 42,040 gpd of wastewater discharged in the main area of Sector IV could reach the Lagoon, but acknowledges the proportion could be much smaller.

There are alluvial sediments, estuary sediments, and beach sand beneath Sector IV. Both high and low permeability are found in this mixture of sand, silt and clay. Generally, nutrient removal by soil bacterial action would be high, but it is not because there is little separation between septic discharges and groundwater. Much of this coastal area has little elevation above sea level.

Sector IV has a sub-sector located near the Lagoon and subject to Lagoon tidal fluctuations. A collective wastewater flow of 25,700 gpd from 73 homes is assigned to the near Lagoon sub-sector. It is estimated that nearly 45% of the 25,700 gpd of the wastewater discharged in this sub-sector reaches the Lagoon.

Sector V – Sector V consists of a narrow coastal corridor located south of Malibu Lagoon and adjacent to Pacific Coast Highway and the Pacific Ocean. Sector V is smallest section and contributes little groundwater flow to the Malibu Lagoon. The topography of the area directs groundwater flow to the ocean. This area is described as the East Shore in the 2004 Stone Report. Bacteria and nitrogen from wastewater discharged directly to the ocean pollute the public beaches in this sector. Nitrogen and bacteria discharged to the beaches south of the Lagoon can be transported toward the Lagoon during short intervals when there is a southern swell, usually in the summer and early fall months when storm center highs are located to the south off the coast of Baja California. At such times, coastal long shore transport can reverse direction.

There are nine commercial facilities and 23 homes located in Sector V. The commercial wastewater discharge volume is estimated at 23,674 gpd. Three of the commercial facilities have advanced OWTS and thus, this volume is a mixture of septic and more treated wastewater. The estimated residential wastewater discharge volume from the 23 homes located in Sector V is 10,800 gpd.

Staff estimates a very small proportion of the wastewater discharged in Sector V, approximately 1% of the total flow, has a chance of being transported northward toward the Lagoon where it could be carried by tidal inflow.

DRAFT AUG 5 2009

Soil Treatment Reduction Factor

Soil Nitrogen Load Reduction Factor for Commercial Sites - Given sufficient separation between the point of wastewater effluent discharge and groundwater, soil bacteria can remove significant amounts of nitrogen. This soil bacteria activity is called "soil treatment". Another factor that influences the removal of nitrogen in the wastewater disposal zone is the soil composition and permeability. This characteristic of the soil is the reason that most permitting agencies require soil percolation testing. If the percolation is too fast (e.g. clean, coarse grained, uniform sand), wastewater flow through the near surface oxygenated zone does not allow time for nitrogen removal by soil bacteria. If the percolation rate is too slow (e.g. very fine soils with high clay content), subsurface disposal of wastewater may not be possible. Table 3 contains information on the depth to groundwater and soil type was utilized to estimate total nitrogen load reduction factors by "soil treatment" ranged from 0% to 20%.

No Soil Treatment Factor for Residential Sites - Permitting of OWDS for residential property is delegated to local agencies, and we do not have information on site-specific conditions needed to make an estimate a "soil treatment" or load reduction factor. Therefore, a nitrogen load reduction factor could not be applied to the nitrogen load estimated for residences located in the Malibu Civic Center area. It is known that many of the Malibu Colony residences lack adequate separation from groundwater. In addition, many residences in the highland sectors of the Malibu Civic Center area use seepage pits rather than leachfields for wastewater disposal. Nitrogen load reduction factors for soil bacteria activity are not applicable where seepage pits are used for wastewater disposal. Filtration of wastewater discharged into seepage pits located in soil or permeable bedrock will remove some bacteria load, but the nitrogen load carried in solution, is not removed by filtration.

Detail calculations for flow reduction and soil treatment reduction are summarized in Table 3.

3. Results

Using staff's loading factors for the numerical fate and transport model, staff estimates that wastewaters transport 29 lb/day into Malibu Lagoon. This model also indicates that loads are increasing. Details of this numerical modeling approach are in the Mass Loading Estimate prepared by Dr. C.P. Lai that is appended to Technical Memorandum #4 as Attachment 4-1.

Also, using the same load factors applied to the 'spreadsheet' model, which characterized the wastewater transport into five hydrogeologic sectors, staff estimates that wastewaters transport 36 lb/day into Malibu Lagoon.

Staff's estimates of 29 lb/day to 36 lb/day from the numerical and 'spreadsheet' models are above two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

DRAFT AUG 5 2009

- Commercial Flows: The third-party models used significantly lower assumptions of commercial wastewater flows.
- Residential Concentrations: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are about one-half of what staff assumed.
- Nitrogen concentration of commercial wastewater: The average nitrogen concentration of commercial wastewater discharges has decreased. Since 2004, 15 additional OWTS have been installed at commercial properties in the Malibu Civic Center area.

The ranges in estimates of nitrogen loads to the Lagoon and key factors are shown in the following Table 4:

	Third-Party Estimates			Staff Estimates	
	Stone (2004) Model	**Questa (2005) Model**	**Tetra Tech (2002)**	**Staff Numeric Model**	**Staff Spreadsheet Model**
Commercial Flow Rate (gal/day)	62,166	100,000	75,000	128, 469	128, 469
Commercial Concentration (mg/L)	50.0	50.0	59.2	3-110	3-110
Commercial Load (lb/day)	26	42	37	42.3	42.3
Residential Flow Rate (gal/day)	126,121	126,121	54,800	126,300	126,300
Residential Concentration (mg/L)	20.0	20.0	59.2	45	45
Residential Load (lb/day)	21	21	27	47.4	47.4
Ratio of Mass loading	36%	32%	50%	32%	38%
Gross Load released from OWDSs	47	63	64	89.7	89.7
Net Load to Malibu Lagoon	17	20	32	29	36

DRAFT AUG 5 2009

Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the waste load allocation of 6 lb/day established in a TMDL[13] adopted by the US EPA on March 21, 2003.

4. Conclusion

Staff has determined that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 29 lb/day to 36 lb/day as well as third-party estimates that range from 17 lb/day to 32 lb/day. All estimates are well above targets needed to restore water quality and protect beneficial uses in Malibu Lagoon.

DRAFT AUG 5 2009

[13] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003), the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies load allocations for on-site wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

References:

California Division of Mines and Geology, 2001, "Seismic Hazard Zone Report for the Malibu Beach 7.5- Minute Quadrangle, Los Angeles, California", Seismic Hazard Zone Report 050, dated 2001.

California Department of Water Resources, Bulletin 63-5, "Seawater Intrusion in California", October 1965.

Crites, R. and Tchobanoglous. G., "Small and Decentralized Wastewater Management Systems" McGraw-Hill, 1998.

Dibblee, T. W., 1982, "Geology of Santa Monica Mountains and Simi Hills, Southern California" , pages 94-130, in Geology and Mineral Wealth of the California Transverse Ranges", 1982.

Dibblee, T. W., "Geologic Map of the Malibu Beach Quadrangle, Los Angeles, California", published by Dibblee Geological Foundation, 1993.

Fife, D. and Minch, J., eds., "Geology and Mineral Wealth of the California Transverse Ranges", South Coast Geological Society, Inc., 1982.

Fugro West, Inc., 2005, "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development, Project No. 3374.001.06, dated March 7, 2005.

Geosyntec Consultants, Inc., 2007, "Geotechnical Site Exploration and Intrepretation of Subsurface Conditions, Malibu Legacy Park Site", Project No. LA0142-02, dated July 30, 2007.

Leighton and Associates, Inc. 1994, "Report of Geotechnical Studies for Planning Purposes in the Civic Center Area, City of Malibu, California", Project No. 2920647-01, dated July 30, 2007.

Malibu Water Company, personal communication between Grant Adamson and Toni Callaway. The Adamson Family owned the Malibu Water Company. Records on water supply wells located in the lower Malibu Creek watershed, are stored at Mariposa Land Company, LLC, offices on Cross Creek Road (2009).

Metcalf & Eddy, Inc., " Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

Metcalf & Eddy, Inc., "Wastewater Engineering. Treatment and Reuse" McGraw-Hill, 4th Edition, 2003.

Salvato, J. A., 1982, "Environmental Engineering and Sanitation", John Wiley & Sons. 1982.

Stone Environmental, Inc., 2004, "Final Report, Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Project No. 011269-W, dated August 30, 2004.

DRAFT AUG 5 2009

Stowell, R., personal communication, Notes from State Board Training Academy training course "Wastewater Engineering 2, Volume 1, The Advanced Class,"2009.

Tetra Tech, Inc., 2001, "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.

U.S. Environmental Protection Agency, 2003, "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.

U.S. Environmental Protection Agency, 2002, "On-site Wasterwater Treatment Systems Manual", 2002.

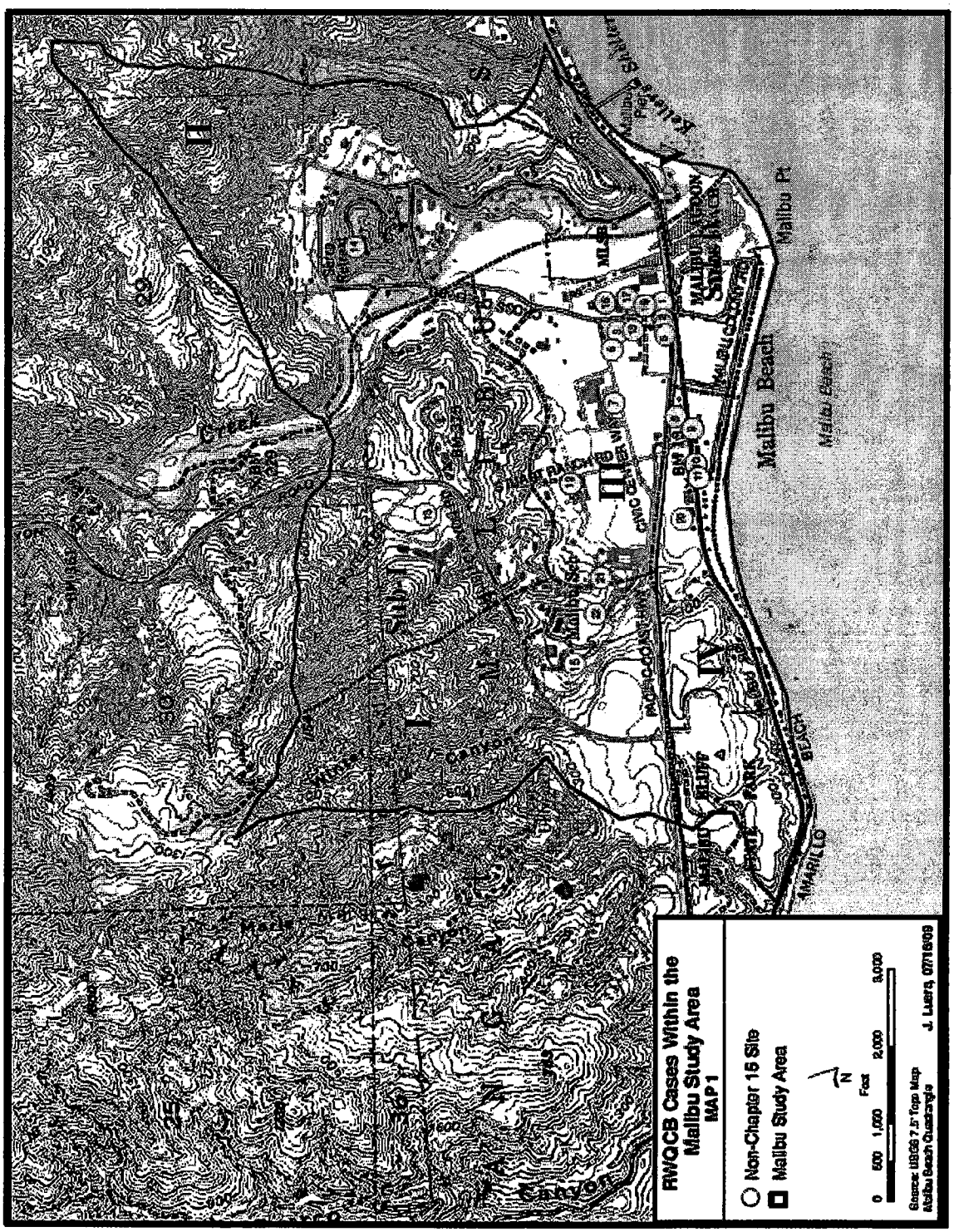
URS Greiner Woodward Clyde, 1999, "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon From On-Site Septic Systems". Project No. 964P170, dated June 7, 1999.

Van Beveren & Butelo, Inc., 2007, "Report of Geotechnical Investigation, Proposed Remodeling of Malibu Lumber Facility", Project No. 07-020, dated July 26, 2007.

Van Beveren & Butelo, Inc., 2007, "Report of Hydrologic Study, Proposed Legacy Park Discharge Area", Project No. 07-020.2, dated September 26, 2007.

DRAFT AUG 5 2009

Map 1 – Malibu Civic Center Area



DRAFT AUG 5 2009

Figure – 1
Correlation of Groundwater and Tidal Levels

Figure -1 Adapted from Figure 4-1 In "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems", 1999, URS Greiner Woodward Clyde

DRAFT AUG 5 2009

Table 1 – continue to next page

Table 1 commercial and residential nitorgen loading

Sector 1	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
HRL^ -3011 Malibu Cyn Rd	3,428	45.0	1.287	469.86
LA. Co. Main. Yard -3637 Winter Cyn Rd	252	40.0	0.084	30.70
*Malibu Colony Plaza^^ -Disposal in Winter Cyn	16,617	18.1	2.510	916.12
Malibu WPCP^^ -3260 Vista Pacifica	22,500	20.4	3.830	1,398.08
Webster Elementary^ -3602 Winter Cyn Rd	5,000	75.0	3.128	1,142.22
Our Lady of Malibu^ -3825 Winter Cyn Rd	2,500	76.0	1.666	671.11
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	75.0	0.839	342.67
Commercial - 7 Business Facilities	51,767		13.345	4,870.76
Residential 61 homes	17,800	45.0	6.684	2,439.79
Total			30.023	7,310.55

*The value of 18.1 for Malibu Colony Plaza was calculated from the 2nd Quarter 2007 to 2nd Quarter 2008 monitoring reports.
^ Assumed cafeteria food waste
^^ Advanced CWTS

Sector 2	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Serra Retreat^ -3401 Serra Rd	720	60.0	0.361	131.58
Commercial - 1 Business Facility	720		0.361	131.58
Residential 83 homes	31,100	45.0	11.679	4,262.77
Total			12.036	4,394.34

^ Retreat and conference center with food service - low utilization

Sector 3	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Malibu Animal Hospital -23431 PCH	500	40.0	0.167	60.92
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	40.0	1.348	491.98
Request Club -23847 Stuart Ranch Rd	1,500	75.0	0.839	342.67
Prudential Realty -23405 PCH	450	40.0	0.150	54.83
Malibu Country Mart I^ -3835 Cross Creek Rd	8,400	80.0	5.606	2,046.86
Malibu Country Mart I^ 23410 Civic Ctr Wy	6,300	80.0	4.208	1,535.15
Malibu Country Mart II^ -3900 Cross Creek Rd	3,400	80.0	2.270	828.49
Malibu Shell^^ -23387 PCH	300	4.2	0.011	3.84
Malibu Prof. Arts Bldg -23440 Civic Ctr Wy	450	40.0	0.150	54.83
Malibu Lumber^^ -23479 PCH	8,500	5.7	0.404	147.58
Mira Mar Properties -23805-23815 Stuart Ranch Rd	3,200	40.0	1.068	389.88
J & P Limited -3806 Cross Creek Rd	500	40.0	0.167	60.92
So. Calif. Edison	400	40.0	0.134	48.73
Verizon South, Inc. -3705 Cross Creek Rd	400	40.0	0.134	48.73
Mariposa Land Company, LLC -3728 Cross Creek Rd	400	40.0	0.134	48.73
Malibu Creek Plaza/Malibu Village^^	11,000	3.0	0.275	100.52
Commercial - 16 Business Facilities	49,738		17.163	6,264.85
Residential 2 homes	600	45.0	0.300	109.65
Total			17.463	6,374.30

^ Influent expected high level of Total Nitrogen (TN), but effluent level of TN reduced by weekly pumping of septic tanks

DRAFT AUG 5 2009

^^ Advanced OWTS

Sector 4	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Malibu Rd., LLC -23676-23712 Malibu Rd	400	40.0	0.134	48.73
Morton-Gerson -23730 Malibu Rd	400	40.0	0.134	48.73
L.A. Co. Fire Station #88 -23720 Malibu Rd	540	30.0	0.135	49.34
Lisa Krasnoff -23655 Malibu Colony Rd	400	40.0	0.134	48.73
Mesa, LLC 23915 PCH	400	40.0	0.134	48.73
Commercial - 5 Business Facilities	2,140		0.669	244.28
Residential 180 homes	65,800	45.0	24.710	9,018.98
Total			25.979	9,263.27

*187 homes were counted in Sector 4 with a total calculated flow of 65800 gpd

Sector 5	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Surfrider Co. Beach -23060 PCH	3,188	40.0	1.064	388.42
Malibu Pier State Park^^ -23000 PCH	3,000	11.7	0.293	106.91
Malibu Shores Motel^ -23033 PCH	2,843	60.0	1.423	519.57
Malibu Beach Inn^^ -22878 PCH	2,843	31.9	0.757	276.24
Jack-in-the-Box^^ -23017 PCH	4,500	26.26	0.986	359.94
Malibu Plaza 22917 PCH	1,500	40.0	0.501	182.76
Malibu Inn & Restaurant^ 22969 PCH	6,200	110.0	5.691	2,077.32
Surfshack/Fish Grill -22935 PCH	400	80.0	0.267	97.47
Spic & Span Cleaners/Chabad -22941 PCH	400	40.0	0.134	48.73
Commercial - 9 Business Facilities	24,074		10.715	3,911.16
Residential 23 homes	10,800	45.0	4.056	1,480.32
Total			14.771	5,391.48

^ Effluent assumed to have high TN because of low septic tank retention time
^^these facilities have package advanced OWTS

Study Area	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Commercial	128,469		42.253	15,422.43
Residential	126,300		47.429	17,311.51
Total	254,769		89.682	32,733.94

2009 0052 GUAFTFARD

Table 2 –List of Residential Septic Systems

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458027034	3547 Malibu Colony Rd	Multi Family	6	3	On-site
I	4458026007	3400 Coast View Dr	Residential	4		On-site
I	4458027002	3401 Coast View Dr	Residential	4	4	On-site
I	4458026006	3436 Coast View Dr	Residential	2	2	On-site
I	4558026015	3502 Coast View Dr	Residential	4	3	On-site
I	4458026014	3504 Coast View Dr	Residential	3	4	On-site
I	4458026004	3524 Coast View Dr	Residential	3	3	On-site
I	4458026003	3536 Coast View Dr	Residential	2	2	On-site
I	4458027030	Coast View Dr	Residential			On-site
I	4458025020	3207 Colony View Cir	Residential	3	3	On-site
I	4458025016	3213 Colony View Cir	Residential	4	4	On-site
I	4458025015	3215 Colony View Cir	Residential	3	4	On-site
I	4458025012	3216 Colony View Cir	Residential	3	4	On-site
I	4458025010	3217 Colony View Cir	Residential	3	2	On-site
I	4458025011	3220 Colony View Cir	Residential	3	3	On-site
I	4458025025	3211 Colony View Cir	Residential	5	5	On-site
I	4458024004	32701 Harbor Vista Dr	Residential	3	3	On-site
I	4458024043	23702 Harbor Vista Dr	Residential	3	2	On-site
I	4458024025	23704 Harbor Vista Dr	Residential	4	3	On-site
I	4458024031	23706 Harbor Vista Dr	Residential	3	2	On-site
I	4458024001	23708 Harbor Vista Dr	Residential	3	2	On-site
I	4458024029	23721 Harbor Vista Dr	Residential	3	3	On-site
I	4458025014	23722 Harbor Vista Dr	Residential	3	4	On-site
I	4458024034	23741 Harbor Vista Dr	Residential	3	2	On-site
I	4458025013	23748 Harbor Vista Dr	Residential	3	3	On-site
I	4458024009	23803 Harbor Vista Dr	Residential	6	7	On-site
I	4458025019	23812 Harbor Vista Dr	Residential	3	2	On-site
I	4458024010	23813 Harbor Vista Dr	Residential	3	2	On-site
I	4458024011	23831 Harbor Vista Dr	Residential	5	4	On-site
I	4458024012	23837 Harbor Vista Dr	Residential	3	1	On-site
I	4458025024	23838 Harbor Vista Dr	Residential	5	6	On-site
I	4458025006	23850 Harbor Vista Dr	Residential	3	3	On-site
I	4458025018	23858 Harbor Vista Dr	Residential	3	3	On-site
I	4458024013	23843 Harbor Vista Dr	Residential	3	2	On-site
I	4458025017	3224 Malibu Canyon Rd	Residential	2	2	On-site
I	4458025004	3338 Malibu Canyon Rd	Residential			On-site
I	4458024038	23800 Malibu Crest Dr	Residential	4	3	On-site
I	4458024042	23805 Malibu Crest Dr	Residential	4	4	On-site
I	4458024041	23806 Malibu Crest Dr	Residential	5	6	On-site

DRAFT AUG 5 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458024039	23808 Malibu Crest Dr	Residential	3	2	On-site
I	4458024040	23812 Malibu Crest Dr	Residential	3	4	On-site
I	4458024022	23814 Malibu Crest Dr	Residential	4	5	On-site
I	4458024023	23816 Malibu Crest Dr	Residential	3	2	On-site
I	4458024021	23854 Malibu Crest Dr	Residential	2	3	On-site
I	4458024015	23870 Malibu Crest Dr	Residential	3	4	On-site
I	4458024014	23880 Malibu Crest Dr	Residential	4	4	On-site
I	4458026010	23901 Malibu Knolls Rd	Residential	4	1	On-site
I	4458026011	23903 Malibu Knolls Rd	Residential	4	3	On-site
I	4458026012	23905 Malibu Knolls Rd	Residential	3	2	On-site
I	4458026013	23907 Malibu Knolls Rd	Residential	3	3	On-site
I	4458026009	23908 Malibu Knolls Rd	Residential	3	3	On-site
I	4458025001	23915 Malibu Knolls Rd	Residential	3	2	On-site
I	4458026008	23916 Malibu Knolls Rd	Residential	4	4	On-site
I	4458025022	23933 Malibu Knolls Rd	Residential	2	2	On-site
I	4458027904	Winter Canyon Rd	Multi-Family			
I	4458027025	3625 Winter Canyon Rd	Residential	6	6	On-site
I	4458027003	3431 Coast View Dr	Residential	3	2	On-site
I	4458027004	3453 Coast View Dr	Residential	5	5	On-site
I	4458027005	3505 Coast View Dr	Residential	4	3	On-site
I	4458027029	3525 Coast View Dr	Residential	3	3	On-site
subtotal			61	198	178	
II	4452015035	3501 Cross Creek LN	Residential	4	4	On-site
II	4452015034	3509 Cross Creek LN	Residential	3	4	On-site
II	4452015023	3510 Cross Creek LN	Residential	4	4	On-site
II	4452015033	3511 Cross Creek LN	Residential	5	6	On-site
II	4452015025	3512 Cross Creek LN	Residential	3	4	On-site
II	4452015026	3520 Cross Creek LN	Residential			On-site
II	4452015031	3535 Cross Creek LN	Residential	4	4	On-site
II	4452015027	3538 Cross Creek LN	Residential	4	3	On-site
II	4452015030	3539 Cross Creek LN	Residential	4	4	On-site
II	4452015042	3550 Cross Creek LN	Residential	5	4	On-site
II	4452014006	3415 Cross Creek Rd	Residential	3	3	On-site
II	4452015024	Cross Creek LN	Residential	5	5	On-site
II	4458023003	3469 Cross Creek Rd	Residential	4	9	On-site
II	4458023009	3515 Cross Creek Rd	Residential	4	4	On-site
II	4452015029	3551 Cross Creek LN	Residential			On-site
II	4458022021	3565 Cross Creek Rd	Residential	4	3	On-site
II	4458022004	Cross Creek Rd	Residential			On-site
II	4458022003	3661 Cross Creek Rd	Residential	2	2	On-site
II	4452015003	23110 Mariposa De Oro St	Residential	5	5	On-site

DRAFT AUG 5 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452015014	2311 Mariposa De Oro St	Residential	3	3	On-site
II	4452015007	23122 Mariposa De Oro St	Residential	4	4	On-site
II	4452015010	23140 Mariposa De Oro St	Residential	5	4	On-site
II	4452015040	23146 Mariposa De Oro St	Residential	6	5	On-site
II	4452015006	23155 Mariposa De Oro St	Residential	4	5	On-site
II	4452015036	23160 Mariposa De Oro St	Residential	2	1	On-site
II	4452015021	23210 Mariposa De Oro St	Residential	5	5	On-site
II	4452015020	23215 Mariposa De Oro St	Residential	3	2	On-site
II	4452015022	23222 Mariposa De Oro St	Residential	5	5	On-site
II	4452015019	23233 Mariposa De Oro St	Residential	3	3	On-site
II	4452015018	23255 Mariposa De Oro St	Residential	5	5	On-site
II	4452027018	23247 Palm Canyon Ln	Residential	5	6	On-site
II	4452027016	23267 Palm Canyon Ln	Residential	2	2	On-site
II	4452027013	23301 Palm Canyon Ln	Residential	4	7	On-site
II	4452027012	23333 Palm Canyon Ln	Residential	3	4	On-site
II	4452027011	23333 Palm Canyon Ln	Residential	6	5	On-site
II	4452014004	23344 Palm Canyon Ln	Residential	4	3	On-site
II	4452012028	23500 Palm Canyon Ln	Residential	5	5	On-site
II	4452027021	3200 Retreat Ct	Residential	8	8	On-site
II	4452027022	3201 Retreat Ct	Residential	6	7	On-site
II	4452027019	3210 Retreat Ct	Residential	5	6	On-site
II	4452027023	3211 Retreat Ct	Residential	5	6	On-site
II	4452026008	3216 Serra Rd	Residential	5	5	On-site
II	4452026009	3220 Serra Rd	Residential	4	3	On-site
II	4452026007	3226 Serra Rd	Residential	5	5	On-site
II	4452026006	3226 Serra Rd	Residential			On-site
II	4452026010	3250 Serra Rd	Residential	4	6	On-site
II	4452026011	3264 Serra Rd	Residential	5	5	On-site
II	4452026019	3268 Serra Rd	Residential	4	4	On-site
II	4452026018	3270 Serra Rd	Residential			On-site
II	4452026012	3314 Serra Rd	Residential	4	3	On-site
II	4452026013	3350 Serra Rd	Residential	5	4	On-site
II	4452026016	3410 Serra Rd	Residential	5	4	On-site
II	4452026014	3426 Serra Rd	Residential	4	3	On-site
II	4452026015	3434 Serra Rd	Residential	4	4	On-site
II	4452018006	3611 Serra Rd	Residential	4	3	On-site
II	4452026003	Serra Rd	Residential			On-site
II	4452018011	3549 Serra Rd	Residential	3	3	On-site
II	4452013001	3556 Serra Rd	Residential	4	3	On-site
II	4452018012	3557 Serra Rd	Residential	3	3	On-site
II	4452013002	3560 Serra Rd	Residential	3	2	On-site
II	4452018013	3567 Serra Rd	Residential	4	4	On-site
II	4452013003	3574 Serra Rd	Residential	6	7	On-site

DRAFT AUG 5 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452018015	3609 Serra Rd	Residential	2	3	On-site
II	4452013009	3610 Serra Rd	Residential	4	4	On-site
II	4452018008	3615 Serra Rd	Residential			On-site
II	4452018016	3621 Serra Rd	Residential	4	4	On-site
II	4452018009	3623 Serra Rd	Residential	4	2	On-site
II	4452018017	3625 Serra Rd	Residential	4	2	On-site
II	4452018018	3627 Serra Rd	Residential	5	4	On-site
II	4452018019	3629 Serra Rd	Residential	4	3	On-site
II	4452018020	3631 Serra Rd	Residential	5	4	On-site
II	4452012014	3633 Serra Rd	Residential	4	4	On-site
II	4452012012	3635 Serra Rd	Residential	3	3	On-site
II	4452012015	3637 Serra Rd	Residential	1	1	On-site
II	4452013005	3644 Serra Rd	Residential	4	7	On-site
II	4452017001	3700 Serra Rd	Residential	4	3	On-site
II	4452012007	3701 Serra Rd	Residential	3	3	On-site
II	4452012016	3705 Serra Rd	Residential	4	3	On-site
II	4452012013	3707 Serra Rd	Residential	2	3	On-site
II	4452012022	3227 Serra Rd	Residential	4	4	On-site
II	4452012009	3737 Serra Rd	Residential	4	4	On-site
II	4452012011	3751 Serra Rd	Residential	3	4	On-site
II	4452012020	3811 Serra Rd	Residential	4	6	On-site
subtotal			83	309	311	
III	4452027010	3200 Cross Creek RD	Residential	3	3	On-site
III	4452027009	3232 Cross Creek RD	Residential	5	5	On-site
subtotal			2	8	8	
IV	4458004044	70 Malibu Colony Rd	Residential	4	3	On-site
IV	4452008025	112 Malibu Colony Rd	Residential	5	5	On-site
IV	4452008017	23314 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008016	23316 Malibu Colony Rd	Residential	4	4	On-site
IV	4452008014	23318 Malibu Colony Rd	Residential	3	5	On-site
IV	4452008030	23324 Malibu Colony Rd	Residential	5	7	On-site
IV	4452010017	23325 Malibu Colony Rd	Residential	2	2	On-site
IV	4452008028	23330 Malibu Colony Rd	Residential	2	4	On-site
IV	4452010024	23331 Malibu Colony Rd	Residential	2	3	On-site
IV	4452008027	23334 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010023	23337 Malibu Colony Rd	Residential			On-site
IV	4452008026	23338 Malibu Colony Rd	Residential	3	4	On-site
IV	4452008024	23346 Malibu Colony Rd	Residential	3	2	On-site
IV	4452010032	23349 Malibu Colony Rd	Residential	4	4	On-site
IV	4452008023	23350 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010031	23351 Malibu Colony Rd	Residential	3	3	On-site

DRAFT AUG 5 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4452008022	23354 Malibu Colony Rd	Residential	2	3	On-site
IV	4452008021	23356 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008020	23360 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010012	23401 Malibu Colony Rd	Residential	4	6	On-site
IV	4452008019	23402 Malibu Colony Rd	Residential	6	4	On-site
IV	4452009027	23410 Malibu Colony Rd	Residential	3	3	On-site
IV	4452009017	23416 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009016	23418 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010008	23425 Malibu Colony Rd	Residential	3	4	On-site
IV	4452009024	23426 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010028	23431 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010009	23435 Malibu Colony Rd	Residential			On-site
IV	4452009018	23438 Malibu Colony Rd	Residential	4	6	On-site
IV	4452009019	23440 Malibu Colony Rd	Residential	5	6	On-site
IV	4452010029	23441 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009022	23444 Malibu Colony Rd	Residential	4	3	On-site
IV	4452010027	23445 Malibu Colony Rd	Residential	5	3	On-site
IV	4452009021	23446 Malibu Colony Rd	Residential	5	4	On-site
IV	4452010005	23449 Malibu colony Rd	Residential	3	5	On-site
IV	4452009020	23450 Malibu Colony Rd	Residential	4	6	On-site
IV	4452009015	23456 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010003	23457 Malibu Colony Rd	Residential	3	4	On-site
IV	4458004031	23460 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004032	23500 Malibu Colony Rd	Residential	3	5	On-site
IV	4452010002	23501 Malibu Colony Rd	Residential	2	1	On-site
IV	4452010019	23505 Malibu Colony Rd	Residential	4	4	On-site
IV	4458004033	23506 Malibu Colony Rd	Residential	2	4	On-site
IV	4458004034	23510 Malibu Colony Rd	Residential	3	3	On-site
IV	4458003023	23511 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004035	23512 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003022	23515 Malibu Colony Rd	Residential	5	5	On-site
IV	4458004036	23516 Malibu Colony Rd	Residential	3	2	On-site
IV	4458003021	23517 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004037	23520 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004038	23524 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004039	23526 Malibu Colony Rd	Residential	5	7	On-site
IV	4458004040	23530 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003019	23531 Malibu Colonr Rd	Residential	4	5	On-site
IV	4458003018	23533 Malibu colony rd	Residential	4	3	On-site
IV	4458004041	23536 Malibu colony rd	Residential	4	3	On-site
IV	4458004042	23538 Malibu Colony Rd	Residential	5	4	On-site
IV	4458003017	23543 Malibu Colony Rd	Residential	5	3	On-site
IV	4458004043	23544 Malibu Colony Rd	Residential	5	4	On-site

DRAFT AUG 5 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458003015	23555 Malibu Colony Rd	Residential	1	1	On-site
IV	4458004046	23556 Malibu Colony Rd	Residential	2	2	On-site
IV	4458004047	23560 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003014	23561 Malibu Colony Rd	Residential	5	4	On-site
IV	4458004048	23562 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004049	23566 Malibu Colony Rd	Residential	3	1	On-site
IV	4458003013	23567 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004050	23570 Malibu Colony Rd	Residential	5	3	On-site
IV	4458004051	23600 Malibu Colony Rd	Residential	2	3	On-site
IV	4458003012	23601 Malibu Colony Rd	Residential			On-site
IV	4458004052	23604 Malibu Colony Rd	Residential	2	3	On-site
IV	4458004053	23608 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004054	23610 Malibu Colony Rd	Residential	5	6	On-site
IV	4458003027	23611 Malibu Colony Rd	Residential	4	6	On-site
IV	4458004055	23614 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003026	23615 Malibu Colony Rd	Residential	4	5	On-site
IV	4458005040	23618 Malibu Colony Rd	Residential	4	5	On-site
IV	4458005039	23620 Malibu Colony Rd	Residential	3	7	On-site
IV	4458005038	23622 Malibu Colony Rd	Residential	7	4	On-site
IV	4458003009	23623 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005037	23626 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003008	23629 Malibu Colony Rd	Residential			On-site
IV	4458005036	23630 Malibu Colony Rd	Residential	4	3	On-site
IV	4458005035	23632 Malibu Colony Rd	Residential	5	3	On-site
IV	4458005034	23634 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003030	23639 Malibu Colony Rd	Residential	2	2	On-site
IV	4458005033	23640 Malibu Colony Rd	Residential	3	4	On-site
IV	4458003004	23641 Malibu Colony Rd	Residential			On-site
IV	4458005032	23644 Malibu Colony Rd	Residential	5	6	On-site
IV	4458005031	23648 Malibu Colony Rd	Residential	3	4	On-site
IV	4458003029	23649 Malibu Colony Rd	Residential	4	4	On-site
IV	4458005030	23652 Malibu Colony Rd	Residential	3	2	On-site
IV	4458005029	23654 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003028	23655 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005028	23660 Malibu Colony Rd	Residential	4	5	On-site
IV	4458002014	23661 Malibu Colony Rd	Residential	5	5	On-site
IV	4458005027	23664 Malibu Colony Rd	Residential	3	2	On-site
IV	4458002011	23667 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005026	23668 Malibu Colony Rd	Residential	3	2	On-site
IV	4458005025	23672 Malibu Colony Rd	Residential	4	5	On-site
IV	4458002010	23673 Malibu Colony Rd	Residential	4	2	On-site
IV	4458005024	23674 Malibu Colony Rd	Residential	3	4	On-site
IV	4458005023	23678 Malibu Colony Rd	Residential	6	6	On-site

DRAFT AUG 5 2009

IV	4458005022	23684 Malibu Colony Rd	Residential	4	3	On-site
IV	4458002006	23687 Malibu Colony Rd	Residential	5	4	On-site
IV	4458005021	23700 Malibu Colony Rd	Residential	8	8	On-site
IV	4458006041	23704 Malibu Colony Rd	Residential	6	3	On-site
IV	4458002004	23705 Malibu Colony Rd	Residential	4	5	On-site
IV	4458006040	23708 Malibu Colony Rd	Residential	5	5	On-site
IV	4458002003	23709 Malibu Colony Rd	Residential	4	3	On-site
IV	4458006038	23712 Malibu Colony Rd	Residential	6	7	On-site
IV	4458002017	23713 Malibu Colony Rd	Residential	2	1	On-site
IV	4458006037	23716 Malibu Colony Rd	Residential	5	4	On-site
IV	4458006036	23720 Malibu Colony Rd	Residential	2	3	On-site
IV	4458006035	23730 Malibu Colony Rd	Residential	5	5	On-site
IV	4458006034	23736 Malibu Colony Rd	Residential	4	4	On-site
IV	4452005025	23006 Malibu Rd	Residential	3	3	On-site
IV	4458004045	23554 Malibu Rd	Residential	3	2	
IV	4458006033	23740 Malibu Rd	Residential	5	4	On-site
IV	4458006032	23746 Malibu Rd	Residential	4	3	On-site
IV	4458006031	23750 Malibu Rd	Residential	4	5	On-site
IV	4458006030	23752 Malibu Rd	Residential	4	4	On-site
IV	4458006029	23754 Malibu Rd	Residential	4	4	On-site
IV	4458006028	23758 Malibu Rd	Residential	3	4	On-site
IV	4458006027	23762 Malibu Rd	Residential	3	4	On-site
IV	4458006026	23764 Malibu Rd	Residential	3	5	On-site
IV	4458006025	23768 Malibu Rd	Residential	3	4	On-site
IV	4458006023	23800 Malibu Rd	Residential	9	10	On-site
IV	4458006022	23808 Malibu Rd	Residential	4	4	On-site
IV	4458007028	23812 Malibu Rd	Residential	4	1	On-site
IV	4458007027	23816 Malibu Rd	Residential	2	3	On-site
IV	4458007026	23822 Malibu Rd	Residential	4	7	On-site
IV	4458007025	23826 Malibu Rd	Residential	4	3	On-site
IV	4458007024	23832 Malibu Rd	Residential	5	3	On-site
IV	4458007023	23834 Malibu Rd	Residential	2	3	On-site
IV	4458007022	23844 Malibu Rd	Residential	3	2	On-site
IV	4458007021	23850 Malibu Rd	Residential	7	5	On-site
IV	4458007016	23858 Malibu Rd	Residential	5	6	On-site
IV	4458007015	23864 Malibu Rd	Residential			On-site
iV	4458007020	23868 Malibu Rd	Residential	5	6	On-site
IV	4458007019	23872 Malibu Rd	Residential	3	2	On-site
IV	4458007018	23900 Malibu Rd	Residential	3	2	On-site
IV	4458007017	23910 Malibu Rd	Residential	3	6	On-site
IV	4458008017	23917 Malibu Rd	Residential	5	4	On-site
IV	4458008016	23920 Malibu Rd	Residential	5	7	On-site
IV	4458008015	23926 Malibu Rd	Residential	6	5	On-site
IV	4458008014	23930 Malibu Rd	Residential	4	5	On-site
IV	4458008013	23936 Malibu Rd	Residential	4	4	On-site

DRAFT AUG 5 2009

IV	4458008018	23940 Malibu Rd	Residential	6	7	On-site
IV	4458008003	23950 Malibu Rd	Residential	4	5	On-site
IV	4458008002	23952 Malibu Rd	Residential	2	3	On-site
IV	4458008001	23956 Malibu Rd	Residential	5	3	On-site
IV	4458009013	23962 Malibu Rd	Residential	3	2	On-site
IV	4458009012	24000 Malibu Rd	Residential	4	3	On-site
IV	4458009009	24016 Malibu Rd	Residential	3	3	On-site
IV	4458009001	24056 Malibu Rd	Residential	2	1	On-site
IV	4458010015	24058 Malibu Rd	Residential	4	2	On-site
IV	4458010016	24102 Malibu Rd	Residential	4	4	On-site
IV	4458010017	24108 Malibu Rd	Residential	3	4	On-site
IV	4458010019	24116 Malibu Rd	Residential	3	3	On-site
IV	4458010018	24116 Malibu Rd	Residential	3	3	On-site
IV	4458010012	24120 Malibu Rd	Residential	3	3	On-site
IV	4458010011	24124 Malibu Rd	Residential	2	2	On-site
IV	4458010010	24128 Malibu Rd	Residential	3	4	On-site
IV	4458010008	24134 Malibu Rd	Residential	2	3	On-site
IV	4458010007	24138 Malibu Rd	Residential	3	3	On-site
IV	4458010006	24142 Malibu Rd	Residential	2	2	On-site
IV	4458010005	24146 Malibu Rd	Residential	4	4	On-site
IV	4458010004	24150 Malibu Rd	Residential	4	3	On-site
IV	4458010003	24154 Malibu Rd	Residential	2	2	On-site
IV	4458010001	24172 Malibu Rd	Residential	3	2	On-site
IV	4458011002	24212 Malibu Rd	Residential	2	2	On-site
IV	4458011003	24216 Malibu Rd	Residential	3	2	On-site
IV	4458018005	24001 Malibu Rd	Residential	3	3	On-site
IV	4458018020	24031 Malibu Rd	Residential	3	2	On-site
IV	4458018011	24109 Malibu Rd	Residential	3	2	On-site
IV	4458018012	24111 Malibu Rd	Residential	3	2	On-site
IV	4452008018	23406 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009026	23414 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009025	23422 Malibu Colony Rd	Residential	4	4	On-site
IV	4452009023	23430 Malibu Colony Rd	Residential	6	6	On-site
subtotal			180	651	658	

V	4452025006	3395 Sweetwater Mesa Rd	Residential	2	2	On-site
V	4452016004	3401 Sweetwater Mesa Rd	Residential	5	10	On-site
V	4452016019	3415 Sweetwater Mesa Rd	Residential	6	7	On-site
V	4452016020	3431 Sweetwater Mesa Rd	Residential	5	7	On-site
V	4452016007	3451 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452017004	3509 Sweetwater Mesa Rd	Residential	5	8	On-site
V	4452017005	3535 Sweetwater Mesa Rd	Residential	6	7	On-site
V	4452017009	3620 Sweetwater Mesa Rd	Residential	6	8	On-site
V	4452013008	3655 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452013007	3669 Sweetwater Mesa Rd	Residential	2	2	On-site

DRAFT AUG 5 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
V	4452016008	3330 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016018	3362 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016017	3380 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016016	3416 Sweetwater Mesa Rd	Residential	3	3	On-site
V	4452016015	3464 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452017008	3556 Sweetwater Mesa Rd	Residential	6	6	On-site
V	4452005004	23018 Pacific Coast Hwy	Residential	3	3	On-site
V	4452005022	23022 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005018	23030 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005002	23034 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005001	23038 Pacific Coast Hwy	Residential	3	2	On-site
V	4452019008	22931 Pacific Coast Hwy	Residential	2	3	On-site
V	4452005020	22860 Pacific Coast Hwy	Multi Family	12	13	On-site
subtotal			23	96	108	
TOTAL			349	1,262	1,263	

DRAFT AUG 5 2009

Table 3 - continue to next page

Table 3 Total Nitrogen Loading to the Lagoon After Adjustment of Flow and Leach Field Reduction

Site Description	Design Flow (gpd)	Conventional Septic Tank Effluent Nitrogen Concentration (mg/L)	Conventional Septic Tank Effluent Nitrogen Load (lbs/day)	Enhanced Treatment Unit Effluent Nitrogen Concentration (mg/L)	Enhanced Treatment Unit Effluent Nitrogen Load (lbs/day)	Leach Field Depth to Groundwater (feet)	Leach Field Soil Type	Leach Field Nitrogen Reduction	Effluent Nitrogen Load to the Lagoon (lbs/day)	Effluent Concentration to the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/day)
HR -3011 Malibu Cyn Rd	3,420	45%	1,542.6	45.0	>10	soil & bedrock	0%	45.0		0.88	
L.A. Co. Mtn. Yard -3837 Winter Cyn Rd	252	1%	26.2	40.0	10	sand, silt & clay	20%	32.0		0.01	
Malibu Colony Pizza^ -Disposal in Winter Cyn	16,617	1%	1,681.7	18.1	varies	sand & silt	6%	16.1		0.26	
Malibu WPCP^^ -3250 Vista Pacifica	22,500	1%	2,250.0	20.4	varies	sand & silt	0%	20.4		0.38	
Webster Elementary^ -3900 Winter Cyn Rd	5,000	1%	629.0	75.0	16	sand & silt	20%	60.0		0.25	
Our Lady of Malibu^ -3823 Winter Cyn Rd	2,500	1%	259.0	75.0		sand & silt	0%	75.0		0.16	
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	45%	676.0	75.0		sand & silt	0%	75.0		0.42	
Commercial - 7 Business Facilities	51,797		6,904.6	75.0		sand & silt	0%	75.0		2.05	
Residential 61 homes	17,800	45%	8,030.0	45.0				45.0		3.34	
Total	121,386		30,000							8.26	

*Seepage Pit Disposal or Failed Leachfield = 0% soil treatment
^Cesspools and septic tanks
^^Uses facilities inside gasborne advanced OWTS

Section 2	Design Flow (gpd)	Conventional Septic Tank Effluent Nitrogen Concentration (mg/L)	Conventional Septic Tank Effluent Nitrogen Load (lbs/day)	Enhanced Treatment Unit Effluent Nitrogen Concentration (mg/L)	Enhanced Treatment Unit Effluent Nitrogen Load (lbs/day)	Leach Field Depth to Groundwater (feet)	Leach Field Soil Type	Leach Field Nitrogen Reduction	Effluent Concentration to the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/day)
Sams Retreat^ -3481 Sierra Rd	750	95%	594.0	60.0	>10	sand & silt	20%	48.0		0.27
Commercial - 1 Business Facility	750		594.0	60.0						0.27
Residential 83 homes	31,100	95%	20,545.0	45.0				45.0		11.09
Total	32,600		21,733							11.63

^ Retreat and conference center with food service - low utilization

Section 3	Design Flow (gpd)	Conventional Septic Tank Effluent Nitrogen Concentration (mg/L)	Conventional Septic Tank Effluent Nitrogen Load (lbs/day)	Enhanced Treatment Unit Effluent Nitrogen Concentration (mg/L)	Enhanced Treatment Unit Effluent Nitrogen Load (lbs/day)	Leach Field Depth to Groundwater (feet)	Leach Field Soil Type	Leach Field Nitrogen Reduction	Effluent Concentration to the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/day)
Malibu Animal Hospital -29431 PCH	600	95%	475.0	40.0	10	sand, silt & clay	20%	32.0		0.13
Malibu Adm. Center -23519 Civic Ctr Wy	4,036	60%	2,422.8	40.0	>10	sand, silt & clay	20%	32.0		0.86
Racquet Club -23847 Stuart Ranch Rd	1,500	20%	300.0	75.0	clay	sand, silt & clay	0%	75.0		0.18
Prudential Realty -29485 PCH	450	95%	427.5	40.0	10	mostly sand	0%	40.0		0.11
*Malibu Laundry Mat I^ -3838 Cross Creek Rd	6,400	95%	7,850.0	60.0	<5	sand & silt	0%	60.0		5.33
*Malibu Country Mart II^ -23410 Civic Ctr Wy	6,300	60%	5,985.0	60.0	<5	sand & silt	0%	60.0		4.00
*Malibu Country Mart III^ -3900 Cross Creek Rd	5,400	80%	3,240.0	60.0	<5	mostly sand & silt	0%	60.0		2.16
Malibu Shell^ -23307 PCH	300	80%	285.0	4.2	5 to 10	mostly sand	20%	3.4		0.01
Malibu Prof. Arts Bldg -23429 Civic Ctr Wy	450	60%	270.0	40.0	10	sand, silt & clay	10%	36.0		0.08
Malibu Lumber^^ -23479 PCH	8,500	60%	5,100.0	5.7	5 to 10	fill, sand, silt & clay	20%	4.6		0.18
*Mtn Mar Properties -23805-23815 Stuart Ranch Rd	3,200	20%	640.0	40.0	>10	sand, silt & clay	0%	40.0		0.21
J & P Limited -3868 Cross Creek Rd	600	95%	475.0	40.0	10	mostly sand	20%	32.0		0.13
So. Calif. Edison	400	95%	380.0	40.0		mostly sand	20%	32.0		0.10
Verizon South, Inc. -3765 Cross Creek Rd	400	95%	380.0	40.0		sand & silt	20%	32.0		0.10
Matthews Land Company, LLC -3728 Cross Creek Rd	400	95%	380.0	40.0		mostly sand	20%	32.0		0.10
Malibu Creek Plaza/Malibu Village^^ -PCH & Cross Creek	11,000	95%	10,450.0	3.0	<5	mostly sand	10%	2.7		9.24
Commercial - 16 Business Facilities*	49,748		39,180.3							13.72
Residential 2 homes	800	95%	760.0	45.0				45.0		0.29
Total	93,814		73,000							54.29

*Exported high level of BOD and Total Nitrogen, but Total Nitrogen reduced by weekly pumping of septic tanks

DRAFT AUG 5 2009

Those facilities have package advanced OWTS
Seepage Pit Disposal or Failed Leachfield = 0% soil treatment

Sector 4	Discharge (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/yr)
Malibu Rd., LLC -23976-23712 Malibu Rd	400	1%	4.0	40.0	<10	sand, silt & clay	20%	32.0	0.09
Morton-Gerson -23730 Malibu Rd	400	1%	4.0	40.0	<10	sand, silt & clay	20%	32.0	0.09
L.A. Co. Fire Station 88[AA] -23720 Malibu Rd	540	1%	5.4	30.0	<10	sand, silt & clay	20%	24.0	0.09
Lina Krasnoff -23558 Malibu Colony Rd	400	1%	4.0	40.0	<10	sand & silt	0%	40.0	0.09
Mass, LLC 23918 PCH	400	1%	4.0	40.0	unknown	unknown	0%	40.0	0.09
Commercial - 6 Business Facilities	2,140		21.4						0.01
73 of 183 Res.@ 50% Flow to Lagoon	25,900	45%	11,655.0	45.0				45.0	4.39
107 of 183 Res.@20% Flow to Lagoon	39,900	1%	399.0	45.0				45.0	0.15
Total									4.85

187 homes were counted in Sector 4 with a total calculated flow of 65500 gpd
Those facilities have package advanced OWTS

Sector 5(1)	Discharge (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/yr)
Surfrider Co. Beach -23000 PCH	3,168	10%	316.8	40.0	>10	mostly beach sand	0%	40.0	0.11
Malibu Pier State Park[AA] -23000 PCH	3,000	1%	30.0	11.7	<10	mostly sand	10%	10.5	0.03
Malibu Shores Motel* -23033 PCH	2,843	1%	28.4	60.0	10	sand & silt	10%	54.0	0.01
Malibu Beach Inn[AA] -22878 PCH	2,843	1%	28.4	31.9	<10	mostly sand	0%	31.9	0.01
Jack-in-the-Box[AA] -23017 PCH	4,600	1%	46.0	28.26	>10	fill, sand & silt	26%	21.0	0.01
Malibu Plaza 22917 PCH	1,600	1%	16.0	40.0	~ 10	fill, sand & silt	0%	40.0	0.01
Malibu Inn & Restaurant* 22969 PCH	6,200	1%	62.0	110.0	~10	sand, silt & clay	0%	110.0	0.68
Surfshack/Fish Grill -22935 PCH	400	1%	4.0	60.0	~10	fill, sand & silt	0%	60.0	0.00
Spic & Span Cleaners/Chabad -22941 PCH	400	1%	4.0	40.0	~10	fill, sand & silt	0%	40.0	0.00
Commercial - 9 Business Facilities	24,074		527.7						0.29
Residential 23 homes	10,600	1%	648.0	45.0				45.0	0.24
Total									

*Effluent assumed to have high TN because of low septic tank retention time
**Those facilities have package advanced OWTS

Study Area	Discharge (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/yr)
Commercial	123,459		47,317.9						19.25
Residential	128,309		51,907.0						19.49
Total	251,768		99,224.9						38.74

DRAFT 5 GUA 2002 9

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

Attachment 4-1

Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loadings from OWDS to the Lagoon

C.P. Lai, Ph.D., P.E.

DRAFT AUG 5 2009

This memorandum summarizes the findings of previous studies on the mass loadings of nitrogen to Malibu Lagoon from on-site wastewater disposal systems (OWDS). Using recent data, staff then estimated the nitrogen loading into Malibu Lagoon based on previous numerical modeling results and a spread sheet model. Finally, staff estimated the nitrogen concentration in Lagoon water resulting from this mass loading by using a continuous stirred tank reactor (CSTR) mass balance model.

1.0 Briefing of Previous Studies

Three previous studies about the subject topics have been reviewed and their estimates of mass loadings of nitrogen at the edge of the Lagoon are summarized as follows:

1.1 Stone Report
(Groundwater-Flow and Solute Transport Modeling as Appendix 3 of the Final Report "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", August 2004)

A numerical model was used to simulate groundwater flow and solute transport in the alluvium deposited along Malibu Creek and Lagoon near the Malibu Civic Center area. The groundwater flow model used in this study is the USGS MODFLOW model and the solute transport model is the USEPA MT3D groundwater transport model. The model is limited by the amount of data that was used to build, calibrate, and verify the model.

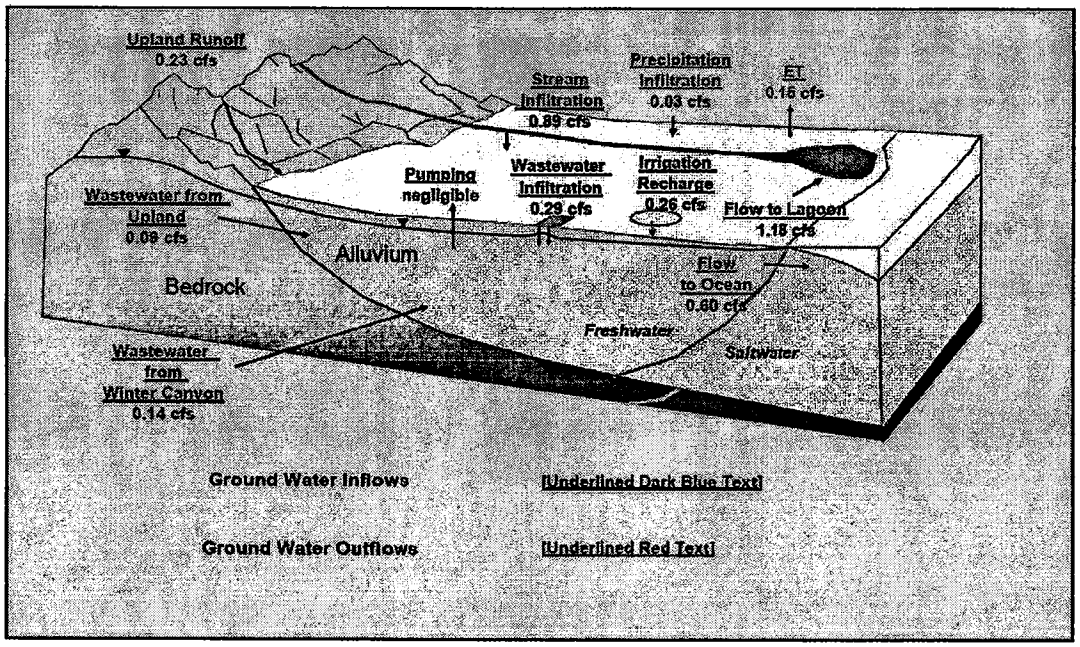
The purposes for constructing a model for the Malibu Civic Center area were to develop a water budget, to determine directions of groundwater flow, to identify which parts of the study area contribute groundwater flow to the beaches and to Malibu Lagoon, to estimate how long it takes groundwater from various parts of the study area to reach the beaches and Malibu Lagoon, and to estimate how much nitrogen is transported by the groundwater from OWDS to the Lagoon and to the ocean. No attempt was made in this model to estimate the mass loading for bacteria.

Results from the flow modeling were used to evaluate directions of groundwater flow, groundwater travel times in the flow system, and the contributing area for the Lagoon and ocean. The transport simulation was run for the period from 1930 through 2090, for a total of 160 years.

The total amount of wastewater disposal assumed as input for the model is approximately 0.52 cubic feet per second (cfs). Commercial wastewater disposal is estimated to be about 0.115 cfs. Source concentrations of nitrogen from OWDS were assumed to be 20 mg/l from domestic wastewater disposal systems and 50 mg/l from commercial systems.

The total average annual inflow to the alluvial groundwater flow system was estimated and is presented in Figure 1 below. The estimated total annual inflow to the alluvial groundwater flow system is approximately 1.93 cfs. The estimated total annual outflow is also 1.93 cfs, which includes 1.18 cfs to Malibu Lagoon, 0.60 cfs to the Pacific Ocean and 0.15 cfs for evapotranspiration.

Figure 1 Average Annual Groundwater Budget for the Malibu Alluvium

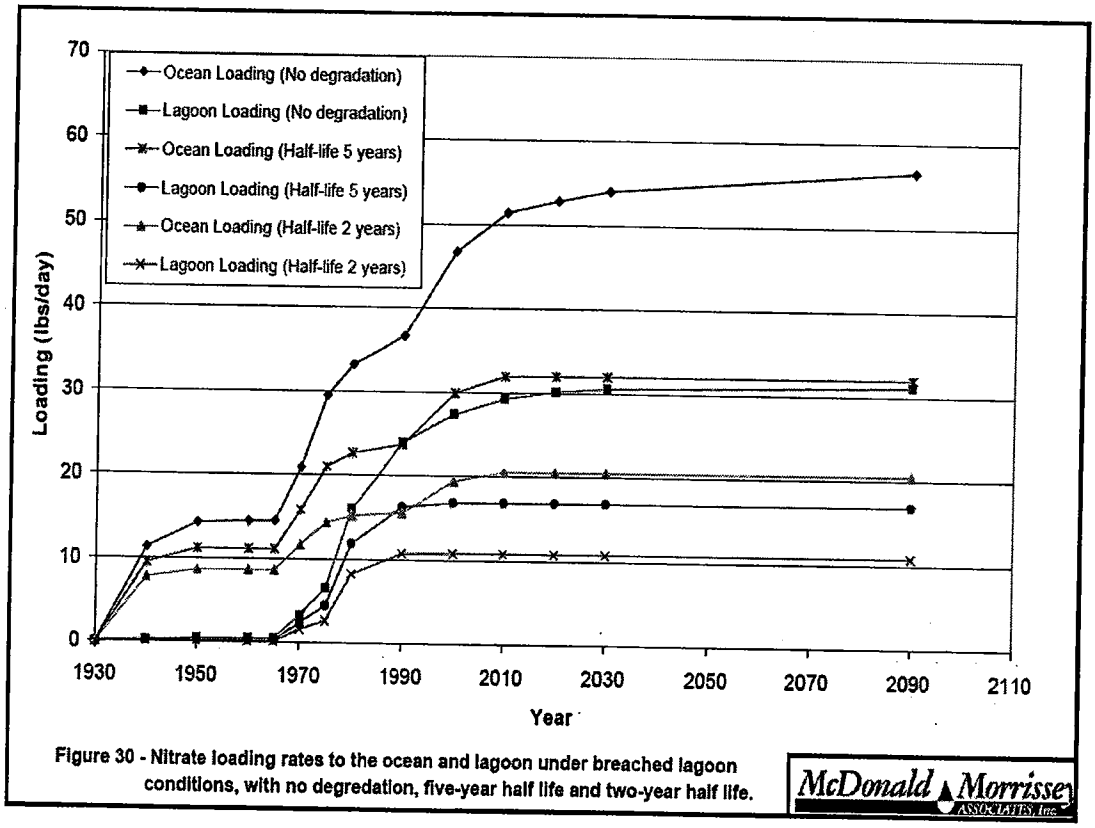


Transport model simulations were run with four steady-state hydraulic stresses, which represent changing source loadings over different time periods, for un-breached and breached Lagoon conditions in order to estimate nitrogen loadings to the ocean and Lagoon from OWDS. Depending upon the assumptions of nitrate degradation, the calculated maximum nitrogen loading to the Lagoon resulting from OWDS ranges from 31 lbs/day (un-breached Lagoon with no degradation) to 11 lbs/day (breached Lagoon with a 2-year half life). The calculated nitrogen mass loading rates to the Malibu Lagoon and the ocean under the breached Lagoon condition are shown in Figure 2. Figure 2 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Additionally, the study modeled groundwater movement to determine the time of travel to Malibu Creek, Malibu Lagoon, the surf zone, and the ocean. Some areas had times of travel as short as six months and others as long as 50 years.

DRAFT AUG 5 2009

Figure 2 Calculated Nitrogen Loading Rates to the Malibu Lagoon and the Ocean under the Breached Condition



1.2. Questa Report

(Groundwater Modeling Report as Appendix D of the Final Report "Civic Center Integrated Water Quality Management Feasibility Study for City of Malibu", April 2005)

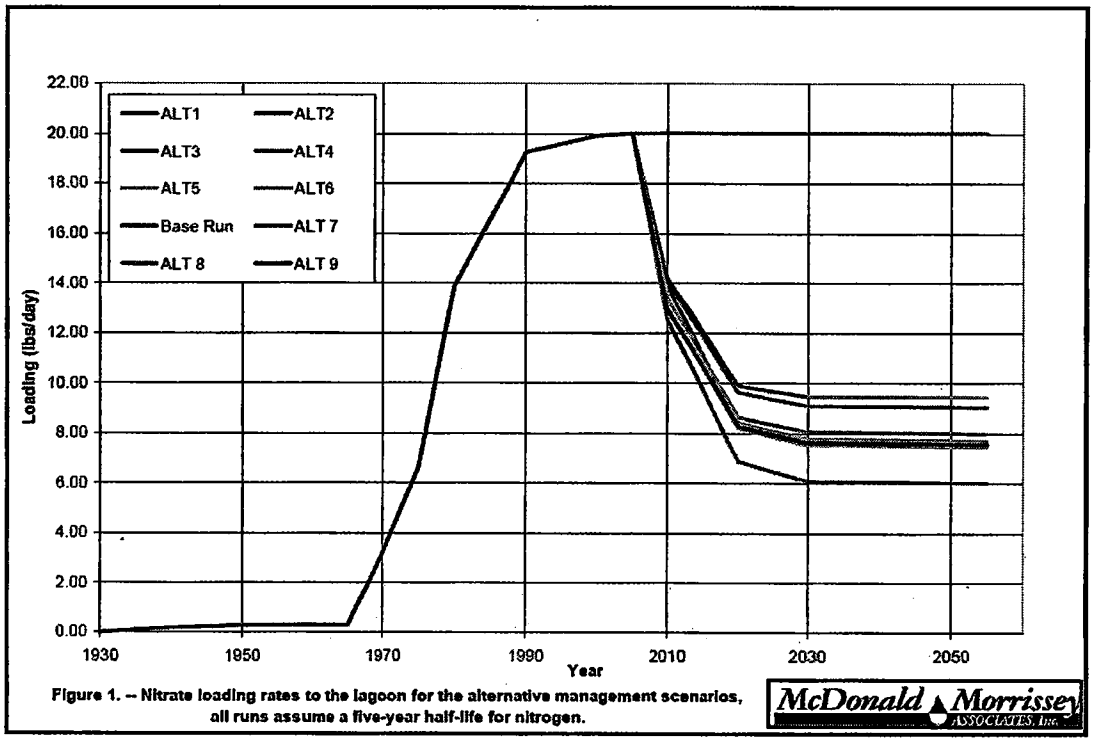
The three-dimensional groundwater flow and solute transport model developed for the Risk Assessment study (the Stone Report) was refined by McDonald Morrissey Associates to assess the potential water quality implications of various combinations of wastewater collection, treatment and dispersal options. Nine options were evaluated along with a baseline condition. Estimated wastewater flows from future development, as well as existing wastewater flows, were considered in the analysis. The model results of nitrogen mass loadings into the Malibu Lagoon for each wastewater management alternative, including the existing condition, are shown in Figure 3.

The nitrogen load at the present condition was estimated to be approximately 20 lbs/day. This result is slightly greater than the result obtained in the Stone Report (17 lbs/day) because

DRAFT AUG 5 2009

additional loading from commercial OWDS was included. Figure 3 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Figure 3 Calculated Nitrogen Loading Rates to the Malibu Lagoon for the Alternative Management Scenarios



1.3 Tetra Tech Report (Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies, December 2002)

The TMDL modeling report estimated that nitrogen loading from residential OWDS is 59.2 milligram/liter (mg/l) with 274 gallons per day (gpd) average effluent flow rate. It also assumed that there are two billion coliform counts per person per day discharged into OWDS, and an average population of 3.4 persons per household.

For "normal" OWDS, the TMDL report assumed 100% of the bacteria load is removed prior to reaching surface water bodies, and that 50% of the nitrogen loading reaches the surface water (TetraTech, 2002). For the "failed" OWDS, it was assumed that 40% of the bacteria reaches the Lagoon and 50% of the nitrogen reaches the Lagoon. For "short circuited" systems, 87% of the nitrogen loads and 20% of the bacteria loads were assumed to enter the Lagoon.

DRAFT AUG 5 2009

Based on the above assumptions, TetraTech (2002) estimated the current total annual bacteria load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 1,176,760 x 10^9 counts per year (3,224 x10^9 counts per day) for fecal coliform.

Similarly, the report estimated the current total annual nitrogen load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 23,434 pounds per year, or 64.2 lb/day (TetraTech, 2002).

2.0 Staff Estimate of Mass Loading Rates into the Malibu Lagoon

2.1 Estimate using Questa Numerical Model Results

The Questa groundwater flow and transport modeling assumed that the unsaturated zone had a negligible effect on nitrogen species and that the tidal actions and influences had a negligible effect on the water table and solute transport. Based on local soil properties, the soil is mostly sand and less clay. As such, the assumption that infiltration flows directly into the saturated zone is reasonable. As far as tidal influences are concerned, the varied tidal level will slightly affect the local water table and will not have much of an effect on the up-gradient groundwater water elevation. Therefore, staff concludes that the model results obtained from the Questa Report can be used to estimate the nitrogen mass loading to the Malibu Lagoon using recent OWDS loading data.

From Figure 2, it can be seen that the maximum loading rate to the Malibu Lagoon for the breached Lagoon condition varies from 31 lbs/day (no degradation) to 17 lbs/day (5-year half life) depending on different nitrate degradation coefficients. To be conservative, staff assumed the breached condition and a 5-year half life for the nitrate degradation rate to estimate nitrogen mass loading to the Malibu Lagoon. The relationship of nitrogen mass loading from OWDS and mass loading entering the Lagoon from the Questa Report is presented in Figure 4. There are four loading periods shown in Figure 4 to represent general changes in rates of mass loading into the Lagoon based on changes in source loading to the groundwater system. The loading period A is the period during 1930 to 1964 in which the simulated sources were from Malibu Colony only. During loading period B from 1965 to 1974, the simulated source loading includes the additional loading from residential areas in uplands adjacent to the alluvium. The loading period C from 1975 to 1989 includes all sources in loading period B plus commercial systems in the main body of alluvium. For the loading period D from 1990 to 2009, the source loading includes all sources in the loading period C plus loading from increased commercial and wastewater disposal at the Malibu Bay Colony plant.

To estimate the current loading to the Malibu Lagoon, the flow rate and concentration of wastewater from OWDS for commercial and residential areas from 2008-2009 were used to calculate the mass loading from OWDS to groundwater in the study area and then, based on the relationship for the loading period D as shown in Figure 4, to estimate the mass loading of nitrogen to the Malibu Lagoon. The resulting estimate of nitrogen mass loading into the Lagoon is 28.7 lbs/day based on mass loading from OWDS of 89.7 lbs/day as shown in Table 1.

DRAFT AUG 5 2009

2.2 Estimate using Spread Sheet Model

Since there are no numerical model input data available, the estimate of mass loading into the Lagoon assumes that the relationship between mass loading from OWDS and mass loading to the Lagoon is linear and the ratio of mass loading of 0.32 obtained from the Questa Report was used. However, the relationship between mass loading from OWDS and mass loading into the Lagoon may not be linear because the increased mass loading from OWDS could contribute more mass loading into the Lagoon due to the limited nitrogen capacity of groundwater during long term discharge and the effect of local groundwater flow net patterns. As such, Regional Board staff in the Groundwater Permitting Unit used a spread sheet model to estimate the mass loading entering the Lagoon based on local geotechnical data, hydraulic conductivity and groundwater flow net patterns. The estimate of mass loading into the Lagoon based on this spread sheet model is ~~39.4~~ **35.7** lbs/day resulting from a mass loading from OWDS of 89.7 lbs/day.

The comparisons of the three previous modeling results and staff estimates of nitrogen mass loading to the Malibu Lagoon using a numerical model and a spreadsheet model are presented in Table 1.

2.3 Evaluation of Nitrogen Mass Loadings into the Lagoon using a Mass Balance Model

To evaluate which estimate of mass loading to the Lagoon presented in Table 1 is the best fit with actual conditions and to understand the effect of mass loading from OWDS to the Malibu Lagoon on nitrogen concentrations in Lagoon water, staff used a continuous stirred tank reactor (CSTR) mass balance model to estimate the resulting concentration due to the mass loading. The CSTR model results for different mass loadings are presented in Figure 5. The results are compared with actual Lagoon nitrogen concentration data. It can be seen from Figure 5 that the predicted nitrogen concentration in the Lagoon due to a mass loading entering the Lagoon of 20 lbs/day (as predicted by the Questa Report) is a good comparison with the average nitrogen concentration of 1.4 mg/L for receiving water data collected by the Tapia wastewater treatment plant from 1995-1999. In addition, the predicted nitrogen concentration due to the load allocations for OWDS developed in the TMDL of 6 lbs/day is less than the nitrogen numeric target of 1.0 mg/L. The maximum of nitrogen mass loading into the Lagoon to maintain the nitrogen numeric target of 1.0 mg/L is about 13 lbs/day.

Staff estimates that the current mass loading into the Lagoon from OWDS may vary from 29 lbs/day to 36 lbs/day based on the predicted nitrogen concentrations in the Lagoon water and measured Lagoon nitrogen concentrations for 2002-2003 data (SCCWRP Technical Report 441) as shown in Figure 5. The current estimate of mass loading into the Lagoon of 35.7 lb/day using the spread sheet method would produce a nitrogen concentration in the Lagoon water of 3.0 mg/L and the current estimate of mass loading of 28.7 lb/day using the Questa numerical model results would cause the nitrogen concentration in the Lagoon water to be 2.4 mg/L. According to the measured data during 1995-1999 and 2002-2003, the nitrogen concentration in the Lagoon water is increasing. As such, the resulting nitrogen concentration of 3.0 mg/L for 2008-2009 falls within the trend of measured data from 1995 to 2003. Thus, the mass loading into the Lagoon of 35.7 lb/day is considered to be an appropriate and reasonable estimate.

DRAFT AUG 5 2009

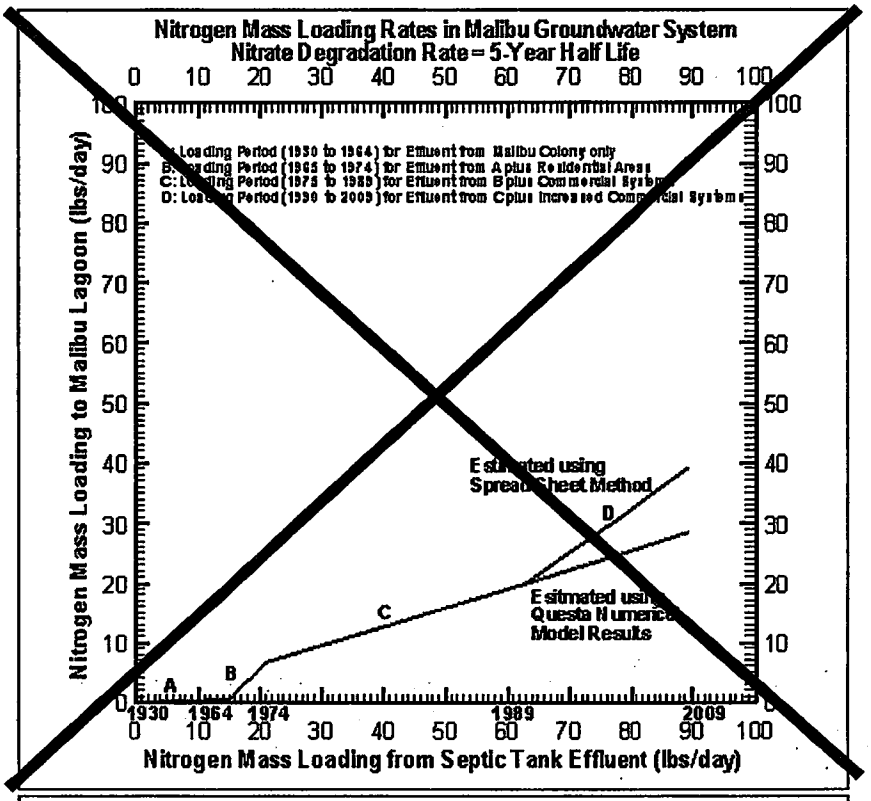
In summary, staff finds that the previous model developed by McDonald Morrissey Associates as presented in the Questa Report was calibrated with measured nitrate data and its modeling results can be used and have been used in this memo to estimate current nitrogen mass loading into the Lagoon. The spreadsheet model also provides a reasonable estimate of current mass loading to the Lagoon. By comparing the results of these two models with measured nitrogen concentration data in the Lagoon, staff estimates that ~~30-40~~ **29-36** lbs/day of nitrogen are loaded to the lagoon, which exceeds the TMDL load allocation and results in exceedances of the TMDL numeric target.

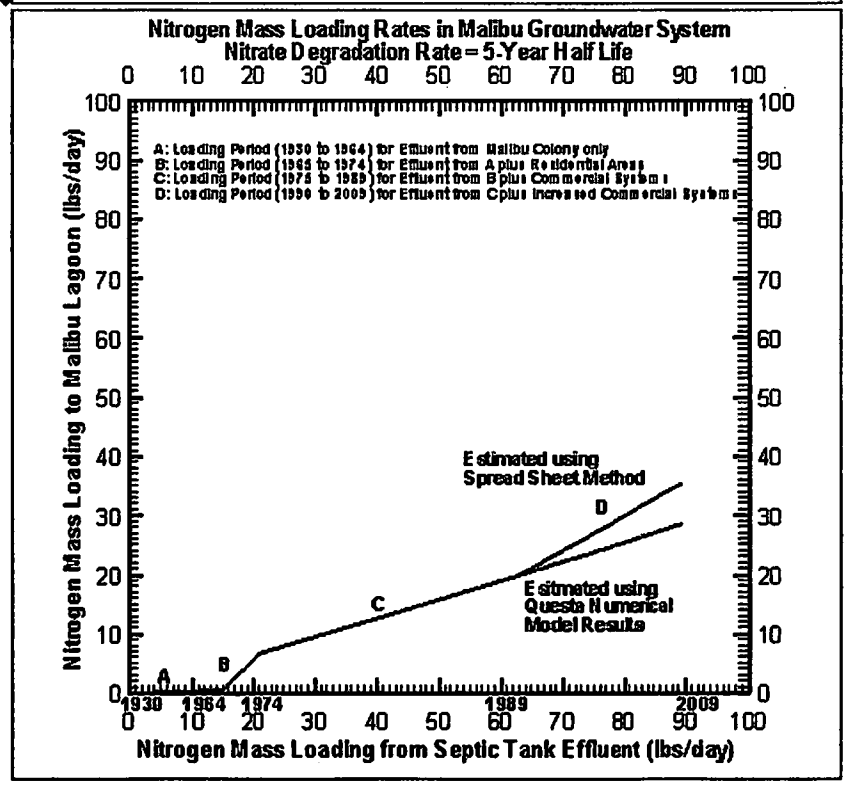
DRAFT AUG 5 2009

3.0 References

1. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Final Report, prepared for Santa Monica Bay Restoration Commission, prepared by Stone Environmental, Inc., August 30, 2004.
2. "Ground-Water Flow and Solute Transport Modeling, Malibu, California", prepared for Santa Monica Bay Restoration Project, prepared by McDonald Morrissey Associates Inc., July 28, 2004.
3. "Malibu Civic Center Integrated Water Quality Management Feasibility Study", prepared for City of Malibu, prepared by Questa Engineering Corporation, April 28, 2005.
4. "Groundwater Modeling Report in the Appendix D of Malibu Civic Integrated Water Quality Management Feasibility Study", prepared by McDonald Morrissey Associates, Inc., April 26, 2005.
5. "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", United States Environmental Protection Agency, Region 9, 2003.
6. "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development", prepared for Sterling Capitol, prepared by Furgo West, Inc., March 2005.
7. "Final Malibu Lagoon Restoration and Enhancement Plan", prepared for the California State Coastal Conservancy & California State Department of Parks and Recreation, prepared by Moffatt & Nichol, June 17, 2005.
8. "Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon", prepared for City of Malibu, prepared by RMC, March 26, 2008.
9. "Lower Malibu Creek and Lagoon Resource Enhancement and Management ", Final Report to the California State Coastal Conservancy, prepared by Richard F. Ambrose and Antony R. Orme, University of California, Los Angeles, May 2000.
10. "Malibu Wetland Feasibility Study", prepared for Malibu Coastal Land Conservation, prepared by Huffman and Carpenter, Inc., August 2000.
11. "Sediments as a Non-Point Source of Nutrients to Malibu Lagoon, California, USA", Southern California Coastal Water Resources Project (SCCWRP) Technical Report 441, October 2004.
12. Las Virgenes Municipal Water District (LVMWD),Tapia Water Reclamation Facilities, Malibu Creek Monitoring Program, 1995-1999 Annual Report, NPDES Permit No. CA0056014.

Figure 4 Relationship of nitrogen mass loading from OWDS and mass loading into the Lagoon





T4-40

DRAFT AUG 5 2009

Table 1 Comparisons of nitrogen mass loading to the Malibu Lagoon for three previous studies and staff estimates

	Stone Report (2004)[b]	Questa Report (2005)[b]	Tetra Tech Report (2003)[c]	Staff Estimate Using Spread Sheet Method[d]	Staff Estimate Using Numerical Model Method[e]
1.Wastewater Flow Rate from Commercial OWDS (gal/day)	62166	100000	75000	128469	128469
2.Concentration in Commercial Wastewater (mg/L)	50	50	59.2	3 - 110	3 – 110
3.Mass Loading from Commercial OWDS (lbs/day)	25.94	41.73	37.05	42.3	42.3
4.Wastewater Flow Rate from Residential OWDS (gal/day)	126121	126121	54800	126300	126300
5.Concentration in Residential Wastewater (mg/L)	20	20	59.2	45	45
6.Mass Loading from Residential OWDS (lbs/day)	21.05	21.05	27.07	47.4	47.4
7.Mass Loading from OWDS (lbs/day)	46.99	62.78	64.12	89.7	89.7
8.Ratio of Mass Loading[a]	0.36	0.32	0.50	0.40	0.32
9.Mass Loading to Malibu Lagoon (lbs/day)	17	20	32	35.7	28.7

Note: [a] the ratio of mass loading entering Malibu Lagoon versus mass loading from OWDS, i.e., value of row 9 divided by value of row 7.

[b] the nitrogen loads were assumed to be mostly nitrate in the OWDS and the model only simulated the nitrate in the Stone and Questa Modeling Reports.

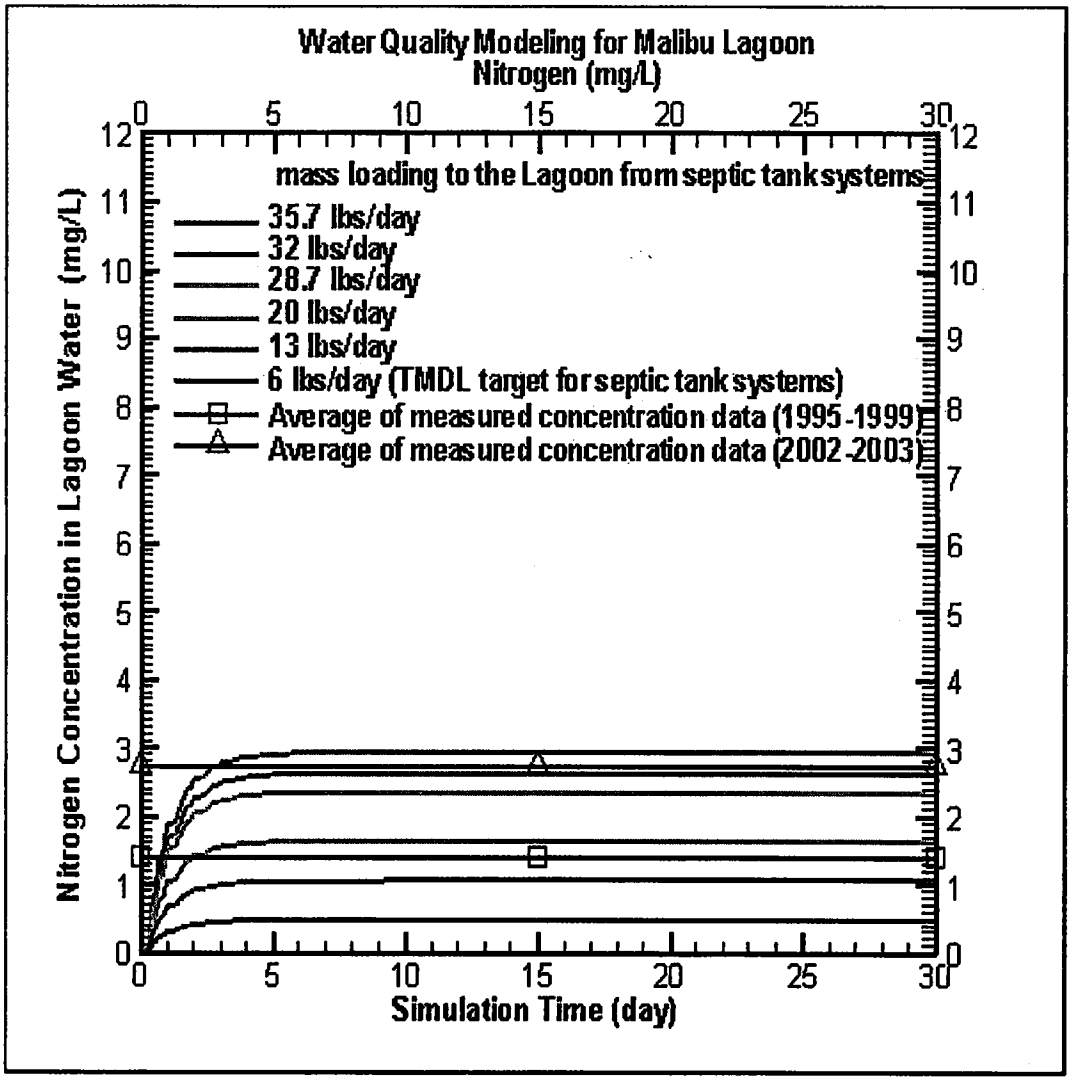
[c] 50 percent of nitrogen loads from the OWDS were assumed to enter the Malibu Lagoon.

[d] the nitrogen mass loading from OWDS was estimated based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L for OWDS. Staff estimated the nitrogen mass loading to Malibu Lagoon by using the spread sheet method.

[e] the nitrogen mass loading based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L from OWDS were used in the model. Staff estimated the nitrogen mass loading to Malibu Lagoon by using Questa numerical model results.

DRAFT AUG 5 2009

Figure 5 Nitrogen concentrations in Lagoon water resulting from different mass loadings entering the Lagoon



DRAFT AUG 5 2009

Wendy Phillips - Malibu Prohibition - Peer review adjustments

From: Wendy Phillips
To: Gerald Bowes
Date: Tuesday, August 18, 2009 12:13 PM
Subject: Malibu Prohibition - Peer review adjustments
CC: Deborah Smith; Elizabeth Erickson; Rebecca Chou; Todd Thompson; Toni Callaway; Tracy Egoscue
Attachments: Peer Review packet 09-08.pdf; Wendy Phillips.vcf

Gerry - Thanks again. As promised, below is the latest schedule, based on our decision to delay our hearing from Oct 1st to Nov 5th.

But - please do not delay review of the N Tech Memo (#4), by Toni Callaway. **We still very much want TM#4 comments back from peer reviewers by our original deadline of Sept 3rd.** You already have all the material for this tech memo. (And I've also attached that Aug 6th request to this e-mail).

For the pathogen Tech Memo (#3), by Elizabeth Erickson, please be advised that we are releasing raw data and re-formatting this tech memo, and we will re-submit it to you by Sept 10th. We would like peer review responses back by Oct 8th. I think you have aleady made progress lining up some peers for this.
Hope this works from your end. Don't hesitate to contact me, Toni (Tech Memo #4), or Elizabeth (Tech Memo #3) with questions. (Our contact info is on the attachment.) And thanks.

Wendy

Wendy Phillips wphillips@waterboards.ca.gov
Chief, Groundwater Cleanup and Permitting Section
CA Regional Water Quality Control Board, LA Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013
phone: (213) 576-6618 fax: (213) 576-5777

From: Wendy Phillips
To: jdrewes@mines.edu
CC: Deborah Smith; Elizabeth Erickson; Gerald Bowes; Rebecca Chou; Toni ...
Date: 9/10/2009 4:58 PM
Subject: Tech Memo #3 - External Peer Review - CA RWQCB - LA
Attachments: Wendy Phillips.vcf; 1 an epidemiological study.pdf; 2 The health effect of swimming in ocean water contaminated by storm drain.pdf; 3 umi.pdf; 4 Healt h Effects Criteria for Marine Recreational Waters.pdf; v. 2 Appendice T3.do c; Revised Attachment 2 - 09-09.pdf; Tech Memo #3 - revised 09-09-10.pdf

Dr. Drewes -

We are hereby initiating an external review of the attached Tech Memo #3, draft dated September 10, 2009, entitled "Pathogens in Wastewaters that are in Hydraulic Connection with Beaches represent a Significant Source of Impairment to Water Contact Recreation." Also, we are transmitting a revision to Attachment #2 (Scientific Issues to be addressed by Peer Review) to our letter dated August 6, 2009. The revised Attachment #2 revises the scientific issues to be addressed in your peer review. Your review must address the topics listed in revised Attachment #2, **as expertise allows, in the order given**, and must follow all guidance in revised Attachment #2.

We have also attached electronic versions of key literature reviewed for Tech Memo #3. Also, the raw data we used for Tech Memo #3 is posted on our Web site, at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public-Hearing-Malibu/index.shtml# (scroll down to the Update posted on August 24, 2009). Although a review of the raw data is not part of the scope of our request for external review, you may nonetheless wish to look at the data.

Due to our time constraints, we need to receive your comments on Tech Memo #3 no later than noon on Thursday, October 8, 2009.

As I will be on vacation until September 21st, would you please e-mail Dr. Rebecca Chou right away to confirm your receipt of these documents, and to advise her if you require more information, hard copies, additional background, or other documents for your review? Also, if we need to provide overnight delivery of documents, please advise her of the address to which the documents should be delivered. Dr. Chou may be reached at (213) 620-6156 or rchou@waterboards.ca.gov.
Thank you.

Wendy Phillips wphillips@waterboards.ca.gov
Chief, Groundwater Cleanup and Permitting Section
CA Regional Water Quality Control Board, LA Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013
phone: (213) 576-6618 fax: (213) 576-5777

From: Wendy Phillips
To: joann.silverstein@colorado.edu
CC: Deborah Smith; Elizabeth Erickson; Gerald Bowes; Rebecca Chou; Toni ...
Date: 9/10/2009 4:57 PM
Subject: Tech Memo #3 - External Peer Review - CA RWQCB - LA
Attachments: Wendy Phillips.vcf; 1 an epidemiological study.pdf; 2 The health effect of swimming in ocean water contaminated by storm drain.pdf; 3 umi.pdf; 4 Healt h Effects Criteria for Marine Recreational Waters.pdf; v. 2 Appendice T3.do c; Revised Attachment 2 - 09-09.pdf; Tech Memo #3 - revised 09-09-10.pdf

Dr. Silverstein -

We are hereby initiating an external review of the attached Tech Memo #3, draft dated September 10, 2009, entitled "Pathogens in Wastewaters that are in Hydraulic Connection with Beaches represent a Significant Source of Impairment to Water Contact Recreation." Also, we are transmitting a revision to Attachment #2 (Scientific Issues to be addressed by Peer Review) to our letter dated August 6, 2009. The revised Attachment #2 revises the scientific issues to be addressed in your peer review. Your review must address the topics listed in revised Attachment #2, **as expertise allows, in the order given**, and must follow all guidance in revised Attachment #2.

We have also attached electronic versions of key literature reviewed for Tech Memo #3. Also, the raw data we used for Tech Memo #3 is posted on our Web site, at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public-Hearing-Malibu/index.shtml# (scroll down to the Update posted on August 24, 2009). Although a review of the raw data is not part of the scope of our request for external review, you may nonetheless wish to look at the data.

Due to our time constraints, we need to receive your comments on Tech Memo #3 no later than noon on Thursday, October 8, 2009.

As I will be on vacation until September 21st, would you please e-mail Dr. Rebecca Chou right away to confirm your receipt of these documents, and to advise her if you require more information, hard copies, additional background, or other documents for your review? Also, if we need to provide overnight delivery of documents, please advise her of the address to which the documents should be delivered. Dr. Chou may be reached at (213) 620-6156 or rchou@waterboards.ca.gov.
Thank you.

Wendy Phillips wphillips@waterboards.ca.gov
Chief, Groundwater Cleanup and Permitting Section
CA Regional Water Quality Control Board, LA Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013
phone: (213) 576-6618 fax: (213) 576-5777

From: Wendy Phillips
To: Robert Arnold
CC: Deborah Smith; Elizabeth Erickson; Gerald Bowes; Rebecca Chou; Toni ...
Date: 9/10/2009 5:00 PM
Subject: Tech Memo #3 - External Peer Review - CA RWQCB - LA
Attachments: Wendy Phillips.vcf; 1 an epidemiological study.pdf; 2 The health effect of swimming in ocean water contaminated by storm drain.pdf; 3 umi.pdf; 4 Healt h Effects Criteria for Marine Recreational Waters.pdf; v. 2 Appendice T3.do c; Revised Attachment 2 - 09-09.pdf; Tech Memo #3 - revised 09-09-10.pdf

Dr. Arnold -

We are hereby initiating an external review of the attached Tech Memo #3, draft dated September 10, 2009, entitled "Pathogens in Wastewaters that are in Hydraulic Connection with Beaches represent a Significant Source of Impairment to Water Contact Recreation." Also, we are transmitting a revision to Attachment #2 (Scientific Issues to be addressed by Peer Review) to our letter dated August 6, 2009. The revised Attachment #2 revises the scientific issues to be addressed in your peer review. Your review must address the topics listed in revised Attachment #2, **as expertise allows, in the order given**, and must follow all guidance in revised Attachment #2.

We have also attached electronic versions of key literature reviewed for Tech Memo #3. Also, the raw data we used for Tech Memo #3 is posted on our Web site, at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public-Hearing-Malibu/index.shtml# (scroll down to the Update posted on August 24, 2009). Although a review of the raw data is not part of the scope of our request for external review, you may nonetheless wish to look at the data.

Due to our time constraints, we need to receive your comments on Tech Memo #3 no later than noon on Thursday, October 8, 2009.

As I will be on vacation until September 21st, would you please e-mail Dr. Rebecca Chou right away to confirm your receipt of these documents, and to advise her if you require more information, hard copies, additional background, or other documents for your review? Also, if we need to provide overnight delivery of documents, please advise her of the address to which the documents should be delivered. Dr. Chou may be reached at (213) 620-6156 or rchou@waterboards.ca.gov.
Thank you.

Wendy Phillips wphillips@waterboards.ca.gov
Chief, Groundwater Cleanup and Permitting Section
CA Regional Water Quality Control Board, LA Region
320 West 4th Street, Suite 200
Los Angeles, CA 90013
phone: (213) 576-6618 fax: (213) 576-5777

Revised *(September 10, 2009)* Attachment 2, Pertaining to Tech Memo #3

Description of Scientific Issues to be addressed by Peer Review

The statute mandate for external scientific peer review (Health and Safety Code Section 57004) states that the reviewer's responsibility is to determine whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods, and practices. We request that you make this determination for each of the following issues that constitute the scientific basis of the proposed regulatory action.

For Technical Memorandum #3: **Pathogens in Wastewaters that are in Hydraulic Connection with Beaches represent a Significant Source of Impairment to Water Contact Recreation**, by Elizabeth Erickson, P.G. *(draft dated September 10, 2009)*:

a. The interpretation of key literature (i.e. the four documents attached to our e-mail dated September 10, 2009), identifying factors that increase the levels of pathogen indicators and risks to human health at the beach.

b. In particular, the interpretation of the Haile et al (1996 and 1999) epidemiology study and the 1983 EPA marine health criteria for health risk.

c. The application of correlation coefficients in Figures 7, 8, and 9. (A detailed table is attached to the e-mail dated September 10, 2009.)

d. The conclusion, on pages T3-7 through T3-9, that water quality persistently fails to meet water quality objectives during dry weather at Surfrider Beach, Malibu Colony Beach, Malibu Pier Beach, Carbon Beach, and Marie Canyon.

e. The conclusion that groundwater, contaminated with indicators of pathogens, is a source of impairment to lagoon and beaches.

Finally, reviewers are not limited to addressing only the specific issues presented above, and we request the scope of the peer review response include the following overarching questions:

(a) In reading Tech Memos #3 and #4, are there any additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

(b) Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices?

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #3: *Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation*

REVISED DRAFT

0 9

By
Elizabeth Erickson,* Professional Geologist
Groundwater Permitting Unit

1 0

2 0 0 9

* *The author would like to thank Regional Board staff, Joe Luera and interns Albert Chu, Shentong Lu, Shannon Liou, Justin Tang, Tessa Nielsen, Ben Leu, Holly MacGillivray, Thomas Palmieri, Ryan Thatcher and Yifei Tong for their assistance in preparing map, tables and graphs.*

Technical Memorandum #3: ***Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation***

By
Elizabeth Erickson, Professional Geologist
Groundwater Permitting Unit

REVISED DRAFT 09 10 2009

1. Purpose

The purpose of the memorandum is (a) to document the discharge of enterococcus, total coliform and fecal coliform, bacteria used to indicate risk of recreational waterborne illness, from on-site wastewater disposal systems (OWDS) in the Malibu Civic Center onto adjacent surface waters and beaches, and (b) to determine human health impacts on beach users of exposure to pathogens given observed levels of enterococcus in beach water..

2. Study Design and Data

The study sought to examine the distribution of bacteria in groundwater beneath the Malibu Civic Center area and surface water around Malibu Civic Center area. Fecal-indicator-bacteria are identified in OWDS discharge, in leachfields/seepage pits, in groundwater, in streams and beaches and, through rainfall records and frequency distributions, related to groundwater discharge. OWDS performance data from permitted commercial facilities, groundwater monitoring data and beach monitoring data at the Malibu Civic Center are studied for the presence of enterococcus bacteria, which can originate in the human gut, have been used as indicators of pathogens, and are the basis of marine recreational criteria for the protection of human health.

Of the twenty permitted commercial facilities in the Malibu Civic Center are under the Regional Water Quality Control Board's (Regional Board) oversight, four provided end-of-pipe measures and ten submitted groundwater monitoring results. End-of-pipe discharge reports from permitted systems document effluent quality as it enters the leachfield/seepage pit. Enterococcus densities were also examined in groundwater monitoring wells surrounding the leachfields.

The City of Malibu measures groundwater quality periodically throughout the Malibu Valley Basin which receives the effluent from the OWDS in the Malibu Civic Center area. The groundwater monitoring of 20 wells in the Malibu Civic Center area completed by the City of Malibu in 2004 and summarized by Stone Environmental, Inc. (Stone, 2004) were used for this study.

Beach data collected as part of the Coordinated Shoreline Monitoring Plan for Santa Monica Bay beaches were used for this study. The "Santa Monica Bay Beaches Bacteria Total Maximum Daily Load Coordinated Shoreline Monitoring Plan, April 7, 2004" (CSMP) went into effect on April 28, 2004. The sites cover 44 beaches that were indentified as impaired due to high fecal-indicator-bacteria and/or beach closures and therefore placed on the California Clean Water Act 2002 section 303(d) list. Detailed descriptions of standardized sampling and testing procedures can be found at http://ladpw.org/wmd/npdes/beachplan.cfm. Attachment 3-A contains a complete list of the beaches in the CSMP. The data collected and compiled and the beach characteristics were released on August 24, 2009

on the Regional water Quality Control Website www.waterboards.swrcb/los angeles. Civic Center beaches are Malibu Colony Beach labeled as MC-1, Malibu Surfrider Beach labeled as MC-2, Malibu Pier Beach labeled as MC-3. Sweetwater Canyon at Carbon Beach., labeled as SMB 1-13, is the Civic Center beach which lies furthest to the southeast. Marie Canyon, labeled as SMB 1-12, is the beach which lies furthest to the northwest and just outside the Malibu Civic Center Prohibition study area.

Attachment 3-B contains an expanded reference list including those documents cited here.

Early Technical Review

An Early Technical Review (ETR) of this work was conducted between June 8, 2009, and the public release of this document. The ETR resulted in recommendations from the reviewers (a) to enhance the confidence of the conclusions using statistics, (b) to recommend additional studies to confirm and extend the results shown here, (c) to emphasize the complexity of the subsurface hydraulic and microbiological environment between OWDS discharge and the ocean, and (d) to verify the relationship between human illness from marine recreational activities and coastal OWDS use. In response to these comments, additional statistical results were generated and human health risks estimates were based on a site-specific study. The Early Technical Reviewers were Dr. Mark Gold (Heal the Bay), Mr. Steve Weisberg and Dr. John Griffith (Southern California Coastal Water Research Project or SCCWRP), Dr. Alexandria Boehm (Stanford University) and Dr. John Izbicki (US Geological Survey), all of whom have completed research on microbial water quality at beaches.

Peer Review

Independent Peer Review was also conducted through contract with the University of California at Berkeley and the State Water Resources Control Board, with the comments and response to comments released to the public and considered with this document by the Regional Board.

Integration with Ongoing Studies

An epidemiology study of Surfrider Beach by SCCWRP is ongoing with fieldwork conducted during the summer of 2009. Groundwater assessment was conducted during a ten-day period in July 2009 by Dr. John Izbicki. The City of Malibu reports that Richard Ambrose and Jenny Jay of UCLA conducted a study of *Bacteroidales*, a group of novel bacteria a subset of which is human-specific, in Malibu Lagoon in 2009. Descriptions of the ongoing studies are available from the Regional Board.

3. Results

Bacteria in Groundwater

End-of-pipe bacteria measurements are reported for four permitted commercial sites in the Malibu Civic Center, where disinfection has high failure rate. The enterococcus values are considered to be typical for non-disinfection systems like most residential OWDSs. A more complete description of the extent of enterocccus in the groundwater basin is included as part of Technical Memo #2.

REVISED DRAFT 09 10 2009

Table 1: End-of-Pipe Effluent Bacteria Densities (MPN/100mL) reported for permitted Malibu Civic Center Commercial Facilities with Disinfection.

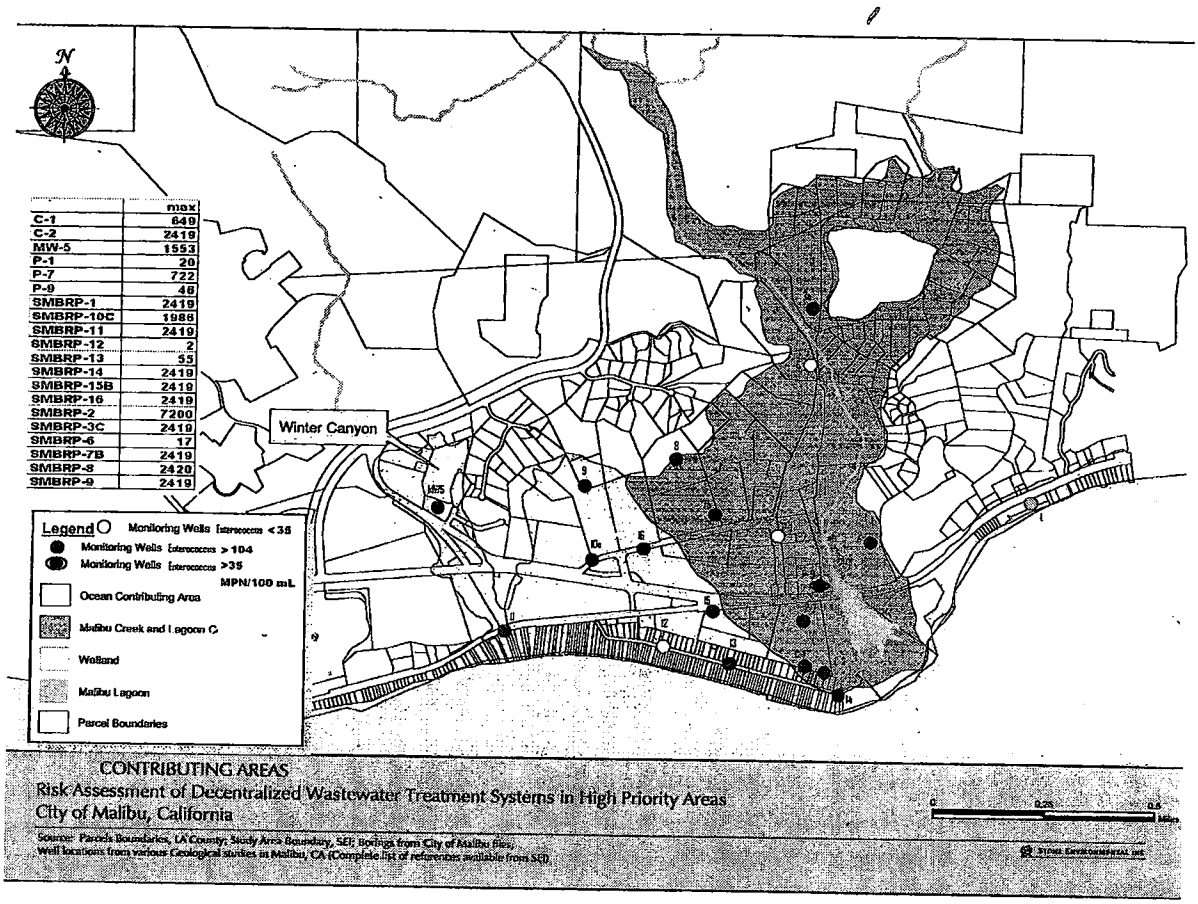
Site	Total	Fecal	Enterococcus
Malibu Creek Preservation	1,600	350	46
	1,600	140	110
Malibu Beach Inn	Not measured	2	2
	Not measured	2	2
Malibu Colony Plaza	105	2	2
	4,000	2	2
	1,600	1,600	2,419
	1,600	1,600	2,419
Fire Station 88	1,600	1,600	2,419
	9,000	Not available	90,000
	24,000	24,000	24,000
	30,000	2,400	50,000
	240,000	Not available	240,000
	300,000	50,000	1,600,000

Highlighted measures on the chart are fecal-indicator-bacteria values in human waste which the water quality objectives for protection of body contract recreation (REC-1)).

Elevated bacteria levels were found throughout the Malibu Valley groundwater basin, which underlies the Malibu Civic Center area, and are also reported in 2004 by Stone Environmental's "Final Report- Risk Assessment of Decentralized Wastewater Disposal Systems in High Priority Areas in the City of Malibu CA". Figure 1 shows the locations of monitoring wells in Stone's study. Elevated subsurface enterococcus densities are seen adjacent to the receiving waters. Fifteen out of 20 City wells, and 16 out of 27 permit monitoring wells, located at the edge of leachfields, contained a maximum enterococcus density exceeding the single sample maximum water quality objective of 104 MPN/100ml for protection of the beneficial use of REC-1, i.e., 31 out of the total 47 wells (76%) have an exceedance (Figure 2 and 3). Importantly, the occurrence of enterococcus in groundwater at these wells illustrates that human waste is present in the groundwater at the study site.

REVISED DRAFT 0910 2009

Figure 1. The maximum enterococcus measures in wells in the Civic Center area after Stone 2004.



REVISED DRAFT 09 10 2009

Figure 2: Chart of Maximum Enterococcus Density (MPN/100 mL) for 20 groundwater wells in the Civic Center area from Stone 2004 Study (well locations are shown in Figure 1).

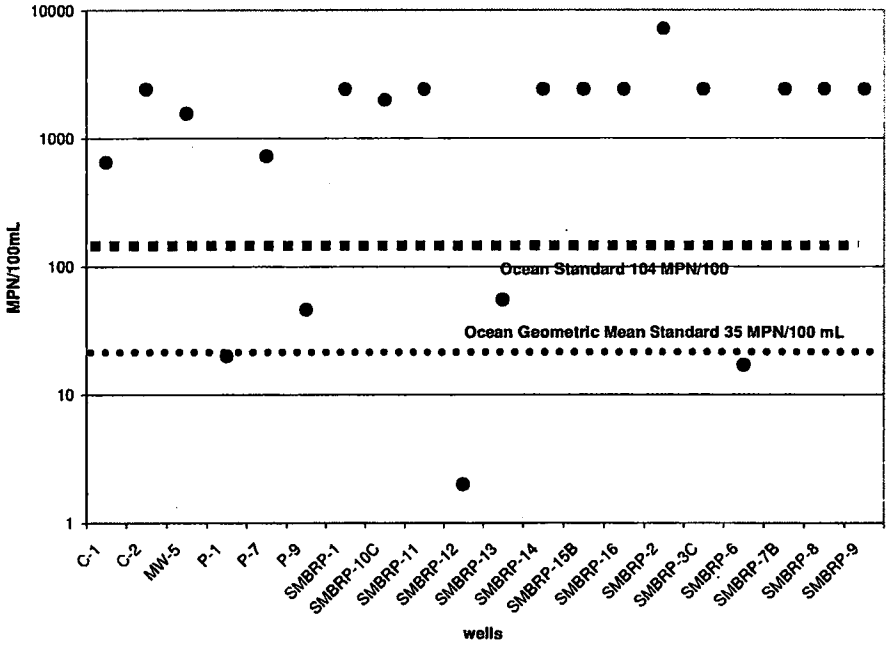
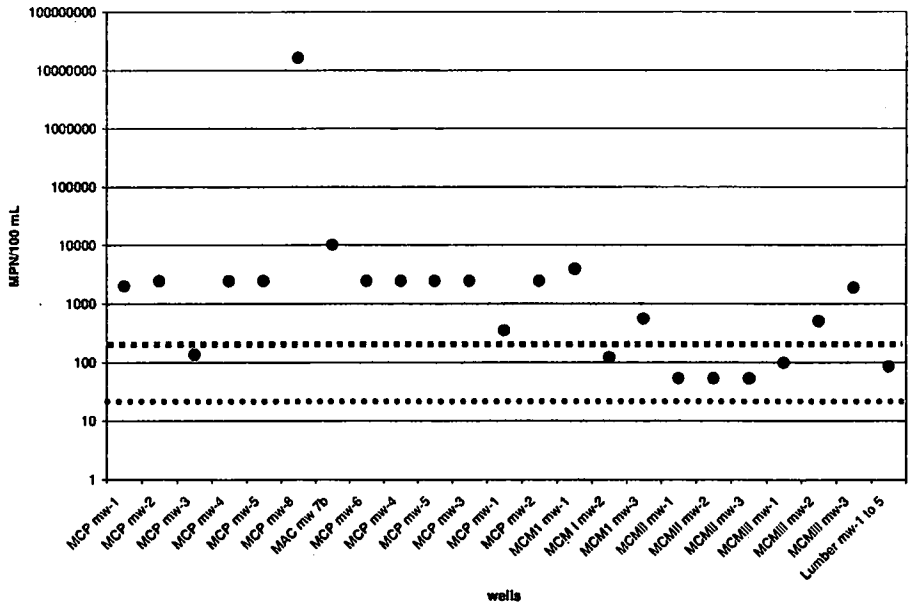


Figure 3: Chart of Maximum Enterococcus Density (MPN/100 mL) for 27 permit monitoring wells in the Civic Center area (well locations are shown in Figure 1 of Technical memorandum #2).



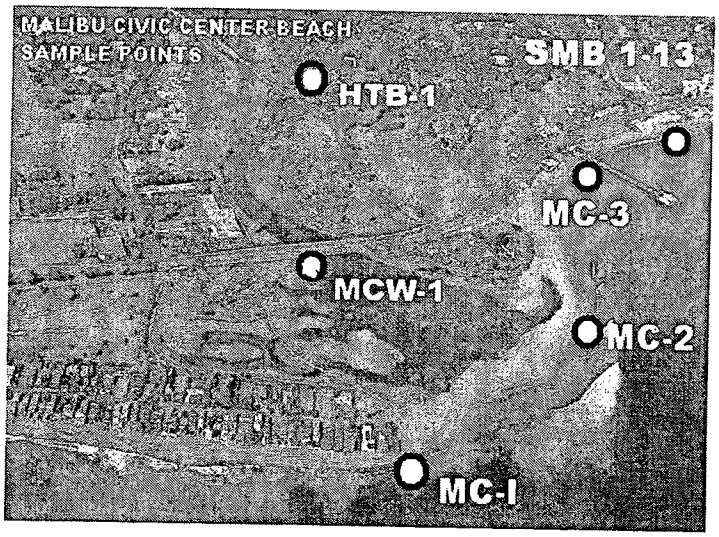
REVISED DRAFT 09 10 2009

Bacteria in Surface Water: Malibu Creek and Lagoon

Recent data shows that last summer's levels of enterococcus are lower in the water entering Malibu Lagoon from the Malibu Creek watershed (see HTB-1 in Figure 4), than downstream of the Malibu Civic Center area (MCW-1). The contrast can be seen at Lower Malibu Creek sampling station HTB-1 and Lagoon sampling station MCW-1.

Given the elevated concentrations of enterococcus observed in the groundwater beneath the civic center, Malibu Civic Center groundwater discharge is a possible source of increased levels of enterococcus in the Lagoon. During the summer, bacteria from any source must travel via groundwater beneath the Surfrider Beach berm before discharging into the wave zone at MC-2, as seen in Figure 4.

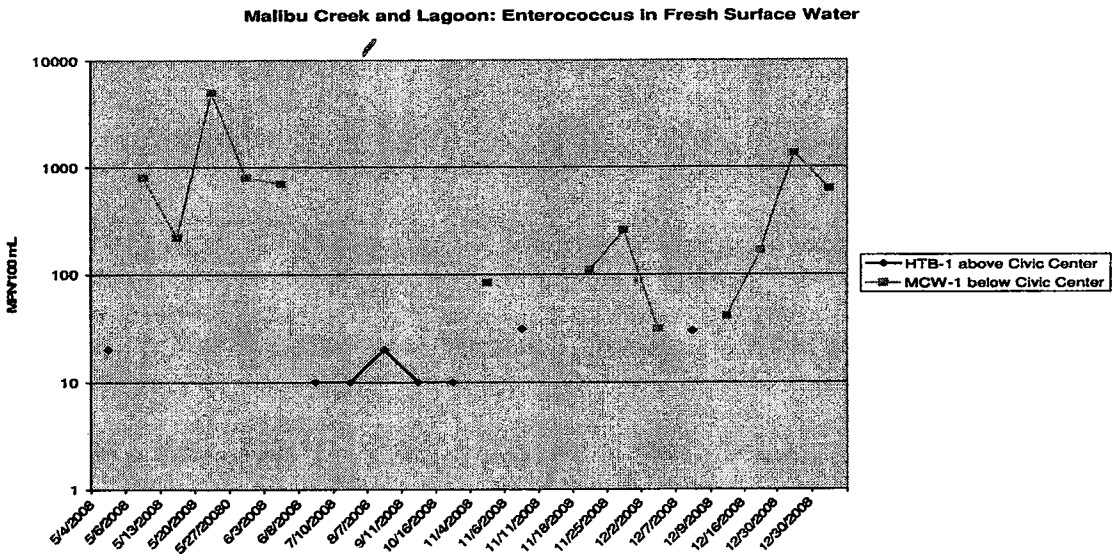
Figure 4: Malibu Civic Center Surface water and Beach Sampling Points.



Sampling Point HTB-1 can be seen in Figure 4 where surface water from Malibu Creek watershed enters the lagoon, MCW-1 where Malibu Creek enters Malibu Lagoon after receiving groundwater discharge from the Malibu Civic Center. The groundwater contains enterococcus which increases in concentration in the lagoon, as shown in Figure 5. Also seen are beach sampling points MC-1 at the Beach adjacent to Malibu Colony, MC-2 at the breach point of Malibu Lagoon on Surfrider Beach, MC-3 at the beach adjacent to Malibu Pier and SMB-1-13 at Carbon Canyon Beach where Sweetwater Canyon discharges

REVISED DRAFT 0910 2009

Figure 5: Summer 2008 Enterococcus above and below Malibu Civic Center in the Lagoon



Bacteria in Surface Water: Beaches

The frequencies with which the Civic Center Beaches at Surfrider Beach, Malibu Colony, Malibu Pier and Sweetwater Canyon, and Marie canyon did not satisfy the water quality objectives for enterococcus in the summers of 2005, 2006 and 2008 are listed here. A figure comparing these violations of the water quality standards for the protection of contact recreation beneficial use (REC-1) are also displayed in Figure 6.

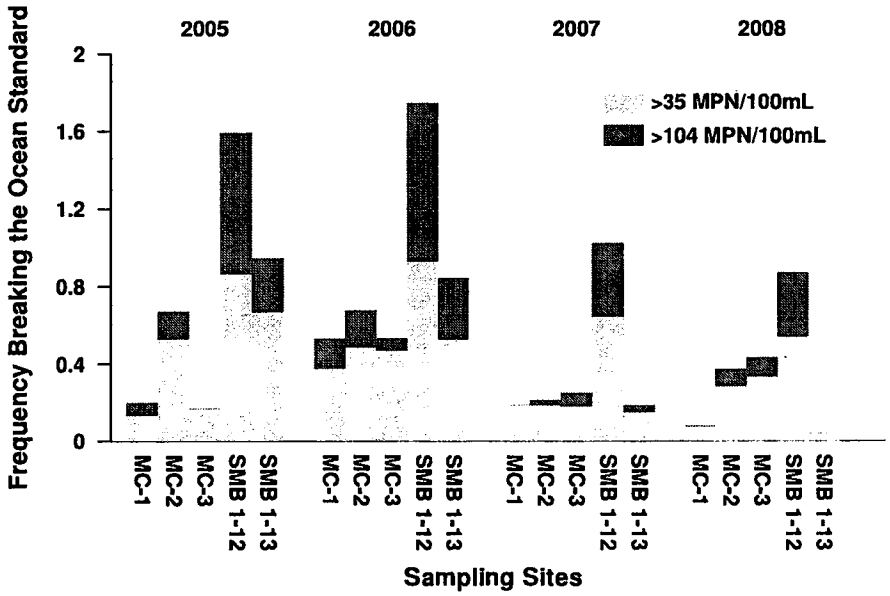
R E V I S E D D R A F T 0 9 1 0 2 0 0 0 9 9

Table 2: Exceedences of single sample Enterococcus water quality standard.

Days/Frequencies with Enterococcus >104 MPN/100mL	2005	2006	2007	2008
Surfrider Beach (MC-3)	0 (0)	2 (6.7%)	2 (7.1%)	0 (0)
Malibu Colony (MC-2)	10 (14.3%)	25 (19.2%)	4 (3.1%)	12 (9.2%)
Malibu Pier (MC 1)	1 (6.7%)	5 (15.6%)	0 (0)	0 (0)
SMB 1-13 Sweetwater Canyon at Carbon Beach (southeast)	5 (27.8%)	12 (31.6%)	1 (3.7%)	0 (0)
SMB 1-12 Marie Canyon (northwest)	16 (72.7%)	55 (82.1%)	16 (38.1%)	13 (33.3%)

REVISED DRAFT 0910 2009

Figure 6: Cumulative frequencies enterococcus concentrations failed to meet the ocean discharge standards in the five Malibu beaches



On the beaches, bacteria are typically present at levels above water quality objectives at Malibu Colony (MC-1), Surfrider Beach (MC-2), and Malibu Pier (MC-3). The pollution on beaches has been quantified in the 2002 303(d) list, Heal the Bay's beach report cards, and the Regional Board's Santa Monica Bay Beaches Bacteria TMDLs. Further, the Regional Board issued a Notice of Violations (NOVs) for bacteria adjacent to the Malibu Civic Center beaches in March 2008. It identified violations of the waste discharge requirements established in Board Order No. 01-182, as amended by Order No. R4-2006-0074 and Order No. R4-2007-0042, pertaining to the Los Angeles MS-4 Permit controlling urban runoff and stormwater discharges.

R E V I S E D D R A F T 0 9 1 0 2 0 0 9 0 9

Table 3: Surfrider beach: Fecal-Indicator Bacteria Violations

Surfrider Beach MC-2 Date of Violation(s)	Single Sample Result (MPN/100 ml)				30-day Geometric Mean Result* (MPN/100 ml)		
	Total Coliform	Fecal Coliform	Enterococcus	Total Coliform (Fecal:Total Coliform Ratio > 0.1)	Total Coliform	Fecal Coliform	Enterococcus
Basin Plan Limit	10,000	400	104	1,000	1,000	200	35
9/14/2006		1,100		6,800	1,390	242	
9/15/2006		1,100		7,900	1,629	276	
9/16/2006					1,827	276	
9/17/2006					2,155	297	
9/18/2006					2,587	321	
9/19/2006					2,341	297	
9/20/2006					2,512	300	
9/21/2006					2,114	280	
9/22/2006					1,904	262	
9/23/2006					1,526	236	
9/24/2006					1,378		
9/25/2006					1,232		
9/26/2006					1,132		
9/27/2006					1,248		
9/28/2006		500			1,414		
9/29/2006		430		2,200	1,443		
9/30/2006				1,400	1,304		
10/1/2006					1,169		
10/2/2006					1,036		
10/3/2006	>13,000	6,300		>13,000	1,169		
10/4/2006					1,058		
10/5/2006	13,000	7,300	1,400	13,000	1,128	222	
10/6/2006						216	
10/7/2006		740				241	
10/8/2006						248	
10/9/2006					1,006	265	
10/10/2006		1,000	530	5,500	1,091	282	
10/11/2006					1,053	272	
10/12/2006					1,058	252	
10/13/2006						246	
10/14/2006						228	
10/15/2006						210	
10/16/2006						224	
10/17/2006		1,300		6,300		246	
10/18/2006			110	1,100		238	
10/19/2006						238	
10/20/2006		500				263	
10/21/2006						263	

REVISED DRAFT 09 10 2009

10/22/2006						283	
10/23/2006					1,155	307	38
10/24/2006						283	
10/25/2006		3,200	160	3,200	1,054	319	38
10/26/2006						319	39
10/27/2006		430	110	3,400		326	42
10/28/2006						317	43
10/29/2006						312	47
10/30/2006						314	51
10/31/2006						289	47
4/6/2007		580		3,400			
4/7/2007	>13,000	1,600		>13,000			
4/24/2007	11,000	740					
4/25/2007	11,000	7,300		11,000			
4/27/2007		430		1,600			
5/18/2007		430	190				
5/19/2007		430					
6/2/2007			270				
6/16/2007		8,700	310	9,600			
10/19/2007		500		1,300			
10/20/2007	>13,000	830					
10/24/2007	11,000	500					
10/30/2007		580	120				
10/31/2007		910		5,900			
Total Violations	**7**	**25**	**9**	**18**	**28**	**37**	**8**

REVISED DRAFT 09 10 2009

Table 4: Malibu Colony: Fecal-Indicator Bacteria Violations

MC-1 Malibu Colony Date of Violation(s)	Single Sample Result (MPN/100 ml)				30-day Geometric Mean Result* (MPN/100 ml)		
	Total Coliform	Fecal Coliform	Enterococcus	Total Coliform (Fecal:Total Coliform > 0.1)	Total Coliform	Fecal Coliform	Enterococcus
Basin Plan Limit	10,000	400	104	1,000	1,000	200	35
9/14/2006					2,235	222	123
9/15/2006					1,442		90
9/16/2006					1,442		90
9/17/2006					1,442		90
9/18/2006							70
9/19/2006							70
9/20/2006							46
9/21/2006							46
9/22/2006							52
9/23/2006							52
9/24/2006							52
9/25/2006							42
9/26/2006							42
6/4/2007		419					
Total Violations	0	1	0	0	4	1	13

Notes: Site ID refers to sites identified in the "Santa Monica Bay Beaches Bacterial TMDLs Coordinated Shoreline Monitoring Plan," dated April 7, 2004.

* Regional Board staff calculated the rolling 30-day geometric mean values presented.

Table 5: Malibui Pier: Fecal-Indicator Bacteria Violations

Malibu Pier MC-3 Date of Violation(s)	Single Sample Result (MPN/100 ml)				30-day Geometric Mean Result* (MPN/100 ml)		
	Total Coliform	Fecal Coliform	Enterococcus	Total Coliform (Fecal:Total Coliform > 0.1)	Total Coliform	Fecal Coliform	Enterococcus
Basin Plan Limit	10,000	400	104	1,000	1,000	200	35
10/10/2006			422				
10/11/2006							40
10/12/2006							40
10/13/2006							40
10/14/2006							40
10/15/2006							40
10/16/2006							40

REVISED DRAFT 09 10 2009

10/17/2006							40
10/23/2006							42
10/24/2006							42
10/25/2006							68
10/26/2006							68
10/27/2006							68
10/28/2006							68
10/29/2006							68
10/30/2006							42
10/31/2006							42
6/4/2007			131				
10/29/2007			109	2,046			
Total Violations	**0**	**0**	**3**	**1**	**0**	**0**	**16**

Notes: Site ID refers to sites identified in the "Santa Monica Bay Beaches Bacterial TMDLs Coordinated Shoreline Monitoring Plan," dated April 7, 2004.

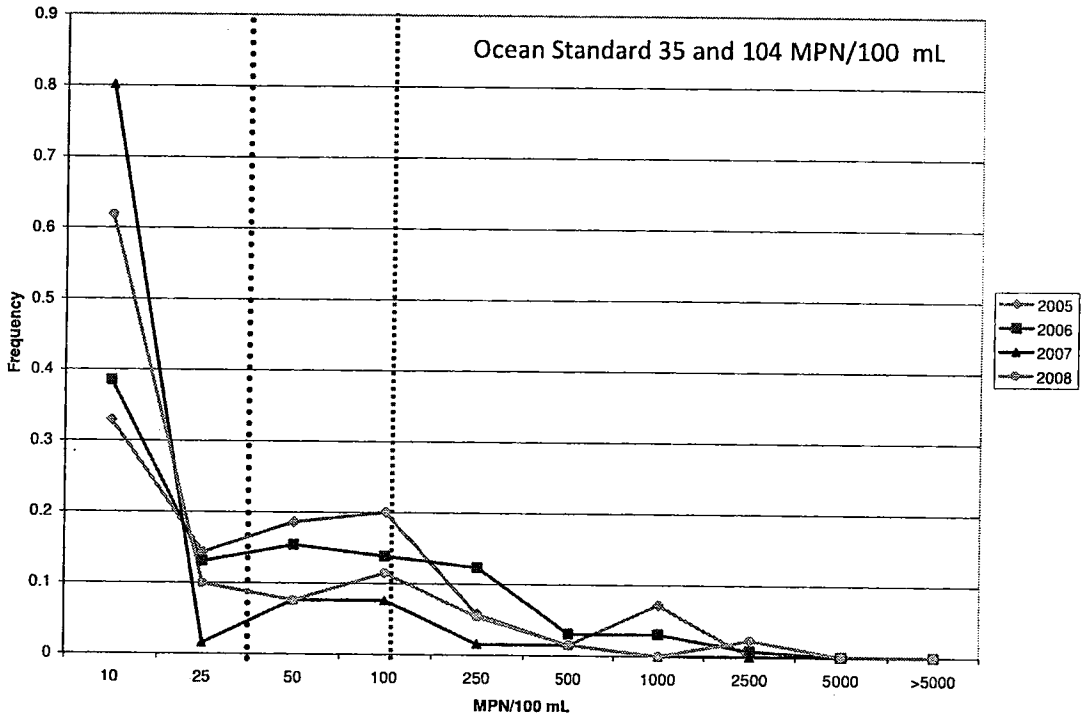
* Regional Board staff calculated the rolling 30-day geometric mean values presented.

Enterococcus on Malibu Civic Center Beaches

The enterococcus measures recorded on beaches adjacent to the Malibu Civic Center area over the summers 2005 to 2008 were sorted by interval frequency and plotted against the concentrations of enterococcus (MPN/100mL) and shown in Figure 7-9. The method was chosen to minimize the impact of varying sample sizes and simplify large variations in the measures and is a commonly used technique to analyze data.

REVISED DRAFT 09 10 2009

Figure 7: Surfrider Beach (site MC-2) Enterococcus Interval Frequency for May-October Summer Single Measures

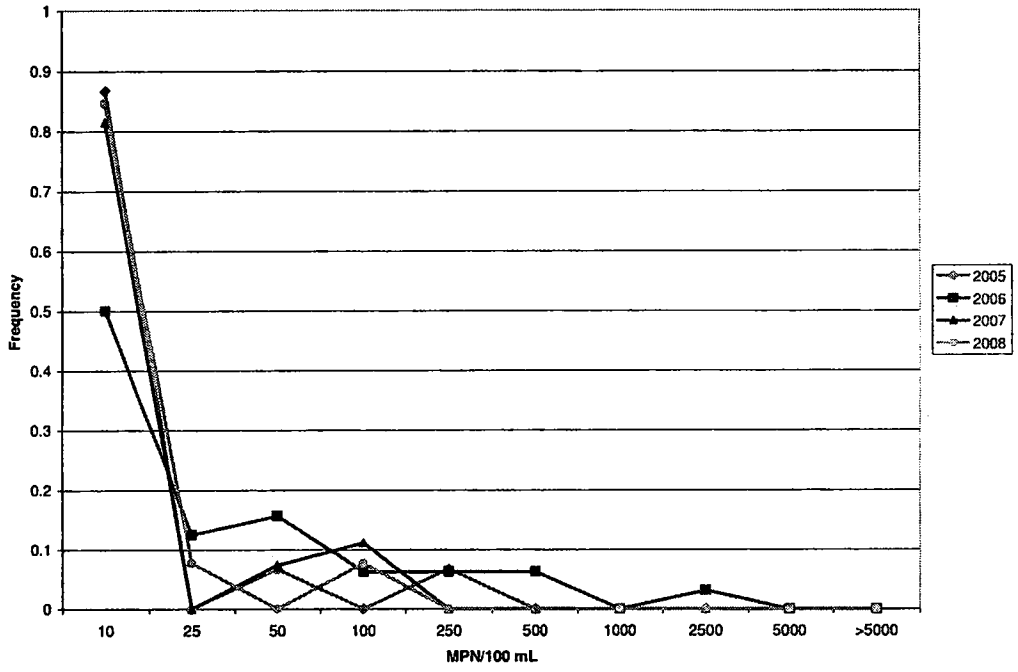


REVISED DRAFT 09 10 2009

Correlation coefficients between annual enterococcus frequency distributions for Surfrider Beach (MC-2) ranged from 0.82 to 0.98 suggesting little change in frequency distribution from year-to-year.

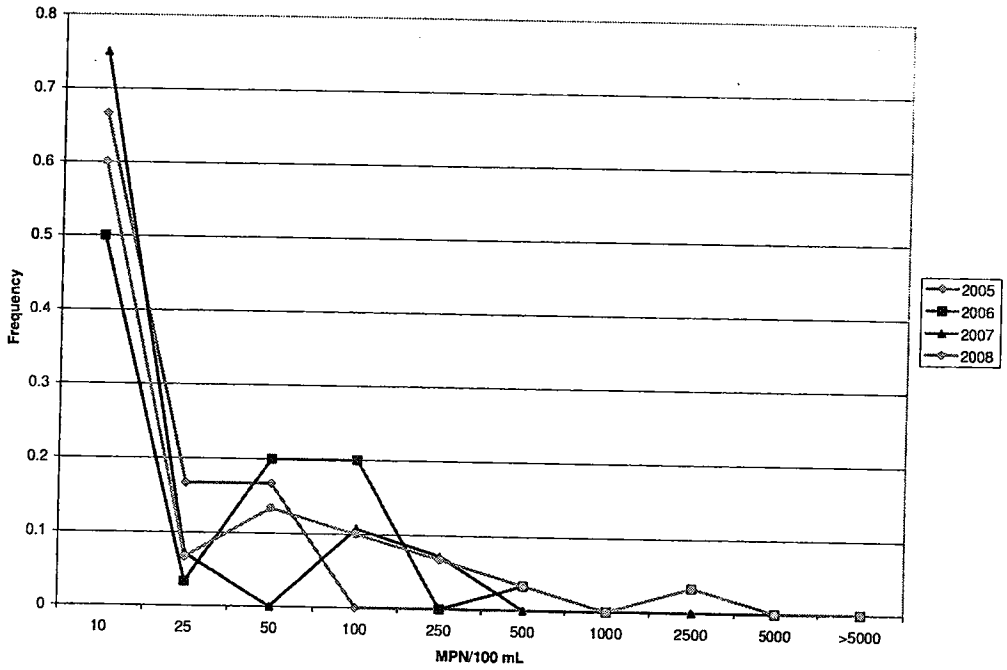
Since enterococcus frequency distributions each year correlate well, this suggests that the distribution of bacteria frequencies is generally consistent at a beach, and not a function of random events such as swimmer shedding, the inappropriate disposal of a diaper or beach use by a homeless person.

Figure 8: Malibu Colony (site MC-1) Enterococcus Interval Frequency for May-October Summer Single Measures



REVISED DRAFT 09 10 2009

Figure 9: Malibu Pier (site MC-3) Enterococcus Interval Frequency for May-October Single Measures



4. Epidemiology Evidence of Human Health Impacts in the Malibu Civic Center.

Robert W. Haile and 13 co-authors (1996) completed an epidemiology study contrasting illness among immersed-head swimmers at Malibu's Surfrider Beach , Will Rogers Beach and Ashland Storm Drain and summarized in Table 6. The first of its kind study on the health impacts of swimming at urban runoff contaminated ocean beaches was completed under the auspices of the USEPA's National Estuary Program's Santa Monica Bay Restoration Project (now a state commission). The study linked increased illness rates to fecal indicator bacteria densities at these beaches between June and September 1995 and showed that Malibu had more exceedances of the Ocean standard than the other two study areas.

Table 6: Epidemiology evidence of human impacts in Malibu

June 22 to September 17, 1995	Enterococcus Number > 104 MPN/100mL	Percentage of days when exceeded 104 MPN/100 mL
Surfrider Beach	26	34.6
100 yards northwest	4	5.1
100 yards southeast	14	17.9

REVISED DRAFT 09 10 2009

Will Rogers Beach	32	45.2
100 yards northwest	5	6.8
100 yards southeast	7	9.6
Ashland Beach	5	6.3
100 yards northwest	0	0
100 yards southeast	1	1.3

Illness rates on each of the days when enterococcus was above 104 MPN/100 mL at Surfrider Beach. As a point of comparison, the EPA bathing water criteria for enterococci (geometric mean of 35 cfu/100 ml and 104 cfu/ 100 ml for single samples) was determined by EPA to lead to a Highly Credible Gastorintestinal Illness (HCGI) rate of an additional 19 people with HCGI out of 1,000."

Highly Credible Gastrointestinal Illness (vomiting, diarrhea and fever)	Significant respiratory Disease (runny nose, coughing and fever)	One of: vomiting, diarrhea and fever or stomach pain and fever.
14 per 1,000 swimmers	45 per 1,000 swimmers	39 per 1,000 swimmers

5. Discussion of Historic and Recent Studies[1]

Historic Studies relating Malibu Civic Center Septic Systems to Human Health Risk and Beach Pathogens

Existing technical studies (summarized in Table 7) link OWDS systems at the Malibu Civic Center area to beach bacteria and are discussed below:

On February 5, 1970, Los Angeles County Health provided a letter to the Regional Board stating that serious potential hazards to human health were expected to result from OWDS systems. LACH has repeatedly closed Surfrider Beach at the Malibu Civic Center due to high bacteria concentrations.

On July 8, 1987, Los Angles County Public Works held a public meeting to discuss a Draft Environmental Impact Report for a centralized waste water treatment plant and sewer for Malibu to

REVISED DRAFT 0909 1002 0009

address human health risk caused by OWDS system pathogens. The City of Malibu subsequently incorporated and a group of citizens brought a lawsuit to block the formation of assessment districts. The legal settlement required the new City of Malibu to provide sufficient oversight of on-site waste water treatment facilities such that they would meet Regional Board requirements.

The 1994 Ph.D. dissertation of Dr. Mark Gold "What are the health risks of swimming in the Santa Monica Bay?" identified human viruses in Malibu Lagoon and identified a potential source of the contamination as adjacent OWDS systems.

On January 24, 2002, the Regional Board adopted a Resolution amending the Santa Monica Beach bacteria TMDL to the Basin Plan. The staff report found that bacteria loads from OWDS systems contribute to beach pathogens.

On August 30, 2004, the Stone report found that bacteria in the groundwater may enter receiving water where OWDS systems are found within 6-month groundwater travel time of the Ocean or Malibu Creek.

The September 17, 2004, Memorandum of Understanding between the City of Malibu and the Regional Board stated that "ordinances shall be drafted by staff, and recommended for adoption within the six-month-time-of-travel zone, as identified in the Risk Assessment Report (Stone), to provide advanced treatment and disinfection. The six-month time-of-travel zone shall include all areas contributing to Malibu Creek and Lagoon, and beaches between Sweetwater Canyon outfall and Winter Canyon outfall. OWTS located outside of the six-month-travel-time zone that cannot demonstrate compliance through inspection or that are identified as impacting groundwater by any other means shall provide adequate vertical separation and/or advanced treatment with disinfection." As of the date of this document, the City of Malibu has not provided documentation that systems within the six-month-time-of-travel zone have been upgraded to prevent bacteria discharge to the subsurface or include disinfection, nor has an ordinance to this effect been passed by the City of Malibu.

On Dec. 13, 2004, the Regional Board adopted a Resolution incorporating the Malibu Creek and Lagoon Bacteria TMDL into the Basin Plan. The staff report references a surface water model prepared by Tetra Tech which quantifies bacteria loads contributed by OWDS systems in the Malibu Civic Center.

Numerous studies have been completed to describe the ecosystem, hydrology, land use, possible mechanisms of waste water treatment, and costs to support policy decisions about bacteria and human health risk in the Malibu Civic Center (Ambrose et al. 2008; Bing Yen and Associates, 2001; Crawford Multari and Clark Associates, 1997, 2006, 2007; Ensitu Engineering, 2008; Gold, 1994; Jones and Stokes, 2008; REGIONAL BOARD, 1972, 1998, 1990, 2002, 2004b, 2008, 2008b; Lucero, 2008; Warshall, 1992; Questa, 2003; RMC, 2008; SMBRP, 1999, 2001; UCLA, 2000; URS Greiner, 1999; EPA, 2003; Stone, 2004a, 2004b, 2004c; Trim, 1994; Thorsen, 2008; and Van Beveren, 2008a, 2008b, 2008c).

REVISED DRAFT
0909
1002
00909

Table 7: Historic Findings of Human Health Risk related to Malibu OWDS System Use.

Date	Source	Summary
Feb 5, 1970	LA County Flood letter to Regional Board	Future OWDS systems will pollute groundwater in Malibu Creek with nutrients
Feb 5, 1970	LA County Health to Regional Board	Serious potential hazard to health from OWDS systems
Feb 11, 1970	CA DWR to Regional Board	Malibu Valley needs an area wide Water Quality plan
Apr. 8, 1970	Public Hearing SWRCB	Discontinue OWDSs, continue Regional Board surveillance
Jan. 21, 1971	CA DPH Status Ocean and streams in Malibu	Local ocean and freshwater bacteria exceed standards to protect shell fish collection in areas of development
Mar. 12, 1971	Regional Board EO to LA County Supervisors	Sewer for Malibu must be provided
May 31, 1972	Regional Board Resolution 72-4	Waste Discharge Requirements only allowed if a timetable is established to provide future connections to LA County sewer
Apr. 10, 1985	CA DPH to LA County Supervisors	Staff report and recommendation to authorize Sewer districts
July 8, 1987-Nov. 30 1988	LA Public Works Public Meeting and Malibu Citizens Committee public meetings	Draft Environmental Impact Report for Sewer, discussion of Malibu incorporating, discuss alternatives for centralized system with wetland treatment
Jan. 18, 1989	LA County Supervisors hearing	STEP WWTP system construction approved
1992	Warshall et al. report finalized	OWDS systems in Malibu described. Pathogen removal quantified. Author states that systems require extensive management and recommends centralized system in some areas like Civic center
1994	Mark Gold Dissertation	Three studies between 1990 and 1992 show high fecal-indicator-bacteria densities at ankle-depth wave wash and human viruses in runoff from three storm drains in Santa Monica Bay including Malibu Creek and Lagoon
May 7, 1996	Haile, et.al. 1996 epidemiology study	22,085 subjects in epidemiology study at Surfrider, Will Rogers and Santa Monica, with detailed study results for Malibu.
Dec. 14, 1998	Regional Board Resolution 98-023	Directs Report of Waste Discharge for all OWDSs and ACL to City of Malibu
Aug 12, 1999	Regional Board Resolution 99-13	El Rio septic staff report: Poorly maintained septic linked to nitrogen contamination in groundwater
January 22, 1999	Haile, et al, 1999 epidemiology study	In Epidemiology July 1999, vol. 10, n. 4 22,085 subjects in epidemiology study at Surfrider, Will Rogers and Santa Monica showing increased risk to immersed-head swimmers for illness where fecal indicator bacteria are present.
1999	Dames and Moore study	Salt tracer, no pathogens found in wells within 200 feet, but tidal reversal confounds results

REVISED DRAFT 0910 2009

1999	URS Greiner study	Salt Tracer found at 20 feet in wells, but pathogens not seen in short period test.
Dec. 12, 2002	Regional Board Resolution	Santa Monica Bay Bacteria Total Maximum Daily Load: beach pathogens attributed to loads from septic systems
March 21, 2003	EPA Malibu Creek Nutrient TMDL	Total Maximum Daily Load sets loads and numeric targets for total Nitrogen
2003	Questa study	Groundwater discharge to receiving water, quantified including volume from septic system discharge.
Aug 30, 2004	Stone study	Bacteria may enter receiving water where septic systems are found within 6-month travel time
Jan. 24, 2004	Regional Board Resolution	Malibu Creek and Lagoon TMDL: Tetra Tech surface water model sets loads for bacteria from septic systems
March 2006	Richard Viergutz, M.S. Thesis	Discharge of sewage-polluted groundwater into Malibu Creek and Lagoon resulting from groundwater surface interactions

OWDS Systems and Transportation of Pathogens

Many studies have been completed within the last twenty years to characterize the transportation mechanisms of pathogens in the leachfield of septic systems or other OWDSs: Schaub and Sorber (1977) reported that virus removal in a rapid infiltration and concluded that removal can be limited by low absorption rate of virus particles to soil. The authors used a mixed compound consisting of the tracer virus f2 and indicator bacteria in the tested septic tank and monitored the mitigation of indicators in well samples. It was found that enteric bacteria were quickly filtrated by soil and concentrated on the soil surface; but the tracer virus was not observed on the upper soil layers but was found in the down-gradient groundwater layers. Vaughn et al. (1983) also observed a similar entrainment of viruses from septic discharge through a shallow, sandy soil aquifer. These results illustrate that even when septic bacteria are not present, viruses may still be present.

Goyal et al. (1979) further investigated the adsorption rates for different types or strains of viruses/bacteria to various types of soils. No specific virus or bacterium was found to represent the general adsorptive behaviors of all viruses to soils, and no specific soil type can serve as a general model for all the soil types. Similarly, Chu et al. (2003) investigated the transportation rates of viruses passing through saturated and unsaturated soil columns. Strong correlations were found between virus adsorption and various factors, i.e. existence of metal oxides, water content, organic matter, pH, etc.

Stramer and Cliver (1984) evaluated the techniques to disinfect septage (pumped sludge from septic systems) and suggested different strategies for different type of pathogens. The most effective method to reduce the concentrations of virus and bacteria was combining heat and hydrogen peroxide treatments, but this method was less applicable in the field.

Bloch et al. (1990) presented a case study of a human virus infection (hepatitis A virus, HAV) due to groundwater contamination from on-site discharge system. The leachfield of the septic system in the studied site (a trailer park) was approximately 30 to 60 meters away from the drinking water well, and the author confirmed the direct association between septic discharge and virus infection. Fecal coliform was not significantly higher during the outbreaks period of hepatitis A.

REVISED DRAFT 0909102009

All the formerly introduced studies indicated the significant differences between viral and bacterial contaminants: viruses have the potential to penetrate the soil layers to a greater extent than bacteria. This highlights a limitation of using bacterial water quality indicators to predict viral groundwater contamination as stated by Borchardt et al. (2003a). However, it can be also implied that when higher indicator bacteria occur, the higher chance the soil layer can be contaminated by viruses. For example, Cuyk et al. (2004) reported a high correlation between virus concentrations and bacteria indicators in well-operated soil columns and field septic systems.

Studies relating OWDS Systems to Beach Pathogens[2]

Research completed over the last ten years has expanded the understanding of beach bacteria sources and mechanisms of transport. For example, it has been demonstrated that the fecal-indicator-bacteria enterococcus are present at many California beaches, a contamination that is related to both human and non-human sources (Yamahara et al, 2007) and can be associated with septic system effluent (De Sieyes et. al , 2008). Enterococcus can be transported, stored and, under some conditions, grown in the beach environment.

In 2003(b), Borchardt et al. reported that the density of septic systems correlated with increased rates of infectious diarrhea in children in central Wisconsin. The authors found that viral diarrhea increased by 8% for every additional holding tank in 640 acres and bacterial diarrhea increase by 22% for every additional holding tank in 40 acres. While household wells were sampled for bacterial, risks related to surface contact with pathogens near septic systems.

In 2004, Boehm et al. reported that groundwater discharge of microbial pollution moved from a shallow beach aquifer on to the beach face at Huntington Beach. While fecal indicator bacteria were found in only one groundwater sample, column studies show that the transport of enterococcus is not inhibited by sand collected in the field. In addition, radium isotopes characteristic of groundwater linked 38% of the enterococcus variation to groundwater discharge.

In 2007, Yamahara et al. reported in Environmental Science and Technology, Vol. 41, No. 12, that 91% of sampled California coastal beaches had enterococcus present in sand. The presence of a putative pollution source such as a river, wave shelter and surrounding anthropogenic land use correlated with higher enterococcus concentrations in the sands.

---

[2] Early Technical Reviewers recommended enhancements or disagree with staff's summary of studies on beach pathogens completed since 2004. While it is beyond the scope of this document to present a complete literature study on the topic, the summary was provided to emphasize the scope and focus of ongoing technical investigations in the field. The authors of the papers cited, some of whom were Early Technical Reviewers (ETR), wished staff to emphasize that additional study is necessary to characterize the physical, chemical and biological processes which allows bacteria and viruses to move through the groundwater for surface discharge. The authors should be contacted for the most up-to-date information on their research and the interpretation of the work already completed.

REVISED DRAFT 0909 1002009

In 2008, De Sieyes et al. reported that fresh nutrient-rich groundwater discharges in fortnightly pulses into the ocean across a beach with adjacent septic systems and leachfields. While fecal indicator bacteria and human enterococcus esp gene analysis found in monitoring wells were attributed to pollution from adjacent septic systems, the concentrations of these pathogens did not increase with nutrients in the surf zone.

In 2009, the American Association for the Advancement of Science summarized studies on Methicillin Resistant Staphylococcus Aureus bacteria (MSRB) found in ocean water and on beaches in Florida in 2009. The bacterial infections are resistant to antibiotics and are more commonly found in hospitals, but are now known to be transmitted to the beach through contact with infected individuals and, according to one report, through municipal effluent. The ability of the bacteria to travel via sewage has not been quantified.

These studies have shown that the beach is a more complex microbiological environment than was previously understood. Enterococcus has been grown in the laboratory setting in unseeded beach sand (Yamahara et al., 2009) and found in a freshwater environment free from human impact (Tiefenthaler et al., 2008). Enterococcus has also been shown to persist in the beach sand and occur in higher concentrations in organic beach debris where it may later be transported to nearshore waters (San Diego Regional Board-Newport Bay Total Maximum Daily Loads; Yamahara et al., 2007).

Recent work also shows that the beach is a more complex hydrologic environment than the steady state condition that previously modeled (Stone 2005 Malibu Risk Assessment). Episodic freshwater transport has recently been documented. Bacteria densities have been tentatively linked to tidal and seasonal changes (Boehm et al., 2004; De Sieyes et al. , 2008, Izbicki, 2009). Hydrological mounding beneath the septic areas may affect water table gradients otherwise dependent on tides and freshwater subsurface movement and may result in unpredicted flow paths and either limit or enhance septic discharge (Izbicki, 2009). Other workers used sand column studies to show bacteria and virus retention and remobilization was related to the movement of organic material and bacteria and viruses have recently been shown to adhere and remain viable in beach material (Yamahara et al., 2007; Azadpour-Keeley et al., 2003; Noble et al., 1996; Schaub et al., 1997, Schijven et al., 2002; Stramer et al., 1984) until remobilized.

Other mechanisms which may result in the preservation of enterococcus include elevated nitrogen and/or oxygen levels (Azadpour-Keeley et al., 2003; Yates, 1985, 1986) in the subsurface or on the beach face. Further, the subsurface septic plumes have been found to stay intact during subsurface movement (Groundwater Monitoring and Assessment Program: Baxter, Minnesota, 1999).

Potential Scenarios for Sources and Transport Mechanisms for Bacteria in the Malibu Civic Center.

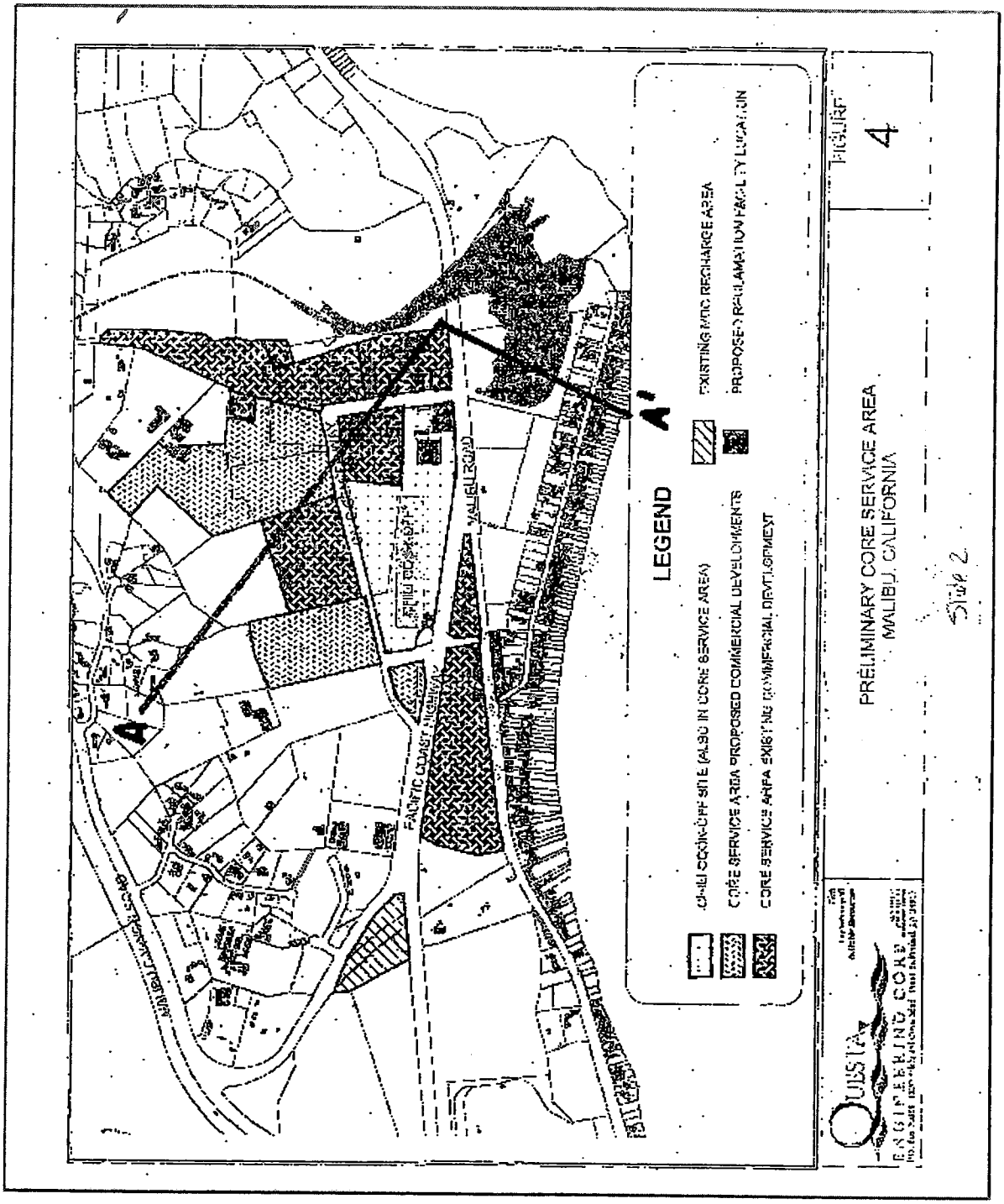
Figure 10 shows the Malibu Civic Center with planned development (Questa, 2003), and the line of the cross section shown in Figure 11. The cross section shows possible paths of transport for the bacteria discharged into OWDS leachfields/seepage pits to Malibu Creek, Malibu Lagoon and the ocean. Note in the cross section that bacteria leaving OWDS systems in Malibu Colony or adjacent to Legacy Park have the shortest travel times and fewest opportunities for subsurface physical detention, chemical attack or biological predation.

REVISED DRAFT 09 10 20 09 09

The movement of septic system bacteria from the Civic Center area north of Pacific Coast Highway via subsurface transport to Surfrider Beach under summer conditions would require movement through the beach barrier with remobilization in marine water (see Figure 11 [cross section]). Enterococcus from septics must survive physical, chemical and biological destruction in the subsurface before their discharge. Enterococcus from higher elevations within the watershed must travel further and both light and distance are known to cause de-activation of both viruses and bacteria (Azadpour-Keeley, 2003;Yates, 1985, 1986).

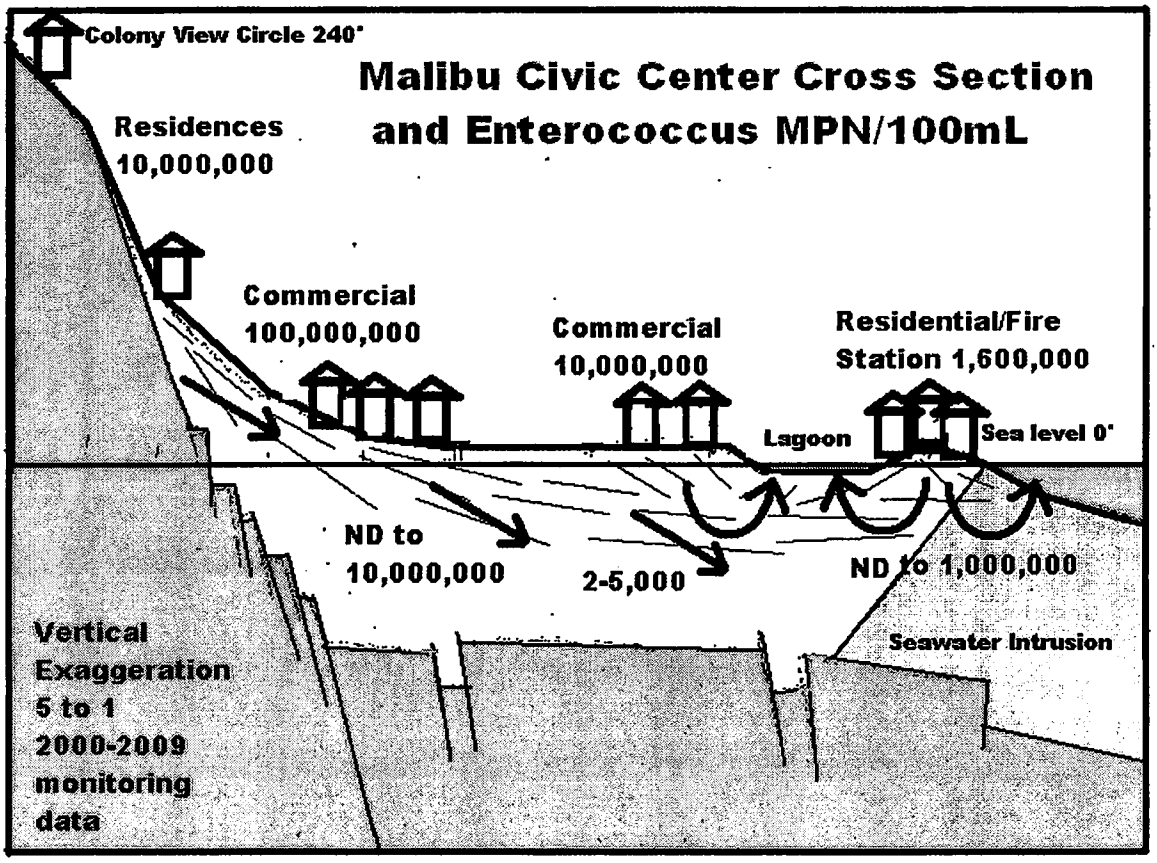
REVISED DRAFT 0910 2009

Figure 10. Planned development in the Malibu Civic Center from Questa 2003 and cross section line



REVISED DRAFT 09 10 2009

Figure 11. Cross Section A to A' showing facility and groundwater bacteria and flow paths



6. Conclusion

Malibu Creek, Lagoon, and nearby beaches are popular within the local community and as a destination for well over 1 million visitors per year. In the Basin Plan, the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards, using the best available science, at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, and consistently have failed to meet State health and water quality standards set to protect swimmers and surfers in contact with the water. Repeated failures to meet standards set to protect public health have resulted in a poor water quality reputation for Surfrider Beach.

To examine the hydraulic connection of discharges from OWDSs through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters likely migrate to surface waters and that, consistent with data supporting the designations of impairments, and threaten human health. This conclusion is

REVISED DRAFT 09 10 20 09

based on our analysis of the indicator bacterium enterococcus. The levels of this bacterium do not meet standards protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center based on work by Haile et al.

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to the beneficial use of water contact recreation.

REVISED DRAFT 09 10 2009

ATTACHMENT 3-A: Monitored Santa Monica Bay Beaches

No	CSMP	Location	Linked Watershed	Treat-ment Type	Strom drain/ freshwater	Total Acres
1	SMB 1-01	Arroyo Sequi Creek, Leo Carrillo State Beach	Arroyo Sequit	Septic	Y	7,549
2	SMB 1-02	El Pescador State Beach	Los Alisos	Septic	N	2,396
3	SMB 1-03	El Matador State Beach	Encinal	Septic	N	1,794
4	SMB 1-04	Trancas Creek	Trancas	Septic	Y	6,514
5	SMB 1-05	Zuma Break at Zuma Beach	Zuma	Septic	Y	6,339
6	SMB 1-06	Walnut Creek	Ramirez	Septic	Y	3,334
7	SMB 1-07	Ramirez Canyon at Paradise Cove Pier	Ramirez	Septic	Y	3,334
8	SMB 1-08	Escondido Creek	Escondido	Septic	Y	2,295
9	SMB 1-09	Latigo Canyon	Latigo	Septic	Y	813
10	SMB 1-10	Solstice Creek at Dan Blocker County Beach	Solstice	Septic	Y	2,841
11	SMB 1-11		Corral	Septic	Y	4,280
12	SMB 1-12	Marie Canyon Strom Drain on Puerco Beach	Corral	Septic	Y	4,280
13	SMB 1-13[3]	Sweetwater Canyon on Carbon Beach	Carbon	Septic	Y	2,320
14	SMB 1-14	Las Flores Creek on Las Flores State Beach	Las Flores	Septic	Y	2,897
15	SMB 1-15	Big Rock Beach	Piedra Gorda	Septic	Y	664
16	SMB 1-16	Pena Creek on Las Tunas	Pena	Septic	Y	608

R E V I S E D D R A F T 0 9 1 0 2 0 0 0 9 9

		County Beach					
17	SMB 1-17	Tuna Canyon	Tuna	Septic	N	1,013	
18	SMB 1-18	Topanga Canyon on Topanga State Beach	Topanga	Septic	Y	12,575	
19	SMB 2-01	Castlerock storm drain aka Parker Mesa Storm Drain	Castlerock	Sewer	Y	4,976	
20	SMB 2-02	Santa Ynez Storm Drain	Santa Ynez	Sewer	Y	1,203	
21	SMB 2-03	Will Rodgers State Beach	Santa Ynez	Sewer	N	1,203	
22	SMB 2-04	Pulga Storm Drain on Will Rodgers State Beach	Santa Ynez	Sewer	N	1,203	
23	SMB 2-04	Temescal Canyon Storm Drain on Will Rodgers State Beach	Pulga Canyon	Sewer	N	1,955	
24	SMB 2-05	Bay Club Storm Drain on Will Rodgers State Beach	Santa Ynez	Sewer	N	1,203	
25	SMB 2-07	Santa Monica Canyon	Santa Monica Canyon	Sewer	Y	10,088	
26	SMB 2-08	Venice Beach Pier	Venice Beach	Sewer	N	5,241	
27	SMB 2-09	Topsail Street, Venice Beach	Venice Beach	Sewer	N	5,241	
28	SMB 2-10	Culver Storm Drain	Dockweiler	Sewer	Y	6,573	
29	SMB 2-11	North Westchester Storm Drain	Dockweiler	Sewer	Y	6,573	
30	SMB 2-12	Dockweiler Beach	Dockweiler	Sewer	N	6,573	
31	SMB 2-13	Imperial Highway Storm Drain	Dockweiler	Sewer	Y	6,573	
32	SMB 2-14	Hyperion Plant, Dockweiler Beach	Dockweiler	Sewer	N	6,573	
33	SMB 2-15	Grand Ave, Dockweiler Beach	Dockweiler	Sewer	Y	6,573	
34	SMB 3-01	Montana Ave, Santa Monica Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	

REVISED DRAFT 09 10 20 09

35	SMB 3-02	Wilshire Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	
36	SMB 3-03	Santa Monica Pier Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	
37	SMB 3-04	Pico-Kenter Storm Drain	Santa Monica	Sewer	Y	8,850	
38	SMB 3-05	Ashland Storm Drain	Santa Monica	Sewer	Y	8,850	
39	SMB 3-06	Rose Ave Storm Drain, Venice Beach	Santa Monica	Sewer	Y	8,850	
40	SMB 3-07	Brooks Ave Storm Drain, Venice Beach	Santa Monica	Sewer	Y	8,850	
41	SMB 3-08	Venice Pavillion	Santa Monica	Sewer	Y	8,850	
42	SMB 3-09	Strand Street, Santa Monica State Beach	Santa Monica	Sewer	N	8,850	
43	SMB 4-01	San Nicholas Canyon	Nicholas	Septic	Y	1,235	
44	SMB 5-01	40th Street, Manhattan Beach	Hermosa	Sewer	N	2,624	
45	SMB 5-02	28th Street Drain, Manhattan Beach	Hermosa	Sewer	Y	2,624	
46	SMB 5-03	Manhattan Beach Pier	Hermosa	Sewer	Y	2,624	
47	SMB 5-04	26th Street, Hermosa Beach	Hermosa	Sewer	N	2,624	
48	SMB 5-05	Hermosa Beach Pier	Hermosa	Sewer	N	2,624	
49	SMB 6-01	Herondo Storm Drain	Redondo	Sewer	Y	3,544	
50	SMB 6-02	Redondo Beach Pier	Redondo	Sewer	Y	3,544	
51	SMB 6-03	Sapphire Street	Redondo	Sewer	N	3,544	
52	SMB 6-04	Topaz Groin	Redondo	Sewer	N	3,544	
53	SMB 6-05	Avenue I	Redondo	Sewer	Y	3,544	
54	SMB 6-06	Malaga Cove	Redondo	Sewer	N	3,544	
55	SMB 01	BC- Ballona Creek	Ballona Creek	Sewer	Y	81,980	

REVISED DRAFT 09 10 2009

56	SMB 01	MC- Malibu Point on Malibu State beach	Malibu Creek	Septic	Y	70,410	
57	SMB 02	MC- Breach Point of Malibu Lagoon on Malibu State Beach	Malibu Creek	Septic	Y	70,410	
58	SMB 03	MC- Malibu Pier on Carbon Beach near Malibu Creek	Malibu Creek	Septic	Y	70,410	
59	SMB 7-01	300 Paseo Del Mar, Palos Verdes Estates	Palos Verdes Peninsula	Sewer		10,023	
60	SMB 7-02	Bluff Cove, Palos Verdes Estates	Palos Verdes Peninsula	Sewer		10,023	
61	SMB 7-03	Long Point, 7200 Palos Verdes Drive South, Rancho Palos Verdes	Palos Verdes Peninsula	Sewer		10,023	
62	SMB 7-04	6000 Palos Verdes Drive South, Rancho Palos Verdes	Palos Verdes Peninsula	Sewer		10,023	
63	SMB 7-05	Portuguese Bend Club, Rancho Palos Verdes	Palos Verdes Peninsula	Sewer		10,023	
64	SMB 7-06	White's Point/Royal Palms County Beach, San Pedro	Palos Verdes Peninsula	Sewer		10,023	
65	SMB 7-07	Midway between White Point County Beach and Wilder Annex	Palos Verdes Peninsula	Sewer		10,023	
66	SMB 7-08	Point Fermin/Wilder Annex, San Pedro	Palos Verdes Peninsula	Sewer		10,023	
67	SMB 7-09	Cabrillo Beach, San Pedro	Palos Verdes Peninsula	Sewer		10,023	

REVISED DRAFT 09 10 2000 9

ATTACHEMENT 3-B: REFERENCES

Ambrose, Richard. May 14, 2008. Ecological Goals. Malibu Legacy Park Project prepared in association with RMC Water and Environment.

Allen, L.A., Brooks, E., Williams, & I.L., 1949. Effect of Treatment at the Sewage Works on the Numbers and Types of Bacteria in Sewage. *The Journal of Hygiene*, **47**(3):303-319.

Azadpour-Keeley, A., Faulkner, B.R., & Chen, J.S. April 2003. Movement and Longevity of Viruses in the Subsurface. United States Environment Protection Agency.

Bales, R.C., Gerba, C.P., Grondin, G.H., & Jensen, S.L. 1989. Bacteriophage Transport in Sandy Soil and Fractured Tuff. *Applied and Environmental Microbiology*, **55**(8): 2061–2067.

Bing Yen & Associates, Inc. January 5, 2001. Report of Malibu Civic Center Groundwater Evaluation. City of Malibu, Camarillo CA.

Bloch, A.B., Stramer, S.L., Smith, D., Margolis, H.S., Fields, H.A., McKinley, T.W. Gerba, C.P., Maynard, J.E., & Sikes, R.K. April 1990. Recovery of Hepatitis A Virus from Water Supply Responsible for a Common Source Outbreak of Hepatitis A. *American Journal of Public Health.*, **80**(4): 428-430.

Boehm, A.B., Shellenbarger, G.G., & Paytan, A. 2004. Groundwater Discharge: Potential Association with Fecal Indicator Bacteria in the Surf Zone. *Environmental Science & Technology*, **38**(13):3558-66.

Borchardt, M.A., Bertz, P.D., Spencer, S.K.,& Battigelli, D.A. 2003a. Incidence of Enteric Viruses in Groundwater from Household Wells in Wisconsin. *Applied and Environmental Microbiology*, **69**(2):1172-1180.

Borchardt, M.A., Chyou, P.H., DeVries, E.O., & Belongia, E.A. 2003b. Septic System Density and Infectious Diarrhea in a Defined Population of Children. *Environmental Health Perspectives*, 111(5):742-748.

Cabelli, V.J. August 1983. Health Effects Criteria for Marine Recreational Waters. Health Effect Research Laboratory Office of Research and Development.

CDM. August 10, 2006. Technical Memorandum Task 10, TMDL Implementation Analysis.

CDM., Irvine CA, February 27, 2007. Integrated Total Maximum Daily Load Implementation Plan for the Malibu Creek Watershed. Los Angeles County Department of Public Works.

City of Malibu. November 5, 2002. Ordinance No. 242. City Council of the City of Malibu.

City of Marco Island. City of Marco Island Position Paper Septic Tank Replacement Program. City of Malibu.

REVISED DRAFT 0909 1002009

Crawford, Multari & Clark Associates. July 1997. Draft, City of Malibu, Civic Center Specific Plan. Prepared for City of Malibu by Crawford, Multari & Clark Associates, San Luis Obispo CA.

Cuyk, S.V., Siergrist, R.L., Lowe, K., & Harvey, R.W. 2004. Evaluating Microbial Purification during Soil Treatment of Wastewater with Multicomponent Tracer and Surrogate Tests, Vadose Zone Processes and Chemical Transport. *Journal of Environmental Quality*, **33**: 316-329.

De Sieyes, N.R., Yamahara, K.M., Layton, B.A., Joyce, E.H., & Boehm, A.B. 2008. Submarine Discharge of Nutrient-Enriched Fresh Groundwater at Stinson Beach, California is enhanced during Neap Tides. *Limnol Oceanography*, **53**: 1434-1455.

Ensitu Engineering Inc. June 30, 2008. Advanced On-site Wastewater Treatment System Design, California Department of Health Services Engineering Report. Malibu Lumber, Morro Bay CA.

Ensitu Engineering Inc. August 13, 2008. Malibu Lumber Wastewater Flow Calculations Commercial Development without Restaurant Use. Letter addressed to Brett Thornton, prepared by Ensitu Engineering, Morro Bay CA.

Ensitu Engineering Inc. 2008. Advanced On-site Wastewater Treatment System Design, City of Malibu Engineering Report. Prepared for Malibu Lumber by Ensitu Engineering Inc., Morro Bay CA.

Gold, M.A. 1994. What are the health risks of swimming in the Santa Monica Bay?: An examination of the issues surrounding the public health debate. Prepared for University of California, Los Angeles.

Gronewold, A.D.,& Wolpert, R.L. April 7, 2008. Modeling the Relationship between Most Probable Number (MPN) and Colony – Forming Unit (CFU) Estimates of Fecal Coliform Concentration. Elsevier.

Ground Water Monitoring and Assessment Program. May 1999. Effect of Septic Systems on Ground Water Quality – Baxter, Minnesota.

Haile, Robert W., Witte, John S., Gold, Mark, et. al. July 1999. "The Health Effect of Swimming in Oceaen Water Contaminated by Storm Drain Runoff" in Epidemiology, vol. 10, n. 4, pg 355-363.

Haile, Robert W., et. al. 1996"An epidemiological study of possible adverse health effects of swimming in Santa Monica Bay", unpublished but peer reviewed, Heal the Bay document, May 7, 1996.

James, Kirsten. November 19, 2008. Comments on Tentative Waste Discharge Requirements, Water Reclamation Requirements and Monitoring and Reporting Program for Malibu Lumber. Heal The Bay, Santa Monica CA.

Jones & Stokes. 2008. Malibu Legacy Park Project, Draft Environmental Impact Report. Prepared for City of Malibu by Jones & Stokes, Los Angeles CA.

REGIONAL BOARD. 1972. Resolution No. 72-4, Policy Statement Relative to Sewage Disposal in the Malibu Area. California Regional Water Quality Control Board, Los Angeles Region.

LARWCB. December 14, 1998. Resolution No. 98-023 Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

R E V I S E D D R A F T

0 9 1 0 2 0 0 0 9

REGIONAL BOARD. 1990. Regional Water Quality Control Board's Interim Policy on the Use of Septic Tanks. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2002. Santa Monica Bay Beaches Wet Weather Bacteria TMDL, Item #5 Regional Board Workshop, June 27, 2002. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2004b. Total Maximum Daily Loads for Bacteria, Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2008. 520th Regular Board Meeting, Item 16, Consideration of Termination of Memorandum of Understanding for On-site Wastewater Treatment Systems for the City of Malibu. California Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2008b. 521st Regular Board Meeting, Item 18, Revised Order, Waste Discharge Requirements/Water Reclamation Requirements and Monitoring and Reporting Program for City of Malibu's Malibu Lumber at City of Santa Monica's Legacy Park. California Regional Water Quality Control Board, Los Angeles Region.

Lucero, Gene. 2008. Submittal of Comments to Tentative Waste Discharge Requirements and Water Reclamation Requirements for Malibu Lumber LLC. Latham & Watkins, LLP.

National Center for Environment Research. 2003. Final Report: Fate for Pathogens in Storm Water Runoff; prepared for National Center for Environment.

Office of Water. October 2006. Occurrence and Monitoring Document for the Final Ground Water Rule. Prepared for Office of Water by the Office of Water.

Peter Warshall & Associates and Philip Williams & Associates. 1992. Malibu Wastewater Management Study, A Human Ecology of the New City. Prepared for City of Malibu by Philip Williams and Associates, San Francisco CA and Peter Warshall & Associates, Tucson AZ.

Pradhan, S., Hoover, M.T., Clark, G.H., Gumpertz, M., Wollum, A.G., Cobb, C., & Strock, J. February 2008. Septic Tank Additive Impacts on Microbial Populations. *Journal of Environmental Health.*

Questa Engineering Corporation. July 7, 2003. Preliminary Conceptual Plan for Wastewater Reclamation in the Civic Center Area, Malibu, California. Prepared for City of Malibu by Questa Engineering, Santa Barbara CA.

RMC Water and Environment. August 15, 2008. Irrigation of Legacy Park with Treated Effluent from Lumber Yard Development. Technical Memorandum prepared by RMC Water and Environment.

RMC Water and Environment. May 14, 2008. Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon. Prepared by RMC Water and Environment for City of Malibu, Legacy Park.

Rong, Y. November 3, 1997. Pitfalls in Statistics for Environmental Sampling Evaluation. *Environmental Geosciences.*

REVISED DRAFT 0910 2009

Santa Monica Bay Restoration Project. 1999. Malibu Creek Watershed Restoration Activities Draft. Malibu Creek Watershed Executive Advisory Council.

Santa Monica Bay Restoration Project. January 2001. Improving Septic System Management in the Santa Monica Bay Watershed. Santa Monica Bay Restoration Project, Septic System Task Force.

Schaub, S.A., & Sorber, C.A. May 1977. Virus and Bacteria Removal from Wastewater by Rapid Infiltration Through Soil. *Applied and Environmental Microbiology*, **33**(3):609-619.

Stone Environmental, Inc. 2004. Final Report- Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu CA. Prepared for Santa Monica Bay Restoration Commission by Stone Environmental, Montpelier VT.

Stone Environmental, Inc. April 9, 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates, Inc by Stone Environmental, Montpelier VT.

Stone Environmental, Inc. May 6, 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates, Inc by Stone Environmental, Montpelier VT.

Stramer, S.L., & Cliver, D.O. 1984. Septage Treatments to Reduce the Numbers of Bacteria and Polioviruses. *Applied and Environmental Microbiology*, **48**(3): 566-572.

Tiefenthaler, L.L, Stein, E.D., & Lyon, G.S. January 2008. Fecal Indicator Bacteria Levels During Dry Weather form Southern California Reference Streams. Prepared for Southern California Coastal Water Research Project.

Tim, Heather. November 1994. Review of Monitoring and Response Protocol for the Malibu Creek Watershed. Santa Monica Bay Restoration Project.

Thorsen, Jim. 2008. Letter in Response to the Los Angeles Regional Water Quality Control Board's Letter Regarding Notification of Incomplete Application for Waste Discharge Requirements for Malibu Lumber. City of Malibu, CA.

United States Environmental Protection Agency. January 2001. Linkage between Water Quality Targets and Pollutant Sources.

United States Environmental Protection Agency. August 2002. Predicting Attenuation of Viruses During Percolation in Soils.

University of California, Los Angeles. May 200. Lower Malibu Creek and Lagoon Resource Enhancement and Management. Final Report to the California State Coastal Conservancy by UCLA.

URS Greiner Woodward Clyde. 1999. Final Report, Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems. Prepared for City of Malibu by URS Greiner Woodward Clyde, Santa Ana CA.

US Environmental Protection Agency. January 10, 2003. Total Maximum Daily Loads for Nutrient, Malibu Creek Watershed, Public Review Draft. US Environmental Protection Agency, Region 9.

REVISED DRAFT 09 10 20 09

Van Beveren & Butelo Inc. 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared for Malibu Lumber, LLC by Van Beveren & Butelo Inc.

Van Beveren & Butelo Inc. February 20, 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. June 27, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. August 11, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. October 13, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Vaughn, J.M., Landry, E.F., & Thomas, M.Z., 1983. Entrainment of Viruses from Septic Tank Leach Fields Through a Shallow, Sandy Soil Aquifer. *Applied and Environmental Microbiology*, **45**(5): 1474–1480.

Viergutz, Richard, 2006, Discharge of Sewage-Polluted Groundwater into Malibu Creek and Lagoon Resulting from Groundwater Surface Interactions: MS Thesis, California State University, Los Angeles.

Yates, M.V., Gerba, C.P., & Kelley, L.M. April 1985. Virus Persistence in Groundwater. *Applied and Environmental Microbiology*, **49**(4): 778–781.

Yates, M.V., Yates, S.R., Warrick, A.W., & Gerba C.P. September 1986. Use of Geostatistics to Predict Virus Decay Rates for Determination of Septic Tank Setback Distances. *Applied and Environmental Microbiology*, **52**(3): 479–483.

Yamahara, K.M., Layton, B.A., Santoro, A.E., & Boehm, A.B. 2007. Beach Sands along the California Coast are Diffuse Sources of Fecal Bacteria to Coastal Waters. *Environmental Sciences & Technology*, **41**(13):4515-4521.

Yamahara, K.M., Walters, S.P., & Boehm, A.B., 2009. Growth of Enterococci in Unaltered, Unseeded Beach Sands Subjected to Tidal Wetting. *Applied and Environmental Microbiology*, **75**(6): 1517-1524.

REVISED DRAFT 09 10 2009

Enterococcus Frequency distributions for Civic Center Beaches and Selected Correlation Coefficients

Malibu Pier

MPN/100mL	2005	2006	2007	2008
<10	0.416667	0.066667	0.464286	0.233333
10	0.25	0.433333	0.285714	0.366667
25	0.166667	0.033333	0.071429	0.066667
50	0.166667	0.2	0	0.133333
100	0	0.2	0.107143	0.1
250	0	0	0.071429	0.066667
500	0	0.033333	0	0.033333
1000	0	0	0	0
2500	0	0.033333	0	0.033333
5000	0	0	0	0
>5000	0	0	0	0

Correlation Coefficients		2005-2006	2006-2008
2007-2008	2006-2007		
0.807527	0.427273	0.43676	0.791923

Sweetwater at Carbon Beach

MPN/100mL	2005	2006	2007	2008
<10	0.166667	0.184211	0.444444	0.730769
10	0.055556	0.184211	0.37037	0.153846
25	0.111111	0.105263	0.037037	0.076923
50	0.166667	0.078947	0.111111	0.038462
100	0.222222	0.131579	0	0
250	0.055556	0.131579	0.037037	0

Surfrider Beach

MPN/100mL	2005	2006	2007	2008
<10	0.214286	0.261538	0.580153	0.4351145
10	0.114286	0.123077	0.221374	0.18320611
25	0.142857	0.130769	0.015267	0.09923664
50	0.185714	0.153846	0.076336	0.07633588
100	0.2	0.138462	0.076336	0.11450382
250	0.057143	0.123077	0.015267	0.05343511
500	0.014286	0.030769	0.015267	0.01526718
1000	0.071429	0.030769	0	0
2500	0	0.007692	0	0.02290076
5000	0	0	0	0
>5000	0	0	0	0

Correlation Coefficients		2005-2006	2006-2008
2007-2008	2006-2007		
0.975783	0.784365	0.903846	0.71737172

Sweetwater at Carbon Beach

MPN/100mL	2005	2006	2007	2008
<10	0.166667	0.184211	0.444444	0.73076923
10	0.055556	0.184211	0.37037	0.15384615
25	0.111111	0.105263	0.037037	0.07692308
50	0.166667	0.078947	0.111111	0.03846154
100	0.222222	0.131579	0	0
250	0.055556	0.131579	0.037037	0

500	0.055556	0.157895	0	0
1000	0.111111	0	0	0
2500	0.055556	0.026316	0	0
5000	0	0	0	0
>5000	0	0	0	0

Correlation Coefficients		2005-2006	2006-2008
2007-2008	2006-2007	0.410575	0.349527
0.850475	0.64587		

500	0.055556	0.157895	0	0
1000	0.111111	0	0	0
2500	0.055556	0.026316	0	0
5000	0	0	0	0
>5000	0	0	0	0

Correlation Coefficients		2005-2006	2006-2008
2007-2008	2006-2007	0.410575	0.34952737
0.850475	0.64587		

United States
EnvironmentalProtection
Agency

Health Effects
Research Laboratory
Research Triangle Park NC 27711

Research and Development EPA-600 / 1-80-031 Aug 1983

EPA

Health Effects Criteria for Marine Recreational Waters

Note: This electronic version was prepared from the original document using optical character recognition software.

EPA-600 / 1-80-031
August 1983

HEALTH EFFECTS CRITERIA FOR MARINE RECREATIONAL WATERS

by

Victor J. Cabelli
Marine Field Station
West Kingston, Rhode Island

HEALTH EFFECTS RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 277711

DISCLAIMER

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWARD

The many benefits of our modern, developing, industrial society are accompanied by certain hazards. Careful assessment of the relative risk of existing and new man-made environmental hazards is necessary for the establishment of sound regulatory policy. These regulations serve to enhance the quality of our environment in order to promote the public health and welfare and the productive capacity of our Nation's population.

The complexities of environmental problems originate in the deep interdependent relationships between the various physical and biological segments of man's natural and social world. Solutions to these environmental problems require an integrated program of research and development using input from a number of disciplines. The Health Effects Research Laboratory, Research Triangle Park, NC and Cincinnati, OH conducts a coordinated environmental health research program in toxicology, epidemiology and clinical studies using human volunteer subjects. Wide ranges of pollutants known or suspected to cause health problems are studied. The research focuses on air pollutants, water pollutants, toxic substances, hazardous wastes, pesticides and nonionizing radiation. The laboratory participates in the development and revision of air and water quality criteria and health assessment documents on pollutants for which regulatory actions are being considered. Direct support to the regulatory function of the Agency is provided in the form of expert testimony and preparation of affidavits as well as expert advice to the Administrator to assure the adequacy of environmental regulatory decisions involving the protection of the health and welfare of all U.S. inhabitants.

This report provides an assessment of the relationship between microbiological indicators of water quality and illness that may have resulted from swimming. The data base resulted from a series of in-house and extramural epidemiological-microbiological research projects designed to develop the criterion for marine waters. The development and periodic reevaluation of such criteria is mandated by Section 304(a)l of Public Law 92-500: Federal Water Pollution Control Act Amendments of 1972; Clean Water Act of 1977.

F. Gordon Hueter, Ph.D.
Director
Health Effects Research Laboratory

PREFACE

Shortly after they were published by the National Technical Advisory Committee to the Federal Water Pollution Control Administration in 1968, the microbiological guidelines for direct contact recreational waters were attacked as being too restrictive. The basis for the attack was the meager and questionable epidemiological data from which they were derived, limitations of the microbial indicator of water quality (fecal coliforms) to be used, and defects in the methodology available for monitoring environmental waters for its presence. It was noted that these guidelines were recommended in the face of seemingly conflicting epidemiological findings from the studies conducted by Stevenson and Moore and a very limited number of outbreaks of infectious disease clearly shown to be associated with swimming in sewage polluted waters.

Early in 1969, it was suggested to the author of this report that he "look into the matter." During 1969 and early 1970, he and his colleagues developed a design for a prospective epidemiological-microbiological study differing from that used by Stevenson in a number of essential ways. A decision was made to look first at saltwater and later at freshwater beaches, and some beaches in New York City were identified for the conduct of a study.

The project was established in 1972 with a target date for completion in 1978-79. Studies were to be conducted at beaches in a number of locations in addition to New York City. The objective of the program was to produce criteria, defined as a mathematical relationship of some untoward effect from swimming in sewage polluted water to the quality of that water as measured by any of a number of potential microbial or chemical indicators; thus, they were to be amenable to risk analysis. The objective was achieved, and this report documents the output from that effort.

In addition, methods were developed and published for a rather large number of potential water quality indicators, and information and methodology were generated and published relative to several other problems in human infectious disease potentially or actually resultant from pollution of marine and fresh recreational waters. Included are the discharge of *Klebsiella* in industrial effluents, the relationship of *Aeromonas hydrophila*, *Acinetobacter* sp., *Pseudomonas aeruginosa*, and *Vibrio parahaemolyticus* densities to nutrient enrichment of aquatic environments, the potential for individuals to become colonized by multiantibiotic resistant coliforms via their activities in sewage polluted waters, the effect of environmental parameters on the survival of human pathogens and indicator microorganisms in marine and fresh waters, transfer frequencies for multiple antibiotic resistance into fecal isolates of *E. coli*, the characterization of a highly chlorine resistant, male specific coliphage from sewage, and the microbial colonization of the external ear canal.

ABSTRACT

This report presents health effects quality criteria for marine recreational waters and a recommendation for a specific criterion among those developed. It is the mathematical relationship of the swimming-associated rate of gastrointestinal symptoms among bathers to the quality of the water as determined by the density of a fecal indicator, enterococci. Thus, it can be used to provide guidelines based upon acceptable rather than detectable risk and is consistent with risk analysis.

The criteria were developed using data collected from an extensive in-house extramural, microbiological-epidemiological research program conducted by the U.S. Environmental Protection Agency over the years 1972-1979. Central to this program was the conduct of prospective epidemiological-microbiological studies using a design developed at the Marine Field Station of the Health Effects Research Laboratory. These multi-year studies were conducted at beaches at three locations in the United States (New York City, NY; Lake Pontchartrain, New Orleans, LA; and Boston Harbor, MA). An additional study was conducted in Alexandria, Egypt; however, for the reasons given, only the United States data were used in the development of the criteria.

The two input parameters to the recommended model (criterion), the type of symptomatology and the specific water quality indicator, were determined from the analysis of data with a design which considered a number of symptom types and potential indicators. In addition, swimming was carefully defined as the exposure of the head to the water, the non-swimming controls were at the beach, and the trials were conducted over relatively short periods of time (1-2 days).

[This page is intentionally blank.]

CONTENTS

Forward	iii
Preface	iv
Abstract	v
Figures	viii
Tables	ix
Acknowledgements	xiii
1. Introduction	1
2. Recommendations	3
3. Background	5
Existing Guidelines and Standards	5
Data Base in Support of Existing Guidelines and Standards	7
Health Effects Recreational Water Quality Indicators	11
Guidelines Based on Acceptable Risk	12
4. Study Design	15
Perceived Deficiencies in Stevenson Design	15
Design Characteristics	16
Indicator Assays	18
Analysis of theData	18
5. Results of the Studies	21
New York City Study	21
Alexandria, Egypt Study	24
Lake Pontchartrain Study	29
Boston Harbor Study	31
6. Development of Criteria	33
The Etiologic Agent(s)	44
7. Limitations in the Use of the Recommended Criteria	49
Small Point Sources	49
Illness Rates in the Discharging Population	49
Fecal Indicators Versus Pathogens	50
References	51
Appendix	55

FIGURES

Number		Page
1	Graphic Representation of Desired Recreational Water Quality Criteria	13
2	Swimming-Associated Gastrointestinal Symptom Rates Against the Mean Enterococcus and *E. coli* Densities in the Bathing Water for New York City Study (1973-1975)	24
3	Data from Figure 2a Shown on a Scale More Akin to that Used in Dose-Response Representations	25
4	Swimming-Associated Rates for Vomiting or Diarrhea Against the Mean Enterococcus Density in the Water (Egyptian Study)	26
5	Swimming-Associated Rates for Vomiting or Diarrhea Against the Mean *E. coli* Density in the Water (Egyptian Study)	27
6	Age-Specific, Swimming-Associated Rates for Vomiting or Diarrhea by Beach and Study Population for the 1977 Egyptian Trials	28
7	Y on X Regression Lines for the Swimming-Associated Rates for GI Symptoms Against the Mean Enterococcus and *E. coli* Densities in the Water	36
8	Swimming-Associated GI Symptom Rates Against the Mean Enterococcus Densities in Water and 95% the Confidence Limits Around the Lines	41
9	Health Effects, Quality Criteria for Marine Recreational Waters Developed by the EPA Epidemiological-Microbiological Program	43
10	Ratios of Swimmer to Nonswimmer, Rates of Gastrointestinal Symptoms Against Mean Enterococcus Density in the Water	45
11	Comparison of the Illness-Indicator Relationships from U.S. Studies with Those from the Egyptian Studies	46
12	Day of Onset of GI Symptoms as Obtained from the 1975 New York City Trials	47

TABLES

Number		Page
1	Methods Development in Support of the EPA Epidemiological Program	12
2	Sequence of Events for Epidemiological-Microbiological Trials	18
3	Success of Follow-up Phone Interviews and the Number of Useable Responses by Beach and Year	20
4	Correlation Coefficients for Total Gastrointestinal Symptoms and the "Highly Credible" Portion Against the Mean Indicator Densities for New York City Study	23
5	Correlation Coefficients for Enterococcus and *E. coli* Densities Against the Gastrointestinal Symptom Rates for U.S. and Egyptian Studies	35
6	Summary of the Mean Enterococcus Density-Gastrointestinal Symptom Rate Relationships Obtained from Clustered Trials for All U.S. Studies	37
7	Summary of the Mean Enterococcus Density-Gastrointestinal Symptom Rate Relationships Obtained,. from Trials Grouped by Beach and Year for All U.S. Studies	38
8	Summary of the Mean *E. coli* Density-Gastrointestinal Symptom Rate Relationships Obtained from Clustered Trials for All U.S. Studies	39
9	Summary of the Mean *E. coli* Density-Gastrointestinal Symptom Rate Relationships Obtained from Trials Grouped by Beach and Year for All U.S. Studies	40
10	Regression Formulae and Correlation Coefficients for Swimming Associated GI Symptoms Against Enterococcus Densities in the Bathing Waters	42
11	Ratio of Swimmer to Nonswimmer Gastrointestinal Symptom Rates by Enterococcus Density	44
12	Relationship of Swimming-Associated to Background (Nonswim) Rates for Gastrointestinal Symptoms	46
13	Duration of Gastrointestinal Symptomatology: New York City, 1975 Trials	48
A1	Total and Fecal Coliform Standards for Primary Contact Recreational Waters as of 1978	55

(continued)

TABLES (continued)

Number		Page
A2	Demographic Characteristics of the Four Subpopulations for 1974 New York City Trials	59
A3	Mean Indicator Densities at the Coney Island and Rockaway Beaches During 1973 and 1974 Trials	59
A4	Swimming-Associated Symptom Rates for New York City Beaches in 1973, 1974	60
A5	Swimming-Associated Rates for Symptom Groups at the New York City Beaches (1973-74)	60
A6	Comparison of *Salmonella* and Total Coliform Densities at Coney Island and Rockaway Beaches	61
A7	Analysis of Gastrointestinal and Highly Credible Gastrointestinal Symptom Rates by Demographic Group	62
A8	Mean and Range of New York City Trials Clustered According to Enterococcus Densities	63
A9	Mean and Range of New York City Trials Clustered According to *E. coli* Densities	63
A10	Mean and Range of New York City Trials Clustered According to Fecal Coliform Densities	64
A11	Mean and Range of New York City Trials Clustered According to Total Coliform Densities	64
A12	Mean and Range of New York City Trials Clustered According to *Kiebsiella* Densities	65
A13	Mean and Range of New York City Trials Clustered According to *Enterobacter-Citrobacter* Densities	66
A14	Mean and Range of New York City Trials Clustered According to *P. aeruginosa* Densities	67
A15	Mean and Range of New York City Trials Clustered According to *A. hydrophila* Densities	67
A16	Mean and Range of New York City Trials Clustered According to *C. perfringens* Densities	68
A17	Mean and Range of New York City Trials Clustered According to *Staphylococcus* Densities	68
A18	Mean and Range of New York City Trials Clustered According to *V. parahaemolyticus* Densities	69

(continued)

TABLES (continued)

Number		Page
A19	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by Enterococcus Densities	70
A20	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *E. coli* Densities	71
A21	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by Fecal Coliform Densities	72
A22	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by Total Coliform Densities	73
A23	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *Klebsiella* Densities	74
A24	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *Enterobacter-Citrobacter* Densities	75
A25	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *P. aeruginosa* Densities	76
A26	Gastrointestinal (61) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *A. hydrophila* Densities	77
A27	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *C. perfringens* Densities	78
A28	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *Staphylococcus* Densities	79
A29	Gastrointestinal (GI) and Highly Credible GI Symptom Rates for NYC Trials Clustered by *V. parahaemolyticus* Densities	80
A30	Mean and Range of Indicator Densities by Beach and Year for NYC Trials	81
A31	Gastrointestinal (GI) and Highly Credible GI Symptom Rates by Beach and Year for NYC Trials	83
A32	Symptom Rates for Trials Conducted at Three Alexandria Beaches in 1976	84
A33	Symptom Rates for Alexandria Residents and Cairo Visitors at the Alexandria Beaches in 1977	85
A34	Symptom Rates for Alexandria Residents and Cairo Visitors at the Alexandria Beaches in 1978	86
A35	Swimming-Associated Symptom Rates for Alexandria, Egypt Study	87
A36	Comparison of Nonswimming Symptom Rates for 1st and 2nd Follow-up Inquiries with Cairo Visitors During 1978 Trials	88

(continued)

TABLES (continued)

Number		Page
A37	Symptom Rates per 1000 Person-days for Cairo Visitors by the Number of Swimming Days per Week (1978)	88
A38	Symptom Rates for Vomiting and Diarrhea and Mean Indicator Densities for Alexandria, Egypt Study	89
A39	Symptom Rates for Swimmers and Nonswimmers During 1977 Lake Pontchartrain Trials	90
A40	Symptom Category Rates for Swimmers and Nonswirnmers During 1977 Lake Pontchartrain Trials	90
A41	Gastrointestinal Symptom Rates by Age for 1977 Lake Pontchartrain Trials	91
A42	Indicator Densities in the Bayou St John as Compared to the Roped-Off Area at Levee Beach on Lake Pontchartrain (1977)	91
A43	Analysis of 1977 Lake Pontchartrain Data by Rainfall (Dry Versus Wet Periods)	92
A44	Gastrointestinal Symptom Rates for 1977 Lake Pontchartrain Trials Clustered by Indicator Densities	93
A45	Gastrointestinal Symptom for the Four 1977 Lake Pontchattraln Trials with the Highest *E. coli* and Enterococcus Densities	94
A46	Clustering of Trials for Calculation of Gastrointestinal Symptom Rates for 1978 Trials at Levee Beach, Lake Pontchartrain	95
A47	Gastrointestinal Symptom Rates and Corresponding Mean Indicator Densities for 1978 Trials at Lake Pontchartrain	96
A48	Symptom Rates for Revere and Nahant Beaches During 1978 Boston Harbor Study	96
A49	Gastrointestinal Symptom Rates and Corresponding Indicator Densities for Revere and Nahant Beaches for 1978 Boston Harbor Study	97
A50	Gastrointestinal Symptom Rates and Corresponding Indicator Densities for Clustered Trials During 1978 Boston Harbor Study	97
A51	95% Confidence Limits for Swimming-Associated Gastrointestinal Symptom Rates Predicted from the Observed Mean Enterococcus Densities (Trials Clustered by Indicator Densities)	98
A52	95% Confidence Limits for Mean Enterococcus Densities Predicted from the Observed Swimming-Associated GI Symptom Rates	99

(continued)

ACKNOWLEDGMENTS

The author gratefully acknowledges the contributions of many individuals who took part in the overall program, especially those of his colleagues, Drs. Alfred P. Dufour and Morris A. Levin of the Marine Field Station, HERL-Cincinnati, who worked with him on the in-house portion of the program. Also included are: Mr. Paul Haberrnan of the Center of Policy Research for his work on the New York City study (R802240, R803254); Drs. K. E. Hakim, M.K. Wahdan, A. El Molla and M: Hussein of the High Institute of Public Health, Alexandria University for their work on the Alexandria study (PM8O 3-542-3); Mrs. Virginia K. Ktsanes, Dr. John E. Diem and Dr. Anne A. Anderson of Tulane University for their work on the Lake Pontchartrain study (R805341), and Dr. David W. Drummond of Tufts University for his work on the Boston study (R806178).

The author is indebted to Mr. Leland McCabe, HERL-Cincinnati, for his advice and help and to Mr. McCabe and Dr. R. John Garner, Director, HERL-Cincinnati, for "keeping the faith" during the execution of this logistically difficult and arduous long-range program. He owes his thanks to Dr. Harold Wolf for suggesting the problem in 1969. He especially appreciates the contribution of a most unique scientific administrator, Dr. John Buckley, for his vision in fostering long-range anticipatory research programs such as this one, for recommending its initiation in 1972, and for maintaining the administrative impetus for its accomplishment.

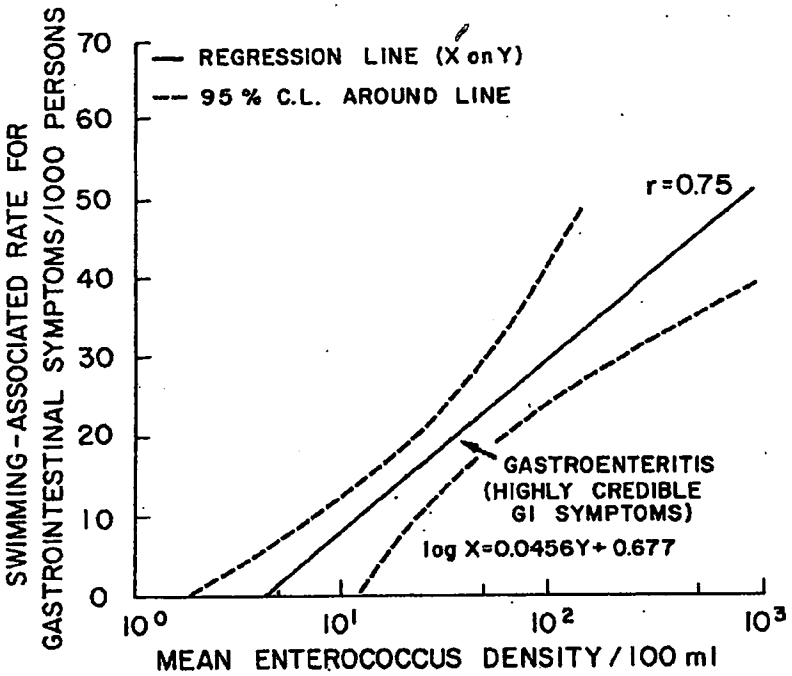
SECTION 1
INTRODUCTION

Existing health effects, water quality guidelines (often referred to as criteria) and standards for primary contact recreational waters, as recommended or promulgated by federal, state and local agencies, are generally stated as upper limits for fecal indicator densities. The current EPA guideline's state that, "Based on a minimum of five samples taken over a 30-day period, the fecal coliform bacterial level should not exceed a log mean of 200/100 ml, nor shall more than ten percent of the total samples taken during a 30-day period exceed 400/100 ml." Without exception, these guidelines suffer from two major deficiencies. The first is the paucity of epidemiological data which support some of them and the absence of any such support for others. At best, they relate to a "detectable risk" of infectious disease; at worst, they are based solely upon "attainment." The second, a consequence of the first, is that officials responsible for making decisions are given a "number," and this inherently limits the options available in decision making to compliance or noncompliance.

With the availability of a sufficient epidemiological base, a second option is available. In general terms, it is the promulgation of a criterion as defined herein; that is, a mathematically expressible relationship (model) of untoward effects among "users" to the quality of the water used. With reference to recreational waters, it is the relationship of the incidence or risk of disease among swimmers to the quality of the water as measured by the density of the infectious agent itself or an appropriate indicator. As shown herein, the major pollution-associated risk to recreationists is that of infectious disease consequent to swimming in waters polluted with human and, to a much lesser extent, lower animal fecal wastes. Therefore, the criterion relates infectious disease among "swimmers" to some measure of fecal pollution of the water. This approach then permits a decision as to "acceptable risk" based upon social, economic, medical, public health, and even political considerations (some form of cost-benefit or cost-effectiveness analysis). The acceptable risk of illness or its incidence can then be extrapolated from the criterion to yield a water quality limit (guideline), and the guideline can then be fixed in law to provide a standard.

This report presents such a criterion for marine recreational water quality, documents its epidemiological base, and discusses its applications and limitations. The recommended criterion shown in the figure below is the mathematical relationship (X on Y regression line) of the quality of the bathing water (X), as measured by the density of a specific fecal indicator (enterococci), to the incidence of swimming-associated gastroenteritis ("highly credible," gastrointestinal symptoms, Y). It is a deterministic model empirically derived from epidemiological and microbiological data obtained at multiple locations over several years. The deterministic form appears to lend itself more to cost-benefit types of analyses. The two input parameters to the model were not chosen arbitrarily. Rather, they were the output from an experimental design formulated to respond to the questions: Which are the "important" types of illnesses, and which is the "best indicator? This is detailed in the body of the report.

This criterion is directed against potential human health effects consequent to the pollution of marine recreational waters with human fecal wastes, notably municipal sewage. It is a generalization which may not always hold true. Nevertheless, the fact that it has been found to be applicable at several locations has some implications concerning the ecology of the etiological agent(s) and the nature of the infectious process,



Recommended health effects criterion for marine recreation waters.

notably, the ubiquity of the agent in feces, sewage, and its receiving water. A similar criterion for freshwaters will probably be required, and the establishment of this criterion does not preclude the possible need for others, i.e... against the proliferation of aquatic organisms pathogenic for man (e.g., *Aeromonas hydrophila*; *Vibrio parahaemolyticus*) which respond to nutrient loading of the water.

The criterion may be used to develop guidelines for sewage treatment and outfall location. Knowledge of the transport and fate of both pathogens and indicator bacteria would provide a refinement for translating these target area criteria into effluent guidelines. It is hoped that the criteria will not be used to close swimming areas but rather to expand the available recreational resource.

Finally, when the study design for the EPA program was being developed in 1969-1970, it was thought that swimming in sewage-polluted waters would constitute a relatively minor route of transmission for gastrointestinal illness and that relatively high levels of pollution (as indexed by microbial indicator densities) would be required before gastrointestinal illness could be detected. These assumptions were made on the basis of existing notions and available information. Both these assumptions were incorrect. If the nonswimming rates for gastrointestinal symptomatology can be considered as those for the population at large, then it must be concluded that swimming in sewage-polluted waters constitutes a significant route of transmission for the illnesses obtained, at least for individuals of "swimming age."

SECTION 2
RECOMMENDATIONS

1. The health effects criterion for marine recreational waters presented herein should be considered for use by EPA since it is a relatively reliable generalization which is amenable to risk analysis, allows a wider choice of options at both the federal and local levels, and can be defended on the basis of epidemiological data.

2. A cost-benefit or cost-effectiveness type model should be developed for determining the acceptable risk or incidence of illness with regard to general and local factors.

3. Work should be continued toward the development of similar criteria for fresh recreational waters.

4. An intensive program should be initiated towards establishing the etiology of the gastroenteritis observed in these studies and developing methods for quantifying the agent(s) in environmental waters. This should be followed by a program to compare the biological decay of the agent(s) to its indicators under conditions best simulating those in open water.

5. The most resource responsible use of these criteria is their translation into effluent guidelines governing the design of sewage treatment facilities, the location of their outfalls and the decisions to be made relative to the degree of treatment and disinfection required. This and the preceding recommendation require the reinitiation of the program towards the development of realistic and facile methods for obtaining decay coefficients for indicators and pathogens on a case-by-case basis.

6. Nonspecific gastroenteritis is the major cause of outbreaks of disease from drinking water and shellfish consumption. The criteria suggest that there are measurable health effects associated with enterococcus or *E. coli* water densities as low as 10/100 ml via a route in which only 10-50 ml of water is ingested. Therefore, prospective epidemiological studies should be conducted as part of the reevaluation of existing standards for drinking water and shellfish-growing areas mandated by Sections 104(n)(l), 304 (a)(1) and 403(c)(l) of Public Law 92-500.

[This page is intentionally blank.]

SECTION 3
BACKGROUND

Historically, the development of health effects, water quality guidelines and standards for recreational waters has followed a pattern characteristic of many such efforts to control pollution-associated health and ecological effects. The first step is the development of guidelines and standards dictated largely by *attainment* with the best available control technology. These are usually based upon limited epidemiological and ecological evidence and little, if any, data quantifying the risk in relation to the level of the pollutant in the environment. The second stage is the modification of these guidelines and standards on the basis of *detectable* risk using a limited quantity of data relating untoward effects to the environmental level of the pollutant. The last step in the process, the development of guidelines based upon *acceptable* risk, requires an epidemiological or ecological data base broad enough to mathematically model the relationship of some measure of water quality to the risk, degree or rate of untoward effects. With reference to health effects, water quality guidelines and standards for recreational waters, we have progressed through the second stage. This report will describe and substantiate criteria from which guidelines and standards based upon acceptable risk can be derived by risk analysis. Sewerage systems for the disposal of domestic wastes from urban areas into nearby fresh and marine waters have been in existence in the United States since the turn of the century. By that time, it was clearly established that agents of enteric disease are excreted in large numbers in the feces of ill individuals and, hence, are potentially present in sewage and its receiving waters. A swiruming-associated outbreak of typhoid fever was reported in 1921(1). Yet, it was not until 1951 that Scott (2) proposed microbial guidelines for the quality of recreational waters; these were based solely upon attainment. It was 1968 (3) before guidelines related to detectable risks were recommended by the National Technical Advisory Committee (NTAC.) to the Federal Water Pollution Control Administration (FWPCA). Criteria permitting the development of guidelines based upon acceptable risks are now available a decade later.

EXISTING GUIDELINES AND STANDARDS

As of 1972, the two guidelines or standards most commonly used by the various states and territories in the United States were a total coliform value of 1000/100 ml of water and a fecal coliform limit of 200/100 ml. The former appears to have developed from two sources, the anticipated risk of salmonellosis as obtained from calculations made by Streeter (4) on the incidence of *Salmonella* species in bathing waters and attainability as determined by Scott (2) from surveys conducted of Connecticut bathing waters. The Joint Committee of the American Public Health Association and the State Sanitary Engineers (5) adopted the Connecticut standard as did many of the state agencies. The fecal coliform limits will be considered in more detail since, as can be seen from Table A1†, it is the most prevalent one used by the various states and it is the guideline currently recommended by the EPA (6). This guideline will be considered in terms of the data base which supports it, how it was derived, and the indicator system used.

The microbial guideline for primary contact recreational waters recommended by the

†When a table number is preceded by "A," the table is to be found in the Appendix.

EPA and adopted by most of the states (Table A1) is essentially that recommended by NTAC in 1968. Their recommendation was as follows:

> Fecal coliforms should be used as the indicator organism for evaluating the microbiological suitability of recreational waters. As determined by multiple-tube fermentation or membrane filter procedures and based on a minimum of not less than five samples taken over not more than a 30-day period, the fecal coliform content of primary contact recreational waters shall not exceed a log mean of 200/100 ml, nor shall more than 10 percent of total samples during any 30-day period exceed 400/100 ml.

Their rationale for specific limits was as follows:

> The studies at the Great Lakes (Mich.) and the Inland River (Ohio) showed an epidemiologically detectable health effect at levels of 2,300-2,400 coliforms per 100 ml. Later work on the stretch of the Ohio River where the study had been conducted indicated that the fecal coliforms represented. 18 percent of the total coliforms. This would indicate that *detectable** health effects may occur at a fecal coliform level of about 400/100 ml; a factor of safety would indicate that the water quality should be better than that which would cause a health effect. . . .The Santee project correlated the prevalence of virus with fecal coliform concentrations following sewage treatment. Virus levels following secondary treatment can be expected to be 1 Plaque-Forming-Unit (PFU) per milliliter with a ratio of 1 virus particle per 10,000 fecal coliforms. A bathing water with 400 fecal coliforms per 100 ml could be expected to have 0.02 virus particles per 100 ml (1 virus particle per 5,000 ml).

The committee pointed out that the Public Health Service's three epidemiological studies on bathing water quality and health were the only base available for setting criteria, that these studies were far from definitive, and that they were conducted before the acceptance of the fecal coliform as a more realistic measure of a health hazard. The committee concluded that there is an urgent need for research to refine the correlation of various indicator organisms, including fecal coliforms, to waterborne disease.

Shortly after its publication, the NTAC guideline was attacked by Henderson (7) as being too restrictive. He set forth several arguments against the promulgation of microbiological standards on a nationwide basis; included were the broad confidence limits on the Most Probable Number (MPN) test (whether for total coliforms or fecal coliforms), temporal and geographic variability in pathogen to indicator levels, and the effect of differing sources of pollution (i.e., treatment plant effluents, stormwater run-off, farm lot wastes, etc.). However, the thrust of his attack was the paucity of defined epidemiological data in support of the NTAC guideline. To the contrary, he used the British experience (8); the observations from Santa Monica Bay, California (9); and the lack of morbidity or mortality data associated with swimming in support of a much less restrictive microbiological standard for bathing beaches, or even no standard at all

In 1972, a panel of the National Academy of Sciences, National Academy of Engineering (10) came to the following conclusion:

> No specific recommendation is made concerning the presence or concentrations of microorganisms in bathing water because of the paucity of valid epidemiological data.

In explaining their inability to recommend a specific value they noted that many of the diseases that seem to be causally related to swimming and bathing in polluted waters are not enteric diseases or are not caused by enteric organisms. Hence, the presence of fecal coliforn bacteria or of *Salmonella* sp. in recreational waters is less meaningful than in drinking water. Nevertheless, the substance of the NTAC guideline was adopted by the EPA in 1976 (6); and, by 1978, the large majority of the states and territories used it as a guideline or a standard (Table A1). Because of the seeming contradictions in the conclu-

*Author's emphasis.

sions drawn by different individuals from the same information, it is worthwhile to critically review that information.

DATA BASE IN SUPPORT OF EXISTING GUIDELINES AND STANDARDS

The data base in support of existing microbial guidelines can be sought from three different sources. These are (i) available morbidity and mortality statistics (including retrospective epidemiological analyses of case reports and disease outbreaks), (ii) output from predictive models, and (iii) the findings from prospective, controlled, epidemiological-microbiological studies.

Recreational Waterborne Outbreaks of Disease and Their Retrospective Analyses

Potentially, all the diseases which are spread by the anal-oral route and whose etiological agents are shed in the feces of ill individuals or carriers could be contracted by swimming in sewage-polluted water. This includes (i) bacterial diseases, such as salmonellosis (including typhoid and paratyphoid levers), shigellosis (bacilliary dysentery), cholera, and gastroenteritis caused by enteropathogenic *E. coli*, *Yersinia enterocolitica*, etc., (ii) viral diseases such as infectious hepatitis, illnesses caused by enteroviruses (poliovirus, coxsackieviruses A and B, echoviruses, reoviruses and adenoviruses), and "nonspecific" gastroenteritis caused by the human rotavirus and parvo-like viruses, and (iii) diseases caused by a variety of protozoan and metazoan parasites, i.e., amoebic dysentery, giardiasis, ascariasis, etc.

In actuality, most of the reported outbreaks and cases of infectious disease in the United States associated with swimming in natural bathing places were nonenteric and included cases and outbreaks of otitis externa, swimmers' itch, leptospfrosis, granulomas of the skin, and even very rare cases of tuberculosis and tularemia (11). The existing guidelines do not prevent these diseases. There have probably been less than 18 reported outbreaks of enteric disease, encompassing less than 700 cases, associated with swimming in sewage-polluted waters. Included are: four outbreaks of typhoid fever, three relatively small ones in the United States (1,12,13) and one of ten cases in Australia (14); an outbreak of shigellosis on the Mississippi River below Dubuque, Iowa (15); two very small and questionable outbreaks of enteroviral infections, one caused by Coxsackie A (16) and the other Coxsackie B (17); and an equally questionable outbreak of infectious hepatitis (18). The largest reported outbreak by far occurred in 1979; 187 individuals developed gastroenteritis within three days from swimming at two lakes within a park in Michigan during a three-day period in July (19).

Thus, it is understandable why workers such as Henderson (7) and Moore (8), after examining such reports, have questioned the need for water quality guidelines, much less standards, for recreational waters. There are, however, a number of considerations which suggest that case and outbreak reports by their very nature markedly understate the actual incidence of swirming-associated enteric disease. First of all, there are a number of other modes of transmission for these enteric diseases (i.e. drinking water, food, person-to-person contact) so that it is difficult to establish an association to a specific route. Second, much of the swimming occurs at beaches used on a daily basis or on weekends by urban and suburban populations who return to their homes each evening. This too adds to the difficulty of establishing a common source association with swimming at a given beach for "sporadic," geographically spaced cases of enteric disease. This is in contrast to drinking water where there is a geographic clustering of cases. It is of interest in this regard that the reported shigellosis and gastroenteritis outbreaks were detected under conditions where the population was geographically restricted, campers at state parks. Third, the levels of pollution at such beaches are relatively constant; thus,

one would not expect outbreaks (recognized because of temporal or spacial limits) but rather sporadic cases. Fourth, as will be pointed out later in this report, the immune status of the population to some of the potential etiologic agents will also tend to produce sporadic cases. Finally, the most commonly reported illness associated with drinking water and shellfish-associated outbreaks, a nonspecific gastroenteritis, is not a "reportable" disease. The usefulness of information from case and outbreak reports in developing criteria, guidelines, and standards is also limited because, with few exceptions and for obvious reasons, data on the quality of the water at the time of exposure are usually not available.

Prior to 1974, the only retrospective epidemiologic analysis concerning the risk of illness associated with swimming in sewage-polluted waters was carried out by Moore and his associates at some coastal communities along the coast of England and Wales (8). The basic design was to compare the incidence of swimming in a two-week period (for the ill individuals, it was the two weeks prior to the onset of illness) between two groups of individuals. The first was children ill with clinical poliomyelitis, and the second was a group of demographically paired controls (cohorts). Using this approach, Moore found no greater association of swimming among children ill with poliomyelitis than among their cohorts. In addition, he found very few cases of salmonellosis for which there was even the remotest association with swimming in polluted waters.

There were a number of problems with the experimental design used: (i) swimming was not defined rigorously; (ii) the time span between the actual swimming experience and the query as to its occurrence was protracted in many cases; (iii) it was difficult to establish a relationship to the quality of the water in which the individuals bathed; (iv) of necessity with this type of analysis in contrast to that used by Stevenson, there was a presumption as to which diseases were "important," poliomyelitis and salmonellosis; and (v) this type of analysis is rather insensitive except; when conducted during an outbreak situation. In their report (8) Moore and his associates (the Committee on Bathing Beach Contamination of the Public Health Laboratory Service) noted some of these limitations and pointed out that, "A survey of this type could clearly not prove that poliomyelitis was never caused by bathing, and in any case such a presumptive finding might be contradicted by future events, but the results of the survey give no indication that further investigation along those lines is likely to be fruitful except in the negative sense recorded." Nevertheless, their findings do not warrant the conclusions drawn: that there is little, if any, risk of enteric disease from swimmii:lg in sewage-polluted waters unless aggregate fecal material is found therein and that aesthetic considerations will limit beach usage long before there is a significant risk of swimming-associated enteric disease. However, with regard to the two specific diseases in question, Moore's conclusions were probably correct since, even in the period subsequent to his report, there have been no outbreaks or cases of poliomyelitis shown to be associated with the recreational use of water, and there has only been one outbreak of this disease even remotely associated with any of the waterborne routes (20).

There have been some cases of salmonellosis attributed to the recreational use of polluted waters, but, as Moore predicted, these have been associated with swimming in heavily polluted waters which were probably aesthetically unattractive. In the Australian outbreak, there was a broken sewage outfall (14); swimming in a sewage-contaminated drainage ditch (fecal coliform MPN 10^7/100 ml) was reported for the Alabama cases (13); the individuals in the Louisiana outbreak had been swimming in a river impacted by a broken sewer line (12); and four cases of typhoid fever detected in the Alexandria, Egypt bathing beach study to be described were all associated with swimming at a heavily polluted beach immediately impacted with raw sewage (21). The relatively few cases of swimming-associated salmonellosis which have been reported in the United States and the findings from those outbreaks are consistent with the high ID_{50}* for salmonellae (22), the decrease in *Salmonella* cases and carriers, and the increase in sewage treat-

*The number of microbial cells required to infect 50 percent of the exposed individuals.

ment. The removal of suspended solids during treatment decreases the number of multisalmonellae-containing particles. When the human ID_{50} data for salmonellae are considered, it would seem that such particulates would be required to produce swimming-associated disease, and the epidemiological setting for the above outbreaks are consistent with this hypothesis. Moreover, prior to 1979, the only outbreak of enteric disease unequivocally shown to be associated with swimming in sewage-polluted waters was a shigellosis outbreak on the Mississippi River below Dubuque, Iowa (15); and the ID_{50} for shigellae has been shown in volunteer studies to be several orders of magnitude less than that for salmonellae (22,23).

The information provided by the retrospective epidemiological analysis of the shigellosis outbreak (15) is of such importance in understanding the criteria which will be described that some detail is warranted (the equally important Michigan outbreak (19) will be discussed later in another context). Of 45 culture-positive cases studied, 43 (96 percent) of the individuals consulted a physician and 18 (40 percent) were hospitalized. Twenty-three individuals had a history of swimming in the area within three days of the onset of symptoms. Thirteen of them were swimming at a park area which, when sampled periodically during the month following the end of the outbreak, had a mean fecal coliform density of 17,500/100 ml *S. sonnei*. The same antibiogram and colicin type as the isolates from seven swimmers, also was recovered from these waters. A case-control analysis and a retrospective, cohort analysis of an additional 262 individuals revealed a statistically significant association of gastrointestinal illness with swimming but not with drinking well water or with food consumption. The illness was defined as diarrhea with fever or cramps occurring within three days. The rate among swimmers at the park was 12 percent. Of the swimmers, the highest attack rate and the best correlation to illness was among individuals who took water in their mouths and among children and adolescents (less than 20 years of age).

These findings must be used with caution since water quality measurements could be obtained only after the end of the outbreak and since the source(s) of the *Shigella* and indicator organisms in the water could not be unequivocally established. In addition, the data relate primarily to shigellosis, one of several swimming-associated diseases. Nevertheless, the report documents a *consequential outbreak of illness clearly associated with swimming in water polluted with fecal wastes*. More important, it would appear that the health effects occurred in the *absence of aesthetic deterioration sufficient to deter individuals from swimming in the area*. The concern with salmonellosis notwithstanding, this was a shigellosis outbreak, and the incidence of shigellosis in Dubuque had been steadily increasing over the four years prior to the outbreak.

Prospective Epidemiological Studies

Prior to 1973, the only prospective epidemiological studies dealing with recreational waterborne disease were those conducted by Stevenson and his associates in the 1950s (24). Since they were the basis for the NTAC and, hence; EPA guidelines and a point of departure for the studies to be described in this report, they will be described and analyzed in some detail. There were three studies. The first was conducted at two beaches on Lake Michigan in the vicinity of Chicago. The second examined illness rates among individuals at two locations, a swimming pool in Kentucky and a nearby stretch of polluted beach on the Ohio River. The third study was conducted at two marine beaches on Long Island Sound, one in New Rochelle, New York and other in Mamaroneck, New York. A calendar approach was used in all three studies, and this led to a number of problems with the experimental design. First of all, swimming was not defined rigorously enough so that any subsequent illnesses could be attributed exclusively to contact of the upper body orifices with polluted water as opposed to consumption of food at the beach, personal contact between beachgoers, aerosols potentially generated by toilet facilities, etc. Secondly because the trials were conducted over the entire summer, the

effects of day-to-day fluctuations in the pollution levels at the beaches were not eliminated. The consequence of this was that the mean indicator densities and, hence, the illness rates at the paired beaches in the first and third studies were not significantly different from each other. A third problem was that measurements were reported only for one indicator, total coliform bacteria.

In the first study, symptom rates among the beachgoers at the South Beach were no different than those at the North Beach. Howeyer, a statistically significant difference was obtained in the rate of total symptoms among individuals who were at South Beach during three "high" coliform density days as compared to those there during three "low" days. This was not true at the North Beach. The mean indicator density during the high days at the South Beach was 2300 total coliforms/100 ml. In the Ohio River study, the rate for total symptoms was higher among people at the chlorinated swimming pool than those at the polluted beach on the Ohio River. However, the age adjusted rate for gastrointestinal symptoms was higher for the individuals at the river beach than those at the swimming pool. The mean coliform density in the stretch of the Ohio River was 2700/100 ml. In the third study, conducted at the marine beaches in the vicinity of New York City, no differences in symptom rates could be obtained even when illness rates during "high" days and "low" days were compared.

Aside from those in the experimental design, there are a number of problems with the analyses of the data and the conclusions drawn thereof. First of all, Stevenson concluded that swimming per se resulted in a higher rate of illness; because of the experimental design, it can only be concluded that going to the beach results in a higher illness rate. Second, the comparison of illness rates for three high days versus three low days during the Lake Michigan study has been criticized in that the differences were shown for only one set of high versus low days, and no data are given for all the other possible combinations. Third, in the first study, the differences were reported for total symptoms, while in the second they were for gastrointestinal symptomatology; yet, both sets of data were used identically in the derivation of the NTAC guidelines. Because of the limitations in the experimental design and analysis, one could conclude the positive results were spurious and that there was no effect of swimming in sewage-polluted waters. Alternatively, the limitations in design and analysis notwithstanding, it might be argued that the findings described a reality obtained with a relatively insensitive epidemiological instrument.

There were also problems in the use of these findings in the derivation of the microbial water quality guidelines as set forth in the NTAC document. As noted earlier, there was no consistency in the type of symptom used in the derivation. Secondly, the authors of the NTAC document converted total coliform values into fecal coliform values in order to state the criteria in terms of "a more fecal specific indicator system." In fact, the lack of specificity in the total coliform values would be carried over into the fecal coliform guidelines in spite of the fact that the relationship between the two indicators was later determined on the same stretch of the Ohio River. Fourthly, it is now evident that the so-called fecal coliforms are not as fecal specific as was thought at the time that the NTAC guidelines were formulated. Finally, the findings from the Stevenson study and their use in deriving the NTAC and hence EPA guidelines are conceptually deficient in that they are not amenable to risk analysis. That is, they describe detectable not acceptable risks. Nevertheless, these were the best guidelines available, and, as noted by Shuval (25), target area guidelines are needed by engineers as the basis for the design of sewage treatment facilities.

Predictive Models

Predictive models based on pathogen densities in the water, the infective dose of the pathogens in question, and the relationship of pathogen to indicator densities have been equally unproductive in terms of producing the kinds of definitive information needed to support the existing guidelines. Attempts by Streeter (4) which were similar to those

used by Kehr and Butterfield (26,27) for other waterborne routes of transmission, assumed an ID_{50} for salmonellae of one, and this is several orders of magnitude less than those obtained later from human volunteer studies (22). A more recent study by Mechelas *et al.* (28) was equally unproductive, not because of the mathematical approach used but rather because of the poor quality of the input data to the model and the assumptions made as to which disease agents are important.

An attempt is made to justify the existing EPA guidelines from information on the relationship of fecal coliform densities to the frequency of *Salmonella* isolations in surface waters (6, 29). As pointed out elsewhere (30), this relationship has not been confirmed, especially when *Salmonella* densities rather than isolation frequencies are examined. Furthermore, it is conceptionally unsound to expect a consistent relationship between a fecal indicator and a pathogen which is not extremely prevalent in the population at large. Finally, considering the ID_{50} for salmonellae, a relationship to the frequency of its isolation hardly seems appropriate as a justification for a guideline. In spite of the absence of epidemiological data showing swimming-associated cases of poliomyelitis, an attempt has been made to justify the guidelines based on some relatively poor data on poliovirus densities (including those of the vaccine strains) in the water, their relationship to fecal coliform densities, and the assumption that ID_{50} of poliomyelitis is one, if the virion is in the right place at the right time (31). This approach also is entirely unconvincing for the reasons stated earlier.

HEALTH EFFECTS RECREATIONAL WATER QUALITY INDICATORS

Ideally, recreational water quality indicators are microorganisms or chemicals whose densities in the water can be quantitatively related to potential health hazards resulting from recreational use therein. Historically, the concern has been with infectious enteric diseases, such as cholera and typhoid fever, whose etiological agents are excreted in feces and are spread by the contamination of water and food with fecal wastes.

There are a number of reasons why the pathogens themselves are not used for this purpose, and most of these are as valid today as they were at the turn of the century when the indicator concept was developed. First of all, as noted earlier, there is a wide variety of infectious agents potentially transmitted by the waterborne route, and, since the density of each will vary both temporally and spacially independent of the others, measurements would have to be made for each agent. Secondly, facile and reliable methods for quantifying most of the pathogens are unavailable, even today; in fact, there are no methods for quantifying what may be the most important (infectious hepatitis) and most prevalent (rotaviruses and parvo-like viruses) agents of enteric disease. Thirdly, and most important of all, because of the temporal variability in pathogen densities in feces and sewage (and hence their receiving waters), monitoring for the pathogens themselves is more akin to measuring the actual rather than the potential for disease. Thus, it is not surprising (i) that the indicator concept was developed shortly after fecal transmission of enteric pathogens was established, (ii) that the first three indicators suggested, *Escherichia coli*, *Streptococcus faecalis* and *Clostridium perfringens*, were fecal organisms (32), and (iii) that these, or groups to which they belong, are the three most commonly used indicators today (33,34). The regrettable fact is that, in each case, methodological rather than conceptual considerations led to the expansion of the group measured, i.e., coliforms and fecal coliforms instead of E. coli, fecal streptococci instead of S. faecalis, and spore-forming, sulfite-reducing anaerobes instead of *C. perfringens*. The health effects, water quality indicators which have been considered and the methods for their enumeration which have been developed under the EPA recreational water quality criteria program are presented in Table 1.

The coliform systems require some further discussion because they are the ones most

TABLE 1. METHODS DEVELOPMENT IN SUPPORT OF THE USEPA EPIDEMIOLOGICAL PROGRAM

Indicator	Method	Ref[1]	Indicator	Method	Ref[1]
Coliforms	mC	(35)	*P. aeruginosa*	mPA	(43)
E. coli	mTEC	(36)	*A. hydrophila*	mA	(44)
Klebsiella	mK	(37)	*V. parahaemolyticus*	mVP	(45)
Enterococci	mE	(38)	*Salmonella*	HVS	(46)
C. perfringens	mCP	(39)	Enteropathogenic *E. coli*	—[2]	(47)
Bifidobacteria	—[2]	(40)			
Coliphage	—[2]	(41)	Coprostanol	—[2]	(48)
C. albicans	—[2]	(42)			

[1] Literature citation for the method.
[2] No specific name.

commonly used and because most of the existing criteria are stated in terms of coliform or fecal coliform densities.

The total coliform population as commonly enumerated includes four genera in the family *Enterobacteriaceae*: *Escherichia*, *Kiebsiella*, *Citrobacter*, and *Enterobacter*. It may also include other organisms, notably lactose positive members of the genus *Aeromonas* (49). Only *E. coli* is consistently and exclusively found in feces (50), although all five genera can be routinely recovered from domestic sewage in rather large numbers (51).

Belatedly, the total coliform system is being discarded for many applications because it is finally recognized that *Citrobacter* and *Enterobacter* species are not fecal specific. However, it is being replaced with the so-called "fecal coliforms," a group which includes thermotolerant Kiebsiella as well as *E. coli* biotypes. There never was any evidence that the adjective "fecal" was properly applied. In fact, it has been known for some time that there are substantial extra-fecal sources of *Kiebsielia*, (50, 52, 53), even for the thermotolerant biotype. In addition, *Kiebsielia* is infrequently present in human feces, and then generally as a minor portion of the coliform population (50). A number of reasons have been given to justify the use of this coliform system instead of *E. coli*. It has been argued that much of the historical data is in terms of fecal coliforms, that the existing standards for recreational and shellfish waters are stated as fecal coliform densities, and that *Kiebsielia* should be enumerated as a fecal indicator because it is an opportunistic pathogen. First of all, much of the historical data is in terms of total coliforms not fecal coliforms; secondly, the little epidemiological data in support of existing recreational or shellfish standards were developed in terms of total coliforms and extrapolated to fecal coliforms (3); thirdly, *Kiebsielia* is an opportunistic pathogen of the respiratory and genito-urinary systems and not the gastrointestinal tract; finally, there are no data showing that *Kiebsiella* infections have been obtained via the waterborne route, much less that they occur at environmental fecal coliform densities of less than 200/100 ml or 14/100 ml, the present EPA guidelines for recreational and shellfish-growing waters, respectively (6).

GUIDELINES BASED ON ACCEPTABLE RISK

Another problem with the existing microbial guidelines for direct contact recreational waters is that they are not amenable to, compatible with, or derived in the context of risk analysis. That is, the data from which the guidelines were derived and the manner of the derivation are related to detectable rather than acceptable risk. Therefore, decisions beyond acceptance or rejection of the specific limits cannot be made on the basis of scien-

tific, health, economic or sociological considerations This does not allow for deliberate decisions by local, state, or federal officials as to the costs to be paid for incremental decreases in the health risks involved. Finally, it presents a philosophical dilemma to individuals or groups who recommend guidelines based upon detectable risks. Once more sensitive epidemiological instruments are developed for measuring the risks involved or extrapolating them from existing information, they are forced to make the limits more restrictive in order to be conceptually consistent. In fact, this is precisely the position in which the EPA finds itself because of the results to be presented. The logical solution is to proceed to the next stage in the evolution of the guidelines, the use of those developed on the basis of acceptable risk.

The microbial water quality criteria for primary contact recreational waters to be recommended in this report and, hence, the guidelines and standards which can be derived from them are a radical departure from the guidelines currently recommended by the EPA and the guidelines and standards currently used by the various states. They differ conceptually from the existing guidelines (referred to as criteria) in that the usable information is presented in the form of dose-response type relationships rather than limiting microbial densities. Because the conceptual basis is different, it becomes important to define certain terms as they will be used throughout this document.

A health effects recreational water quality *criterion* developed for use with indicator systems is defined as a quantifiable relationship between the density of the indicator in the water and the potential human health risks involved in the water's recreational use. It is a set of facts or a relationship upon which a judgment can be made. A water quality *guideline* derived from the criterion is a suggested upper limit for the density of the indicator in the water which is associated with health risks which are considered unacceptable. The concept of acceptability implies that there are social, cultural, economic, and political as well as medical inputs to the derivation and that these may vary in time as well as space. A water quality *standard* obtained from the criterion is a guideline fixed by law. The relationship of guidelines to the criteria from which they are derived is shown graphically in Figure 1. Derivation of the guidelines from the criteria requires a

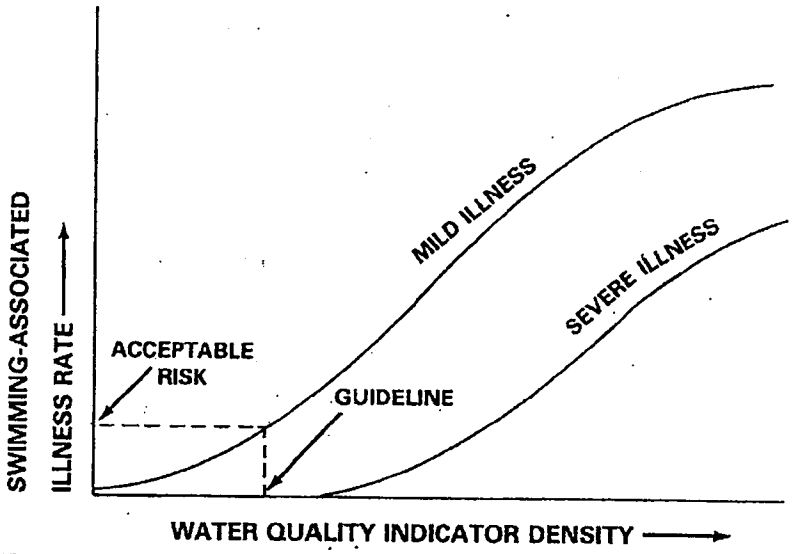


Figure 1. Graphic representation of the desired recreational water quality criteria. It is assumed that only an extremely small risk of "serious" illness will be accepted.

decision as to acceptable risk. This, in turn, is best obtained from some manner of cost-benefit or cost-effectiveness analysis which should include economic and socio-logic considerations. Guidelines derived from such criteria differ from those currently in use in that they are consistent with risk analysis, allow for decision making, and are based on acceptable rather than detectable risks. This report presents such a criterion for marine recreational water quality, documents its epidemiological data base, and discusses its applications and limitations.

SECTION 4
STUDY DESIGN

The design of the epidemiological-microbiological program to develop health, effects recreational water quality criteria was started in January 1969, shortly after the publication of the NTAC guidelines, and concluded in 1970. From the onset, the objective was to develop criteria amenable to risk analysis rather than guidelines based upon detectable risk (54). The experimental work was initiated in 1972 and concluded in 1978. A prospective approach similar to that used by Stevenson (24) was taken, in part to avoid prejudgements as to which diseases are spread by the recreational route, in part because a "nonspecific" gastroenteritis was the most common illness associated with the drinking water (55) and shellfish (56) routes of transmission, and in part because of Moore's (8) conclusion that further retrospective studies are unlikely to yield results other than those obtained in his study. Marine beaches were chosen for the initial program because Stevenson's study at marine beaches did not produce demonstrable swimming-associated health effects, yet his freshwater findings were being applied to such beaches. Furthermore, if swimming-associated health effects were not obtained, this would tend to confirm the observed differences between fresh and saltwater beaches. If they were obtained, this would signal the need for a freshwater program, and the saltwater criteria could be used on an interim basis for freshwater beaches as well. The freshwater program was initiated in 1976. Finally, there were a number of heavily used and sewage-impacted marine beaches which could be studied along the Middle Atlantic and New England coasts.

PERCEIVED DEFICIENCIES IN STEVENSON DESIGN

An analysis of Stevenson's (24) study design, relative to the difficulties encountered and the results obtained, revealed several deficiencies which may have contributed to the inconclusiveness of his findings. To a large measure, they were due to the necessity of using the less expensive and time-consuming "calendar approach."

Definition of Swimming

Neither Stevenson, in defining his bathers as opposed to his nonbathing controls, nor Moore (8), in his inquiries concerning bathing, appears to have defined swimming such that individuals actually *at risk* - those whose upper body orifices were significantly in contact with the water - were isolated and examined. Thus, if swimming is not defined precisely, it is possible that differences in pollution-associated illness may be sought between two populations in both of which most of the individuals never were appreciably exposed. We considered this to be important from the assumption that less than 10 percent of the beachgoers would be classified as swimmers when immersion of the head in the water was used as the criterion for swimming. In fact, we were wrong. In almost every study, more than 60 percent of the beachgoers were classified as swimmers.

Multiple Exposures

The day-to-day variability in pollution levels requires that, ideally, the study group be limited to individuals who have had a single (one-day) swimming experience during the observation interval associated with a given trial. In both the freshwater (Lake Michi-

gan) and saltwater (Westchester) studies, the day-to-day variability as measured by coliform indicators was considerable; in fact, the range of indicator densities at each pair of beaches appreciably overlapped each other. Furthermore, in both these studies, the use of "calendars" to record illness made it necessary to limit the study to seashore residents. This maximized the probability that multiple exposures would occur. Stevenson, in comparing the incidence of illness during "high" and "low" pollution days, obviated only part of this difficulty.

Nonswimming Controls

Stevenson's nonswimming controls were individuals who did not go to the beach. Thereby, beach-going but not swimming-associated illnesses, such as gastroenteritis from improperly stored food, increased personal contact, use of communal toilets, etc., could be erroneously included in calculating the illness rates of the swimming as opposed to nonswimming populations. This could have affected illness-rate comparisons between "high" and "low" days as well as between beaches.

Demographic Considerations

Stevenson analyzed his data with consideration to age and sex but not to ethnic or socioeconomic (SES) factors. However, especially in the saltwater study, the test beaches appear to have been paired with reference to ethnic and SES factors of the resident populations. Susceptibility to disease, background rate of illness, nature of the swimming experience, and even the reliability of the respondents' information concerning illness and the swimming experience could vary by ethnic or social class.

Tidal Effects

Hourly variability in the pollution levels due to tide, wind, rainfall, etc., can present a problem in the interpretation of findings from epidemiological-microbiological trials. In Stevenson's study this was uncontrolled. Except in those instances where a "captive" study population is available, such as institutionalized individuals or organized groups, there is little that can be done to mediate such effects. Individuals at the beach during a given day can be expected to swim on several occasions during a half tidal cycle.

Indicators of Pollution

At the time of Stevenson's study, the state of the art was such that only two microbiological parameters were measured. Coliform determinations were made in accordance with confirmed test procedures described in the 13th Edition of "Standard Methods" (57). Enterococcus levels were also examined. These data were not used in the analysis because it was subsequently determined that, because of problems in assay methodology, the density estimates were too unreliable.

DESIGN CHARACTERISTICS

In response to the perceived deficiencies in the Stevenson studies, the calendar approach was not used (58). Rather, the participants were recruited at the beach and queried some 7-10 days later by phone or personal interview (mail questionnaires were tried and found to be unsatisfactory) concerning symptomatology which developed subsequent to the swimming experience. Other features of design were as follows:

1. Only individuals whose upper body orifices were exposed to the water were classified as swimmers, and subjects were queried on the nature and duration of swimming activity. The validity of this information was pretested in the New York City study by observing family groups over a day at the beach and comparing these observations with information obtained at the day's end from a representative of the group. The more rigorous definition of swimming allowed for a beach-going

but nonswimming control group and thereby eliminated the bias from nonswimming associated illnesses.

2. Beach interviews were conducted only on weekends. Exposure was limited to a single day or at most two successive days on a weekend. This was accomplished by eliminating individuals who swam in midweeks before and after the weekend trials from the study. The use of weekends maximized the size of the study population but limited the illness observation period to 8-10 days. This feature of the study facilitated the analysis of the data "by days," thereby obviating the effect of day-to-day variability in pollution levels. However, it eliminated from consideration illnesses with incubation periods exceeding nine days, notably infectious hepatitis (this was examined in the portion of the Egyptian study which dealt with Cairo visitors to the Alexandria beaches).
3. The impact of within-day variability in pollution, primarily attributable to tidal effects, could not be eliminated. However, in the first two years of the New York City study, an attempt was made to minimize this effect by choosing test and control beaches which were markedly different in the pollution levels reaching them. There also was an attempt to select trial dates when minimal tidal effects coincided with peak beach usage periods (usually 11 A.M. to 5 P.M.). This problem was potentially even more acute in the Boston Harbor study because of the greater tidal excursions and the unappealing nature of the intertidal zone. Because of this, swimmer and even bather densities were very low during low tides, Therefore, trials were conducted on those weekends when high or mid-tide corresponded to the hours of peak activity (11 A.M. to 5 P,M,). This forced the acceptance of lower mean indicator densities for this study.
4. Demographic effects, which could assert themselves as differences in susceptibility to infection, in swimming activity and in the reliability of respondent information, were minimized. This was done by selecting test and control beaches whose populations were demographically similar and by obtaining age, sex, ethnic, and SES information that could be used in isolating and identifying the influence of these factors.
5. The respondents were asked whether they remained home, remained in bed or sought medical advice because of the symptoms. This information was used to indicate disability.
6. In the pretest year of the New York City study, an attempt was made to validate the illness information provided by the respondents. This was done by providing the name of a physician in the reminder letter sent on the Monday following a trial and by requesting the names of other physicians consulted during the observation period. This was unsuccessful, and an alternative system was devised for validating gastrointestinal (GI) symptomology. Highly credible GI symptoms (HCGI) were defined as (i) vomiting, (2) diarrhea with a fever or disabling enough for the individual to remain home, remain in bed or seek medical advice, or (ii) stomachache or nausea accompanied by a fever, The rates for HCGI symptoms were calculated and compared to those for total GI symptoms in order to determine if the trends were the same.
7. The illness questionnaire solicited information on irritations and disturbances of the skin, upper respiratory tract, eyes, and ears. This was done not only against the possibility of pollution-associated infectious processes but also against that possibility of toxic and hypersensitive conditions attributable to chemical pollution and to pollution-associated changes in marine biota.

The sequence of events during and subsequent to the beach interview is shown in Table 2.

The experimental design as stated was generally followed for all the studies conducted. The notable exception was the Egyptian study and especially the portion dealing with health effects among Cairo visitors to the Alexandria beaches.

TABLE 2.. SEQUENCE OF EVENTS FOR EPIDEMIOLOGICAL-MICROBIOLOGICAL TRIALS

Day of week	Day number	Activity	Function
Saturday	1	Beach interview, water sampling	(a) Obtain name, address, phone, etc. (b) Reject pre-trial midweek swimmers (c) Query on beach activity (d) Assay of water samples
Sunday	2	Same as Saturday	As above
Monday	3	Reminder letter	(a) Provide name of physician (b) Reminder to note illness
Monday	10	Phone or mail interview	(a) Obtain illness information (b) Reject post-trial midweek swimmers (c) Obtain remainder of demographic information.

INDICATOR ASSAYS

Water samples were collected in sterile bottles from just below the surface of the water, at "chest high depth," and periodically during the time when people were in the water. They were collected at 2-3 locations along the beach; and, in general, 3-4 samples were collected between the hours of 11 A.M.-5 P.M., the period of maximum swimming. The samples were "iced" and returned to the laboratory for assay within six hours of collection.

Assays of the water samples were performed to determine the densities of a number of potential microbial indicator systems. These are given in Table 1. Appropriate, evaluated methods were not available for bifidobacteria, coliphage, *Candida albicans*, and enterophathogenic *E. coli* or for the chemical, coprostanol, by the second year of the New York City study. Therefore, these indicators could not be included in the study. Membrane filter procedures were developed and used for most of the indicator systems examined. The methods are noted and referenced in Table 1. Membrane filter procedures were chosen because they provide more precise estimates than MPN determinations and allow larger samples to be examined than pour or streak plate procedures. A high volume (55.5 liters), MPN procedure (46) was used for *Salmonella*, *Klebsiella*, and *Enterobacter-Citrobacter*. Densities were determined by the mC procedure (35), although a method specifically for *Klebsiella* (37) was developed subsequent to the completion of the New York City study. In addition, fecal coliform densities were determined by the MPN procedure given in *Standard Methods for the Examination of Water and Wastewater* (57). Staphylococci were enumerated by a modification of the Chapman-Stone method for use in a membrane filter procedure (M. Levin, personal communication).

ANALYSIS OF THE DATA

Since the objective of the program was to relate the swimming-associated rates for symptoms, classes of symptoms or syndromes to some measure of the quality of the water, a temporal and spacial control population was provided. This was nonswimmers

(head not immersed in water) who were at the beach and, in general, came from the same family groups as the swimmers. Therefore, in most of the analyses, the swimming rate for a given symptom or group of symptoms was first compared to the nonswimming rate. Such differences were then examined relative to the pollution levels at different beaches or on different days or groups of days at the same beach. During the first two years of the New York City study, two beaches were used which, according to existing standards, varied widely with regard to their pollution levels. One was "barely acceptable" (BA) in that it was immediately adjacent to a beach posted as being unsafe for swimming; the other was "relatively unpolluted" (RU) according to existing guidelines and was at a much greater distance than the BA beach from any known pollution source. The choice of the beaches permitted making a decision as to "important" symptoms without recourse to a direct comparison with indicator densities. Chi-square analysis was used for this purpose. The second premise of the program was that there would be no prejudgment as to which is the "best" indicator. Therefore, regression analyses of the geometric mean densities of each indicator against the symptom rates were used to determine which indicator provided the best correlation and, hence, was the best water quality indicator.

In the regression analyses, each point was defined by the symptom rate for a single trial (day), a cluster of trials with similar indicator densities or all the trials conducted over a given summer at a given location and by the corresponding geometric mean indicator density for all the samples collected at the beach. Regression analysis was also used to define the final criteria.

The studies conducted under the EPA program to develop recreational water quality criteria, the number of individuals from whom usable information was obtained, and the success rate for follow-up interview are presented in Table 3. The detailed findings from individual studies have been or will be presented in individual reports (21, 59-64).

TABLE 3. SUCCESS OF FOLLOW-UP PHONE INTERVIEWS AND THE NUMBER OF USABLE RESPONSES BY BEACH AND YEAR FOR STUDIES CONDUCTED UNDER THE EPA PROGRAM

Location	Beaches	% Follow-up During Study Year[1]			Number of Usable Responses During Year		
		1	2	3	1	2	3
New York City, NY	Coney Island	82.3	78.3	78.3	641	3146	6491
	Rockaway	86.6	82.9		681	4923	
Lake Pontchartrain, LA	Levee	77.2	77.9[2]		3432	2768	
	Fontainebleau					551	
Boston Harbor, MA	Revere	81.2			1824		
	Nahant	81.2			2229		
Alexandria, Egypt	Maamoura[3]	88.6	84.8	84.4	819	1492	1786
	—[4]		91.2	88.3		1696	2173
	Ibrahemia[3]	81.2	87.8	90.4	823	1117	2050
	—[4]		87.5	87.2		1159	1820
	Mandara[3]	82.9			1163		
	Sporting[3]		90.7	90.6		1257	2025
	—[4]		84.9	88.5		1243	2457

[1] Coney Island, Rockaway, 1973-1975; Levee, 1977-1978; Fontainebleau, 1978; Revere, Nahant, 1978; Maamoura, Ibrahemia, 1976-1978; Manara, 1976; Sporting, 1977-1978.
[2] Fontainebleau included with Levee.
[3] Alexandria residents.
[4] Cairo visitors.

3-218

SECTION 5
RESULTS OF THE STUDIES

NEW YORK CITY STUDY

This study was conducted in three phases (years) at Coney Island and Rockaway beaches selected with the assistance of the Bureau of Public Engineering, New York City Department of Health. The first phase, conducted in 1972 and 1973, was a pretest of the microbiological and epidemiological methodology and an evaluation of the suitability of the test beaches. In 1972, the reliability of information obtained from the interviewees concerning their bathing activities was examined using the method described earlier. Their responses were quite accurate regarding entrance into the water and immersion of the head therein. However, their perceptions as to how long they were in the water were less reliable, possibly because many of them bathed or swam on several occasions during the day. In 1973, trials were conducted at two beaches: the first, located between 18th and 22nd Streets on Coney Island, was designated as the BA beach; and the second, around 67th Street at the Rockaways, was designated as the RU beach (61).

The demographic distributions of the populations at the two beaches were similar (60); about two-thirds of the beachgoers were classified as "swimmers," and there were no striking differences between the Coney Island and the Rockaways populations with regard to the percentage so classified. Swimming was more frequent among males, Hispanic Americans, and the 0-19 years of age groups (Table A2). The differences in pollution levels as seen from the densities of a number of potential water quality indicators were markedly different (Table A3). The success rate for follow-up phone (not mail) interviews was acceptable (Table 3); however, an alternative to medical follow-up examination for validation of the respondents' information on symptomatology was required. The differential (swimming minus nonswimming) rates for the individual GI symptoms were generally greater at the Coney Island than at the Rockaway beach (Table A4), and statistically significant differences in the rates for GI symptomatology were obtained at the Coney Island but not the Rockaway beach (Table A5). The rate for respiratory symptoms was higher among swimmers than nonswimmers at the Rockaways, presumably due to the aerosolization of noninfectious material because of the heavy surf activity at the beach. Assays for *Salmonella* densities in the water were omitted from subsequent studies because of the low densities obtained (Table A6).

A detailed analysis of the second phase (1974) trials is presented elsewhere (60). The RU beach was changed from 67th Street to Riis Park at the Rockaways in order to in-crease the size of the study population. The consequence of this was a somewhat greater discrepancy between the BA and RU beaches with regard to ethnic and SES factors (60). With two exceptions, nearly all the 1973 findings were confirmed in 1974. They were the much lower mean indicator densities (Table A3) and the absence of differences between swimmers and nonswimmers for the individual respiratory symptoms or respiratory symptoms taken as a whole (Tables A4 and AS). Of the nonswimmers at the Coney Island and the Rockaway beaches, only 8.5 percent and 5.4 percent, respectively, did not go swimming because of existing symptoms or illness. None of the individuals at the BA beach and only 0.1 percent of those at the RU beach did not go swimming because of GI symptomatology.

Because of the larger study population, the rates for GI symptoms could be examined by demographic groups. However, the increase notwithstanding, data for disabling GI symptoms by type could not be analyzed statistically because of the small size of the resultant cells. The disabling GI symptom rate for swimmers was 10/1000 people higher than that for nonswimmers at the BA beach. At the RU beach, the rate for nonswimmers was higher than that for swimmers by 2/1000.

The results from the analysis of GI symptom rates by demographic groups for swimmers and nonswimmers at both beaches are presented in Table A7. The rates among children, Hispanic-Americans, and low-middle SES individuals who swam at Coney Island were significantly and appreciably higher than among those who did not. This was not so for the residual from each demographic category (adults, blacks plus whites, and the highest SES group). The GI symptom rate for nonswinmers among the children at the RU beach was appreciably higher than that for the corresponding group at the BA beach. The rate for nonswimming children at the RU beach was significantly higher than that for children who swam. This anomalous finding probably was not due to over-reporting, since this was also true of the "highly credible" portion. The nonswimming children may have been more prone to illness, although only 0.1 percent of these children or their respondents reported that they did not swim because of existing GI symptoms. The investigators favor the explanation that predominately white or black, higher SES children did not or were not allowed to swim because they were in the early stages of the illnesses for which they later reported symptoms (60).

Secondary transmission of illnesses within a family did not appear to provide an erroneous picture of the symptom rates associated with swimming (60). The credibility of the information on gastrointestinal symptomatology was assessed by comparing the trends of all responses to those considered "highly credible." The rates for the "highly credible" symptoms among the four study groups were examined for the total population and separately for the children, Hispanic-Americans, and the low to middle SES groups. The trends for the highly credible portion were similar to those for all GI symptoms (Tables AS and A7). Rates of HCGI symptoms for the three most sensitive groups of swimmers also were significantly higher than those for their nonswimming controls.

The finding of a statistically significant, swimming-associated rate of GI symtomatology at a BA but not at a RU beach showed that such effects could be determined and suggested that measurable health effects do occur even within existing guidelines and standards. However, these results did not speak to the overall objective of the EPA program, the development of criteria amenable to risk analysis as described earlier. The data from the third phase (1975) of the New York study along with the data obtained the previous two years were analyzed to further explore this possibility since a preliminary examination of the data from 1973 and 1974 suggested that criteria could be developed and that either *E. coli* or enterococci was the most appropriate indicator (61). Four beaches on Coney Island were studied in 1975. These were a "posted" area between 34th and 38th Streets and nonposted beaches between 18th and 24th Streets, 8th and 10th Streets, and 2nd and 4th Streets, Brighton.

As noted earlier, the data from the three years of the New York City study were examined by regression analysis in two ways. The first was by clusters of trials with similar mean indicator densities during a given summer. The second was by summers, that is, all the trials at a given beach during a given summer. Clustering was necessary in order to avoid data points with N values of less than 100 persons. This was accomplished with one exception, a N of 96 for nonswimmers in the analysis of *E. coli* densities. In a few instances, however, this was accomplished at the cost of grouping some trials with widely divergent densities. In almost all cases, this occurred with trials at the upper end of the density distribution for a given indicator. Where possible, "natural breaks" in the distribution of mean densities were utilized in clustering the trials. Nevertheless, this was somewhat arbitrary.

In both approaches, the attack rates for GI symptoms or the "highly credible" portion thereof (HCGI) were regressed against the mean indicator density. The log-linear regression equation:

$$Y = a \log X + b$$

was used in which X was the mean indicator density and Y the symptom rate.

The clustering of the trials for each of the indicators along with geometric mean density and range for each cluster is shown on Tables A8 through A18. The mean densities along with the data used in calculating the swimming-associated rates (swim-nonswim) of GI and HCGI symptoms for each cluster (some single trials were unavoidable) are shown for each indicator in Tables A19 through A29. The coorelation coefficients are presented in Table 4.

TABLE 4. CORRELATION COEFFICIENTS FOR TOTAL GASTROINTESTINAL SYMPTOMS AND THE "HIGHLY CREDIBLE" PORTION AGAINST THE MEAN INDICATOR DENSITIES FOR 1973-1975 TRIALS CONDUCTED AT NEW YORK CITY BEACHES

Indicator	Correlation Coefficients (r) for Highly Credible GI[1]		Gastrointestinal (GI)[2]		Number of Points (N)	
	Summ[3]	Clust[4]	Summ	Clust	Summ	Clust
Enterococci	.75	.96	.84	.81	8	9
E. coli	.52	.56	.56	.51	8	9
Klebsiella	.32	.61	.35	.47	8	11
Enterobact.-Citrobact.	.26	.64	.23	.54	8	13
Total coliforms	.19	.65	.12	.46	8	11
C. perfringens[5]	.19	.01	.38	−.36	5	8
P. aeruginosa	.19	.59	.25	.35	8	11
Fecal coliforms	−.01	.51	.01	.36	8	12
A. hydrophila	−.09	.60	−.08	.27	7	11
V. parahaemolyticus[5]	−.20	.42	.19	.05	5	7
Staphylococci[5]	−.23	.60	.71	.09	5	10

[1] Highly credible GI symptoms (see text for definitions).
[2] Total gastrointestinal (GI) symptoms.
[3] Analysis of data by summer by beach.
[4] Analysis of data by summer, by cluster of trials (days) with similar indicator densities.
[5] No data for 1973.

The mean densities and the ranges for each indicator for all the trials conducted during a given summer at a given beach are presented in Table A30. The corresponding data on GI symptom rates are given in Table A31, and the correlation coefficients for the regression of the swimming-associated rates on the mean densities in Table 4.

When the results from both approaches for examining the relationship of the indicator densities to GI symptoms (and especially the highly credible portion thereof) were considered, it was apparent that enterococcus densities provided the best correlation. Nevertheless, as planned; the two best-correlated indicators, enterococci and E. coli, were used in subsequent studies. It is of equal importance that total coliform and especially fecal coliform densities were less well correlated with gastrointestinal symptomatology.

The regression lines obtained for swimming-associated GI and HCGI symptoms against the mean *E. coli* and enterococcus densities when examined by summers and clusters of trials with similar indicator densities are presented in Figure 2.

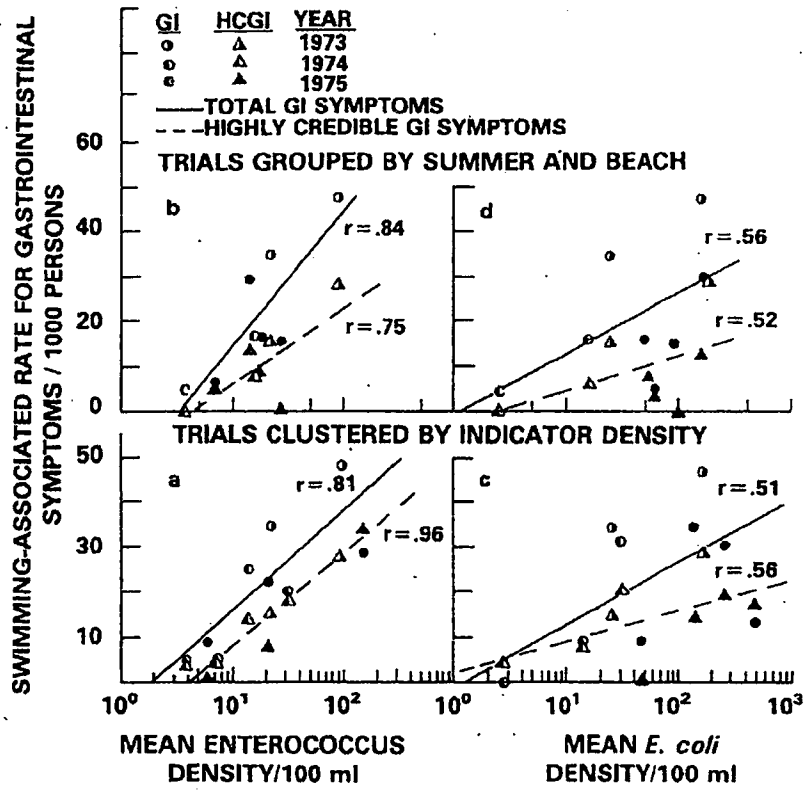


Figure 2. Swimming-associated (swimmer minus nonswimmer) gastrointestinal symptom rates against the mean enterococcus and *E. coli* densities in the bathing water for New York City study (1973-1975). Highly credible GI symptoms defined in text. In "a" and "c," trials clustered by similar indicator densities to yield points as shown. In "b" and "d," trials clustered by summer and beach. The actual trials clustered are given in Tables 8A through A31, Appendix A.

ALEXANDRIA, EGYPT STUDY

Animal infectivity studies conducted with most infectious agents yield sigmoid dose-response curves. At the inception of the EPA program, the relationship of illness among swimmers to indicator densities in the bathing waters was also expected to be sigmoid in nature. However, when the swimming-associated rates for GI symptoms were plotted in percentages on a scale that was not expanded to show differences (see Figure 3 as an example), the slopes of the lines were quite shallow relative to those seen in most dose-response curves. They may have represented the first parts of sigmoid curves, from which the expectation was accelerated increases in the symptom rates with further increases in the indicator densities at the beaches. An equally plausible explanation was that the regression lines obtained were the linear portions of basically sigmoid relationships (i) in which a measurable response was associated with the ingestion of very low

enterococcus or *E. coli* densities (note the Y axis intercepts in Figure 2) because of the differential survival of the indicators relative to the etiologic agent(s) over the travel time between the beaches and the sources of pollution, (ii) in which the shallow slopes of the regression lines were due to high levels of immunity to the infective agents(s) in the swimming populations, and (iii) from which the expectation was that the rates for the specific illness(es) involved would not accelerate with increasing levels of pollution as seen from the indicator densities.

Ideally, Figure, 3 should be a log probability plot; practically, it makes no difference because of the low rates and relatively good "r" values obtained. Furthermore, since this is an indicator-illness rather than agent-response relationship, a log probability plot may not be appropriate.

It was thought that the nature of illness-indicator relationships obtained from studies conducted at beaches more heavily impacted with more immediate sources of raw sewage could be used to differentiate between the two possibilities. Therefore, an extensive search was made for beaches in the United States which not only met the above requirements but also were used by large numbers of individuals and were not posted as unsafe. No such beaches were found in the United States; however, several saltwater beaches which met these requirements were identified in Alexandria, Egypt and could be studied under the sponsorship of the PL480 program. Most of them were very heavily used during the summer, and, according to existing information, they varied in their pollution levels from some which were heavily polluted (even aesthetically undesirable) to some which were acceptable according to the EPA guidelines. The sources of pollution to the beaches were a number of short (about 50 meters) outfalls originally designed to accommodate overloading of the disposal systems due to rainfall. However, they now discharge sewage daily because the growth of the city created demands for sewage disposal which exceeded the capacity of the existing system.

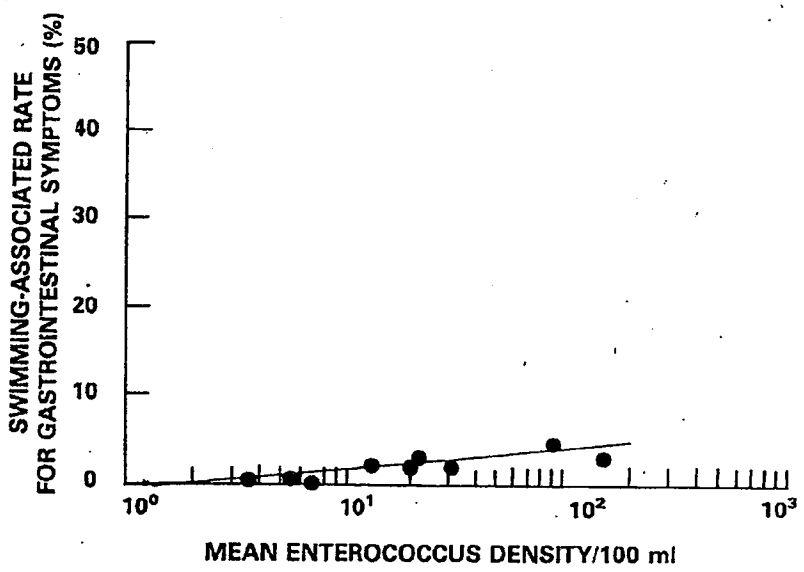


Figure 3. Data from Figure 2a shown as percentages on a scale more akin to that used in dose-response representations.

A preliminary survey of microbiological, demographic and user characteristics identified three beaches for the study - one very heavily polluted (Mandara), one moderately polluted (Ibrahemia), and one acceptable, but barely so according to the EPA guidelines (Maamoura).

The findings from the first year (pretest) of the study were similar to those obtained at the New York City beaches. Greater differences in the rates for vomiting and diarrhea among swimmers relative to nonswimmers were obtained at the heavily and moderately polluted beaches than at the acceptable one; and gastrointestinal symptomatology alone seemed to follow pollution as seen from *E. coli* and enterococcus densities, although the rates for most symptoms were higher for swimmers than nonswimmers at all three beaches. Children appeared to be the most susceptible portion of the population. However, a preliminary examination of the indicator-GI symptomatology relationship suggested an even shallower response curve than that obtained in the New York City study, this in spite of the higher pollution levels. Furthermore, there were indications that the GI symptom rates plateaued at mean *E. coli* and enterococcus densities of 200-300/100 ml (see data points for 1976 Alexandria residents in Figures 4 and 5). Finally, the *E. coli* and enterococcus densities associated with a "detectable" illness response (X axis intercepts) were higher than those obtained in the New York City study; those for enterococci were higher than those for *E. coli* the indicator with the poorer survival characteristics in saltwater (65) These findings recommended the second hypothesis noted earlier in this section. discharge sewage daily because the growth of the city created demands for sewage disposal which exceeded the capacity of the existing system.

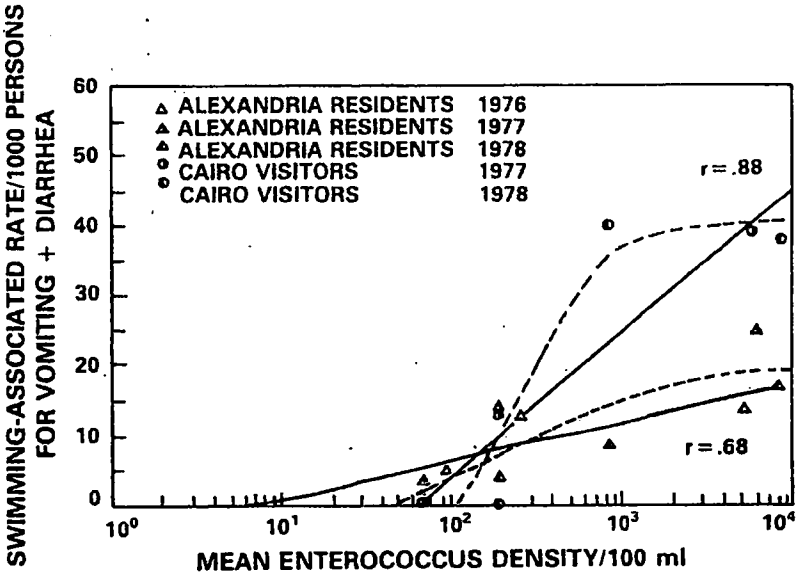


Figure 4. Swimming-associated rates for vomiting or diarrhea against the mean enterococcus density in the water (Egyptian study). The correlation coefficients (r) are those for the linear relationship. The dotted lines are the author's interpretation of the overall relationship from those seen for the individual years. Data given in Table A38, Appendix A.

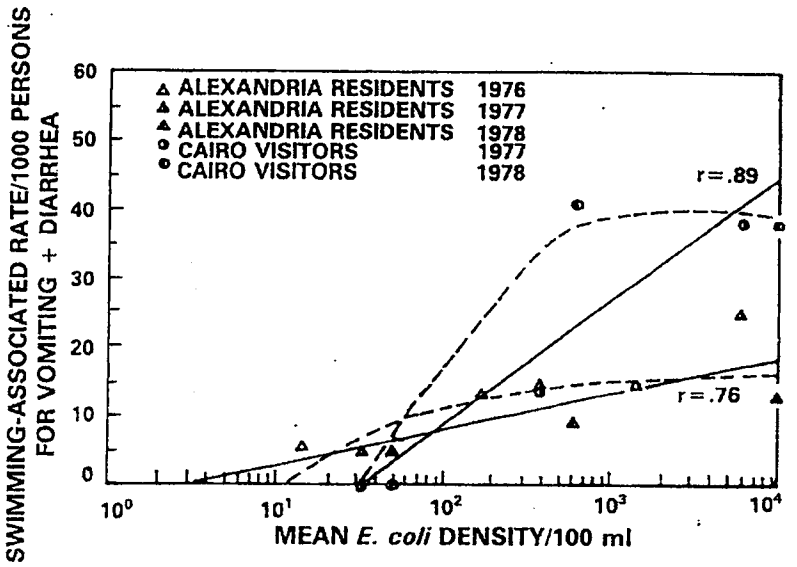


Figure 5. Swimming-associated rates for vomiting or diarrhea against the mean *E. coli* density in the water (Egyptian study). See Figure 4 caption for explanations.

Because of the above findings, the study was not only continued but extended to examine Cairo tourists at the Alexandria beaches as a population which, with regard to its immune status, might be more akin to that in the New York City study. In addition, the follow-up period with the Cairo population was extended to consider infectious hepatitis which, along with typhoid fever, is much more prevalent in Egypt than in the United States. This required a somewhat altered experimental design. The "Cairo visitors" were recruited at the beach shortly after their arrival in Alexandria. Follow-up inquiries were made in Alexandria and, as required, in Cairo at weekly intervals over a 30-35 day observation period. Follow-up in Alexandria was facilitated because most of the tourists remained in Alexandria for 2-4 weeks in rented cabanas at the beach. The altered design with the Cairo visitors precluded the use of "weekend trials" and, therefore, made the results more subject to the vagaries of day-to-day variability in pollution levels. However, the levels were relatively constant since there was little rainfall during the summer and the sewage impacting these beaches was untreated.

The pumping schedule at the Mandara outfall was changed in 1977, presumably because of the 1976 findings; this was reflected in the lower *E. coli* and enterococcus levels obtained at this beach in the spring of 1977. Because of this, "Sporting" was substituted for Mandara as the heavily polluted beach in the 1977 and 1978 trials.

The swimming and nonswimming rates for the various symptoms among the Alexandria residents and the Cairo visitors for each of the three years of the study are given in Tables A32 through A34. The swimming-associated (swimmer minus nonswimmer) rates are summarized in Table A35. Only data from the first weekly follow-up with the Cairo visitors were used in the analyses of the 1977 findings in order to maintain comparability with the data obtained for the Alexandria residents. For the same reason, the symptom rates given for the Cairo visitors in 1978 are those for individuals who swam

1-2 days during the week. Because of the resulting decrease in usable responses and because of the disparity in the rates of GI and upper respiratory tract symptoms for nonswimmers obtained from the first as compared to the second follow-up inquiry (Table A36), the data for the first two follow-up inquires were used to calculate the symptom rates for Cairo visitors in the 1978 trials. It can be seen from Table A35 that, with only three exceptions, the rates for the various symptoms were higher for swimmers than nonswimmers. However, only with the gastrointestinal symptoms (vomiting or diarrhea) and possibly fever did the rates generally increase with the pollution levels at the three beaches as seen from the *E. coli* or enterococcus densities (Table A35). The rates were higher for children than adults (Figure 6).

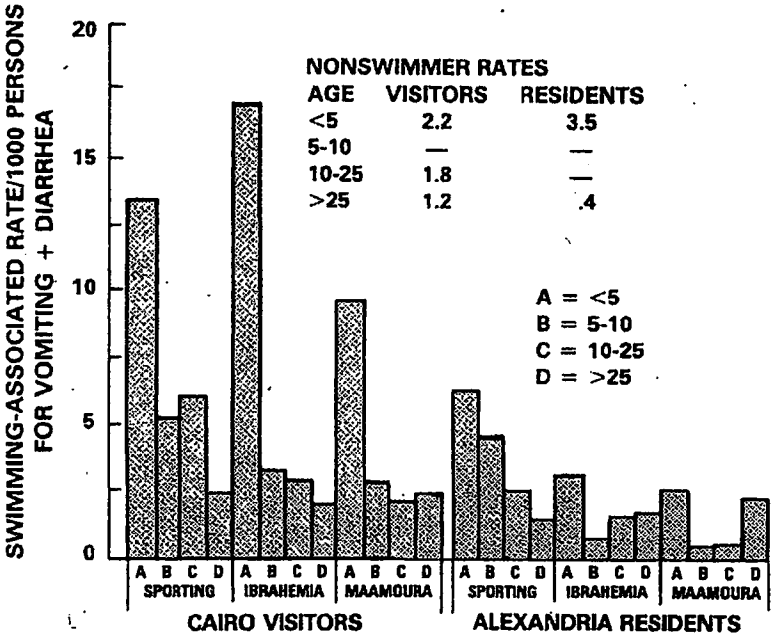


Figure 6. Age-specific, swimming-associated rates for vomiting or diarrhea by beach and study population for the 1977 Egyptian trials. The age-specific rates for the nonswimming Alexandria residents and Cairo visitors are shown as an insert.

Another finding that paralleled one obtained in the New York City study was that, with the exception of GI symptoms (vomiting or diarrhea) at the least polluted beach (Maamoura) and ear complaints at the other three beaches, the swimming-associated symptom rates per 1000 person-days decreased with increasing swimming activity. This can be seen from the analysis of the 1978 data from the Cairo visitors by the number of swimming days per week (Table A37).

Only three cases of jaundice were detected among the Cairo visitors, and there was no association to swimming, much less swimming in polluted waters. Four cases of typhoid

fever were found among swimmers at Sporting, the most heavily polluted beach. The regression lines for the swimming-associated rates for vomiting or diarrhea against the enterococcus and *E. coli* mean densities for the Alexandria residents and Cairo visitors are shown in Figures 4 and 5. The data from which the lines were drawn are given in Table A38. As expected, the slopes of the lines for the Cairo visitors were greater than those for the Alexandria residents. Straight lines could be fitted to these illness-indicator relationships for the data from both the Cairo visitors and the Alexandria residents. However, examination of the relationships for the individual years suggests that there are plateaus as shown.

The plateaus, the differences in the indicator-illness curves for the Cairo visitors as compared to the Alexandria residents, and the higher GI symptom rates for children as compared to adults support the premise that the swimming populations were largely immune to the etiological agent(s). Moreover, from the similarities in the symptomatology and age distributions of symptoms in the Egyptian and New York City studies and the differences in the slopes and intercepts on the Y axis of the indicator-illness curves, we recommend the second explanation for the relationships obtained in the New York City study. However, these predictions relate only to the specific agent(s) responsible for the observed GI symptomatology. Swimming-associated illness rates exceeding those predicted by the illness-indicator relationships obtained from the New York City and Egyptian studies could occur with etiologic agents to which there is little immunity in the population . Thus, an attack rate of 13 percent appeared to be associated with fecal coliform densities of about 17,500/100 ml in the Dubuque shigellosis outbreak (15).

In addition to providing insights into the widespread distribution of the swimming-associated, pollution-associated gastroenteritis, its etiology and the role of immunity, the results of the Egyptian study suggest the circumstances under which typhoid fever could become a problem via the recreational route, i.e., near an outfall for untreated sewage. This finding, along with the available ID_{50} data for these agents (22), suggests the importance of the removal of particulates during primary and secondary sewage treatment in preventing the recreational transmission of this disease and other diseases whose agents have high infective doses. The absence of swimming-associated infectious hepatitis in an area where the endemic rate is high would suggest that, by the time they start to swim, even the Cairo children have been exposed and are immune to infection with hepatitis A virus.

LAKE PONTCHARTRAIN STUDY

This study was conducted during the summers of 1977 and 1978 at Levee beach which is located near the "mouth" of Bayou St. John on Lake Pontchartrain. Individuals swam both in the mouth of the Bayou and in a nearby roped-off area. In 1978, a second beach (Fontainebleau) located across the Lake was also included. The setting for the study differed in a number of important ways from that for the New York City study; there is very little tidal activity; the water is brackish (about 5 percent) and warmer during the summer; there is no beach as such but rather a series of steps leading downward from the grassy bank into the water. Most important of all, the sources of pollution were much less defined. According to local authorities, there were no discharges of sewage wastes mto the Lake or Bayou St. John. However, high coliform densities were observed at the beach following rainfalls during "wet years." Presumably these were due to stormwater discharges reaching the beach via canals and bayous which empty into the Lake west of the beach.

Because of the ill-defined pollution sources, there was some reluctance to conduct a study at this location. However, the findings from sampling conducted in 1976 confirmed the high indicator densities following rainfalls and revealed moderate enterococcus densities during dry weather. Because of this, because of the desire to test the illness-indicator relationships under a different set of environmental conditions and

because this study could be a vehicle for separating the two indicators which emerged as the best ones from the New York City study, trials were conducted in the summer of 1977.

When the rates for the individual symptoms were compared for swimmers versus nonswimmers, statistically significant differences were obtained only for vomiting, diarrhea, stomachache, earache, and skin complaints (Table A39). When the symptoms were grouped into categories, significantly higher rates for swimmers were obtained only for GI and "highly credible" GI symptoms, although there were differences for all the categories (Table A40). In general the GI symptom rates were higher for children than adults (Table A41). There were, several striking aspects of the findings which suggested (i) that the major source of the infective agents was in the Bayou and not stormwater runoff arriving from west of the beach, (ii) that enterococcus densities were better correlated with the GI symptom rates, and (iii) that, because of this, the source of the pathogens was rather remote (in time) from the beach.

First of all, the mean enterococcus densities in the "mouth" of the Bayou were generally higher, and at times markedly so, than those at the beach (roped-off area); this was much less true of *E. coli* (Table A42). Secondly, in contrast the findings from the New York City and Egyptian studies wherein the *E. coli* and enterococcus densities tended to parallel each other, high *E. coli* densities were associated with low enterococcus levels and vice versa. The former occurred during the period 7/30-8/28 when the average daily rainfall exceeded 0.43 inches per day. The overall swimming-associated GI symptom rates for the trials conducted during this period were less than those for the trials conducted prior to July 30 when the average daily rainfall was 0.12 inches per day and the enterococcus densities exceeded those of *E. coli* (Table A43). Thirdly, the indicator densities in the roped-off area approached those in the Bayou only during the rainy period and then only for *E. coli* (Table A43). Moreover, the lower enterococcus densities and GI symptom rates during the "wet period" suggested that stormwater reaching the beach from the west reduced the pathogen and enterococcus densities at the beach by dilution or exclusion of organisms whose source presumably was in the Bayou. Fourthly, the trials during which there were high rates of swimming-associated GI symptoms corresponded better with high enterococcus than high *E. coli* densities (Table A44); in fact, when the swimming-associated GI and HCGI symptom rates for the four lowest *E. coli* days were compared to those for the four highest days, the former were higher than the latter.(Table A45). Finally, it has been reported (65) that enterococci survive better than *E. coli*, especially in salt water.

The input data to the criteria model are given in Table A44. The considerable trial-to-trial variability in the indicator densities required that, even for the regression analysis by summers, the trials be clustered according to their indicator densities. The findings from the 1978 trials differed from those obtained in 1977 in a number of ways, and some of the differences made the interpretation of the illness-indicator density data even more difficult: 1978 was a somewhat "drier" year than 1977, and, in general, the densities of both indicators were reduced. Nevertheless, the swimming-associated rate for GI symptoms was almost the same (39/1000 persons in 1978 as opposed to 42/1000 in 1977). This suggested that rainfall induced stormwater runoff to the beach (and the resulting elevated indicator densities) was not the source of the infective agents responsible for the observed symptomatology.

The rationale derived from the examination of the 1977 information was applied to the 1978 data as follows. It was assumed: (i) that, during a "relatively dry" year, the travel time down the Bayou was even more protracted, (ii) that because of this, even the enterococcus densities were reduced relative to the pathogens, and (iii) that these lower enterococcus densities would be masked at the beach and even at the Bayou by those carried in with the stormwater. Three trials were associated with especially high *E. coli* and enterococcus densities in which the levels at the beach were as high or higher than those in Bayou (Table A46). Because these were the same three days during which there was

a half-inch or more rainfall (Table A46), the data from these three trials were eliminated from the analysis. Since the premise was that the source of the infective agents was the Bayou and since the roped-off area was expected to be more heavily impacted by stormwater, the remaining trials were grouped into high and low. days based upon the Bayou indicator densities (Table A46), and these were used to calculate the mean indicator densities to which the symptomatology rates were compared. The mean indicator densities and associated GI and HCGI symptom rates as used later in the development of the criteria are given in Table A47.

The data from Fontainebleau beach, because of the relatively little trial-to-trial variability in the indicator densities, were used to derive a single relationship.

The 1978 data differed from the 1977 data in yet another way. In 1978 there were also statistically significant differences between swimmers and nonswimmers for the respiratory, other, EEN (ear, eye and nose) as well as disabling GI symptoms. This may have reflected a change in the pathogens present.

The Lake Pontchartrain study achieved its major objective. It, along with the third year of the New York City study, clearly showed enterococci to be superior to *E. coli* as a recreational water quality indicator. In addition, there were some important implications of the results obtained. First, they suggested some conditions under which even the enterococci may be deficient as a recreational water quality indicator. Second, they suggested that the etiological agent(s) of the swimming-associated gastroenteritis survives transport in the aquatic environment extremely well. Third, they provided a reasonably clear indication that stormwater runoff is less hazardous than wastewater discharges, and, because the two indicators are not specific for human fecal wastes, they may overstate the risk under these conditions.

BOSTON HARBOR STUDY

This study was conducted at two beaches in Boston Harbor in 1978. Its objective was to expand the data base for the criteria being developed and to confirm the observation that the measurable swimming-associated health effects were obtained at strikingly low indicator densities. As in the Lake Ponchartrain study, the sources of pollution to the two beaches, Revere and Nahant, were not as well defined as those in the New York City or Alexandria, Egypt studies. At the time it was screened for suitability in 1978, the mean enterococcus and *E. coli* densities at Revere beach were about 80/100 ml and exceeded those at Nahant by about an order of magnitude.

Four trials were conducted at each beach during June and July of 1978. The rates for the symptom categories are presented in Table A48. At both the Revere and Nahant beaches, the highest swimming-associated rates were for the total and HCGI symptoms, although the differences between the swimmer and nonswimmer rates were not significantly different. The differential rates were consistently greater at Revere than at Nahant beach, even though the mean indicator densities at the two beaches were not appreciably different (Table A49). This observation underscores the fact that the relationships being derived are generalities which may vary somewhat with a number of factors in the swimming population (i.e., their immune status, background illness rates, and even in the temporal and spacial relationship of the beach to its source of pollution). Nevertheless, the swimmer rates for GI symptoms were consistently higher than those for nonswimmers even at rather low levels of pollution as seen by the enterococcus or *E. coli* densities. The mean enterococcus and *E. coli* densities at Revere beach were less than those observed the previous year. These and the corresponding rates for GI and HCGI symptoms calculated by summer and by clusters of trials are given in Tables A49 and A50. The relationship of the swimming-associated rates to the indicator densities were more akin to those obtained at Lake Pontchartrain rather than New York City, i.e., higher rates for given indicator levels. This suggests differential biological decay of the indicators relative to the pathogens over more protracted transport times between the sources of pollution and the impacted beaches.

[This page is intentionally blank.]

SECTION 6
DEVELOPMENT OF CRITERIA

In order to reach the objective of the overall program, the development of health effects criteria for marine recreational waters, four questions needed to be answered. They were:

1. *Does swimming in sea water per se carry with it an increased risk of illness and, if so, to what type?*

Stevenson's findings (24) suggested that it is so for fresh, but not sea, waters Those from the EPA program indicated this was true of sea water swimming as well. In the Stevenson study, it was observed most with ear, eye and nose complaints, less so with upper respiratory symptoms and least with gastrointestinal symptomatology.

2. *Is there an association of the illness rates to pollution from domestic sewage; and if so, to what type of illness?*

Stevenson's results (24) suggested there is such an association for swimming in freshwater but not in seawater. His results were equivocal as to the type of symptom. Moore (8) could find no association for poliomyelitis or salmonellosis. The conclusion from the EPA program is unequivocal; there is an increased risk of gastroenteritis associated with swimming in waters more as opposed to less polluted with sewage. Furthermore, the increased risk occurs at beaches which meet and even exceed the existing EPA guidelines and those of most of the states. Both the Egyptian and American studies suggest that fever often accompanies the GI symptoms. There were no indications in any of the American studies that anyone required hospitalization.

With the Cairo visitors to the Alexandria beaches, no association between swimming and infectious hepatitis (IH) could be detected, even among individuals who swam in waters so heavily polluted that they were aesthetically undesirable. The assumption was that the children of the Cairo visitors, coming from better sanitary environments and swimming in waters receiving waste loads from a population with a high endemic rate of IH, would be the most susceptible portion of the swimming population. However, even these children may have been exposed and rendered immune to the agents by the age they start swimming (immersion of the head in the water). A different study population is needed to resolve this question.

It is of interest that four cases of typhoid fever did occur among swimmers at the heavily polluted, aesthetically undesirable beach. This was not statistically significant and may have been a spurious result. However, since the ID50 for salmonellae is high (22), and that for IH is thought to be fairly low, these results lend credence to the postulated immunity explanation for the absence of IH among swimmers. There was no indication of poliomyelitis in any of the studies. Thus, Moore's conclusions (8) with regard to poliomyelitis and salmonellosis remain as true today as they were then.

3. *Which, if any, of the potential indicators of water quality best defines the association of GI symptomatology to water quality?*

The New York City study was designed to answer this question for beaches impacted with the sewage effluents from large urban areas. The Coney Island beaches were affected primarily by sewage emerging from the mouth of the Hudson River, and

although these were combined effluents subject to the effect of rainfall, treated to various degrees, and chlorinated only in part, they nevertheless represented a relatively well defined source. The criterion used to select the "best" indicator was the degree of association between its levels in the bathing water and the swimming-associated rate for gastrointestinal symptoms. It was evident from the New York City study that enterococci and, to a *much lesser extent, E. coli* were the best indicators of those examined (Table 4). *Fecal coliforms were a relatively poor indicator system.*

The marked superiority of enterococci over *E. coli* as a recreational water quality indicator was confirmed in the subsequent studies conducted in the United States. Higher correlation coefficients (r) for the mean indicator densities in the water against the swimming-associated rates for total or highly credible GI symptoms were obtained with enterococci than with *E. coli* (Table 5). However, comparable correlation coefficients were obtained for the two indicators in the Egyptian studies (Table 5). One explanation for this difference lies in the nature and proximity of the pollution sources. The sources of fecal pollution to the Alexandria beaches were untreated, not disinfected, and relatively close to the beaches. A portion of those to the New York City beaches were both treated and disinfected, and they were more distant from the beaches. Furthermore, more of the sewage emerging from the Hudson River and Upper Hudson Bay was treated and/or disinfected in 1975 than in 1974. This appears to correspond with poorer correlations of the indicator densities to gastrointestinal symptomatology, especially for *E. coli* (compare the 1973-74 to 1973-75 "r" values in Table 5). Insofar as could be determined, there were no nearby sources of human fecal wastes to either the Lake Pontchartrain or Boston Harbor beaches.

Implicit to the above explanation is the conclusion that enterococci more closely resembles the pathogen(s) than does *E. coli* with regard to its survival characteristics during sewage treatment, disinfection, and transport in the marine environment. Furthermore, as the level of sewage treatment and disinfection increases and/or the transport time becomes more protracted, even the densities of the enterococcus indicator are not maintained comparable to those of the pathogen. This and other considerations to be discussed notwithstanding, the mean enterococcus density does provide a meaningful and useful index of the potential for the observed gastrointestinal symptomatology.

Four possible indicator Systems were not evaluated in the course of the New York City studies. As part of the EPA program, new methods have been developed or existing methods have been modified for each of the four indicators, *Candida albicans* (42), bifidobacteria (40), coprostanol (48) and male specific DNA, coliphage (41). Some preliminary evaluations were made with the first two. The densities of *C. albicans* were too low and variable in sewage-polluted waters to be of much value. Bifids were found to be fecal specific and reasonably human specific; however, their use as the basis for the criteria is precluded by their exceedingly poor survival during chlorination and transport in aquatic environments. Nevertheless, the recovery of these bacteria from environmental water samples indicates an "immediate" source of undisinfected human or, to a lesser extent, porcine fecal wastes (40). Coprostanol and the f-1 male specific coliphage need to be evaluated as water quality indicators and as conservative tracers.

4. *Can the relationship of swimming-associated health effects to the quality of the water, as determined by a microbial or chemical indicator, be quantified sufficiently to produce health effects quality criteria for marine recreational waters?*

The response to this question will be considered in the next section.

The Criteria

The regression lines for the rates of swimming-associated GI and HCGI symptoms against the mean enterococcus and *E. coli* densities when examined by trials clustered by indicator density or by summer are presented in Figure 7. The input data for the analyses

TABLE 5. CORRELATION COEFFICIENTS FOR ENTEROCOCCUS AND *E. coli* DENSITIES AGAINST THE GASTROINTESTINAL SYMPTOM RATES FOR UNITED STATES AND EGYPTIAN STUDIES

Symptom	Studies	Years	Correlation Coefficients (r) for trial clustered by: Indicator Densities[2]		Summers[3]	
			Enterococcus	*E. coli*	Enterococcus	*E. coli*
Gastrointestinal	New York City	1973-74	.90		.95	.96
	New York City	1973-75	.81	.94	.84	.56
	L. Point.-Boston Harbor[1]	1977-78	.84	.51	.86	.02
Highly Credible GI	All U.S.	1973-78	.82	.16	.86	.20
	New York City	1973-74	.98	.25	.96	.97
	New York City	1973-75	.96	.96	.75	.52
	L. Point.-Boston Harbor	1977-78	.62	.56	.74	.54
	All U.S.	1973-78	.75	.57	.72	.52
	Alex., Egypt (Resid.)[4]			.54	.69	.76
	Alex., Egypt (Visit.)[5]				.88	.87

[1] Lake Pontchartrain and Boston Harbor studies analyzed together.
[2] Trials clustered by similar indicator densities.
[3] Trials grouped by summers.
[4] Alexandria residents at Alexandria beaches.
[5] Cairo visitors to Alexandria beaches.

EPA-823-R-98-003

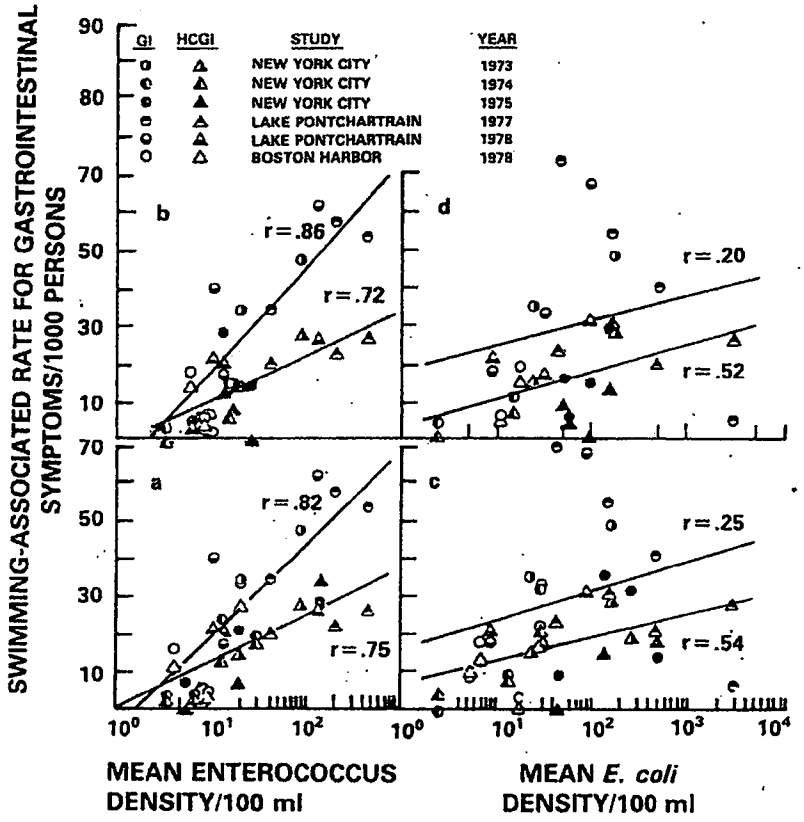


Figure 7. Swimming-associated rates for GI symptoms against the mean enterococcus and *E. coli* densities in the water. Data from all U.S. studies. Values for the points given in Tables 6-9. Definition of highly credible GI symptoms given in text, as is the rationale for clustering the trials. See Figure 2 for the meanings of a, b, c, and d. The actual trials clustered are shown in Tables A8 through A31, A44, A46, A47 and A50 in Appendix A.

are given in Tables 6-9 and the results of the regression analyses are given in Table 10. It is obvious that enterococcus densities in the bathing water provide the most meaningful and useful relationship to the observed GI symptomatology. The formulae for the two pairs of enterococcus regression lines, the correlation coefficients (r) for the lines, and the corresponding p values are given in Table 10 along with the equations obtained by averaging the slopes and intercepts of each pair of lines. The "fits" for quadratic equations were no better than those for linear equations. These lines are shown in Figure 8 along with the 95 percent confidence limits around the lines. These were obtained from the data for the clustered trials. The confidence limits of the predicted rates for the clustered trials are given in Table A51.

The Y and X regression lines, given in Table 10 for enterococcus and shown with their confidence limits in Figure 8, predict the illness rates for the indicator densities. However, as noted earlier in this report, the conceptual framework for the program was that a decision would be made as to the *acceptable* risk level and this would be

TABLE 6. SUMMARY OF THE MEAN ENTEROCOCCUS DENSITY—GASTROINTESTINAL SYMPTOM RATE RELATIONSHIPS OBTAINED FROM CLUSTERED TRIALS FOR ALL THE U.S. STUDIES (INPUTS TO THE REGRESSION ANALYSIS, FIGURE 7a, TABLE 10)

Study	Beach	Year	Enterococcus Density per 100 ml	N		Symptom Rates In Cases Per 1000					
						Total Gastrointestinal			Highly Credible GI		
				Swim	Nonswim	Swim	Nonswim	▲[1]	Swim	Nonswim	▲
NYC[2]	Rock[5]	1973[8]	21.8	484	197	81	46	35	30.4	15.2	15.2
	C. Is.[6]		91.2	474	167	72	24	48*	46.4	18.0	28.4
		1974	3.6	1391	711	27	23	4	7.6	4.2	3.4
			7.0	951	1009	38	34	4	10.5	6.9	3.6
			13.5	625	419	42	17	25*	16.0	2.4	13.6
			31.5	831	440	43	23	20	18.1	—	18.1*
		1975	5.7	2232	935	63	55	8	18.8	19.3	-0.5
			20.3	1896	678	59	37	22*	14.8	7.4	7.4
			154	579	191	60	31	29	34.5	—	34.5*
Lake Pont.[3]	Levee	1977	44	874	451	86	51	35*	32.0	11.1	20.9*
			224	720	456	108	50	58**	31.9	8.8	23.1*
			495	895	464	108	54	54**	35.8	8.6	27.2**
	Levee	1978	11.1	1230	415	75	34	41**	36.6	14.5	22.1*
	Font.[7]		14.4	248	303	81	63	18	44.3	23.1	21.2
	Levee		142	801	322	112	50	62**	42.4	15.5	26.9*
Boston H.[4]	Revere	1978	4.3	697	529	83	66	17	23	11	12
	Nahant		7.3	1130	1099	71	67	4	33	28	5
	Revere		12.0	222	376	108	74	34*	41	13	28*

[1] Difference (swimmer rate minus nonswimmer rate).
[2] New York City, NY.
[3] Lake Pontchartrain, LA.
[4] Boston Harbor.
[5] Rockaways.
[6] Coney Island.
[7] Fontainebleau.
[8] Study population too small to cluster trials by similar indicator densities.

*p<0.05; **p<0.01

3-235

TABLE 7. SUMMARY OF THE MEAN ENTEROCOCCUS DENSITY—GASTROINTESTINAL SYMPTOM RATE RELATIONSHIPS OBTAINED FROM TRIALS GROUPED BY BEACH AND YEAR FOR ALL U.S. STUDIES (INPUTS TO THE REGRESSION ANALYSIS, FIGURE 7b).

Study	Beach	Year	Enterococcus Density per 100 ml	N		Symptom Rates in Cases Per 1000 Study					
						Total Gastrointestinal			Highly Credible GI		
				Swim	Nonswim	Swim	Nonswim	▲[1]	Swim	Nonswim	▲
NYC[2]	Rock[5]	1973	21.8	484	197	81	46	35	30.4	15.2	15.2
	C. Is.[6]		91.2	474	167	72	24	48*	46.4	18.0	28.4
	Rock.	1974	3.5	2767	2156	39	35	4	12.0	12.0	0.0
	C. Is.		16.4	1961	1185	42	26	16*	16.0	9.3	6.7
	C. Is.(1)	1975	17.9	1534	590	70	54	16	21.2	12.6	8.6
	(2)		27.7	1744	623	57	42	15	21.8	22.5	−0.7
	(3)		6.7	1131	475	50	44	6	13.7	8.5	5.2
	(4)		14.2	298	96	60	31	29	23.5	10.4	13.1
Lake Pont.[3]	Levee[8]	1977	44	874	451	86	51	35*	32.0	11.1	20.9*
			224	720	456	108	50	58**	31.9	8.8	23.1*
			495	895	464	108	54	54**	35.8	8.6	27.2**
	Levee[8]	1978	11.1	1230	415	75	34	41**	36.6	14.5	22.1*
			142	801	322	112	50	62**	42.4	15.5	26.9*
	Font.[7]		14.4	248	303	81	63	18	44.3	23.1	21.2
Boston H.[4]	Revere	1978	6.3	919	905	89	70	19	27.0	12.0	15.0
	Nahant		7.3	1130	1099	70	64	6	33.0	28.0	5.0

[1-7] See Table 6 for abbreviations.
[8] Data from Levee Beach were only clustered by trials with similar indicator densities for reasons explained in text.
*p<0.05; **p<0.01

TABLE 9. SUMMARY OF THE MEAN *E. coli* DENSITY—GASTROINTESTINAL SYMPTOM RATE RELATIONSHIP OBTAINED FROM TRIALS GROUPED BY BEACH AND YEAR FOR ALL U.S. STUDIES (INPUTS TO THE REGRESSION ANALYSIS, FIGURE 7d)

Study	Beach	Year	*E. coli* Density per 100 ml	N		Symptom Rates in Cases Per 1000					
						Total Gastrointestinal			Highly Credible GI		
				Swim	Nonswim	Swim	Nonswim	▲[1]	Swim	Nonswim	▲
NYC[2]	Rock.[5]	1973	24.8	484	197	81	46	35	30.4	15.2	15.2
	C. Is.[6]		174.0	474	167	72	24	48*	46.4	18.0	28.4
	Rock.	1974	2.4	2767	2156	39	35	4	12.0	12.0	0
	C. Is.		15.3	1961	1185	42	26	16*	16.0	9.3	6.7
	C. Is.(1)	1975	52.4	1534	590	70	54	16	21.2	12.6	8.6
	(2)		98.6	1744	623	57	42	15	21.8	22.5	−0.7
	(3)		61.3	1131	475	50	44	6	13.7	8.5	5.2
	(4)		157	298	96	60	31	29	23.5	10.4	13.1
Lake Pont.[3]	Levee[8]	1977	44	372	222	132	45	87**	32.3	9.0	23.3
			161	910	306	120	65	55**	52.7	22.8	29.9*
			497	574	307	85	45	40*	32.9	13.0	19.8
			3091	419	204	88	83	5	31.0	4.9	26.1
	Font.[7]	1978	9.0	248	303	81	63	18	44.3	23.1	21.2
	Levee[8]		32.6	1123	382	78	44	34*	38.3	20.9	17.4
			93.7	918	355	103	36	67**	39.2	8.5	30.7*
Boston H.[4]	Revere	1978	18.0	919	905	89	70	19	27.0	12.0	15.0
	Nahant		11.5	1130	1099	70	64	6	33.0	28.0	5.0

[1-R] See Table 7 for abbreviations and notations.
*p≤0.05; **p≤0.01

3-237

TABLE 8. SUMMARY OF THE MEAN *E. coli* DENSITY—GASTROINTESTINAL SYMPTOM RATE RELATIONSHIP OBTAINED FROM CLUSTERED TRIALS FOR ALL THE U.S. STUDIES (INPUTS TO THE REGRESSION ANALYSIS FIGURE 7c)

Study	Beach	Year	*E. coli* Density per 100 ml	N		Symptom Rates in Cases Per 1000					
						Total Gastrointestinal			Highly Credible GI		
				Swim	Nonswim	Swim	Nonswim	▲[1]	Swim	Nonswim	▲
NYC[2]	Rock.[5]	1973[8]	24.8	484	197	81	46	35	30.4	15.2	15.2
	C. Is.[6]		174.0	474	167	72	24	48*	46.4	18.0	28.4
		1974	2.2	2514	1641	25	34	−9	8.0	3.7	4.3
			13.3	1304	1045	38	29	9	14.1	5.7	8.4*
			30.5	600	425	65	33	32*	23.3	2.4	20.9
		1975	46.8	1945	1099	55	51	4	13.4	17.8	−4.4
			142	775	194	76	41	35	24.5	10.3	14.2
			278	1049	330	55	24	31*	21.0	3.0	18.0*
			514	937	271	68	55	13	24.5	7.4	17.1
Lake Pont.[3]	Levee	1977	44	372	222	132	45	87**	32.3	9.0	23.3
			161	910	306	120	65	55**	52.7	22.8	29.9*
			497	574	307	85	45	40*	32.8	13.0	19.8
			3091	419	204	88	83	5	31.0	4.9	26.1
	Font.[7]	1978	9.0	248	303	81	63	18	44.3	23.1	21.2
	Levee		32.6	1123	382	78	44	34*	38.3	20.9	17.4
			93.7	918	355	103	36	67**	39.2	8.5	30.7
Boston H.[4]		1978	5.5	541	874	72	63	9	39	29	10
			7.0	477	410	86	68	18	23	10	13
			17.5	589	225	70	67	3	27	27	0
			29.5	442	495	93	71	22	32	14	18

[1-8] See Table 6 for abbreviations.

*p<0.05; **p<0.01

a mean indicator density limit to be used as a guideline. This requires the regression of X on Y. These lines along with their confidence limits, correlation coefficients and formulae are given in Figure 9. The 95 percent confidence limits for the mean enterococcus densities predicted for the observed swimming-associated rates are given in Table A52. The author favors the use of the criteria for HCGI symptoms because of the greater credibility of its data base and because it is more conducive to economic analysis. The 95 percent confidence limits for the regression lines as shown (Figure 9) are rather broad although the slopes are significantly different from zero. This was not unexpected since the relationships obtained are generalizations which may be altered by any of a number of temporal and spacial factors relative to the indicator, the pathogen, the relationship of the pollution sources to the bathing beach, the levels of the specific illnesses in the overall population, and the immune status of the swimmers. These will be discussed in the next two sections

Examination of the illness-indicator relationships by location and by year at a given location could provide some insight as to possible spatial and temporal effects. The latter was not attempted because of the small number of points available for analysis by year. The regression lines for the New York City study were compared to those obtained from

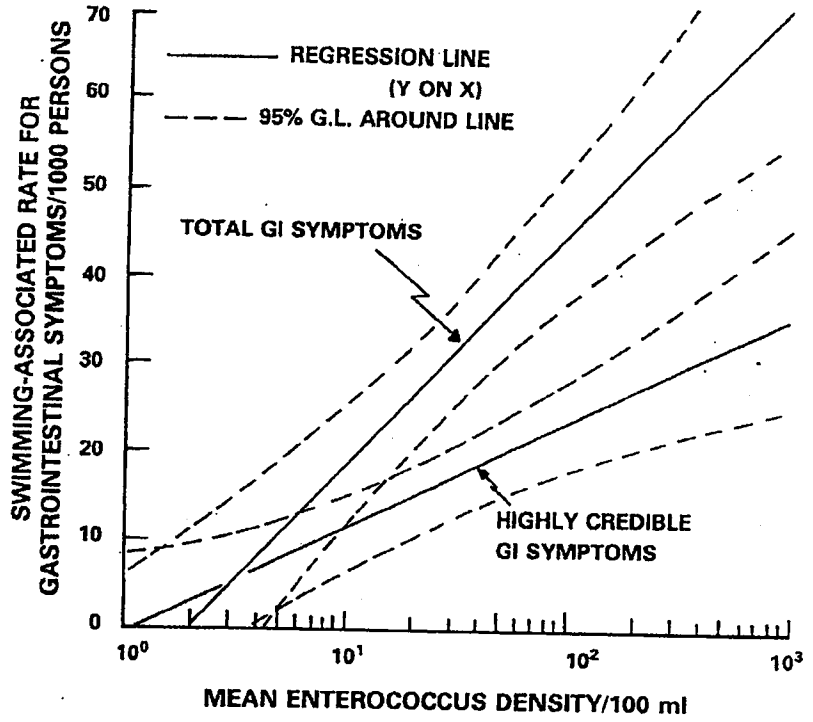


Figure 8. Regression lines for swimming-associated GI symptom rates (Y) against the mean enterococcus densities in water (X). Lines drawn from averages of slopes and intercepts from Figures 7a and 7b. Confidence limits are those for the regression lines shown in Figure 7a. Representation predicts the illness rates from the indicator densities and presents the 95% confidence limits of the former.

3-240

TABLE 10. REGRESSION FORMULAE AND CORRELATION COEFFICIENTS FOR SWIMMING-ASSOCIATED GI SYMPTOMS AGAINST ENTEROCOCCUS DENSITIES AND AGAINST *E. coli* DENSITIES IN THE BATHING WATERS (ALL U.S. STUDIES)

Indicator	Analysis by	N	Gastrointestinal Symptoms				HCGI Symptoms[1]			
			Slope	Intercept	r	p	Slope	Intercept	r	p
Enterococcus	Trials	18	24.19	−5.09	.82	<.001	12.17	0.20	.75	<.001
	Summers	16	27.37	−9.52	.86	<.001	11.53	−1.38	.72	<.005
Average			25.78	−7.31			11.85	−0.58		
E. coli	Trials	20	7.37	15.73	.25		6.30	5.88	.54	
	Summers	17	6.63	17.72	.20		7.30	2.79	.52	

[1] Highly credible gastrointestinal symptoms

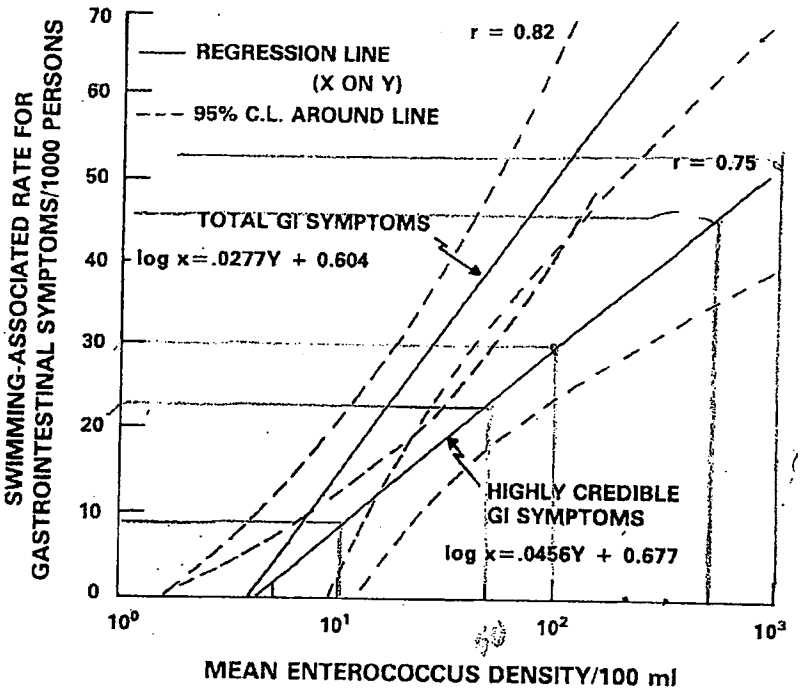


Figure 9. Health effects criteria for marine recreational waters developed by the USEPA epidemiological-microbiological program. Criteria are X on Y regression lines of the mean enterococcus density in the water against the swimming-associated rate of gastrointestinal symptoms. Lines drawn in the same manner as those shown in Figure 8. The 95% confidence limits around the lines are those for data given in Table 6.

the combination of the Lake Pontchartrain and the Boston Harbor studies; however, even for the trials clustered by similar indicator densities (Table 6), each line was defined by only nine points. Significant differences were obtained between the lines for highly credible but not total GI symptoms. The lines for total GI symptoms were not significantly different; however, those for HCGI symptoms were, although the two lines stay virtually within the 95 percent confidence limits of the total data. This provides some basis for the generalization obtained from the single regression line. This generalization may not be totally accurate in all situations. Thus, in the present case, the sources of pollution to the beaches in the Lake Pontchartrain and Boston Harbor studies were ill-defined and, presumably, more distant. This and the effect of the immune status of the swimming population could explain the significant differences between the regression lines for highly credible but not total GI symptoms. In any event, these results emphasize the conclusion that guidelines derived from these criteria cannot be used without judgment; rather, they must be used in concert with good public health practice (e.g., taking into consideration changes in the incidence of enteric disease in the discharging population), an environmental (sanitary) survey, and judgment with regard to their limitations in time and space. In fact, the correlations obtained are remarkably

good when the sources of temporal and geographic variability are considered, and this has some interesting implications concerning the agent(s) and host population, i.e., ubiquity, infectivity, survival, immunity, etc.

THE ETIOLOGIC AGENT(S)

When the study design for the EPA program was being developed in 1969-1970, it was thought that swimming in sewage-polluted waters would constitute a relatively minor route of transmission for GI illness and that relatively high levels of pollution (as indexed by microbial indicator densities) would be required before GI illness could be detected. These assumptions were made on the basis of existing notions and available information (8,24). Both these assumptions were incorrect. If the nonswimming rates for GI symptomatology can be considered as those for the population at large, then swimming in sewage-polluted waters constitutes a significant route of transmission for the illnesses obtained, at least for individuals of "swimming age." This can be seen from the tabular (Table II) and graphic (Figure 10) representations of the ratios of the rates for

TABLE 11. RATIO OF SWIMMER TO NONSWIMMER GASTROINTESTINAL SYMPTOM RATES BY ENTEROCOCCUS DENSITY[1]

Enterococcus	Swim/Nonswim GI Symptom Rate	
Density/100 ml	Total Gastrointestinal	Highly Credible GI
3.6	1.17	1.81
4.3	1.26	2.09
5.7	1.15	0.97
7.0	1.12	1.52
7.3	1.06	1.18
11.1	2.21	2.52
12.0	1.46	3.15
13.5	2.47	6.67[2]
14.4	1.29	1.92
20.3	1.59	2.00
21.8	1.76	2.00
31.5	1.87	I[3]
44.0	1.69	2.89
91.2	3.00	2.58
142.0	2.24	2.74
154.0	1.94	I[3]
224.0	2.16	3.63
495.0	2.00	4.13

[1] Data taken from Table 6.
[2] Due to unusually low nonswimmer rate.
[3] Indeterminate because of no cases among nonswimmers.

swimmers divided by those for nonswimmers against the enterococcus densities for the clustered trials. In fact, at enterococcus densities of 70 and 10/100 ml, respectively, the rates for total and HCGI symptoms among swimmers were twice those for nonswimmers, and they are projected to be equal (a ratio of "I") at an enterococcus density of about 1/100 ml. This suggests that the etiologic agent(s) for the observed GI symptomatology is present in sewage in large numbers, that it is highly infective and/or that it survives sewage treatment, disinfection and/or transport better than the indicator.

C enterococcus = 1
swim = nonswim

One of the desired outputs from the program was an answer to the question: Does the swimming-associated illness rate increase with the levels of these specific illnesses in the population at large? This relationship was not observed for the types of illnesses obtained in this study (Table 12), probably because of the high level of immunity to the agent in the population.

Initially, it was thought that the Egyptian data could be used in the derivation of the final criteria. By the end of the first year of the Egyptian study, it was obvious that the data from the Alexandria residents could not be so used, and by the end of the third year, it was concluded that this was also true of data from the Cairo visitors. The regression lines for the rates of swimming-associated vomiting and diarrhea from these two groups along with those for GI and HCGI symptoms from the United States studies against the corresponding mean enterococcus densities are presented in Figure 11. It can be seen that, in the United States studies, gastrointestinal illness rates comparable to those obtained in the Egyptian study were associated with bathing in waters with much lower enterococcus densities. Part of the dissimilarity is probably due to differences in the nature (raw vs. treated) and proximity of the pollution sources in the United States and Egyptian studies. However, disparities in the immune state of the populations to the etiologic agent(s) probably accounts for most of the differences in the indicator-illness relationships obtained.

The importance of immunity in the epidemiology of the swimming-associated gastroenteritis is also supported by the age distribution of the attack rates. In most of the studies, children (<10 years of age) were found to have the highest symptom rates.

The following characteristics of the swimming-associated illness were obtained in or can be inferred from the findings of the EPA program: (i) The illness is a relatively benign gastroenteritis with a short incubation period (Figure 12), acute onset, short

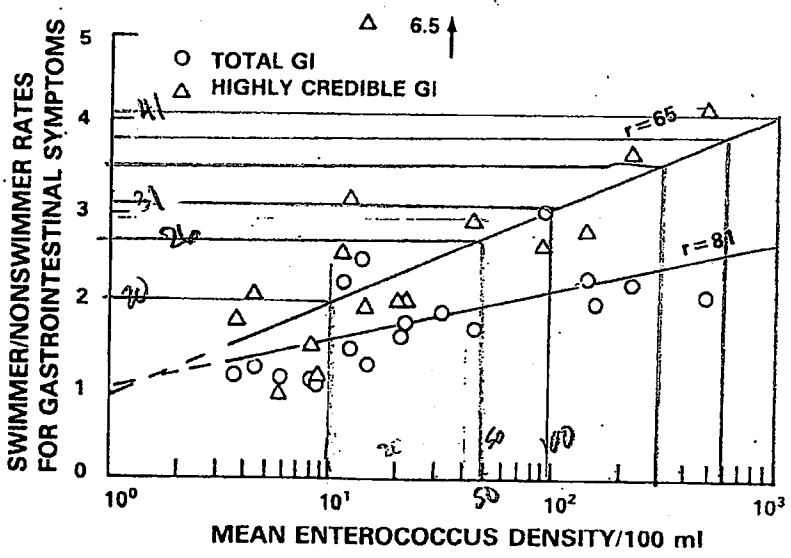


Figure 10. Ratios of swimmer to nonswimmer rates of gastrointestinal symptoms against the mean enterococcus density in the water. Data from Table 6. One value not used in the calculations.

TABLE 12. RELATIONSHIP OF SWIMMING-ASSOCIATED (▲) TO BACKGROUND (NONSWIM) RATES FOR GASTROINTESTINAL SYMPTOMS

Enterococcus Density[1]	Rates Per 1000 Persons: Total GI Nonswim	Total GI ▲	Highly Credible GI Nonswim	Highly Credible GI ▲
3.6-7.0	23	4	4.2	3.4
	34	4	6.9	3.6
	55	8	19.3	−0.5
	66	17	23.0	11.0
	67	4	28.0	5.0
11.1-21.8	17	25	2.4	13.6
	34	41	13.0	28.0
	37	22	14.5	22.1
	46	35	14.8	7.4
	63	18	15.2	15.2
	74	34	23.1	22.1
91.5-154	24	48	15.5	26.9
	31	29	18.0	28.0
	50	62	—[2]	34.5

[1] Values ordered according to the nonswimming rate within a density cluster. Only clusters of 3 or more reasonably close values used.
[2] Nonswimming rate "0."

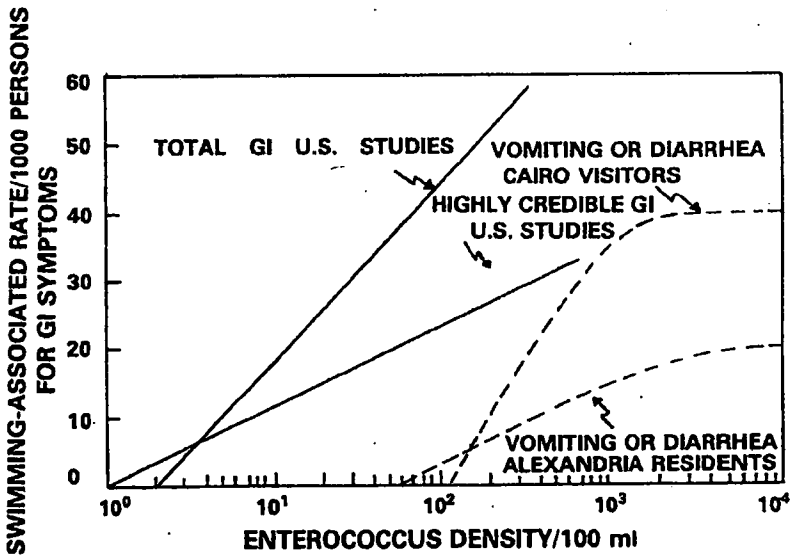


Figure 11. Comparison of the illness-indicator relationship obtained from the U.S. studies with those for the Cairo visitors and Alexandria residents in the Egyptian studies. Those for the U.S. populations taken from Figure 7 and those for the Egyptian study from Figure 4.

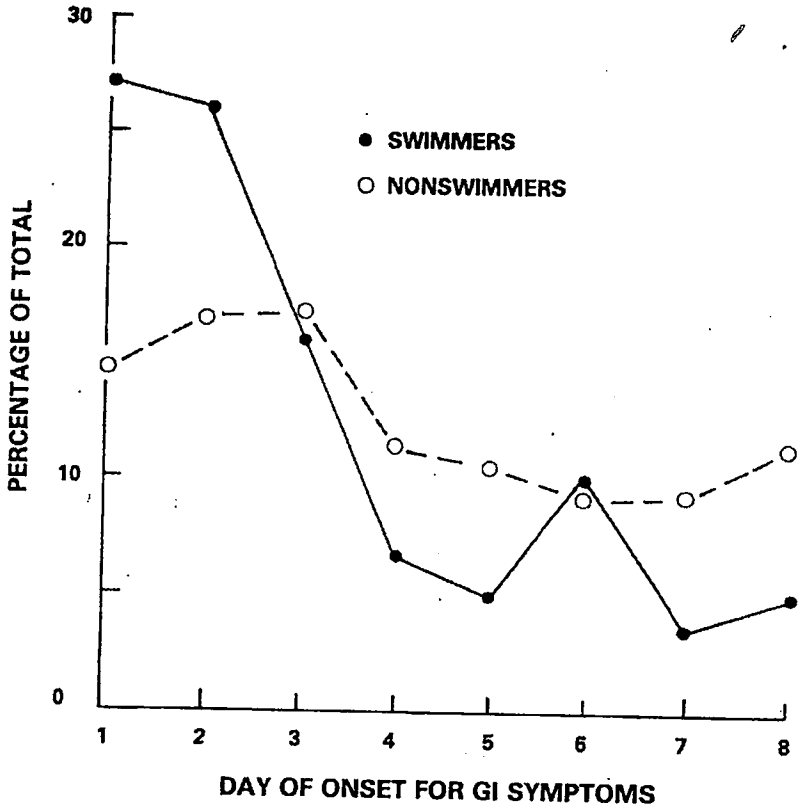


Figure 12. Day of onset of GI symptoms as obtained from the 1975 New York City trials.

duration (Table 13) and rare, if any, sequelae. (ii) It is widely distributed; most individuals are immune, and, in general, children have the highest attack rates. (iii) The etiologic agent is highly infectious, is present in sewage in large numbers, and/or survives sewage treatment disinfection and transport in the marine environment somewhat better than the indicators. These considerations suggest the human rotavirus and/or the parvo-like viruses as. the etiologic agents.

There are at least three explanations for the observations that individuals who swim during several days in a given week (from the Egyptian study) or for prolonged periods during a given day (from the New York City study) have low GI symptom rates. The obvious one is that these are "healthier" individuals. The second assumes that the extent of swimming is correlated with age, that is, individuals who swim regularly and extensively are more experienced and ingest less of the bathing water. However, it is commonly assumed that children are in the water the longest and also ingest the most water. The third explanation requires that the illnesses involved have short (< 3 days) incubation periods and that there may be a good immunity to the etiological agents The rationale for the Egyptian observations is that the susceptible individuals become ill within a day or so of the time they start swimming.

TABLE 13. DURATION OF GASTROINTESTINAL SYMPTOMATOLOGY: NEW YORK CITY, 1975 TRIALS

Symptom	Duration of Symptoms in Days for Swimmers		Nonswimmers	
	Number Reporting	Average Duration	Number Reporting	Average Duration
Total				
Vomiting	30	2.8	10	2.6
Diarrhea	73	2.6	26	2.7
Stomachache	101	2.7	36	2.4
Nausea	64	2.7	18	2.8
Disabling				
Vomiting	17	3.7	5	2.6
Diarrhea	22	3.0	11	3.2
Stomachache	36	3.5	12	3.0
Nausea	24	2.6	8	3.2

SECTION 7
LIMITATIONS IN THE USE OF THE RECOMMENDED CRITERIA

The criteria presented in this report (the enterococcus density in the bathing water against the swimming-associated rates for total and HCGI symptoms) are generalizations which have been found to apply in a number of situations. Nevertheless, a number of considerations, including the limitations in the indicator concept itself, impact on the use of the criteria as well as the guidelines and standards derived therefrom. More important, these considerations require that the findings from monitoring programs be interpreted in the light of good public health and environmental practice. They have been described elsewhere (49, 66) and several of the more important ones will be considered herein.

SMALL POINT SOURCES

The rationale for the use of guidelines and standards based on fecal indicator densities for indexing the health hazards in sewage polluted waters is that, under average conditions of illness in the discharging population, there is a reasonably constant indicator to pathogen ratio in the sewage and its receiving waters. Thereby, an acceptable probability of illness caused by the pathogen can be extrapolated to a given indicator density, which is then recommended as a guideline and promulgated as a standard. Such relationships appear to hold for waters receiving the discharges from relatively large municipal sewage treatment facilities. However, as the number of individuals who contribute to the source of the fecal wastes becomes smaller and smaller, the indicator-pathogen ratio will vary more and more from the average upon which the guideline or standard is based. In the extreme case where the fecal wastes of a single ill individual or carrier are discharged into the water, the number of pathogens may equal or exceed the number of indicator microorganisms. Routine examination of such waters for fecal indicators would be of no value. Furthermore, the routine examination for the pathogens would not be especially useful since the release of enteric pathogens will be sporadic. The solution is administrative action prohibiting such discharges into recreational waters.

ILLNESS RATES IN THE DISCHARGING POPULATION

Most epidemiologists and health officers recognize that, under epidemic conditions, the actual indicator-pathogen ratio may change sufficiently from that upon which a guideline was based so that the acceptable risk of illness will be exceeded unless the guideline is temporarily made more restrictive. The recent swimming-associated outbreak of shigellosis on the Mississippi River below Dubuque, Iowa (15) appears to represent an instance where, although the 200/100 ml fecal coliform guideline was probably exceeded, the outbreak did not occur until there was a large enough number of ill individuals and carriers in the discharging population. Conversely, if there is a significant and consistent decrease in the illness rate in the discharging population over a prolonged period of time, the rate for that specific illness associated with an existing indicator guideline or standard may be considerably less than predicted. The absence of recreational water-associated salmonellosis probably represents a case in point.

FECAL INDICATORS VERSUS PATHOGENS

The use of fecal indicators such as coliforms or portions of the coliform population, fecal streptococci, and *C. perfringens* for indexing the health hazards in drinking and recreational waters dates back to the late 1800s and early 1900s (32). This occurred shortly after these organisms were first isolated and associated with the fecal wastes of warm-blooded animals. Within the context of the limitations being discussed, such practices were and are sound both on theoretical and practical grounds since it is recognized that (i) there are large number of pathogenic bacteria and viruses potentially present in municipal sewage (67,68), each with its own probability of illness associated with a given dose; (ii) monitoring for each of the pathogens on a routine basis would be a herculean task; (iii) enumeration methods for some of the more important pathogens are unavailable and for the rest are difficult; (iv) pathogen density data are difficult to interpret because the methodology generally is imprecise and inaccurate and because of the meager dose-response data available; and (v) on theoretical grounds, the intent is not to index the presence of the pathogen but rather its potential to be there in sufficient numbers to cause unacceptable health effects.

By no means should the foregoing be construed as suggesting that recreational water quality criteria and the derived guidelines are unnecessary. To the contrary, criteria amenable to risk analysis are absolutely essential. It is evident from the nature of the illness indicator (Y on X) lines and the heavy usage of estuarine and coastal beaches in the United States that large numbers of individuals are becoming ill as a consequence of swimming in sewage-polluted waters. Furthermore, as seen from the Dubuque outbreak (15), the potential for more serious illness exists. Nevertheless, since the illnesses involved are relatively benign, there is undoubtedly a rate which is acceptable; however, *the acceptances of the risks involved should be deliberate decisions with consideration of all the factors involved and with local input.*

A temporary consequence of the application of the criteria may be the withdrawal of certain recreational resources from public use. However, the long range impact should be pollution abatement. This requires better technology for obtaining the data base needed for the translation of the target area criteria which have been developed into effluent guidelines on a case-by-case basis.

The findings from the EPA program have raised a number of questions. One is the nature of the etiologic agent for the gastrointestinal symptomatology. A second is the need for a more human fecal specific and environmentally resistant indicator. This relates to the difficult question of stormwater runoff and nonpoint sources. The third is need for separate criteria for fresh waters. Studies in progress which address these questions should be continued.

REFERENCES

1. Campolini, E. 1921. A Study of Typhoid Fever Incidence in the Health Center District of New Haven. Unpublished Report.
2. Scott, W. J.1951. Sanitary Study of Shore Bathing Waters. Bull. Hyg. 33:353.
3. National Technical Advisory Committee. 1968. Water Quality Criteria. Federal Water Poll. Control Adm. Dept. of the Interior. Washington, DC, p. 7.
4. Streeter, H. W. 1951. Bacterial Quality Objectives for the Ohio River. A Guide for the Evaluation of Sanitary Condition of Waters Used for Potable Supplies and Recreational Uses. Ohio River Valley Water Sanitation Commission. Cincinnati, OH.
5. Cox, C. R. 1951. Acceptable Standards for Natural Waters Used.fbr Bathing. Proc. Amer. Soc. Civ. Eng. 77:74.
6. U.S. Environmental Protection Agency. Quality Criteria for Water. U.S.E.P.A., Washington, DC. 1976.
7. Henderson, J. M. 1968. Enteric Disease Criteria for Recreational Waters. J. San. Eng. Div. 94:1253.
8. Moore, B. 1959. Sewage Contamination of Coastal Bathing Waters in England and Wales: A Bacteriological and Epidemiological Study. J. Hyg. 57:435.
9. Garber, W. F. 1956. Bacteriological Standards for Bathing Waters. Sewage & Indust. Wastes. 28:789.
10. Committee on Water Quality Criteria, National Academy of Sciences National Academy of Engineering. Water Quality Criteria. U.S. Environmental Protection Agency EPA-R3-73-033, 1972. Washington, DC.
11. Cabelli, V.1.1978. Swimming-Associated Disease Outbreaks. Jour. Water Poll. Control Fed. 50:1374.
12. Center for Disease Control. Typhoid Fever at Covington State Park, Louisiana. In: Salmonella Surveillance CDC No.18, Nov., 1963.
13. Center for Disease Control. Epidemiologic Notes and Reports. Typhoid Fever-Alabama. Morbidity and Mortality Weekly Reports. USDHEW/PHS Vol.21, No.32, 12 August, 1972, p.280.
14. Flynn, M. J., and D. K. B. Thistlewayte. 1964. Sewage Pollution and Sea Bathing. Second Int'l. Conf. on Water Pollution Res.
15. Rosenberg, M. L., K. K. Hazlet, J. Schaefer, J. G. Wells, and R. C. Pruneda. 1976. Shigellosis from Swimming. JAMA 236:1849.
16. Denis, F. A., E. Blanchouin; A. Delignieres, and P. Flamen. 1974. Coxsackie A_{16} Infection from Lake Water. JAMA 228:1370.
17. Hawley, H. B., D. P. Morin, M. E. Geraghty, 3. Torakow, and C. A. Phillips. 1973. Coxsackie Virus B Epidemic at a Boys' Summer Camp. JAMA 226:33.
18. Bryan, J. A., J. D. Lehmann, I. F. Setiady, and M. H. Hatch. 1974. An Outbreak of Hepatitis A Associated with Recreational Lake Water. Amer. J. Epidemiol. 99:145.
19. Center for Disease Control. Gastroenteritis Associated with Lake Swimming-Michigan. Morbidity and Mortality Weekly Reports. USDHEWI PHS Vol.28 No.35, 7 September, 1979.p. 413.
20. Mosley, J. W. 1965. Transmission of Viral Diseases by Drinking Water. In: Transmission of Viruses by the Water Route. Ed. G. Berg, Wiley, New York. p.5.

REFERENCES (Continued)

21. Wahdan, M. H. Alexandria, Egypt Study. In: International Symposium on Health Effects of Liquid Waste Disposal, June 4-7, 1979. Alexandria, Egypt. High Institute of Public Health, Alexandria University. In press.
22. Hornick, R. B., S. E. Graisman, T. E. Woodward, H. L. Dupont, A. T. Dawkins, and M. J. Snyder. 1970. Typhoid Fever: Pathogenesis and Immunologic Control. New Eng. J. Med. 283:686.
23. Dupont, H. L., R. B. Hornick, A. T. Dawlcins, M. J. Snyder, and S. B. Formal. 1969. The Response of Man to Virulent *Shigella flexneri* 2a. J. Infect. Dis. 119:1969.
24. Stevenson, A. H. 1953. Studies of Bathing Water Quality and Health. J. Amer. Public Hlth. Assoc. 43:529.
25. Shuval, H. I. The Case for Microbial Standards for, Bathing Beaches. In: Discharge of Sewage from Sea Outfalls. Ed. H. Gameson. Pergamon, London. 1975. p.95.
26. Kehr, R. W. and C. T. Butterfield. 1943. Notes on the Relation Between Coliforms and Enteric Pathogens. Public Health Rpts. 58:589.
27. Kehr, R. W., B. S. Levine, C. T. Butterfield and A. P. Miller. 1941. A Report on the Public Health Aspects of Clammming in Raritan Bay. Public Health Service Report. Reissued in 1954 by Division of Sanitary Engineering Services USPHS.
28. Mechalas, B. J., K. K. Hekimian, L. A. Scbinazi, and R. H. Dudley. An Investigation into Recreational Water Quality. Water Quality Criteria Data Book. Vol.4. 18040 DAZ 04/72 Environmental Protection Agency, Washington, DC. 1972.
29. Geldreich, E. B. 1970. Applying Bacteriological Parameters to Recreational Water Quality. JAWWA 62:113.
30. Cabelli, V.3.1976. Indicators of Recreational Water Quality. In: Bacterial Indicators/Health Hazards Associated with Water. Eds. A. W. Hoadley and B. J. Dutka. ASTM, Philadelphia, p.222.
31. Melnick, J. L. 1976. Viruses in Water. In Viruses in Water: Ed. G. Berg, H. L. Bodily, E. H. Lennette, J. L. Melnick and T. G. Metcalf, American Public Health Assn., Washington, DC. p.5.
32. Prescott, S.C., C. A. Winslow, and M. McCrady. 1945. Water Bacteriology, 6th Ed. Wiley, New York.
33. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 14th Ed. Amer. Public Health Assoc., Washington, DC. 1976.
34. Department of Health and Social Security, Government of Great Britain. The Bacteriological Examination of Water Supplies, Reports on Public Health and Medical Subjects No.71 Appendix I. London: Her Majesty's Stationary Office, 1969, 4th Ed.
35. Dufour, A. P., and V.J. Cabelli. 1975. Membrane Filter Procedure for Enumerating the Component Genera of the Coliform Group in Seawater. Appl. Microbiol. 29:826.
36. Dufour, A. P., E. R. Strickland, and V. 3. Cabelli. A Procedure for Enumerating Thermotolerant *E. coli* in Surface Waters. Proc. 9th National Shellfish Sanitation Workshop. June, 1975.
37. Dufour, A. P., and L. B. Lupo. A Membrane Filter Method for Enumerating *Klebsiella* Species. Abst. Ann. Meet. Am. Soc. Mjcrobiol. 1977. p.262
38. Levin, M. A., J. R. Fischer, and V.3. Cabelli. 1975. Membrane Filter Technique for Enumeration of Enterococci in Marine Waters. Appl. Microbiol. 30:66.
39. Bisson, J. W., and V.J. Cabelli. 1979. Membrane Filter Enumeration Method for *Clostridium perfringens*. Appl. and Environ. Microbiol. 37:55.
40. Resnick, G., and M. A. Levin. Enumeration of *Bifidobacterium* in Aquatic and Fecal Samples. Abstr. Ann. Meet. Am. Soc. Microbiol. 1977. p.261.

REFERENCES (Continued)

41. McBride, G. A Bacteriophage Simulant for Enteric Virus Behavior in Water Systems. M. S. Thesis, Univeristy of Rhode Island, Kingston. 1979.
42. Buck, J. D., and P. M. Bubucis. 1978. Membrane Filter Procedure for Enumeration of *Candida albicans* in Natural Waters. Appl. Environ. Microbiol. 35:237.
43. Levin, M. A., and V.J. Cabelli. 1972. Membrane Filter Technique for Enumeration of *Pseudomonas aeruginosa.* Applied Microbiol. 24:864.
44. Rippey, S. R., and V.J. Cabelli. 1979. Membrane Filter Procedure for Enumeration of *Aeromonas hydrophila.* Appl. Environ. Microbiol. 38:108.
45. Watkins, W. D., C. D. Thomas, and V.J. Cabelli. 1976. Membrane Filter Procedure for Enumeration of *Vibrio parahaemolyticus* Appi. Environ. Microbiol. 32:679.
46. Levin, M. A., 3. R. Fischer, and V.J. Cabelli. 1974. Quantitative Large-Volume Sampling Technique. Appl. Microbiol. 28:515.
47. Calderon, R., and M. A. Levin. 1980. Quantitative Method for tne Enumeration of Enteropathogenic *Escherichia coli.* J. Clin. Microbiol. 13:130.
48. Wun, C. W., R. W. Walker, and W. Litsky. 1976. The Use of XAD-2 Resin for the Analysis of Coprostanol in Water. Water Res. 10:995.
49. Cabelli, V.J. Evaluation of Recreational Water Quality, the EPA Approach. In: Biological Indicators of Water Quality. Eds. S. James and L. Evison, Wiley, London. 1979. p.14-1.
50. Dufour, A. P. *E. coli*: The Fecal Coliform. In: Bacterial Indicators/Health Hazards Associated with Water. Eds. A. W. Hoadley and B. J. Dutka. ASTM, Philadelphia, 1976. p.48.
51. Miescier, J.J. The Occurrence and Variability of Bacterial Indicator Organisms in Raw and Treated Sewage. M. S. Thesis, Univ. of Rhode Island, Kingston. 1977.
52. Vlassoff, L. T. *Kiebsiella.* In: Bacterial Indicators/Health Hazards Associated with Water. Ed. A. W. Hoadley and B. J. Dutka. ASTM. Philadelphia, 1977.1). 275.
53. Seidler, R. J., J. E. Morrow, and S. T. Bagley. 1977. *Klebsielleae* in Drinking Water Emanating from Redwood Tanks. Appi. Environ. Microbiol. 33:893.
54. Cabelli, V.J., and L. J. McCabe. 1974. Recreational Water Quality Criteria. News of Environmental Research in Cincinnati.
55. McCabe, L. J. Epidemiological Consideration in the Application of Indicator Bacteria in North America. In: Bacterial Indicators/Health Hazards Associated with Water. Ed. A. W. Hoadley and B. J. Dutka. ASTM, Philadelphia, 1977. p.15.
56. Verber, J.L. 1972. Shellfish-Borne Disease Outbreaks. Internal report. Northeast Technical Service Unit, U.S. Food and Drug Admin., Davisville, Rhode Island.
57. American Public Health Association, Standard Methods for the Examination of Water and Wastewater, 13th Ed. Amer. Public Health Assoc., Washington, DC. 1971.
58. Cabelli, V.J., M. A. Levin, A. P. Dufour, and L. J. McCabe. The Development of Criteria for Recreational Waters. In: International Symposium bn Discharge of Sewage for Sea Outfalls. Ed. H. Gameson, Pergamon, London, England. 1974. p.63.
59. Haberman, P. W. Study of Sanitary Criteria for Criteria for Salt Water Beaches: Pretest of Illness Inquiry System and Site Selection, Part 11972 (Jan. 1973), Part 2 (Jan.1974). Epidemiological Study of Health Effects Among Swimmers at New York Recreational Beaches Part 1, 1974 (Feb.1975); Phase 111 1975 (April 1976). Reports to United States Environmental Protection Agency on Grant Nos. 802240 and 803254.
60. Cabelli, V.J., A. P. Dufour, M. A. Levin, L. J. McCabe, and P. W. Haberman. 1979. Relationship of Microbial Indicators to Health Effects at Marine Bathing Beaches. Am. J. Public Health. 69:690.
61. Cabelli, V.J., A. P. Dufour, M. A. Levin, and P. W. Haberman. The Impact of Pollution on Marine Bathing Beaches: An Epidemiological Study. In: Middle Atlantic Continental Shelf and the New York Bight. Limnology and Oceanography, Special Symp. Vol.2. Ed. G. Gross, 1976. p.424.

REFERENCES (Continued)

62. Ktsanes, V K., A. C. Anderson, and J. H. Diem. Epidemiological-Microbiological Study of Health Effects Among Swimmers at Lake Pontchartrain in New Orleans: 1977-1978. Final report to United States Environmental Protection Agency on Grant No. 805341.
63. Cabelli, V.J. United States Studies. In: International Symposium on Health Effects of Liquid Waste Disposal. June 4-7,1979, Alexandria, Egypt. High Institute of Public Health, Alexandria University. In press.
64. El, Molla, A. Isolation of Pathogenic Enteric Organisms from Recreational Marine Waters in Alexandria. In: International Symposium on Health Effects of Liquid Waste Disposal. June 4-7, 1979, Alexandria, Egypt. High Institute of Public Health, Alexandria University. In press.
65. Hanes, N. B., and R. Fragala. 1967. Effect of Seawater Concentration on Survival of Indicator Bacteria. Jour. Water Poll. Control Fed. 39:97.
66. Cabelli, V.J. New Standards for Enteric Bacteria. In: Water Pollution Microbiology. Ed. R. Mitchell, Wiley, New York, 1978. p.233.
67. Kelly, S. M., and W. W. Sanderson. 1960. Density of Enteroviruses in Sewage. J.W.P.C.F. 32:1269.
68. SCS Engineers. Health Effects Associated with Wastewater Treatment and disposal Systems: State-of-the-Art Review. Vol. 1. EPA-600/1-79-016a. U.S. Environmental Protection Agency. April, 1979. p.66.

AN EPIDEMIOLOGICAL STUDY OF POSSIBLE ADVERSE HEALTH EFFECTS OF SWIMMING IN SANTA MONICA BAY

Final Report

Submitted by: Robert W. Haile and, in alphabetical order, James Alamillo, Kevin Barrett, Ron Cressey, John Dermond, Carolyn Ervin, Alice Glasser, Nina Harawa, Patricia Harmon, Janice Harper, Charles McGee, Robert C. Millikan, Mitchell Nides, John S. Witte

May 7, 1996

TABLE OF CONTENTS

Glossary iii

Executive Summary 1

I. INTRODUCTION 7

II. MATERIALS AND METHODS

Overview 8

Study Preparation

Staff Recruitment and Selection 10

Questionnaire Development 11

Orientation and Training 14

Data Collection

Personnel Structure 15

Beach Interviews 15

Telephone Interviews 22

Office Operations (Other than telephoning)

Symptom Evaluation 25

Data Editing 26

Data Management 27

Collection of Water Samples 28

Laboratory Determination of Bacterial Indicators 29

(Total and fecal coliforms, *E. coli*, enterococcus)

Samples 29

Media 29

Membrane Filtration Procedure 30

Quality Assurance 34

Virus Sampling and Assay for Enteric Viruses 34

Statistical Analyses 36

III. RESULTS

Descriptive Data (from beach and telephone interviews) 37

Descriptive Data for Bacterial Indicators 41

Associations Between Distance from the Drain and Health Outcomes 42

Associations Between Bacterial Indicators and Health Outcomes 45

E. coli 45

Enterococcus 45

Total Coliforms 46

Fecal Coliforms 46

Total Coliforms to Fecal Coliforms Ratio 46

Total Coliforms to Enterococci Ratio 48

Results of Multivariate Modeling 48

Summary of Bacteriologcal Results 50

IV. DISCUSSION 52

V. REFERENCES 69

VI. TABLES 1-74 AND FIGURES 1-7 71

VII. APPENDICES (INCLUDING MAPS)

GLOSSARY

Bacterial Indicator Counts - one way of estimating the amount of untreated sewage in contaminated water is to test it for bacteria that are commonly found in human waste. The amount of these bacteria found can then "indicate" the amount of contamination even if they themselves are not pathogenic.

Bathing (or swimming) - by bathing, subjects had to immerse their faces in the water; incidental splashing of the face would not qualify as "bathing" for purposes of this study.

"Cabelli-type" -refers to the Victor Cabelli's classic studies comparing health outcomes in swimmers versus non-swimmers while monitoring marine water quality. His studies were sponsored by the Environmental Protection Agency in the late seventies and early eighties.

Cohort - the study group being followed over a defined period of time.

Colony forming units (cfu) - the unit of measure used to evaluate the bacterial indicator counts. It refers to the density of the bacterial colonies grown per 100mL of water sampled.

Confounder - an independent risk for the outcome of interest that is also associated with the exposure of interest so it can distort its apparent effect on disease outcome.

Cytopathic Effect (CPE) - microscopic observations of changes in the morphology and/or growth rate of a cell culture assay system resulting from infection of the cells by virus.

Downcoast - in this study refers to the area south of the storm drain of interest.

Enteric Viruses - refers to a group of viruses transmitted through human waste. Can cause a variety of adverse health effects.

Enterococcus - (formerly known as Streptococcus faecalis). A bacteria that is part of the normal flora found in human and animal waste. Commonly used as a bacterial indicator.

E. coli - another bacteria normally found in human waste. Is sometimes used as a bacterial indicator.

Fecal Coliforms - a group of bacteria from the intestinal tract of humans, mammals and birds, commonly found in urban run-off. Commonly used as a bacterial indicator of the presence of sewage.

HCGI1 - (highly credible gastroenteritis one) - defined for this study as a person having either 1) vomiting 2) diarrhea and fever 3) stomach pain and fever. This is the standard definition for this symptom complex as defined by the EPA and used by many previous studies.

HCGI 2 - (highly credible gastroenteritis two) - defined for this study as a person having vomiting and fever.

Indicator Counts-refers to bacterial indicator counts as defined above.

Odds Ratio - it approximates the risk ratio in this study. (See Risk Ratio below).

Pathogenic - refers to organisms that cause disease.

PEPS - Population Estimation and Projection System from LA County 1993.

Plaque Forming Unit (PFU) - macroscopic hole(s) in the monolayer of a cell culture assay system resulting from localized lysis of the cells in the monolayer that initially

began with infection of one cell by an infectious unit of virus. In the PFU assay technique, agar is incorporated into the medium so that cell lysis resulting in release of additional infectious virus restricts the infection of new cells to only the adjacent healthy cells. Multiple cycles results in a hole in the monolayer.

Plume - refers to the quantity and direction the run-off from the storm drain takes when it enters the ocean. Due to ocean currents, it is generally believed that plumes from the storm drains considered in this study usually go downcoast, but this may not always be the case.

RR (Risk Ratio) - a measure of relative effect comparing the symptom risk of exposed subjects to subjects in a different exposure category.

SRD (significant respiratory disease) - in our study defined as a complex of symptoms that include; 1) fever and nasal congestion; 2) fever and sore throat and 3) cough with sputum.

Study Area 1 - defined as the area within 100 yards upcoast and downcoast of the storm drain of interest, the "exposed area".

Study Area 2 - defined as the area 400+ yards upcoast and downcoast of the storm drain of interest, the "control area".

Total Coliforms - bacteria that can originate from soil, plants, human and animal waste. Commonly used as a bacterial indicator.

Total Coliform/Fecal Coliform Ratio - a ratio used by bacteriologists as an additional bacterial indicator. For those wishing to know more, the baseline ratio is derived from the cut-off points of total and fecal coliforms, 1000(total)/200(fecal)=5. When one is

EXECUTIVE SUMMARY

A cohort study was conducted to investigate the possible adverse health effects of bathing in Santa Monica Bay and whether the risks of ill health outcomes were associated with urban runoff from storm drains. Exposures of primary interest were pathogens that produced acute illnesses (for reasons discussed in our original proposal, chronic health effects were not studied).

Three beaches with a wide range of indicator counts and high density of bathers were studied. The beaches were Santa Monica Beach (near the Ashland Avenue storm drain), Will Rogers Beach (Santa Monica Canyon Channel or storm drain) and Surfrider Beach (near Malibu Creek).

Persons who bathed and immersed their heads in the ocean water were potential subjects for this study. There were no restrictions based on age, sex, or race. Persons who had bathed at the study beaches, Mothers' Beach in Marina del Rey or near the Santa Monica Pier within seven days of the study date were excluded, as were subjects who bathed at the study beaches (or Mothers Beach or near the Santa Monica Pier) between the date of the beach interview and the telephone follow-up. Subjects who bathed on multiple days had to be excluded since one of our primary research questions was whether risk of health outcomes was associated with levels of specific indicator organisms on the day a subject entered the water. Given the range of incubation periods for the outcomes of interest and that the counts were quite variable from day to day, it would have been impossible to link subjects' experiences with specific counts on a given day if they were in the water on numerous days. Persons bathing within 100 yards upcoast or downcoast of the storm drain and persons bathing greater than 400 yards beyond a storm drain were targeted for this study.

For this study, 22,085 subjects were interviewed on the beach to ascertain eligibility and willingness to participate. Of these, 17,253 subjects were found to be eligible and able to participate (had a telephone and were able to speak English or Spanish). Of these, 15,492 agreed to participate. Eligible subjects who agreed to

respectively. Diarrhea with blood RR=4.23 (1.12-15.91) and HCGI 1 RR=1.44 (1.03-2.03) were associated with enterococci, using the higher cutpoint of 106 cfu.

It is conceivable that real increases in risk might have been missed with these cutpoints, particularly since they were not based on data that were generated by previous studies of Santa Monica Bay, so we also calculated odds ratios from categorical models using quintiles (of bacterial indicator levels) and from continuous models. For the continuous linear (on logistic scale) models, the odds ratios correspond to a unit increase equal to the difference between the 90th and 10th percentiles (i.e. the difference between the midpoints of the fifth and first quintiles). In general, results from the categorical models resembled results using the cutpoints (to define dichotomies) described above. The continuous models yielded a number of positive associations. For *E. coli*, small but statistically significant associations were seen for skin rash and stomach pain. Only skin rash was associated with total coliforms. Fever, skin rash, and HCGI 1 and 2 were associated with fecal coliforms. For enterococci, significant positive associations were noted for fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, HCGI 1, HCGI 2, and SRD.

In addition to investigating single bacterial indicators, associations between adverse health effects and the ratio of total to fecal coliforms, and the ratio of total coliforms to enterococci were investigated. For the total to fecal ratio, we initially used a cutpoint of 5.0, assuming the risk may be higher when the ratio is smaller. For the entire data set, significant associations were observed for diarrhea RR=1.28 (1.08-1.51) and HCGI 2 RR=1.87 (1.20-2.90). We then estimated effects of this ratio restricted to subjects in water where the total coliforms exceeded 1,000 cfu. Significant effects were observed for nausea RR=1.48 (1.08-2.04), diarrhea RR=1.40 (1.07-1.85), and HCGI2 RR=3.12 (1.60-6.07). We also conducted a similar analysis restricted to subjects in water where the total coliforms exceeded 5,000 cfu. Significant effects were observed for fever, eye discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and SRD. Risk ratios ranged from 2-7. We then conducted a similar analysis restricted to subjects in water where the total coliforms exceeded 10,000 cfu. Here we observed significant

participate were then interviewed about basic demographic data and about their bathing, including type of bathing activity (particularly immersion of the head into ocean water). Distance from the storm drain, gender, age, and race of the subject were noted by the interviewer.

On the same days that subjects were recruited, morning water samples were collected at ankle depth at 0, 100 yards north and south of the storm drain, and 400 yards north or south (depending on which area was used as a "control" area). Samples were analyzed for total and fecal coliforms, enterococci, and *E. coli*. In addition, one sample each Friday, Saturday, and Sunday of the study was taken in the storm drain (0 yards) at each study beach and analyzed for enteric viruses.

Nine to fourteen days after the interview date, subjects were interviewed by telephone to ascertain the occurrence(s) of fever, chills, eye discharge, earache, ear discharge, skin rash, infected cut, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, sore throat, and a group of symptoms indicative of highly credible gastrointestinal illness (HCGI) and significant respiratory disease (SRD). Of the 15,492 subjects interviewed on the beach, we were able to contact and interview 13,278 (86% follow-up). Of these 13,278, 1,485 were found to be ineligible because they bathed (and immersed their heads) at a study beach between the day of the beach interview and the telephone follow-up. This left 11,793 eligible subjects who provided data that were analyzed for this study. Of these, 107 were excluded because they reported not immersing their faces in the ocean water, leaving 11,686 subjects for analysis.

Analyses addressed the following two questions: 1) What are the relative risks of specific adverse health outcomes in subjects bathing at 0, 1-50, and 51-100 yards from a storm drain compared to subjects bathing at the same beach, but beyond 400 yards from a storm drain? 2) Are risks of specific outcomes (e.g. highly credible gastrointestinal illness; ear, eye and sinus infections; upper respiratory infections; skin rashes and lesions) among subjects associated with levels of the bacterial indicators (or viruses) mentioned above.

exposed to sewage contaminated water the fecal coliforms increase thus decreasing the ratio to <5.

Upcoast-refers to the area north of the storm drain of interest.

Water Sampling-In this study refers to taking samples of ocean water in front of the storm drain and at 100 and 400 yards away in order to test for the following indicators, total and fecal coliforms, enterococus, E. coli and enteric viruses.

As a measure of strength of association, we relied initially on the risk ratio (RR), which expresses the risk (proportion of subjects who report a given symptom) among subjects who bathed, for example, in front of the drain (0 yards) versus the risk among subjects who bathed 400+ yards from the drain. Comparing subjects who swam at 0 versus 400+ yards from the drain for all three beach sites combined, statistically significant increases in risk were observed for fever, where the RR=1.57 (95% C.L. = 1.17-2.10), chills RR=1.58 (1.04-2.39), ear discharge RR=2.27 (1.14-4.51), vomiting RR=1.61 (1.01-2.56), coughing with phlegm RR=1.59 (1.10-2.29), a group of symptoms we labeled highly credible gastrointestinal illness (HCGI 2) RR=2.11 (1.12-3.97), and a group of symptoms indicative of significant respiratory disease (SRD) RR=1.66 (1.25-2.21). These increases in risk were observed predominantly at the distance of 0 yards.

A second set of analyses was completed, restricted to days when the total coliforms to fecal coliforms ratio was greater than 5 for the water samples taken at 400 yards. The rationale was to exclude days when the plume from the drain or some other source of high counts apparently reached the 400 yard area, making this less than an ideal "control" zone. The relative risks for the seven outcomes cited above all increased. In addition, some significant increases in risk were observed for adverse health effects at distances of 1-50 and 51-100 yards from the drain, compared to 400+ yards from the drain.

The results for distance did not change when adjusted for age, beach, gender, race, California versus out-of-state resident, socioeconomic status, and worry about potential health hazards at the beach. Distance results also did not change substantially when controlled for each bacterial indicator.

A number of approaches to analyzing the effects of bacterial indicators were taken. We first calculated risk ratios for the lower and higher cutpoints described in the text (e.g. 200 and 400 colony forming units, or cfu, for fecal coliforms). Very few associations were observed when these cutpoints were used. None were detected for *E. coli* at lower cutpoints (35 or 70 cfu). Earache RR= 1.46(1.06-2.00) and runny nose RR=1.24(1.00-1.53) were associated with *E. coli* at the highest cutpoint of 320 cfu. Only skin rash was associated with total and fecal coliforms using the cutpoints of 10,000 and 400 cfu,

indicator) of interest. For a number of outcomes, the attributable number ranged into the 100's of new cases per 10,000 exposed subjects (complete results are presented in Tables 65-70).

In summary, both sets of results (the positive associations between adverse health effects and a) distance from the drain and b) bacterial indicators and presence of enteric viruses) taken together strongly suggest that there is an increased risk of a relatively broad range of symptoms caused by swimming in ocean water at the beach sites included in this study, particularly close to the drains and when indicator densities increase or ratios between selected indicators decrease.

Persons who bathed and immersed their heads in the ocean water were potential subjects for this study. There were no restrictions based on age, sex, or race. Persons who bathed at the study beaches, Mothers' Beach in Marina del Rey or near the Santa Monica Pier within seven days of the study date were excluded, as were subjects who bathed at the study beaches (or Mothers Beach or near Santa Monica Pier) between the date of the beach interview and the telephone follow-up. Subjects who swam on multiple days had to be excluded since one of our primary research questions was whether risk of health outcomes was associated with levels of specific indicator organisms on the day a subject entered the water. Given the range of incubation periods for the outcomes of interest and that the counts were quite variable from day to day, it would have been impossible to link subjects' experiences with specific counts on a given day if they were in the water on numerous days. Persons bathing within 100 yards upcoast or downcoast of the storm drain and persons bathing greater than 400 yards beyond a storm drain were targeted for this study.

For this study, 22,085 subjects were interviewed on the beach to ascertain eligibility and willingness to participate. Of these, 17,253 subjects were found to be eligible and able to participate (had a telephone and were able to speak English or Spanish). Of these, 15,492 agreed to participate. Eligible subjects who agreed to participate were then interviewed about basic demographic data and about their bathing, including type of bathing activity (particularly immersion of the head into ocean water). Distance from the storm drain, gender, age, and race of the subject were noted by the interviewer.

On the same days that subjects were recruited, morning water samples were collected at ankle depth at 0, 100 yards north and south of the storm drain, and 400 yards north or south (depending on which area was used as a "control" area). Samples were analyzed for total and fecal coliforms, enterococci, and *E. coli*. In addition, one sample each Friday, Saturday, and Sunday of the study was taken in the storm drain (0 yards) at each study beach and analyzed for enteric viruses.

interview. Interviewing instructions contained in the original version of the beach questionnaire were eliminated after a few days of field-testing, streamlining it from two sheets (3-sides) to one double-sided sheet that could be folded up while remaining attached to a clipboard. Interviewers were able to write down respondents' phone numbers and useful comments on the flip side of the beach questionnaire (field sheet) without worrying about it being lifted and carried away by a sudden gust of wind.

The telephone questionnaire was finalized after consultation with the study physician, the Chief of Infectious Disease at Olive View/UCLA Medical Center, and the California State Department of Health Services. Previous studies have suggested that acute infectious diseases including gastroenteritis, ear and respiratory infections, conjunctivitis, and skin rashes can be transmitted through polluted salt or brackish water. Therefore, sixteen questions representative of easily recognizable symptoms of these illnesses were asked during the telephone interview. The instrument was designed with space available for comments. In addition, the questionnaire contained sections for recording demographic information obtainable from the field sheet or the telephone interview. At the end of the telephone interview, respondents were queried about their levels of concern regarding health hazards at the beach. Interviewers used probing techniques to elicit better information whenever respondents experienced difficulty in answering questions clearly. Questions concerning types and durations of water activities were not included because participants in our pilot study found them annoying and too difficult to answer.

The symptoms and corresponding probes are listed below:

1. **Fever** - defined as a temperature equal to or greater than 100° F or 38° C. If the temperature was not taken, a subjective answer was considered positive if the respondent either volunteered or answered positive to the probes of feeling warm, achy and/or having chills.
2. **Chills** - substantiated by probing for uncontrollable shaking. Not considered "yes" when fever was "no."

associations with eye discharge, ear discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and HCGI 2. The significant RR's ranged from 2-39. All the effects noted above became consistently stronger as the analyses were increasingly restricted to occasions with higher counts of total coliforms. Since this ratio appeared to be informative, a range of cutpoints (2, 4, 6, 8) was subsequently investigated. There was a consistent pattern of stronger risk ratios as the cutpoint became lower (when the analyses were restricted to times when total coliforms exceeded 1,000 or 5000 cfu), with the strongest effects generally observed when the cutpoint of 2 was used. The consistency of the results suggests the observed associations are real.

None of the bacterial results changed when adjusted for age, beach, gender, race, California versus out-of-state resident, socioeconomic status, and worry about potential health hazards at the beach. They also did not change when we adjusted the bacterial results for distance from the drain.

The analysis of samples for enteric viruses yielded seventeen samples (taken in the storm drain) that were positive for enteric viruses. This number of positive samples did not enable us to conduct many analyses; however, we were able to compare the frequency of outcomes reported by subjects who were swimming within 50 yards of the drain on days when samples were tested for viruses and found to be negative versus days when the samples were positive for viruses. Results are presented in Table 73. Although based on small numbers, a number of outcomes were reported more often on days when the samples were positive for viruses, including fever (RR=1.53, 95% CI 0.97-2.42, p=value 0.07); vomiting (RR=1.89, 0.94-3.78), HCGI-1 (RR=1.74, 0.99-3.06) and HCGI-2 (RR=2.26, 0.91-5.60). Results remained essentially unchanged when adjusted for covariates or for each bacterial indicator. Research with gene probes is ongoing and will be presented in an addendum at a later date.

The attributable number for noteworthy distance and bacterial indicator results was also calculated. This attributable number is an estimate of the number of new cases of a specific adverse health outcome that is attributable to the exposure (distance or bacterial indicator) of interest. For a number of outcomes, the attributable number ranged into the

Beaches in Santa Monica Bay are heavily used during the summer months. It is estimated that 50-60 million persons visit Santa Monica Bay beaches annually. Concern about adverse health effects due to swimming in the bay has been raised by interested parties (SMBRP, 1995), citing numerous anecdotal reports of illnesses that were perceived to be caused by swimming in the bay. "Is it safe to swim in Santa Monica Bay?" appeared to be a prevalent concern.

These circumstances (high volume of urban runoff in storm drains, numerous days with high levels of bacterial indicators, isolation of pathogenic human enteric viruses even when water quality indicator densities were low, heavily populated beaches, and concern about adverse health effects) provided the motivation to study the possible health effects of swimming in the bay. It was decided by the Technical Committee and the Management Committee of the Santa Monica Bay Restoration Project (SMBRP) that an epidemiological study of bathers in Santa Monica Bay was the most direct and relevant means of addressing the question, "Is it safe to swim in Santa Monica Bay?" A pilot study was conducted in the summer of 1994 to assess the feasibility of a large-scale study. The protocol for the large scale study was revised as a result of this pilot study and was subsequently approved by SMBRP.

II. MATERIALS AND METHODS

Overview:

A cohort study was conducted to investigate the possible adverse health effects of bathing in Santa Monica Bay and whether the risks of ill health outcomes were associated with urban runoff from storm drains. Exposures of primary interest were pathogens that produced acute illnesses (for reasons discussed in our original proposal, chronic health effects were not studied).

Three beaches with a wide range of indicator counts and high density of bathers were studied. The beaches were Santa Monica Beach (near the Ashland Avenue storm drain), Will Rogers Beach (Santa Monica Canyon Channel or storm drain) and Surfrider Beach (near Malibu Creek). Maps indicating beach sites are included in Appendix E.

Nine to fourteen days after the interview date, subjects were interviewed by telephone to ascertain the occurrence(s) of fever, chills, eye discharge, earache, ear discharge, skin rash, infected cut, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, sore throat, and a group of symptoms indicative of highly credible gastrointestinal illness (HCGI) and significant respiratory disease (SRD). Of the 15,492 subjects interviewed on the beach, we were able to contact and interview 13,278 (86% follow-up). Of these 13,278, 1,485 were found to be ineligible because they swam (and immersed their heads) at a study beach between the day of the beach interview and the telephone follow-up. This left 11,793 eligible subjects who provided data for this study. We excluded 107 of these subjects because they reported not immersing their faces in ocean water, leaving 11,686 subjects for analysis.

Analyses addressed the following two questions: 1) What are the relative risks of specific outcomes in subjects bathing at 0, 1-50, and 51-100 yards of a storm drain compared to subjects bathing at the same beach, but beyond 400 yards of a storm drain? 2) Are risks of specific outcomes (e.g. highly credible gastrointestinal illness; ear, eye and sinus infections; upper respiratory infections; skin rashes and lesions) among subjects associated with levels of the bacterial indicators (or viruses) mentioned above. Given this design of the study, we are not able to address the effects of repeated exposures or chemical contamination or special at risk populations.

A detailed description of the study follows, including sections on study preparation, data collection (beach and telephone interviews), collection of water samples, laboratory analyses of water samples, and statistical analyses of the data.

Study Preparation:

Staff Recruitment and Selection:

The project coordinating team of the Santa Monica Bay Beach Study consisted of a multi-ethnic group of researchers with extensive experience in the design and conduct of epidemiologic studies. Included in this team were the study's principal investigator, the principal project coordinator, the study physician, and several professionals with

I. INTRODUCTION

At the time this study began, there had never been an epidemiologic study of persons who swam in marine waters contaminated by heavy urban runoff. Waters adjacent to the County of Los Angeles receive runoff from a system of storm drains year round. Even in the dry months of the summer, an average of 10-25 million gallons of runoff (or non-storm water discharge) per day enter Santa Monica Bay from the storm drain system (this includes, of course, substantial flows from permitted discharges beyond the control of the owner/operator at the facility). These drains are separated completely from the municipal sewage system of pipes and treatment plants; waters collected by the storm drain system are not subject to treatment and are discharged directly into the ocean at a number of sites. Years of monitoring by public agencies and recent surveys by the Santa Monica Bay Restoration Project have demonstrated that total and fecal coliforms as well as enterococci are sometimes elevated in surfzones adjacent to storm drain outlets; pathogenic human enteric viruses have been isolated from storm drain effluents, even when levels of all indicators, including F2 male-specific bacteriophage, were low (SMBRP, 1991). Sewage spills and hydraulic overload following rainstorms occur intermittently and may lead to discharge of primary-treated sewage and floatables such as tampon applicators into storm drains (NRDC, 1991); leaky sewer lines, illegal sewer connections, blocked sewer overflows, leaky septic tanks and local direct human sources (such as the transient population and illegal dumping of recreational vehicles) may also contribute human waste to storm drains emptying into the bay (SMBRP, 1990, 1992). At least 338 beach closures/advisories (many due to high bacteria levels attributable to storm drain runoff) occurred in Los Angeles and San Diego Counties in 1990 (NRDC, 1991). Water sampling at varying depths and distances from storm drains has established that a gradient of water quality (as measured by bacterial indicator densities) exists at Santa Monica Bay beaches receiving storm drain effluent (SMBRP, 1991).

diverse research backgrounds and practical expertise in data collection, management and analysis.

Other staff were recruited from several sources (mainly UCLA and Santa Monica City College) by fliers and adds in the UCLA newspaper. Ideal candidates were those who could be trained to interview both at the beach and on the telephone. First, a project coordinator screened each applicant for experience and telephone demeanor, then explained the job requirements. Next, applicants were interviewed by three to four project coordinators. Staff members who had worked on the pilot study two years earlier were contacted and offered positions as experienced interviewers and/or mid-level supervisors.

The mid-level supervisory and interviewing/office staffs were comprised of individuals representing various ethnicities and educational backgrounds. Twenty-four interviewers were undergraduate students, 17 were college graduates and 9 had worked toward or achieved graduate degrees. Thirteen telephone and beach interviewers were bilingual in English and Spanish and several students, although not completely bilingual, could manage the beach interview in Spanish. Other interviewers' language skills allowed for the conduct of interviews in Japanese, French and German. Fifty staff members worked the majority of the summer -- 24 mainly full-time, 26 part-time.

Questionnaire Development:

The beach questionnaire and the follow-up telephone questionnaire were developed by the project coordinating team during a series of meetings. The beach questionnaire was photocopied on colored paper in order to distinguish among the three beaches (Santa Monica/Ashland: yellow; Surfrider/Malibu:pink; Will Rogers/Santa Monica Canyon Channel: blue). The telephone questionnaire was formatted to be scanned by an optical mark reader. Both questionnaires were fully translated into Spanish, with special attention paid to the diversity of Latino/a subgroups living around and within the Los Angeles area. Appendix A contains a copy of each questionnaire.

The coordinating team designed the beach questionnaire to serve as an instrument on which to record subjects' names, telephone numbers and swimming locations, plus as an aid in determining subject eligibility and accessibility for the follow-up telephone

Orientation and Training:

All office and interviewing personnel were introduced to general interviewing techniques, the study background and protocol, and participated in role-playing exercises during an 8-hour orientation and training session. Pertinent information and materials were provided in a "Santa Monica Bay Beach Study Training Manual" (See Appendix D). During the following week, the supervisory staff underwent a day of practice training on the beach, and then worked during the following four days one-on-one practice training with the rest of the beach interviewers. At the beginning of data collection staff meetings were held each day to discuss experiences on the beach and to address questions and problems. Emphasis was placed on ways to observe and approach potential subjects and strategies were standardized for handling answers to their questions. As a result of these early meetings, the field sheet was streamlined and the method of assigning interviewers to designated areas on the beach was developed.

New beach interviewers who joined the project after the onset of the study first trained in the office with experienced interview supervisors, and then were taken to the beaches and allowed to practice the interview by interacting with beach patrons in non-study areas. This protocol was used for training beach interviewers throughout the summer.

A separate 8-hour training session was later held for telephone interviewers in which telephone interviewing techniques and the telephone questionnaire were emphasized. Interviewers were instructed on the use of standardized probes to clarify symptom events and to document answers to probes as well as comments voluntarily offered by subjects.

Telephone interviewers continued their training by conducting interviews under the direction and observation of a trained supervisor. These interviewers and their supervisors became adept at handling numerous scenarios by sharing experiences during the first few days of telephone interviews. Phone supervisors provided suggestions to beach interviewers about the types of comments on the field sheet (i.e., respondent's demeanor, swimming behavior, etc.) most useful in expediting the phone interview. The

3. **Redness and discharge from eyes** - used to evaluate the diagnosis of conjunctivitis. Both redness and discharge were documented because BOTH had to be positive for a "yes" answer. Standard probes to "don't know" responses were "Did you have pink eye?...Did you have yellow discharge?" This was done to exclude irritation from salt water, smog and other sources.
4. **Earache** - To substantiate a positive response, the respondent was also asked if he/she had an ear infection.
5. **Discharge/draining from ear** - used to assess swimmer's ear.
6. **Skin rash** - The respondent was asked the location of the rash. Only rashes covering the body (as opposed to small patches, for example, on the foot or arm) were marked positive on the questionnaire. This was done to increase the chances that the observed rash was a generalized viral exanthem or contact rash that was more likely to be caused by immersion in polluted ocean water.
7. **Cuts or scrapes that became infected** - several probes were used to delineate a positive answer including more redness, swelling, pus and red streaks around the cut.
8. **Nausea** (not related to pregnancy) - The two probes that were used were, "Did you feel like throwing up?" or "...feel so sick that you couldn't eat?".
9. **Vomiting** - self-explanatory.
10. **Diarrhea** - self-explanatory.
11. **Diarrhea with blood** - would narrow condition down to certain diseases that present with this symptom, like Shigellosis or *E. coli* 0157.
12. **Stomach pain or cramps** - menstrual cramps were excluded. Interviewers were instructed to circle which symptom was experienced if not both.
13. **Coughing** - a probe for allergies and smoking was used.
14. **Coughing with phlegm** - self-explanatory.
15. **Nasal congestion/runny nose** - allergies/smoking probe used.
16. **Sore throat** - interviewers probed by asking if one had trouble with swallowing or eating (e.g, "Was it difficult to swallow food?").

water. Appendix B contains pamphlets and forms used on the beach. (The field sheet is in Appendix A.)

The number of staff members required at the beach sites ranged from 3 to 12 depending on the expected size of the crowd that day. Anticipating the crowd size depended primarily on weather prediction, and the number of interviews collected from a particular day of the week during previous weeks. For example, unless unusual weather was predicted, Sundays and holidays were consistently the days with the largest crowds at all three beach sites. Generally numbers increased at all the sites as the week progressed from Monday to Friday. Sometimes, uncertainty in the weather resulted in office staff being sent to the beach when beach crowds were unexpectedly large.

The average work day at the beach usually began around 11:00 A.M. Monday through Thursday; 10:00 - 10:30 A.M. Friday through Sunday. Beach interviewers could be easily identified by blue T-shirts bearing the "Santa Monica Bay Beach Study" logo. Upon arrival, the first item of business for the beach supervisor was to measure the areas within 50 and 100 yards on both sides of the selected storm drain. This was usually done by pacing off steps and was done daily because the outlets shifted for two of the three storm drains. The storm drain at Ashland was fixed (concrete), whereas those at Will Rogers and Malibu were often dredged by bulldozers or temporarily maintained by dry weather flows. They were occasionally reforming, straying, multiplying or disappearing.

The area boundaries (at 50, 100, and 400 yards) were marked with visible objects such as trash cans or beach umbrellas, although these markers were not used when the area happened to be bordered by a life guard station. In either case, survey areas could be easily delineated without arousing suspicion by beachgoers as to why these areas were important to the study.

Beach interviewers were responsible for determining and recording the locations of eligible participants. On the field sheet (see Appendix A) the storm drain was designated as point 0 (as indicated by the diagram on the next page, subjects did not have to be in the middle of the drain to be coded as point 0; they had to be in the water within a range of distance (usually a matter of 2-20 yards) where the flow from the drain entered

methods for training telephone interviewers were maintained throughout the summer as new staff members were enlisted.

Data Collection:

Personnel Structure:

The scope of data collection and management required the availability of workers seven days a week from 9 A.M. to 9:30 or 10 P.M. Each task accomplished at the beach and at the study office was managed by a mid-level supervisor. The study employed three telephone room supervisors and seven beach supervisors. Although specialists were developed for each task, the success of the study depended on staff flexibility. In essence, each full-time staff member had a main job (e.g. beach interviewer) and an alternative job (e.g. data editor or telephone interviewer.) Most workers were skilled in multiple tasks and clerical tasks were shared. Staff members generally settled into the roles where they felt most comfortable, resulting in maximum productivity.

Project coordinators organized and supervised mid-level supervisory personnel and at times assumed some of their responsibilities. Beach and telephone supervisors, along with at least two project coordinators, attended weekly meetings during which schedules were planned and employee performances were discussed. Supervisors staggered beach interviewers' schedules to insure adequate crews on the beach during the afternoons when beaches tended to be busier. Basically, flexibility was encouraged so that beach interviewers, phoners and data editors could switch tasks depending on weather conditions and beach attendance on a particular day.

Beach Interviews:

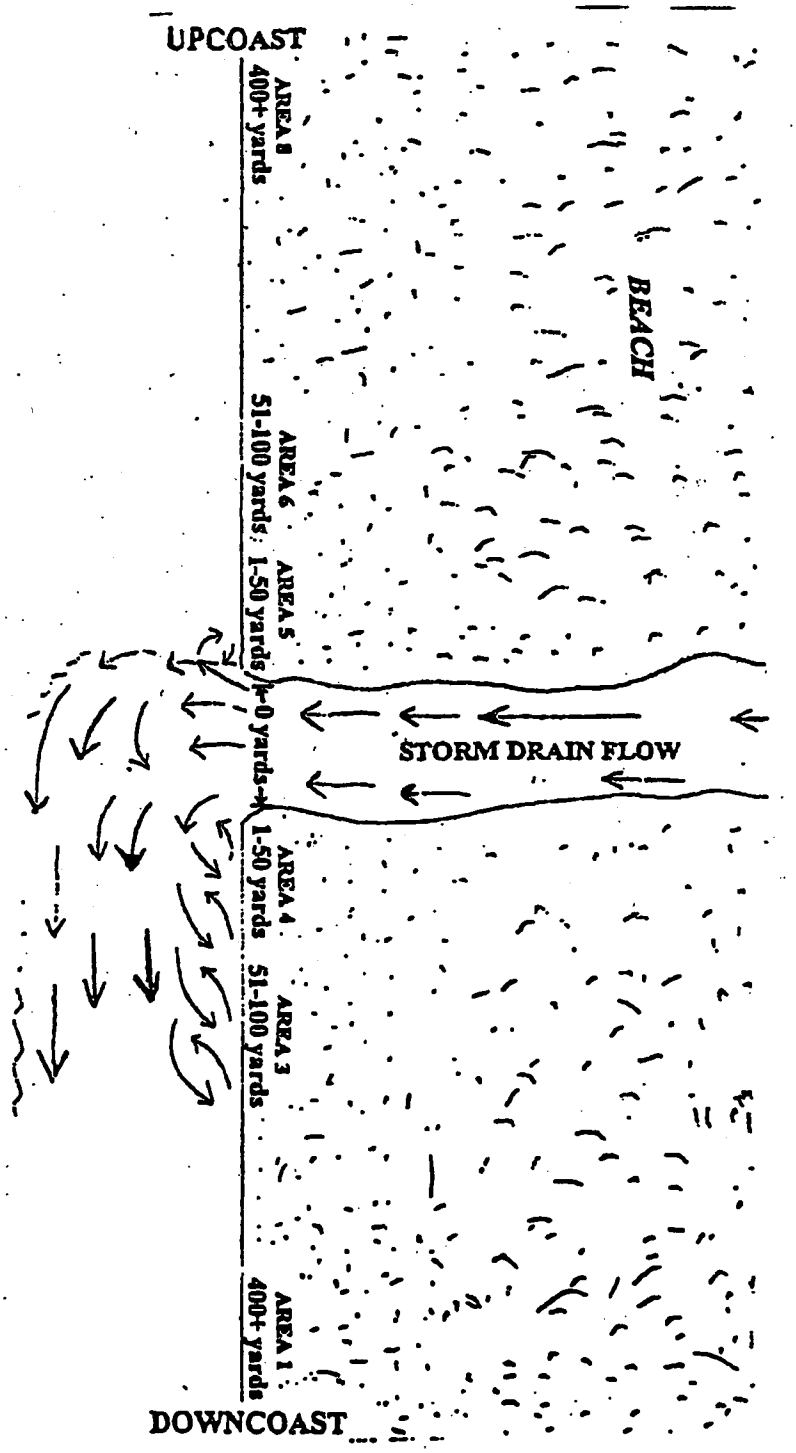
Staff assigned to recruit subjects at the beach sites gathered each morning one half hour before leaving the office in carpools. The selected supervisor of each beach site was responsible for insuring that the crew assigned to her/his beach was transported and had the appropriate supplies. Supplies included pencils and clipboards, field sheets, forms on which to tally non-participants and ineligibles, forms on which to tally completed interviews and monitor interviewers, information pamphlets in English and Spanish, gifts for respondents (frisbees, visors and buckets), umbrellas, beach towels, ice chests, and

the bay); the two zones spanning up to 50 yards on either side of point 0 were designated 4 and 5; zones 3 and 6 spanned from 50 to 100 yards in either direction; and zones 1 (downcoast) and 8 (upcoast) were 400 yards and beyond in either direction. All zones except for 1 and 8, i.e., up to 100 yards on either side of the storm drain, were considered exposure zones and were referred to as **Study Area 1.** Zones 1 and 8, i.e., 400 yards and beyond, were considered control zones and were referred to as **Study Area 2.** Mostly zones 1 and 8 served as Study Area 2 at Malibu and Ashland beaches, respectively. The sampling strategy required that one subject be recruited from Study Area 2 for every 3 subjects in Study Area 1. It was extremely rare that a subject either swam across zones or entered the water in different zones. When this occurred, the subject was coded in the zone closest to the drain.

Generally one or more interviewers covered each zone, but this depended on the number of interviewers working that day and on the number of beachgoers occupying each zone. Bilingual interviewers were often placed strategically, either in heavily populated areas, one on each side of the drain, or were encouraged to traverse zones -- often being called out of assigned zones to assist in an interview. Covering small areas of the beach insured that surveyors could recognize those in their area who were newly arrived, those who had already been approached, and those who did not need to be approached since they had not immersed their heads in the water. Having individuals responsible for small areas provided the best opportunity for contacting every eligible participant. This system also insured that beachgoers were not disturbed by repeated approaches about the survey.

On a typical weekday during the earliest phase of the study, the majority of time was spent recruiting participants from Study Area 1 (exposure). Recruitment from Study Area 2 (control) was usually left until later in the day when the beach crew had an idea of the number of people needed from that area. For instance, if by 2:00 p.m. 30 interviews had been completed in Study Area 1, the supervisor would send a team to Study Area 2 until the necessary number of interviews was accumulated, say 10 or more. As the study progressed, the supervisors became more familiar with the beaches and knew how to

DIAGRAM ILLUSTRATING ZONES



17

Participants were told that someone from the beach study office would phone them in 9 days and asked the number and time of day at which they could most easily be contacted. All respondents received an information pamphlet that described the study, provided the study office telephone number, and served as a reminder of the follow-up telephone interview. This pamphlet was printed in English as well as Spanish. Participants were encouraged to call the study office to be interviewed if they happened to be inaccessible on the scheduled phone interview date. Information about all members of a particular household was recorded on the same field sheet.

Unsuccessful interviews were tallied on a "Log of Non-Participants" sheet by race, gender and reason for non-participation (Appendix B). Only individuals who could be approached directly were tallied, as it was not feasible to determine the identity and number of accompanying children under 12.

Most essential to data quality was the careful observation of the bathing/swimming behaviors of the respondents approached for interview. Different techniques were used to approach potential subjects. Sometimes an interviewer waited until a group came back from the water to their towels, let them rest for a few minutes, and then approached. An alternative approach involved waiting until several unassociated groups had gone in and come out of the water. The interviewer then made "rounds" of 4-8 groups at a time. Many of the written parts of the interview were completed later at the encampment where beach interviewers were situated.

Since the beach contact laid the groundwork for the follow-up telephone interview, the interviewers spent as much time as each individual or family needed to establish rapport and convey a sense of professional interest in their swimming behavior. A level of trust had to be established in order to obtain phone numbers. In the early stages of the study, telephone interviewers were faced with a significant percentage of calling attempts resulting in wrong telephone numbers. Some of these were undoubtedly due to people's reluctance to give out their correct numbers. However, the percentage of wrong numbers decreased considerably when it became policy for beach recruiters to repeat the number aloud and verify it as written with the person being interviewed.

dispatch interviewers to Study Area 2 earlier in the day. On crowded days, such as weekends, interviewers were automatically assigned to Study Area 2 for the entire day, and supervisors provided them with regular notice as to the numbers needed from their area. Similarly, interviewers provided supervisors with regular reports on the quantity of their interviews.

Interviewers approached every potentially eligible beach visitor in their assigned zones. During the first few weeks of data collection, eligibility for adults and children was determined differently. Adults were eligible only if their heads or faces had been submerged in the ocean water (subjects with only incidental wetting of their faces, e.g. from splashing, were not recruited). Early on, children 12 years and younger were eligible if they had had any contact with the water, preferably hands and face (we assumed a lower standard of sanitary practices might place them at risk of exposure); however, once it seemed as though the projected sample size would easily be achieved, project coordinators decided to have children recruited under the same criteria as adults. Members of the same family were allowed to be subjects in this study because a) we judged that it would have been very difficult to identify and recruit only one member per family and b) it would have been impossible to achieve our sample size since we had to approach every potentially eligible subject throughout the study period to achieve our sample size.

A single adult or any adult member of a family could serve as the source of information on him-/herself or other family members. That adult was also often the source of information on children who were not part of the family but had come to the beach under his/her supervision. Children 12 years or older could be questioned directly if the interviewer had obtained consent from an accompanying adult. Teenagers who were not accompanied by adults were recruited and told to inform their parents about the follow-up telephone interview. Finally, in theory, a person could have been recruited into the study more than once, if they met the eligibility criteria each time. In reality, only a handful (perhaps 5) of subjects participated in the study twice.

temporarily affected by algal blooms that made swimming unpleasant. One of the study zones at Ashland within Study Area 2 is approximately 250 yards from the Pico-Kenter storm drain -- a drain with a history of high indicator counts, usually diverted during previous summers.

Telephone Interviews:

The majority of telephone interviews were conducted from the beach study office, although occasionally an interviewer called from home if an interview could not be completed during regular office hours. Interviewers were scheduled to begin calling at 8 A.M. and interviewing generally continued until 9 or 10 P.M. Study participants were telephoned 9 to 14 days after their interviews at the beach. Interviews were conducted in English and Spanish.

In order to conduct telephone interviews, callers needed the field sheet in hand so that they could review the household size, names and ages of potential study eligibles, and read useful comments regarding eligibility and approachability. For this reason, a "calling queue" system was established in which field sheets were organized by scheduled call date, preferred call time (i.e., morning, afternoon, evening), and whether or not they were Spanish-only or out-of-area calls. Often phone numbers had to be obtained for participants that were interviewed as part of a group at the beach but lived in a different household.

Usually the contact person for the telephone interview was the respondent who had provided information at the beach interview; however, other options were utilized. A spouse could answer questions about the other's health when knowledgeable and comfortable with the idea; otherwise, the interview was conducted with each spouse separately. Interviewers were instructed not to allow participants existing in non-marital relationships to answer for partners, since they were considered more likely to be in a "honeymoon" phase wherein confidences about health problems might not be shared.

Adults were generally required to answer for children under 12, but could do so for any of their children if preferred. Often interviews were conducted with the parent asking the child questions. A divorced or separated parent could respond for a child only

Interviewers carrying toys experienced enhanced success upon approaching households with children. In such cases, it was advantageous to have two interviewers approach the group, one with toys and the other with paperwork. The interviewer with the toys was able to keep the children occupied, relieving the parent's concern or need to watch them while participating in the interview, probably offsetting a fair number of refusals. An example of a typical beach interview is included in Appendix C.

Beach interviewers usually left the beach to return to the study office around 4:30 P.M. on weekdays and 5:30 P.M. on weekends. Supervisors collected the field sheets and non-participation log sheets, edited them for accuracy and completeness, and tallied the day's interviews on the "Beach Interview: Daily Tally Sheet" (Appendix B). One of the office staff was responsible for reviewing the field sheets on a daily basis and contacting beach interviewers, if necessary, to obtain missing information.

Several conditions at the study beaches resulted in logistical dilemmas for the survey. At study onset, the creek outlet at Malibu was close to the pier and most of the interviews were conducted on its south side where the people were swimming. In addition, no-flow days were common, i.e., there was no visible outlet from the creek to the ocean. Moreover, lifeguards often placed flags designating surfing-only areas such that Study Area 1 was off-limits to families and swimmers. When strictly enforced, swimmers were made to leave the area before they became eligible for the study. It was also not uncommon for lifeguards to approach people playing directly in the area of the storm drain and tell them to move to a "safer" area before they could become eligible to be interviewed. This happened at Ashland and Will Rogers as well.

Malibu's creek outlet was eventually moved upcoast for the summer in order to create greater accessibility to the more popular beach area during peak season. The noise and fumes emitted by bulldozers disrupted several days of interviewing, especially since it took several park service outings to get the outlet to stay upcoast. The outlet at Will Rogers beach also shifted positions so that it was subjected to bulldozings in order to create more usable beach. When the outlet was dredged, parts of the beach, especially within Study Area 1, were not available to beachgoers. Ashland and Will Rogers were

following the beach interview (the first calling day), the field sheets were placed in a "call-back" compartment to receive priority attention during the next 5 days. All "call-backs" were attempted at least 3 times a day. Generally, interviews were completed within the 9- to 14-day window period, but there were exceptions. For a few days beyond the 5th calling day, field sheets were kept in a compartment for special priority calls. If these participants were accessed after the 5th day, interviewers made sure that the reported symptoms had occurred within the study window period. Families with small children were not called after 9 P.M., while the success rate among young singles was enhanced when calling hours were extended to 10 P.M. on some nights. At least one bilingual (English/Spanish) interviewer telephoned from the study office. Unattainable phone interviews were tracked on the "Log of Weekly Loss-To-Follow-Up" sheet (Appendix B).

The interviewing staff became very skilled at developing immediate rapport with the respondents over the phone. The interview proceeded smoothly once the interviewer introduced her/himself, the purpose for the call, and established eligibility. The telephone questionnaire was relatively easy to administer, as there were no open-ended questions. Interviewers sometimes linked questions about symptoms that regularly occur together, improving the flow of the interview without de-emphasizing the importance of each symptom. Information regarding swimming location was generally bubbled after the interview was completed, and interviewers were always blinded as to any preliminary analyses relating locations to health outcomes. The average interview took about 3 minutes per respondent. Appendix C contains a typical example.

When attempted calls were answered by an answering machine or someone other than a designated contact person or eligible participant, the interviewer left a message asking that the contact person return the call by phoning the study office and asking to speak to "Toni" -- a unisex name which none of the interviewers normally used. Afterwards, the corresponding field sheet was placed in the appropriate "Toni" folder according to beach, so as to be easily retrievable upon call-back. In this way, anyone answering the telephone could interview a caller asking for "Toni", having been trained

if he/she was the custodian since the beach interview. With older children, interviews were facilitated once the interviewer had introduced her/himself and the study to a parent or guardian. Only rarely, when a language difficulty was otherwise unresolvable, would a capable child be allowed to interpret for an adult or another child. Nannies or babysitters who were daily care-givers could answer for charges.

Beach participants were eligible to respond to the follow-up telephone interview if they had not been back in the water at any of the 3 study beaches or at Mothers' Beach in Marina del Rey and the area around Santa Monica Pier since the day of the beach interview (subjects in the water at Mother's Beach or around the Santa Monica Pier were excluded because these areas are associated with high bacterial counts and swimming there may have caused symptoms such as the ones under investigation in this study). Very few subjects visited beaches other than the study beaches. Ineligible participants were tallied on a "Log of Weekly Loss-To-Follow-Up" sheet (Appendix B) according to ethnicity, age group (younger than 12, 12 and older), gender and map code. The telephone interviewer also verified that the participant had gotten her/his face wet in ocean water on the beach interview day. If both these criteria were met, the participant was deemed study eligible. A telephone interview form was dedicated to each participant who was then assigned a unique identifier.

The identifier consisted of a letter corresponding to the visited beach, a number designating the household, and a letter specific to a participating household member. Telephone interview forms were preprinted with sequential household identifying numbers and grids premarked with those numbers. At the time of the phone interview, an interviewer reviewed the field sheet to determine the number of forms required. The interviewer bubbled (i.e. darkened in pencil the circle indicating the correct data item) in the beach letter, the household number, and the participant letter in the provided section on the telephone interview form. The same identifier(s) was recorded on the field sheet.

The first attempt at calling the contact person was determined by the preferred time indicated on the field sheet. Respondents who said they could be called "anytime" were first called in the morning. If calling attempts were unsuccessful on the 9th day

to the beach visit, the interviewer asked for a description of how often the symptom was experienced. This was done to decide whether the symptom was associated with an ongoing condition such as an allergy or smoker's cough, etc. In the majority of cases, if the symptom was already present at the time of the beach visit, it was not considered an event. A "don't know" (DK) was also not considered an event.

Phone interviewers were encouraged to write comments on the questionnaire form. Comments volunteered by the respondent were written on the left side of the page to differentiate them from answers to standard probes that were written on the right side. These comments were used in symptom ascertainment, especially when the respondent reported having had the symptom prior to the beach visit. The study physician reviewed these comments, and if the information was unclear, would question the interviewer for a better understanding. Sometimes, the study physician would re-phone the respondent to clarify the response. There were a few rare cases where an existent symptom worsened so dramatically after the beach visit that it was considered an event. In these cases, the study physician darkened the extra bubble associated with each symptom on the far right of the questionnaire form.

Data Editing:

Each completed telephone questionnaire underwent at least four reviews before it was scanned. Interviewers reviewed each questionnaire upon completion, although on busy telephoning shifts this step might have been bypassed. Telephone supervisors reviewed each interview and addressed any immediately apparent inconsistencies or omissions prior to the form's subsequent examination by a project coordinator. The study physician verified all ambiguous symptom events. Finally the forms were subjected to the final edit step.

In the final edit step, one staff person reviewed the field sheet while another reviewed the accompanying telephone form(s). The editor with the telephone form read aloud all the information which appeared on the top, i.e., identifier, beach and phone dates, interviewer numbers, age category, gender, map code, and whether or not respondent had gotten his/her face wet. The editor with the field sheet would check this

in advance to recognize a "Toni call." On average, 10 to 15 interviews were conducted in this fashion on a daily basis.

Interviewers kept track of their calls on the "Telephone Tally Sheet" (Appendix B), an instrument designed to keep account of the telephone activity of each work shift, i.e., 9 A.M. - 3 P.M.; 3 P.M. - 9:30 P.M. Calls were tallied within the following categories: completed interview, answering machine, "Toni call", busy signal, later appointment, no answer, disconnected, and wrong number. Also tallied were the number of households and individuals, and the number of attempts to complete these interviews. These tally sheets were helpful in allocating staff to the most productive hours.

The close supervision of telephone interviews allowed for optimum quality control. Telephone interviews were always monitored by a supervisor to insure that probes were used uniformly and answers to respondents' questions were addressed in an accurate and unbiased manner. Supervisors reviewed each questionnaire for content soon after the interview took place so that interviewers were directed as to how to unravel inconsistencies and recall or obtain missing information, even calling the respondent back if necessary. There were occasions when supervisors made these calls in order to validate information. All interviews were also reviewed by a project coordinator within 24 hours after completion.

Office Operations (Other Than Telephoning):

Symptom Evaluation:

For our purposes, determining that a participant experienced a specific health outcome depended on the self-report of having one or more representative symptoms. Each of the 16 symptoms listed in the phone questionnaire was associated with 3 possible questions. For each symptom, the first question was asked, "Did you or your child have (symptom) at any time since your visit to the beach?" When the response was negative, the interviewer moved on to the next symptom. If the response was positive, the interviewer continued by asking, "Was this a problem you had before going to the beach?" If the answer was "no", this was considered a symptom event, and the interviewer moved on. However, if the respondent reported having had the symptom prior

A similar method was used for the detection and correction of logical errors, for example, inadherence to skip patterns. Records containing logical errors were listed and corrections were entered into a computer file that was merged with the original data set.

Other aspects of data management involved the creation of new variables like symptom groups, and the merging of bacterial indicator counts and household income estimates with the questionnaire data. Bi-weekly progress reports describing the numbers of completed interviews as well as respondent characteristic were generated using Excel 5.0. Excel was also used to enter and report daily beach interviews, daily non-participation and weekly loss-to-follow-up counts.

Collection of Water Samples

Samples were collected daily from mid-June to September at three locations; Santa Monica Beach near the Ashland Avenue storm drain (Ashland), Will Rogers Beach near the Santa Monica Canyon storm drain (Will Rogers), and Surfrider Beach near Malibu Creek (Malibu). Four samples were taken at each location. Three of the sampling points at each location (0 yards, 100 yards upcoast and downcoast of the storm drain flows) represented a grid presumably covering the most elevated indicator bacteria counts in the surf-zone. The fourth sample (400 yards upcoast or downcoast) represented a control site that was presumably unaffected by high indicator densities from storm drain flows. For quality assurance purposes, one duplicate per beach site was collected on each sampling day. Discharge flow rates at the time of sampling were not made.

All samples were collected at ankle depth with sampling poles and one liter, high-density, sterile polypropylene bottles. Samples were taken at ankle depth because 1) all shoreline monitoring is done with ankle depth samples; 2) children were presumed to be at higher risk and are exposed mostly to water at ankle depth; 3) previous studies (SMBRP, 1990) demonstrated that bacterial densities at chest depth were at least an order of magnitude lower than ankle depth samples; 4) additional samples would increase the costs and demands on the lab to unacceptable levels. The samples were collected from the incoming surf as the surf foam reached the sample bottle at the height of the sampler's ankle. The sample bottles were immediately sealed and placed on ice. All samples were

vocalized information against that on the field sheet. Any necessary corrections were made on the telephone form and the entire telephone form was inspected for dark and thorough marking (bubbling.) Unresolvable inconsistencies were referred to the telephone interviewer and corrected. Once edited in this manner, the telephone forms were set into a pile separate from the field sheets, ready for scanning. The field sheets were stamped "Completed", initialed by the editor, and filed in sequential identifier order for later reunification with the telephone form.

Data Management:

The telephone interview forms were scanned on a NCS OPSCAN 5 optical mark reader. Edit checks were conducted to locate and correct miscoded identifiers, inappropriately missing responses to variables, and logical response errors. In most cases, missing data were the result of the scanner having failed to pick up marked responses.

Miscoded identifiers and missing data for selected variables, i.e., beach and phone interview dates, gender, age, interviewer numbers, and map code, were initially manually edited in the data set if the information was written on the form but not coded or lightly bubbled. At this point, the forms were reunited with the field sheets and filed.

Most data management tasks were performed using Dbase IV. The data manager printed a list of identifiers and values from the telephone forms that could be verified with the field sheets. This list was used as a final check for data consistency between the two interview forms. Corrections were made to the telephone forms along with brief notations describing the corrections, and photocopies of the forms were given to the data manager to perform manual edits.

The data manager next produced a hard-copy list and computer file on which to enter the remaining missing responses. Office staff examined the field sheet and telephone interview and either entered the correct responses or confirmed the nonexistence of data. The missing data were entered into the computer file and merged with the original data set.

(52 grams per 1 liter, with the addition of 10 mL of 1% of Bacto rosolic acid in 0.2N NaOH) was used for fecal coliforms. Difco mE Agar (7.12 grams per 100 mL with the addition of 0.024 grams nalidixic acid and 1.5 mL of 1% triphenyl tetrazolium chloride) was used for the initial isolation of enterococci. BBL Esculin Iron Agar (16.5 grams per 1 liter) was used for the substrate test for enterococci. Each batch of agar media was tested for pH and sterility. Positive and negative control cultures were also inoculated onto representative portions of the prepared plates. Only media that passed all QA checks were used.

E. coli was analyzed using Hach m-ColiBlue24 Broth, which is commercially prepared and packaged in PourRite ampules. The ampules were refrigerated until the day of use when the tops were broken and the liquid broth aseptically poured onto a sterile absorbent pad in a sterile 47mm petri dish with a tight-fitting lid. All ampules were used before their expiration dates.

Sterile phosphate buffered water was used as the diluent for all dilutions and also as a rinse water during membrane filtration. The phosphate buffer was made according to Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1992) Section 9050C1. The buffer was prepared with 1.25 mL stock phosphate buffer solution (34 grams potassium dihydrogen phosphate in 1 liter deionized water) and 5 mL stock magnesium chloride solution (81.1 grams magnesium chloride per 1 liter deionized water) per 1 liter deionized water. Buffer was dispensed into either 1 liter screw-capped flasks (for rinse water) or into screw-capped test tubes (9 mL per tube) for dilution blanks. The buffer was autoclaved, cooled, and then tested for pH and sterility. Buffer was stored at room temperature until used. The holding time for the prepared buffer was three months.

Membrane Filtration Procedure

Water samples were analyzed by the membrane filtration procedure according to Standard Methods. Total coliform densities by membrane filtration were determined as recommended in Standard Methods Section 9222B and fecal coliform densities were determined according to Section 9222D. Enterococci densities were analyzed according

collected between 8:00 A.M. and 11:00 A.M. in the following order; Malibu, Will Rogers, and Ashland. After all samples were collected, they were transferred to the Los Angeles Bureau of Sanitation's Environmental Monitoring Division's microbiology laboratory at the Hyperion Treatment Plant by noon for analysis. Samples were taken in the morning because a) it was not feasible to collect samples later in the day and have them analyzed given the daily schedule in the lab and b) it was not advisable to have staff obviously collecting water samples at specific locations relative to the drain at the same time subjects were being interviewed on the beach.

Laboratory Determination of Bacterial Indicators (Total and Fecal Coliforms, *E. coli*, Enterococcus)

All laboratory work was conducted by the City of Los Angeles, Environmental Monitoring Division, Biology Section - Microbiology Unit.

Samples

All samples were collected using clean, sterile 1 liter polypropylene sample bottles, leaving ample air space in the bottle to facilitate mixing by shaking. After collection, samples were transported to the lab in an iced cooler to maintain sample temperature below 10°C. Samples were received within six hours of sample collection and analyses started within two hours of arrival to the lab.

Media

Agar used for the culturing of the indicator bacteria total coliforms, fecal coliforms, and enterococci were prepared according to the manufacturers' directions using a New Brunswick Scientific Co., Inc. AgarMatic benchtop sterilizer. Each agar was cooled to approximately 45°C and aseptically dispensed via a pump and sterile tubing into sterile, disposable 60mm petri dishes for total coliforms and enterococci. Agar for fecal coliforms was dispensed into 47mm sterile petri dishes with tight-fitting lids. Prepared plates were placed in covered containers and refrigerated until used. The maximum holding time for the prepared plates was two weeks.

Difco mEndo Agar LES (51 grams of dehydrated media to 1 liter of deionized water containing 20 mL of 95% ethanol) was used for total coliforms. Difco mFC Agar

10. The walls of the funnel are rinsed down three times with approximately 30 mL of sterile, buffered rinse water. When the rinse water has drained through, the vacuum is turned off.

11. The funnel is lifted off and the filter is aseptically removed using a sterile forceps. The filter is aseptically placed, using a rolling motion, grid side up onto the surface of the appropriately labeled petri dish containing agar or a broth-saturated pad. Care is taken to avoid trapping air between the agar or pad surface and the filter.

12. Steps 6-11 are repeated for each sample volume or dilution required for the sample. The smallest sample volume is filtered first, followed by increasing sample volumes.

13. If dilutions are required, 1:10 serial dilutions are made, using sterile 9 mL dilution blanks and 1 mL of sample. The most dilute sample aliquot is filtered first, followed by increasing sample concentration dilutions.

14. When all the sample volumes or dilutions have been filtered for the sample, the plates are placed into the appropriate incubators.

    a. Total coliform mEndo LES agar plates are incubated for 24 ± 2 hours at 35.0 ± 0.5°C.

    b. Fecal coliform mFC agar plates are incubated for 24 ± 2 hours at 44.5 ± 0.2°C. These plates are incubated within 20 minutes of filtration to ensure heat-shock of the non-fecal bacteria. The plates are placed in either dry heat-sink incubators or sealed in water-proof bags and placed in a 44.5 ± 0.2°C water bath.

    c. Enterococcus mE agar plates are incubated for 48 ± 2 hours at 41.0 ± 0.5°C.

    d. *E. coli* broth plates are incubated for 24 ± 4 hours at 35.0 ± 0.5°C.

15. All sample collection, filtering, and incubation times are recorded in the sample log book.

B. Colony Morphology

to Section 9230C. *E. coli* densities by membrane filtration were determined as recommended by Hach Method 10029 for m-ColiBlue24 Broth.

A. Filtration/Incubation

Millipore's Microfil System, consisting of disposable 100 mL polypropylene "push-fit" sterile funnels and HA 0.45 μm sterile membrane filters, were used for filtering each sample. Samples were filtered under partial vacuum provided by a vacuum pump. The filtration procedure used is as follows:

1. Using an alcohol flamed-sterilized forceps, a new sterile membrane filter is aseptically placed, grid side up, onto the sterile filter support base.
2. The Microfil sterile, disposable funnel is aseptically placed on the support and pushed down to fix it firmly in place.
3. The funnel is rinsed with approximately 20-30 mL of sterile, buffered water. This is the sample QA blank to ensure that the equipment and the buffered rinse water were sterile.
4. The vacuum is applied and the buffered rinse water is allowed to drain through the filter. The vacuum is turned off.
5. The funnel is lifted off and the filter is aseptically removed using a sterile forceps. The filter is aseptically placed, using a rolling motion, grid side up, onto the surface of the appropriately labeled petri dish containing agar. Care is taken to avoid trapping air between the agar surface and the filter.
6. A new sterile filter is aseptically placed onto the filter support base.
7. The membrane filter is wet with approximately 20-30 mL of sterile, buffered rinse water before the sample aliquot is added, using sterile disposable pipets or sterile graduated cylinders.
8. The sample is swirled in the filter funnel by moving the funnel in a gentle circular motion to evenly distribute bacterial cells on the filter surface.
9. The vacuum is applied and the buffer and sample is allowed to drain through the filter.

adding the counts of all the sample volumes filtered and multiplying by 100 and then dividing by the sum of all the volumes (mL) filtered.

Quality Assurance

Quality assurance and quality control tests were performed to verify the validity of the analytical data collected. All areas that influence the reported data were subjected to established microbiological quality control procedures in accordance with Standard Methods. These areas included sample storage and holding, lab facilities, personnel, equipment, supplies, media, and analytical test procedures. In addition, duplicate analyses were performed on ten percent of all samples. When quality control results were not within acceptable limits, corrective action was initiated. The laboratory also participated in performance evaluation samples sent by the State Department of Health Services. The quality assurance program helped ensure the production of uniformly high quality and defensible data. The Hyperion microbiology laboratory has been certified by the California State Department of Health Services.

Virus Sampling and Assay for Enteric Viruses

All laboratory work was conducted at the Environmental Sciences Laboratory of the County Sanitation District of Orange County.

Sampling Design and Frequency

Method 9510 C g of Standard Methods for the Examination of Water and Wastewater, 18th edition was used in all virus sampling. The sampling was performed at three storm drain sites on Friday, Saturday and Sunday from June 23 to September 24, 1995. Sampling days and duration of the project reflected heaviest beach usage during the 1995 swimming year. Water samples as large as 100 gallons were filtered through electropositive filters at ambient pH. Flow rate through the adsorption filter was kept below 5 gpm. Adsorption filters were eluted in the field with one liter of sterile 3% beef extract adjusted to pH 9.0 with sodium hydroxide.

Field eluates were returned to the laboratory where they were reconcentrated using an organic flocculation procedure described by Katezenelson et al., 1976. In this method, the eluate was adjusted to pH 3.5 by dropwise addition of 1N HCI while mixing

A stereoscopic microscope with a fluorescent lamp is used to aid in identifying and counting colonies after the appropriate incubation times. All colony counts, counting times, and any other notable information is recorded on the sample data worksheet.

1. Total coliforms: typical colonies have a pink to dark-red color with a shiny, greenish-gold, metallic surface sheen. The sheen may appear only in the central area or on the periphery.
2. Fecal coliforms: any colony exhibiting any light or dark blue color, whether covering the entire colony or only in or on part of the colony.
3. Enterococcus: after 48 ± 2 hours incubation, mE filters with growth on them are transferred to room temperature EIA plates. These EIA plates are incubated for 20 minutes at 41.0 ± 0.5 °C. Enterococci are pink to red-brown colonies with black or reddish-brown precipitate or halos on the underside of the filter when place on EIA agar.
4. *E. coli*: all blue to purple colored colonies (total coliforms are all red plus blue/purple colored colonies).

C. Calculations

Due to the possible adverse effect of colony crowding on sheen or color development on the membrane filter, and to be assured of a statistically valid colony count, minimum and maximum levels are adhered to for each of the indicator organisms. The minimum and maximum ranges are as follows:

1. Total bacteria: <200 total colonies (background and indicator bacteria)
2. Total coliform: 20 - 80 coliform colonies
3. Fecal coliform: 20 - 60 fecal coliform colonies
4. Enterococcus: 20 - 60 enterococcus colonies
5. *E. coli*: 50 coliform colonies

Indicator bacteria are expressed as bacterial density - colony forming units (CFU) per 100 mL of sample. Counts within the statistical range for the bacterial indicator are calculated by multiplying the colony count by 100 and dividing by the volume (mL) of sample filtered. If no counts fall within the ideal range, the density is calculated by

final concentrate that could be quantified. The remaining concentrate volume was split in half and analyzed using the liquid overlay technique known as the cytopathic effect assay (CPE). The CPE assay is generally considered to detect a greater number of viruses, but it is not quantitative. All flasks of BGMK cells used in the CPE method were frozen after a maximum of 10 days. The flasks were then thawed and a portion of the original flask was transferred to a fresh flask of BGMK cells. Flasks that did not exhibit CPE in the initial CPE assay or the subsequent passage to fresh cells were considered to be negative for detectable infectious viruses. Any flask exhibiting CPE in either initial or subsequent passages was further examined by the plaque forming unit method to confirm the presence of infectious viruses.

Statistical Analyses

From the initial data set of 11,793 subjects who were successfully contacted and eligible, 107 were excluded due to reporting that they (or their child) did not get their face wet when swimming, leaving a total of 11,686 subjects included here. When looking at the bacteriological exposures, subjects with missing values (for the bacterial densities) were excluded (subject counts for each of these exposures are given in the tables). Socioeconomic status (SES) was estimated from census data (based on median values for each subject's zip code); missing SES values (for 1,546 subjects) were imputed as the median value among all subjects.

To assess the health effects of swimming near storm drains and high bacteriological levels, we first used simple descriptive statistics, such as histograms, tabular comparisons, and stratified analyses. We then calculated odds ratios (ORs) and 95% confidence intervals (CIs) from logistic regression models. These models provided approximate relative risks while allowing for control of potential confounding. We fit models for the two primary exposures (i.e., distance of swimming from the storm drain and measures of bacteriological exposure) for each of the outcomes of interest. We present results from modeling the exposure categorically and continuously. For the continuous models, we either present ORs and 95% CIs, or P values for trend; note that one can assess the trend P from the continuous 95% CIs.

continuously on a magnetic mixer. After reaching pH 3.5, mixing continued for an additional 30 minutes in order to maximize the potential for virus particles to adsorb to the organic floc. The entire eluate was then centrifuged at 3000 X g for 10 minutes in order to recover the floc. The pelletized floc was then resuspended in 0.45N Na_2HPO_4. In most cases, the final concentrate was in the 10 to 15 mL range.

Analyses of initial samples on tissue culture indicated that some of the final concentrates were toxic to host cells. Because of this toxicity, all final concentrates were detoxified prior to assay using the procedure described by Glass et al, 1978.

Additional parameters measured by the field team was ambient pH, temperature, conductivity and Total Dissolved Solids.

Seed Studies

Seed studies were performed at the laboratory using water collected from each sample location. Six studies were performed in water collected from Santa Monica Canyon, seven in water from Malibu and seven in water from Ashland. These studies were done to measure the effectiveness (i.e., percent recovery) of the virus adsorption, elution and reconcentration procedures in actual storm drain effluent.

Two 35 gallon containers were filled with water from each location. The water was trucked to the L.A. County Sanitation Districts Laboratory where a known amount of vaccine strain poliovirus was added to the water. Three grab samples were taken from the 35 gallon containers at the beginning and end of each experiment. These grab samples were diluted 1:10 in Hank's Balanced Salt Solution (HBSS) to minimize any toxic effect to the virus by the water itself. Percent recovery was measured by comparing the concentration of virus as measured in the grab samples to the concentration measured in the final sample concentrates.

Enteric Virus Assay

All samples were analyzed for infectious human enteric viruses on Buffalo green monkey kidney cells (BGMK). Ten percent of the final concentrate volume was initially analyzed by the plaque forming unit (PFU) technique. The reason for this initial screening was to determine whether there were viruses present in a small portion of the

participants at the beach, ineligible, lost to follow-up, or from whom we obtained completed interviews did not differ by beach site (Figure 2). Reasons for non-participation are listed in Table 2. The major reason for non-participation was that the subject was ineligible because of a prior visit to a study beach (usually the same beach) or Mothers' Beach in the prior seven days (17% of beach contacts). Of the 22,085 persons approached on the beach, only 1761 (8%) refused to participate. Whites were slightly more likely to be non-participants than other racial ethnic groups (usually because they were ineligible). There were no major differences in the ethnicity or gender of non-participants across beaches (Figure 3). Reasons for "non-actualized" telephone interviews, meaning the attempt did not result in a completed interview from a subject interviewed at the beach, are presented in Table 3. The major reason was that subjects were found to be ineligible because they had returned to a study beach and immersed their heads in the water subsequent to the day of the beach interview (10% of beach interviews). The major reason for losses to follow-up was an apparently wrong or disconnected number (8% of beach interviews), which occurred predominantly early in the study. The proportions of "non-actualized" telephone interviews did not differ substantially by ethnicity, gender, or age (Figure 4) (although there was a slight tendency for whites and older subjects to fall into this category).

Table 4 presents characteristics of the 11,793 subjects who remained eligible throughout the study and completed the beach and telephone interviews. An objective was to have a ratio of 3:1 for subjects 0-100 versus greater than 400 yards from the storm drain. We achieved a ratio of 2.9:1. The majority of subjects (78%) came from family units where we included more than one subject per family. Only ten percent of subjects had residences in zip codes where the median household income was less than $25,000. This percentage was slightly higher at Ashland (13%). Eighty-eight percent of subjects were residents of California and there were no differences in this percentage by beach. We compared the study subjects with residents of Los Angeles County using the Population Estimation And Projection System (PEPS) for 1993 provided to us by the Toxics Epidemiology Program of the Department of Health Services of Los Angeles

Potential confounders adjusted for include: age, beach, race, gender, SES, California versus out-of-state residence and worry about potential environmental hazards due to swimming in the Santa Monica Bay. In addition, we adjusted the distance results for each of the bacteriological exposures and we adjusted the bacteriological results for distance. We also performed subgroup analyses by age and beach for the exposures/outcomes of interest. Interactions between distance from the drains and bacteriological exposures were assessed (with logistic regression) as well. Finally, for the significant results, we estimated the number of cases attributable to the corresponding exposure. The list of variables available for analysis is presented after the narrative portion of the Results and Discussion sections.

III. RESULTS

For clarity of presentation, we will describe all major results in this narrative section, followed by the Discussion Section. All of the tables and figures are provided after the References Section (before the Appendices). Results will be described in four sections: descriptive data from the beach and telephone interviews, descriptive data from the laboratory determinations of bacterial indicators, associations between risk of health outcomes and distance from the storm drain, and associations between bacterial indicators and risk of health outcomes. At the end of the last section, we present results of multivariate modeling where we included both distance from the drain and the bacterial indicators in the same model. After the section on multivariate modeling, we present an analysis of the virus data. Final results for all associations we examined are included here.

Descriptive Data (from the beach and telephone interviews)

Table 1 presents a calendar with the number of completed interviews by day. As expected, more interviews were completed on weekends. Also, more interviews were completed in July than other months. As stated earlier, we were able to successfully complete telephone follow-up interviews for 84% of the eligible subjects who were interviewed on the beach (Figure 1). The proportions of subjects who were non-

be due to swimming in the ocean making it more difficult to detect any excess risk due to swimming). This decision was made prior to seeing what risk ratios were associated with this variable.

With respect to proportions of subjects reporting symptoms, there were no differences by gender. There were no substantial differences by age, although the proportion of children 0-12 with fever and vomiting was slightly higher than among older subjects and the proportion of children 0-12 with cuts that became infected was slightly lower than among older subjects. There were generally no differences by ethnicity, socioeconomic status (SES), or residence in California versus outside of California, with the following minor exceptions. Latino/a subjects reported less diarrhea, stomach pain or cramps, and nasal congestion. Based on the opinion of many of our bilingual staff, we suspect this may reflect some underreporting of these symptoms, rather than a real difference in outcomes. Persons who lived in zip codes where the median household income was less than $25,000 reported higher rates of fever, while subjects who lived in zip codes with median household incomes greater than $25,000 reported higher rates of diarrhea, but generally there were no striking differences by this ecological measure of SES. Overall, there was a tendency for California residents to report more symptoms than non-residents, but these differences were small.

Finally, Table 11 also presents results for the variable regarding level of concern about environmental hazards at the beach. As level of concern increases, the proportion of subjects reporting symptoms increases. This question was asked only at the end of the telephone interview because we did not want to bias responses to the list of symptoms by asking before then and we did not want to ask it at the beach because we wanted a streamlined questionnaire and we did not want to raise concerns about the beach for subjects who participated in this study. The manner in which it was asked does not enable us to distinguish between two possibilities: people with a high degree of concern overreported their symptoms relative to the other subjects or, more plausibly, those who subsequently experienced symptoms after the beach interview had their level of concern raised (after the fact). In either event, this variable was not strongly associated with

County (Table 5). As expected, the study subjects were younger (e.g. 48% were under 12 years of age versus 22% from PEPS). This reflects the fact that beachgoers who enter the water tend to be younger, which allowed us to examine possible differences in effects by age. The proportion of male study subjects was slightly higher in the study than in Los Angeles County (55% vs 50%). For White and Latino/a subjects, there were no substantial differences between study subjects and their proportions in L.A. County.

Table 6 presents subject age by map area (distance from the drain) for each beach. Table 7 presents similar data by gender for each beach and Table 8 presents these data by ethnicity. A summary for all beaches combined is presented in Table 9. Children 0-12 years of age tended to swim at the drain more than older subjects (63% of subjects swimming at the drain were children 0-12, whereas children 0-12 represented only 48% of all subjects). There were no differences by gender (e.g. 53% of subjects swimming at the drain were males and they constituted 55% of all study subjects). There was a tendency for Latino/a subjects to swim at the drain more so than Whites (59% of subjects swimming at the drain were Latino/a, whereas they comprised 43% of the total study subjects).

Table 10 presents counts of each symptom ascertained from the telephone interview. Table 11 presents rates for each symptom by various categories. The most commonly reported single symptoms were: nasal congestion (reported by 9.1% of respondents), coughing (7.1%), sore throat (6.8%), stomach pain or cramps (6.2%), diarrhea (5.3%), and fever (4.8%). The most commonly reported composite variable was significant respiratory disease or SRD (5%), which is defined as all those reporting any one or more of the following symptom groups: 1) fever and nasal congestion or 2) fever and sore throat or 3) cough with phlegm. The other composite variables were HCGI 1 (3%) and HCGI 2 (0.9%). HCGI 1 included all those experiencing any one or more of the following symptom groups: 1) vomiting or 2) diarrhea and fever or 3) stomach ache and fever. HCGI 2 includes all those reporting both vomiting and fever (we decided to exclude diarrhea in this second composite since diarrhea was reported relatively commonly by study subjects and much of it may represent background rates that may not

Avenue for each indicator, Figures 6A-D present the counts for Malibu, and Figures 7A-D for Will Rogers.

From the tables and figures, four major points are evident: 1) the counts were highly variable from day to day; 2) for a substantial proportion of days, the counts exceeded the established cutoffs; 3) the counts were generally higher in front of the drain and then dropped off with increasing distance from the drain; 4) the water samples taken at 400 yards were not always "clean" with respect to the bacterial indicators (i.e. counts occasionally exceeded the established cutoffs). Also, in general, the water quality (as judged by these indicators) was relatively poor compared to previous years.

Associations Between Distance from the Drain and Health Outcomes

As a measure of the strength of association, we rely predominantly on the risk ratio (labeled RR in the tables). This ratio expresses the risk (proportion of subjects who report a given symptom) among subjects who swam, for example, in front of the drain (designated 0 yards) versus the risk among subjects who swam 400+ yards from the drain. For the sake of brevity, subjects who swam 400+ yards from the drain are referred to as "controls" since they served as the reference group for all calculations in this section. Ninety-five percent confidence intervals are presented for each RR. For example, in Table 17, the RR for fever is 1.57, suggesting that the risk of fever for subjects swimming at 0 yards (in front of the drain) is 57% higher than the corresponding risk for subjects who swam at 400+ yards from the drain. The interval estimate is 1.17-2.10, which is narrow and the lower bound is above 1.0, indicating the result is informative and statistically significant at alpha = .05. For interested readers, we also present the absolute number of subjects in each comparison group who reported a symptom and the absolute risk in each group, facilitating calculations of excess risk and attributable numbers.

Since the predominant direction of the plumes traveling from the storm drains into the ocean was downcoast, we distinguished distance from the drain by designating upcoast and downcoast distances. Tables 17-21 present risks and RR's for subjects swimming at 0 versus 400+yards, 1-50 yards upcoast versus 400+yards, 51-100 yards

upcoast vs. 400+ yards, 1-50 yards downcoast vs. 400+ yards, and 51-100 yards downcoast vs. 400+ yards, respectively. The effects for 0 yards and the downcoast distances are also summarized in Table 22, and the 0 yards and upcoast distances are summarized in Table 23. Comparing subjects who swam at 0 versus 400+ yards from the drain, we observed statistically significant increases in risk for fever, where the RR=1.57 (95% C.L. = 1.17-2.10), chills RR=1.58 (1.04-2.39), ear discharge RR=2.27 (1.14-4.51), vomiting RR=1.61 (1.01-2.56), coughing with phlegm RR=1.59 (1.10-2.29), HCGI 2 RR=2.11 (1.12-3.97), and SRD RR=1.66 (1.25-2.21). These increases in risk appeared to be limited to the 0 yards distance, since we observed very few significant effects at other distances upcoast or downcoast from the drain, and no significant trends with increasing distance from the drain (data not shown).

As we noted earlier, there were a number of days when the bacterial indicators at 400 yards exceeded the cutoff points, suggesting that this distance was not always a "clean control" area. As we describe in the next section, one of the better indicators for predicting health risks is the total coliforms to fecal coliforms ratio. We conducted a second set of analyses restricted to the days when the total to fecal ratio was greater than 5 for the water samples taken at 400 yards for a given beach (we noted that the enterococci count was always less than 106 during these times). The rationale was to exclude days when the plume from the drain (or some other source of higher counts, such as septic tanks) apparently reached the 400 yard point, making this point less than an ideal "control" zone. The prior expectation was that health risks associated with distance should increase since we "cleaned up" the control area. Results are presented in Tables 24-30. The relative risk point estimates for the seven outcomes found significant above (fever, chills, ear discharge, vomiting, coughing with phlegm, HCGI 2, and SRD) all increased for the 0 yards versus 400+ yards comparison (see Table 24). The interval estimates were wider since the results were based on fewer numbers of subjects. It was also of interest to see if health effects were observed for the other distances of 1-50 and 51-100 yards versus 400+ yards from the drain. A number of higher RR's were observed for the effect of swimming 1-50 yards upcoast, but none reached statistical significance

(Table 25). For subjects at 51-100 yards upcoast versus 400+ yards, significant increases in risk were observed for sore throat RR=1.45 (1.01-2.09) and SRD RR=1.91 (1.16-3.16) (Table 26). Similarly, for swimmers 1-50 yards downcoast, we observed a number of higher risks (Table 27); only the effect of SRD was statistically significant RR=1.77 (1.07-2.95). At 51-100 yards downcoast, significant increases in risk were observed for coughing, coughing with phlegm, nasal congestion, and SRD. Results are summarized in Tables 29 (downcoast) and 30 (upcoast).

Distance Effects Adjusted For Potential Confounders: We then used logistic regression to adjust for potential confounders. The resulting odds ratios provide close approximations to risk ratios and using logistic regression allows for more efficient and complex modeling of associations. Results are presented in Table 31. Adjusting for beach, age, race, gender, SES, California versus out-of-state residents, and worry about potential health hazards at the beach did not change the essential findings, although the associations for vomiting and HCGI 2 were slightly attenuated and no longer significant. It is possible, but, in our opinion, highly unlikely that we have missed a major confounder of the distance effects.

Possible Heterogeneity By Beach and By Age: We hesitate providing results for subgroups since the study was never designed to have sufficient power to detect subgroup differences. With this caveat, we explored possible differences in effects by beach and by age. Results for each beach separately are presented in Tables 32-34. There appear to be some differences in effects by beach, but it is difficult to judge what is real versus what is due to random variation with smaller numbers; the only noteworthy result from a test of heterogeneity was for earache ($p<0.01$). Results for three age categories (0-12, 13-25, 26+) are presented in Tables 35-37. It appears that children and young adults have higher risks associated with distance than older adults for a number of outcomes. In fact, the highest risks were usually noted for subjects aged 13-25 years of age. A heterogeneity test was significant only for SRD ($p=0.05$)

Associations Between Bacterial Indicators and Health Outcomes

We took a number of approaches to analyzing the effects of bacterial indicators. For each indicator, we calculated risk ratios using the higher and lower cutpoints described earlier (e.g. 200 and 400 cfu for fecal coliforms). This ratio expresses the risk of a given outcome among subjects who swam in water where the bacterial indicator was higher than the cutpoint (presumably higher risk) compared to the risk of the same outcome among subjects who swam in water where the same bacterial indicator was below the cutpoint. It was conceivable that we might have failed to detect a real increase in risk with these cutpoints, particularly since they were not based on prior data that were obtained for Santa Monica Bay, so we also calculated odds ratios from categorical models using quintiles (instead of dichotomies, as above), and from continuous models. For the categorical models, the quintile medians, total number of subjects in each quintile, and the number reporting a given symptom in each quintile are provided in the tables. For the continuous linear (on logistic scale) models, odds ratios correspond to a unit increase equal to the difference between the 90th and 10th percentiles (i.e. the difference between the midpoints of the fifth and first quintiles). Results for each bacterial indicator are presented below.

E. coli. Results are presented in Tables 38-42. We observed no effects on risk using the cutpoints of 35 or 70 cfu for any symptom (Tables 38 and 39). We also investigated effects associated with cutpoints of 160 and 320 (Table 40). At the highest cutpoint of 320, associations were observed for earache RR=1.46(1.06-2.00) and nasal congestion RR=1.24(1.00-1.53). Results for the categorical and continuous models are presented in Table 41. No effects were observed for the categorical model (quintiles). With the continuous model, small but significant effects were noted for skin rash, nausea, and stomach pain. These associations were slightly stronger for skin rash and no longer statistically significant for nausea and stomach pain after adjustment for covariates (Table 42).

Enterococcus. Results are presented in Tables 43-46. No increases in risk were detected when 35 cfu was used as the cutpoint (Table 44). When 106 cfu was used as the

cutpoint, significant effects were noted for diarrhea with blood RR=4.23 (1.12-15.91) and HCGI 1 RR=1.44 (1.03-2.03) (Tables 43 and 44). Results from the categorical model suggest positive associations for diarrhea and stomach pain, where the odds ratios for the fifth versus first quintile were 1.31 (1.00-1.72) and 1.31 (1.02-1.68) respectively. In the continuous model, positive associations were noted for fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, and HCGI 1 (Table 45). The categorical findings were substantially weakened, while the continuous results were essentially unchanged after adjustment for covariates (Table 46).

Total Coliforms. Results are presented in Tables 47-50. No significant effects were seen when the cutpoint of 1,000 cfu was used (Table 48). When 10,000 cfu was used as the cutpoint, only skin rash exhibited a positive association RR=3.00 (1.86-4.83) (Tables 47 and 48). Similarly, the categorical model only showed an association with skin rash and the continuous model did not yield any associations (Table 49). Results did not materially change after adjustment for covariates (Table 50).

Fecal Coliforms. Results are presented in Tables 51-54. No significant effects were seen when 200 cfu was used as the cutpoint (Table 52). When 400 cfu was used, only an association with skin rash was evident RR=1.88 (1.21-2.94) (Tables 51 and 52). A similar effect was observed in the categorical model, where the odds ratio for skin rash comparing the fifth to the first quintile was 2.04 (1.09-3.81). In the continuous model, significant effects were observed for fever, skin rash, and HCGI 1. Adjusting for the potential confounders did not change the results except, with the continuous model, nasal congestion was now positively associated with fecal coliforms.

In addition to investigating effects for single indicators, as above, we also assessed the effects of the total coliforms to fecal coliforms ratio and the ratio of total coliforms to enterococcus. Results are summarized below.

Total coliforms to fecal coliforms ratio. As initially suggested by Jack Petralia (Los Angeles County Department of Health Services) we initially used a ratio of 5.0 for the cutpoint, assuming that the risk may be higher when the ratio is smaller than 5.0. When the effects of this ratio were estimated for the entire data set, significant effects

were noted for diarrhea RR=1.28 (1.08--1.51) and HCGI 2 RR=1.87 (1.20-2.90) (Table 55). We then estimated effects of this ratio restricted to subjects in water where the total coliform levels were greater than 5,000 cfu. Significant effects were observed for fever, eye discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and SRD (Table 56). The significant RR's ranged from 2-7. We then conducted a similar analysis restricted to subjects in water where the total coliform level exceeded 10,000 cfu. Here we observed significant increases in risk for eye discharge, ear discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and HCGI 2 (Table 57). The significant RR's ranged from 2-39. Results for all three analyses (the entire data set, counts > 5,000 cfu, counts > 10,000 cfu) are summarized in Table 58. It is noteworthy that all the effects noted above became consistently stronger as the analyses were increasingly restricted to occasions with higher total counts.

Since this ratio appeared to be informative (using 5.0 as a cutpoint), we decided to explore a range of cutpoints (2, 4, 6, 8) to see which cutpoint yielded the strongest associations (Table 59a for all the data, 59b restricted to times when the total coliforms exceeded 1,000 cfu and Table 59c for occasions when the total coliforms were greater than 5,000. When the ratio cutpoints were analyzed for all days, diarrhea and diarrhea with blood were associated with the ratio at some cutpoints but no consistent patterns across cutpoints was evident. In contrast, when analysis was restricted to times when the total coliforms exceeded 5,000 cfu, there was a strong and consistent pattern of increasing RR's as the ratio decreased, with the strongest effects observed using a cutpoint of 2.0. When the analysis was restricted to times when the total coliforms exceeded 1,000 cfu, the pattern was not as strong or consistent, although most effects were again strongest using the cutpoint of 2.0.

Results for the categorical and continuous models are presented in Table 60 (note: this analysis included the entire data set). The categorical model indicated a positive association with diarrhea, coughing and coughing with phlegm and the continuous model yielded associations with diarrhea, stomach pain, cough, coughing with phlegm, and sore throat. Results were, in general, slightly weaker when adjusted for covariates (Table 61)

and statistical significance remained only for cough and cough with phlegm; nevertheless, for the associations with diarrhea, stomach pain, and sore throat from the continuous model, adjusting for covariates only shifted the lower 95% C.I. bound from 1.00 to 0.98 or 0.97.

Total coliforms to enterococci ratio. Accepted cutpoints are not available for this ratio, so the analysis explored a range of cutpoints (4, 7, 10, 13), in addition to categorical and continuous models. Results for the range of cutpoints are presented in Table 62. Diarrhea was associated with this ratio at all cutpoints with an odds ratio of 1.4-1.5. In general, the highest cutpoint of 13 yielded the greatest number of significant associations (fever, nausea, diarrhea, and stomach pain were associated with this ratio when 13 was used as the cutpoint). In the categorical model, the ratio was associated with increases in risk for nausea, diarrhea, and HCGI 1 (Table 63). In the continuous model, no effects were noted. Results were slightly weaker for nausea and HCGI-2 and essentially unchanged for diarrhea and HCGI-1 after adjustment for covariates (Table 64).

Results of Multivariate Modeling With Both Distance and Bacterial Indicators

To further assess the associations for distance and bacterial indicators, these exposures were simultaneously included in logistic regression models. Hence, in these models, distance was adjusted for the bacterial indicator and vice-versa. When modeling the potential associations with distance from the drain, including *E. coli*, enterococcus, total coliform, or fecal coliform one-at-a-time as covariates generally did not alter the findings presented here; the only differences were that earache now appeared positively associated with enterococcus (adjusted OR=1.51, 95% CI=1.0-2.28) and with fecal coliform (adjusted OR=1.61, 95% CI=1.06-2.44) comparing the highest to lowest quintile and that the total coliform-skin rash association was slightly weakened. A model that included both distance and all indicators together did not materially alter our general findings.

To investigate further the potential associations for distance and bacterial measures, we modeled the interactions between these exposures using logistic regression. In particular, we looked at the interaction between swimming (at zero or four-hundred yards from the drain) and swimming when the bacterial level was above or below the highest cutpoints used here. For example, for fecal coliform, we compared the risk for those swimming at the storm drain when fecal coliform > 400 cfu versus the risk for those swimming at 400+ yards when fecal coliform <= 400 cfu (i.e., the referent group). In addition, we compared the risk from swimming at 400+ yards when fecal coliform > 400 cfu and the risk from swimming at the storm drain when fecal coliform <= 400 cfu to the risk for those swimming at 400+ yards when fecal coliform <= 400 cfu. This type of modeling helps distinguish whether a combination of exposures (e.g., swimming at the storm drain and swimming on high count days) increases one's risk over the exposures alone. Based on these models, we observed the following noteworthy results (i.e. a pattern of increased risk associated with both high bacterial counts and distance in front of the drain). In comparison with swimming at 400+ yards when *E. coli* <= 70 cfu, the relative risk of vomiting for swimming at 400+ yards when *E. coli* > 70 cfu was 0.63 (95% CI=0.19-2.05), for swimming at the storm drain when *E. coli* <= 70 cfu was 1.26 (95% CI-0.65-2.47), and for swimming at the storm drain when *E. coli* >70 cfu was 2.11 (95% CI=1.14-3.89). The relative risk of HCGI 2 for swimming at 400+ yards when *E. coli* > 70 cfu was 0.74 (95% CI=0.38-1.44), for swimming at the storm drain when *E. coli* <= 70 cfu was 1.65 (95% CI=0.70-3.90), and for swimming at the storm drain when *E. coli* > 70 cfu was 2.45 (95% CI1.08-5.57), again in comparison with swimming at 400+ yards when *E. coli* <= 70 cfu. Finally, the relative risk of HCGI 2 for swimming at 400+ yards when enterococcus > 106 cfu was 6.34 (95% CI=0.81-49.36), for swimming at the storm drain when enterococcus <= 106 cfu was 1.71 (95% CI=0.76-3.87), and for swimming at the storm drain when enterococcus > 106 cfu was 4.68 (95% CI=1.97-11.10), in comparison with swimming at 400+ yards when enterococci <=106 cfu. Note that the interaction model for distance and total coliform did not converge.

Summary of Bacteriological Results

Tables 65-70 summarize the noteworthy distance and bacterial indicator results presented above. For each association, the relative risk and attributable number are presented. The attributable number is an estimate of the number of new occurrences of the specified outcome that are attributable to the exposure of interest. For example, based on the results from this study, the first row of table 65 indicates that approximately 259 new cases of fever will occur for every 10,000 people who swim at the drain instead of 400 yards (or more) away from the drain. These values are estimated as:

$$\text{Attributable number} = A * (RR-1) / RR,$$

where A = the number of exposed and diseased subjects, and RR = the risk ratio. The attributable numbers have an important public health interpretation: they provide an estimate of the maximum number of potential cases that could be prevented (based on the specific point estimate and assuming a causal effect) if the exposure was completely eliminated. The attributable numbers per 10,000 subjects exposed ranged into the 100's for a number of exposures. At meetings organized by the SMBRP prior to the start of the study (and attended by senior scientists who were to direct the study, SMBRP staff and technical advisors, and public health practitioners from the L.A. County Department of Health Services), an excess risk of 1 case per 100 exposed subjects was identified by verbal consensus as a "noteworthy" risk. The attributable number corresponds to this excess risk and any number above 100/10,000 represents an excess risk greater than 1/100. For bathing at the drain versus 400+ yards, attributable numbers for fever (259), chills (138), vomiting (115), coughing with phlegm (175) and SRD (303) all exceeded 100 cases/10,000 exposed. For bacterial indicators, when the entire data set was analyzed (Table 66), attributable numbers exceeded 100 cases/10,000 exposed for HCGI1 (130 for enterococcus), skin rash (165 for total coliforms), diarrhea (277 for the total to fecal ratio), nausea (147 for the total to enterococcus ratio), diarrhea (262 for the total to enterococcus ratio, and HCGI1 (111 for the total to enterococcus ratio). The attributable numbers from the continuous models were much smaller because the odds ratios from these models were relatively weak (Table 67). Table 68 presents attributable numbers for

the range of cutpoints (2, 3, 4, 5, 8) for the ratio of total to fecal coliforms for the entire data set. Diarrhea was most often associated with higher attributable numbers, but there was no consistent pattern across the range of cutpoints. When a similar analysis was done, but restricted to occasions when the total coliforms exceeded 1,000 cfu (Table 69B), the highest attributable numbers were generally associated with the cutpoint of 2.0. Many of these numbers were in the range of 100-400 cases per 10,000 exposed subjects. When this analysis was restricted to days when the total coliforms were greater than 5,000 cfu, there was a consistent pattern of higher attributable numbers associated with lower cutpoints. At the cutpoint of 2, attributable numbers ranged into the mid- and high 100's of cases per 10,000 exposed subjects for a number of outcomes. Finally, Table 70 presents a similar analysis for a range of cutpoints for the ratios of total coliforms to enterococcus. Diarrhea had the higher attributable numbers across all cutpoints (around 200 cases/10,000 exposed). Higher attributable numbers were associated with the highest cutpoint of 13.

Results of Virus Sampling Procedures

Results of the virus sampling procedures are presented in Tables 71 and 72. The percentage recovery from the seed experiments was quite high. Enteric viruses were detected on 8/11, 8/26, 9/3, 9/9, 9/10, 9/16 for Ashland; 7/21, 7/28, 8/25, 8/26, 9/9, 9/10, and 9/16 for Malibu, and 7/7, 7/18, 7/28, and 8/4 for Santa Monica Canyon. This number of positive samples did not enable us to conduct many analyses; however, we were able to compare the frequency of outcomes reported by subjects who were swimming within 50 yards of the drain on days when samples were tested for viruses and found to be negative versus days when the samples were positive for viruses. Results are presented in Table 73. Although based on small numbers, a number of outcomes were reported more often on days when the samples were positive for viruses, including fever (RR=1.53, 95% CI 0.97-2.42, p-value 0.07); vomiting (RR=1.89, 0.94-3.78), HCGI-1 (RR=1.74, 0.99-3.06) and HCGI-2 (RR=2.26, 0.91-5.60).

In Table 74, we present results for the virus analysis, adjusted for covariates. Results remained essentially unchanged. Finally, we also adjusted these results further

by including the bacterial indicators, one at a time, into the model (results not shown). These last series of adjustments made essentially no difference in the results (e.g. for fever, the crude RR=1.53 p=0.07, adjusted for covariates RR=1.56 p=0.06, adjusted for covariates plus fecal coliforms RR=1.57 p=0.06, covariates plus *E. coli* RR=1.58 p=0.06, covariates plus total coliforms RR=1.56 p=0.06, and covariates plus enterococcus RR=1.57 p=0.06).

Research with gene probes is ongoing and will be presented in an addendum to this report sometime in the near future (the lab conducting this work hopes to complete the assays by Spring, 1996).

IV. DISCUSSION

The following circumstances provided the motivation to conduct an epidemiological study of the possible acute health effects of swimming in Santa Monica Bay: A) the beaches are heavily populated in the summer months, B) there is a measurable volume of discharge into the bay from storm drains even in the summer months when there is little rainfall, C) there are numerous days with high levels of bacterial indicators, D) pathogenic human enteric viruses have been isolated from storm drain effluent even when bacterial indicator counts are low, and, E) anecdotal reports raised concern about adverse health effects of swimming in the bay. Based on numerous meetings and extensive peer review, the Santa Monica Bay Restoration Project decided that an epidemiological study of subjects swimming at selected beaches in Santa Monica Bay was the most direct and relevant means of addressing the question of possible adverse health effects.

The initial goal, as stated in the approved protocol, was to recruit 9000 subjects. Through refining our office and field techniques, we were able to complete interviews on 11,793 subjects who remained eligible throughout the follow-up phase of the study while completing the study at least $100,000 below the projected budget. Of the 22,085 subjects approached on the beach, only 1761 refused to participate, for a response rate on initial contact of 92%. Also, of the 15,492 eligible subjects interviewed on the beach, we

were able to contact by telephone and interview 13,278 (86% follow-up). The potential for selection biases would seem to be minimal, given the high response rates. It is also worth noting that the proportions and reasons for ineligibility or loss to follow-up were similar by beach.

The three beach sites where the study was conducted, Surfrider/Malibu, Will Rogers/Santa Monica Canyon, and Santa Monica/Ashland Avenue, were selected because prior data indicated they were heavily populated and experienced a wide range of indicator counts in the past. Throughout the summer, we encountered the size of crowds we expected at Malibu and Ashland Avenue. Work at Will Rogers by the Los Angeles County Department of Public Works throughout much of the summer substantially diminished the crowds at this beach. Our prior expectation of a wide range of indicator counts was realized throughout the summer of this study. We also observed a high degree of variability from day to day, and a substantial proportion of days when levels exceeded generally established cutpoints, particularly for samples taken at the drain. Malibu and Will Rogers exceeded cutpoints more often than Ashland Avenue; in fact, the lower standard cutpoints were exceeded the majority of the time for most of the bacterial indicators at Malibu and Will Rogers. Counts were generally highest at the drain and then diminished as distance from the drain increased. Of note, however, is that the counts for water samples taken at 400 yards sometimes exceeded cutpoints at all three beaches, suggesting this distance did not always represent a "clean control area".

We operationalized the issue of health effects from swimming in Santa Monica Bay into two research questions. 1) What are the relative risks of specific health outcomes among subjects bathing at 0, 1-50, and 51-100 yards of a storm drain compared to subjects bathing at the same beach but beyond 400 yards from a drain? We reasoned that if pathogens were coming from a storm drain and causing symptoms in swimmers, the risk of these specific symptoms should be higher in subjects who swim closer to the drain. 2) Are the risks of specific outcomes associated with levels of indicator organisms (as they are commonly monitored by departments of public health). This second question is motivated primarily by policy considerations, so we wanted to test the predictive value

of feasible, common monitoring practices. Results addressing each question are discussed below.

Associations between distance and health outcomes.

We observed differences in risk when we compared subjects swimming at 0 yards (meaning where the drain enters the bay) versus subjects swimming at 400+ yards. Significant increases in risk were noted for the single symptoms of fever, chills, ear discharge, vomiting, and coughing with phlegm, and the composite variables of HCGI 2 and SRD. Most of the risk ratios ranged from 1.5-2.0, suggesting a 50-100% increase in risk. The strongest effects were for ear discharge and HCGI 2. Very few increases in risk were observed for subjects swimming at 1-50 or 51-100 yards from the drain compared to subjects swimming at 400+ yards. This was an unexpected result. We are aware of at least two alternative explanations. One is that the risk is actually limited to subjects swimming in front of the drain, possibly because the level of pathogens at greater distances from the drain was quickly diluted below an infectious dose. This seems implausible since the plume clearly traveled beyond this point and high bacterial counts were noted at 1-50 and 51-100 yards (and some of these bacterial indicators were associated with increased risk of disease). Another explanation is that the risk is highest at 0 yards, but there may also be an elevated but smaller risk at 1-50 or 51-100 yards, which we were unable to detect because the reference group (subjects at 400+ yards) was occasionally exposed to water with high bacterial counts. To address this possibility, we analyzed a subset of the data restricted to days and beaches where the total:fecal ratio for the water sample taken at 400 yards was greater than 5.0. We chose this ratio because it was associated with adverse health effects (see below). This reanalysis yielded stronger relative risks when comparing subjects at 0 versus 400+ yards (compared to the original analysis of the entire unrestricted data set) and we also observed some increases in risk at 1-50 and 51-100 yards. This suggests that risk may not be limited to the 0 yards distance, and argues against a standard that discourages swimming only at the mouth of the drain (although the risks are clearly higher there).

The results regarding distance were not changed when we controlled for potential confounders, and are very unlikely to be due to confounding. The concern with confounding has been raised previously (Saliba 1990, Fleischer 1993, Kay 1994,), but it dealt with a different study design, sometimes referred to as the "Cabelli-type" study. In this design, risks in swimmers are compared to risks in non-swimmers. The problem with that design is that swimmers and non-swimmers are self-selected and may differ with respect to background risks since there are presumably many other exposures/pathways that can produce the symptoms under investigation. Some of these are unknown or difficult to quantify, so doubt remains, even after adjustment for the known and measured potential confounders, that the swimmers and non-swimmers are actually comparable. We implemented a design that should have substantially reduced the potential for confounding by restricting it entirely to swimmers (who immersed their heads in the water) and making comparisons between groups of swimmers (defined, for example, by distance from the drain) to estimate risk ratios. A priori, we believed that the background risk of subjects swimming closer to a drain should not be materially different from the background risk of subjects swimming farther away (they are all self-selected swimmers). When we compared a number of characteristics between subjects at different distances, the only variables that were differentially distributed by distance were age and ethnicity. Younger subjects and Latino/a subjects tended to swim closer to the drains. These variables, however, were not independent risk factors for the outcomes. When we controlled for these, as well as other covariates, there was no evidence of confounding.

We limited analyses of subgroups for three reasons: 1) the study was never designed to detect subgroup differences with reasonable power; 2) there were few reasons, a priori, to expect differences in effects between subgroups defined by most variables (e.g. gender, California resident, ethnicity, etc); and 3) policies that may emerge from this work would most likely have to apply to the "general population" and not to specific subgroups (it would seem implausible to establish one policy for one subgroup of the population defined, for example, by age, race, gender, and SES, and other policies for other subgroups). Based on discussions with interested parties, we agreed to explore

differences by beach and by age of the subjects. There appeared to be some differences when we stratified by beach; however, it is difficult to judge whether these are real differences or simply the result of random variation with smaller sample sizes per subgroup. When we stratified by age into three categories (0-12, 13-25, >25), the increased health risks observed earlier appeared to be stronger for children and adults less than 25. In fact, the strongest associations were usually evident in the 13-25 year age group. We presume this is due mostly to their increased activity (and hence exposure) in the water, which we did not attempt to quantify, and less so to any increased susceptibility for a given dose of exposure.

We decided not to restrict recruitment to one subject per family for two reasons. 1) It would have been impossible to achieve the sample size we needed. As it was, we approached every single potentially eligible subject throughout the study period to achieve our sample size. 2) We believed it would have been very difficult to only select and recruit one subject per family and explain this to the satisfaction of the family. Given the strong reasons for accepting other family members, we decided to proceed with this plan since we believe the effects on our results and conclusions are trivial. When we consider the effects of possible intra-familial transmission, the following distinction is helpful. If a case of illness was caused by swimming at a study beach and that case infects other family members and results in illness, all of these cases are rightly attributed to the swimming related exposure. On the other hand, if a case of illness was caused by some other exposure and this case transmitted the infection to other cases in the family during the follow-up period for that family, these cases should not be (and are not) attributed to the swimming exposure. Families such as these should be distributed similarly by distance from the drain and by levels of indicator counts and are reflected in the background rates. To the extent this happened, it would reduce our power only. Nevertheless, to further address this issue, we included a family variable as a covariate (controlling for it in the logistic models did not change any of the results) and stratified the results by this variable to look for heterogeneity (and similar effects were noted in the stratum comprised of single subjects and the stratum comprised of subjects from families

where more than one subject per family was included). We have added results and text to the Results and Discussion sections to address this issue.

Associations between bacterial indicators and health outcomes.

In general, when we estimated risk ratios using the established cutpoints, there were very few positive associations with any single indicator. There were none for *E. coli* at the lower cutpoints of 35 and 70 cfu. At the highest cutpoint of 320 cfu, earache and nasal congestion were weakly associated with *E. coli*. Only skin rash was associated with total and fecal coliforms at the higher cutpoints of 10,000 cfu and 400 cfu, respectively. Enterococci were positively associated with diarrhea with blood and HCGI 1 at the higher cutpoint of 106 cfu. The risk of diarrhea with blood was four times higher, but this estimate was based on very few cases. There was about a 40-50% increase in risk of HCGI, consistent with previous results by Cabelli (1982) and Genthe (preprint).

We recognize that these cutpoints do not have a strong scientific basis, particularly when applied to West Coast beaches with heavy urban runoff such as Santa Monica Bay, so we also investigated possible effects of the bacterial indicators with the use of categorical models (where quintiles were assessed) and continuous models. For the most part, the categorical models yielded results similar to the dichotomous results described above. The continuous models generally yielded more positive associations, particularly for enterococci. No additional associations were detected for total coliforms; fever, skin rash, and HCGI 1 were associated with fecal coliforms; skin rash, nausea, and stomach pain were associated with *E. coli*. Continuous results for enterococci indicate positive associations with fever, skin rash, nausea, diarrhea, stomach pain, coughing, runny nose, and HCGI 1.

In addition to evaluating single indicators, associations with the total coliform to fecal coliform ratio and the total coliform to enterococci ratio were investigated. For the total:entero ratio, the categorical model indicated inverse associations with nausea, diarrhea, and HCGI 1. This ratio was not more predictive of health risks than the continuous model for enterococci alone. In contrast, the ratio of total to fecal coliforms proved to be quite informative. There were two components to the rationale for this

analysis. First, as the level of fecal coliforms increased relative to total coliforms (i.e. the ratio was low), concern increased that there was substantial fecal contamination of the storm drain, possibly increasing risk of adverse health effects. Second, the effect of this lower ratio should be stronger when there was a higher degree of contamination, indicated by total coliform counts in excess of 1,000, 5,000 or 10,000 cfu. The results were consistent with this rationale. Using a ratio of 5.0 as the cutpoint, diarrhea and HCGI 2 were associated with a lower ratio when all the data were analyzed, regardless of the absolute level of total coliforms. When this analysis was restricted to subjects in water where the total coliforms exceeded 5,000 cfu, significantly higher risks were detected for nine different outcomes. Further, when this analysis was restricted to subjects in water where the total coliforms exceeded 10,000 cfu, the risk ratios for these nine outcomes all increased again (with the absolute risk in the exposed group reaching 14-19% for each symptom). Although the number of subjects became small in some subgroups, the strong consistency of the results across the increasing levels of total coliforms is persuasive that the associations are probably real. Which cutpoint (for the ratio) is associated most consistently with risk is an important question. When a range of cutpoints (2, 3, 4, 5, 6, 8) was analyzed using the entire data set, no consistent pattern emerged. This is not entirely surprising since an analysis of all data points treats all ratios of similar numerical value equally, even though a ratio of 5 when the total coliforms are very low may not increase risk (although the same ratio of 5 may be associated with increased risks when the density of total coliforms is high (say, above 1,000 or 5,000 cfu). When this type of analysis was restricted to days when the total coliform densities were high (above 1,000 cfu and particularly above 5,000) a consistent pattern emerged, with higher risks and attributable numbers associated with low ratios.

For reasons developed in the previous section on distance effects, it is very unlikely that the bacterial indicator associations observed in this study are confounded to any substantial degree. It is highly unlikely that the background risks are different for subjects exposed to higher or lower levels of a given indicator level, which were unknown to the subjects, particularly if one stratifies by distance.

It is worth considering which bacterial indicators are the most useful. This will depend, of course, on criteria used to define "usefulness". It would seem that the magnitude of the attributable numbers and the frequency that selected cutpoints are exceeded may be useful components of any set of criteria. From Tables 66 and 67, when all data are considered together no single indicator (or ratio of indicators) stood out as having the highest attributable numbers. Enterococci (at levels above 106 cfu) were associated with an attributable number of 130 cases of HCGI 1 per 10,000 exposed subjects; total coliforms (at levels above 10,000 cfu) were associated with an attributable number of 165 cases of skin rash; the ratio of total to fecal coliforms had an attributable number of 277 cases of diarrhea; and the ratio of total coliforms to enterococci had attributable numbers of 147 and 262 for nausea and diarrhea, respectively. From the continuous models, enterococci had the greater number of associations but the effects (estimated by odds ratios) and the attributable numbers were small. The largest attributable numbers were observed for the total to fecal coliforms ratio when the analyses were restricted to subjects in water where the total coliforms exceeded 5,000 cfu. The attributable numbers increased very consistently as the ratio decreased from 8 to 6 to 5 to 4 to 2. However, these stronger effects would be limited to a smaller proportion of the beach going population (those swimming in water where the total coliforms exceeded 5,000 cfu). It is also worth noting (from Table 65) that the effect of swimming at the drain (0 yards) versus 400+ yards from the drain was associated with relatively large attributable numbers (e.g. 303/10,000 exposed subjects for SRD, 115 for vomiting, 175 coughing with phlegm).

We very briefly review results of other studies to lend a broader context to our results, although we point out that results of other studies may not be relevant to the situation in Santa Monica Bay and different designs were employed in these other studies.

The question of whether acute infectious disease can be acquired through bathing in marine water contaminated with sewage has been the subject of several large epidemiological studies conducted throughout the world. The most consistent finding of

these studies is that bathers, defined as those that immerse their heads in water while swimming, are at a higher risk of contracting gastrointestinal (GI) disease than those who do not immerse their heads, the non-bathers. However, this has not always been observed. Another aspect of these studies has been to investigate whether elevated counts of certain bacterial indicators commonly found in sewage contaminated water are predictive of disease, even though the bacteria themselves may not be pathogenic. To date, the reported results trying to associate elevated indicator counts with health outcomes have been inconsistent.

Cabelli (1979) was the first investigator to demonstrate an association between water quality at ocean beaches and health outcomes. He conducted a large, prospective cohort study of 8,000 subjects sponsored by the EPA that has subsequently become a classic study of health outcomes and marine water quality. The study compared symptom rates among bathers and non-bathers at two beaches that had been classified as relatively unspoiled (RU) and barely acceptable (BA) using coliform counts as the indicators to make this determination. Family groups were interviewed on the beach to document bathing behavior and again by phone 8-10 days later to assess the development of GI and respiratory symptoms. Water sampling for bacterial indicators (total and fecal coliforms, *E. coli*, Enterobacter, Enterococcus, Klebsiella and P. aeruginosa) was done concurrently at the two beaches. The BA beach not only reported higher symptom rates than the RU beach but also mean levels of the bacterial indicators were significantly higher than at the RU beach. A noteworthy result of this study was that measurable health effects occurred at both marine beaches within guidelines (total and fecal coliforms standards) developed for fresh water beaches.

Cabelli (1982) next used the results of a large prospective cohort study to develop a linear regression model for the relationship between mean enterococci density and gastroenteritis among bathers. Almost 26,000 subjects were identified on weekends over a six year period in three locations: two ocean beaches (New York and Boston), and one brackish/fresh water lake (Louisiana). Exposure status (bathers were defined in Cabelli's study as having the head immersed underwater, non-bathers included waders and those

who stayed out of the water) was determined by interview on each study day. Individuals who swam immediately prior to or after the weekend under study were excluded from the analysis. Incidence of gastroenteritis was obtained by telephone interview 8-10 days later; subjects did not make use of a toll-free number or local clinic for medical advice/diagnosis. Enterococci densities were determined for each study day. Based upon the results of the regression analysis, the authors concluded that bathing in water containing as little as 10 enterococci/100 ml of sample represented an absolute risk of GI illness of 10 per 1000 bathers and a relative risk of 2.0 comparing bathers and non-bathers.

Current EPA criteria concerning the sanitary quality of marine waters are based upon these results (Cabelli, 1984; Cabelli, 1989). Several criticisms have been leveled against the 1982 study (Fleisher, 1991): (1) Results were pooled for marine and estuarine water locations, despite the fact that survival of pathogenic organisms may be inversely correlated with salinity (Dufour, 1984); (2) Results from several beach locations were combined without considering local differences in marine flora, sewage outflow, immunity/demographic characteristics of subjects, beach contour and sediment/turbidity characteristics. Fleisher's analysis of Cabelli's data showed significant variation in the mathematical relationship between indicator levels and disease outcome among the beaches studied: in addition, a surprisingly poor fit for HCGI relative to total GI symptoms in the linear regression model led Fleisher to fit an alternative (logistic) model to the data -- one with more "biological support" -- choosing covariates "not based solely on statistical considerations but rather on hypotheses generated by previous epidemiologic studies" (Fleisher, 1991, p. 262). From this reanalysis, Fleisher concluded that "not only the magnitude...but the existence of any relationship between enterococci density and gastroenteritis may be site specific" (Fleisher, 1991, p. 263). (3) Cabelli had speculated earlier (1979) that the primary disease outcome -- an acute, relatively mild gastroenteritis which had a short incubation period and duration -- was most compatible with exposure to human rotaviruses or Norwalk-like viruses, so that estimates of water

quality based upon proxy measures might be subject to considerable error (further discussed below).

The Cabelli-EPA study design has been endorsed by the World Health Organization and the United Nations environment program. "Cabelli-style" ocean studies have been carried out at a number of locations throughout the world. Most report higher morbidity among bathers (head immersed in water) as compared to non-bathers for gastrointestinal illness, eye and ear infections. Correlations with indicator organisms however are inconsistent (for review, see Saliba 1990). In Hong Kong (Cheung, 1990), Staphylococci levels were correlated with ear, respiratory, and total illness, while *E. coli* was found to be the best predictor of gastroenteritis. In South Africa (von Schirnding, 1992), bathers and non-bathers were compared for incidence of gastro-intestinal, respiratory, and skin symptoms at two beaches, one with high levels of indicators (enterococcus and coliforms) and the other relatively clean: symptom rates were higher for swimmers at the polluted beach, but "were not statistically significant." In the United Kingdom (Balarajan, 1991), enterococcus and coliform levels "varied appreciably" and could not be correlated with illness; overall, a relative risk of 1.31 (95% confidence interval 1.04 to 1.64) was obtained for occurrence of at least one symptom (GI, respiratory, other) in bathers compared to non-bathers after controlling for age and sex. Genthe (19..) reported that enterococcus was the most predictive of gastroenteritis, although fecal coliforms were also significantly associated with risk. Staphylococcus was not associated with risk. Several investigators have recently suggested that these studies may underestimate the true risk: (1) Non-differential measurement error in estimated organism densities could result in a 30 to 57% underestimate of true risk (Fleisher, 1990). Both the MPN and MF methods of enumerating coliforms are imprecise; Fleisher points out that none of the studies cited above made use of replicate determinations on individual samples, nor did they consider diurnal and other variations which may occur in bacterial indicator levels, particularly at marine locations. (2) Bacterial indicators do not reflect the occurrence of enteroviruses in marine waters, which are likely to be the true pathogen of interest (Gerba, 1979), nor do they reflect levels of Vibrio spp., marine

pathogens recently linked to a variety of human health outcomes including necrotizing wound infections (Howard, 1988) (3) These studies attempted to gain power by including subjects from a variety of locations without accounting for variations between beaches. Smaller studies focussing on subgroups (such as snorkelers, windsurfers, and bathers) within a given location have reported a more pronounced effect (Dewailly, 1986; Philipp, 1985; Deitmer, 1990); for example, Dewailly reported a relative risk of 5.5 for symptoms of gastroenteritis among windsurfers at a specific estuarine location.

Using a Cabelli-like approach the New Jersey Department of Health commissioned a large prospective cohort study in the late 1980's to investigate water quality and health outcomes after swimming in fresh and ocean water in that state. 16,089 subjects were recruited from nine ocean and two lake beaches. Again, bathers and non-bathers were identified, interviewed on the beach and telephoned up to 10 days later to ascertain the development of symptoms. Water sampling for bacterial indicators, total and fecal coliforms, enterococcus, C. Perfringens as well as F2 male-specific bacteriophage (developed by Cabelli et al to estimate levels of viral pathogens) was concurrently done. Bathers at all beaches had higher symptom rates than non-bathers (an excess of 12.1 cases per 1000 subjects was reported) even though illness could not be correlated with any elevation of any of the bacterial indicators. However, these findings are not surprising since none of the beaches were located near any areas of heavy urban run-off. The water tested was "generally of high quality"[3] leading the authors to conclude that the observed health effects were "the natural consequences of bathing, not the result of contaminated water".

A number of concerns have been raised about the New Jersey study. (See our original proposal for a detailed description - available from the Santa Monica Bay Restoration Project). Some of the concerns were: (1) The study had little power to detect an association between health effects and sewage contamination. None of the beaches studied were located near heavy urban runoff areas, so that the water tested was "generally of high quality" at all beaches. Little variability in indicator levels was observed between sampling sites, so that the effect of a range of indicators (either within

or across beaches) was not assessed. Water samples were collected only at chest depth and not ankle depth; children (at increased risk for symptoms in most studies when compared with adults) wade, play and swim in the near shore areas where their activities and wave action may disturb sediments, releasing absorbed bacteria and virus into the water. (2) The conclusions rely heavily on p-values. Measures of effect, such as risk ratios with confidence intervals, were not calculated. (3) The issue of residual confounding was not addressed; confounding may be due to lack of comparability of exposed and unexposed groups.

Finally, it should be noted that Cabelli-like studies are not the only kind that have been used to investigate health outcomes after immersion in marine water contaminated by sewage. Fleisher, (1993) using a randomized intervention and follow-up design, conducted the first epidemiological study that related indicator organism density to an individual bather. In 1989 and 1990, he recruited 484 subjects from various locations in the United Kingdom. Subjects were given an interview, a physical exam to exclude ongoing illness and then randomly assigned to a bather or non-bather group. On the day of the trial non-bathers were assigned to a roped off beach area while bathers were carefully monitored. Water sampling for elevated bacterial indicators, total and fecal Coliforms as well as enterococcus (in his papers, Fleisher uses the older nomenclature for enterococcus, Streptococcus faecalis) was done at the actual time bathers were in the water. Food consumption habits at the time of the trial were also monitored in order to exclude food-borne illness as a confounder. After the trial, follow-up for GI disease was done through either an interview or a mailed questionnaire. Results showed that only enterococcus cultured from water samples taken from the surface at chest depth was predictive for development of GI symptoms. Fleisher continued the randomized intervention and follow-up studies with more detailed follow-up exams after bathing (1993), the results of which still support enterococcus as the best predictor of GI disease.

As was mentioned, the study design employed here is different in fundamental ways from the study designs commonly employed by other investigators. The major difference between the design used here and the Cabelli-type study design is that all of

our analyses were between different groups of swimmers whereas studies employing the Cabelli-type design compare risks between swimmers and non-swimmers. A major challenge with the Cabelli-type design is to ensure comparability between swimmers and non-swimmers. For example, in one of Cabelli's studies, there was an anomalous finding among children of a significantly higher rate of gastrointestinal symptoms for nonbathers relative to bathers at the unpolluted beach, suggesting that the two groups were not comparable. Perhaps parents tended to keep children out of the water who were feeling ill or incubating gastrointestinal illnesses. Differences between persons who choose to bathe and those who do not are difficult to measure and account for in the analysis of such studies (Saliba, 1990). The Cabelli-type design is similar to the one used here in that it is an observational cohort study and it relies on measurements of bacterial indicators that are feasible on a large scale and are similar to those that are commonly practiced by various health agencies. Fleischer (1993) and Kay (1994) have raised additional concerns with this type of study. The major concern deals with measurement errors and misclassification of exposure status due to "failure to control for the substantial amount of temporal and spatial variation in indicator organism densities shown to occur within just a few hours at marine water bathing locations" and the fact that "the microbiological quality of water was not assigned to each bather at the time and place of bathing".

To address the concerns with confounding and misclassification of exposure status, Fleischer and Kay used a very different design. Instead of an observational study, they used a randomized trial wherein subjects were randomly assigned to bathing and non-bathing groups and numerous water samples were taken every half-hour over the exposure period every 20 meters and at three depths (at surf, mid, and chest depths). In principle, if the trial is large enough, randomization should generate a balance between comparison groups ("exposed" and "unexposed") with respect to the distribution of other risk factors for the health outcomes under study. Also, as they argue, the water testing protocol should reduce misclassification of exposure status for individual subjects.

As we see it, with respect to measurement of bacterial indicators, the two approaches are addressing slightly different questions and may be seen, at some level, as complementing each other. The approach taken by Fleischer aims at estimating a more accurate dose-response relationship for indicator counts as they pertain to individuals by reducing misclassification of exposure for individual subjects as it pertains to this objective. This generates interesting, useful data and may detect associations missed by a Cabelli-type approach, but it is also a step further removed from helping to set policy based on bacterial indicators. Given a predictive result generated from this more intense sampling scheme, the policy implication for where, when, and what to monitor for is not obvious, given limited resources of the agencies responsible for monitoring. For example, Kay (1994) suggests that, based on their results, enterococci should replace coliforms as the basis for setting standards and that adverse health effects were identified when concentrations exceeded 32 per 100 ml. It is not so obvious where and when one should monitor for enterococci. Clearly the intense protocol used in the trial is not feasible. If one does less (read less accurate in terms of assessing exposure for a given subject) monitoring, the nature of the dose-response curve probably changes since "dose" is being measured differently. A level of 32 per 100 ml may no longer be associated with the same risk as in the trial. The approach taken by Cabelli addresses more directly the question of whether bacterial indicators, as they are commonly measured by health departments, do in fact predict risk of adverse health effects. If the results of such a study are negative, as they have been in a number of studies with respect to specific indicators, the only appropriate conclusion is that these indicators, **as measured**, do not predict risk. Left unanswered is whether different, perhaps more intense, sampling and measurement protocols would yield different results. If the results are positive, the connection to a monitoring policy is more obvious since the sampling scheme employed in the study is close to the usual monitoring protocol.

Since there is no perfect design for all scientific and policy purposes, we settled on an observational design that would minimize the potential for confounding, which we viewed as a major lingering concern with previous studies. We had doubts about the

feasibility and ethics of trying to conduct a randomized trial given the "charged" nature of the debate regarding Santa Monica Bay. Given the observational design, we chose to focus on two questions (Is distance associated with risk of adverse health outcomes? Do bacterial indicators, as they are commonly monitored, predict risk of adverse health outcomes?) that were primarily motivated by policy considerations.

Aside from the emphasis on distance and bacterial indicators, this is the first large scale study of which we are aware that also included measurements of viruses. The standard method, which appeared to be running very well, as judged in part by the excellent recovery rates, detected virus on a number of occasions. Only limited statistical analysis was possible. It was of interest that a number of adverse health effects were reported more often on days when the samples were positive, suggesting assays for viruses may be informative for predicting risk. The research involving gene probes is ongoing. We hope to include the results as an addendum to this report. Cabelli (1982) and Kay (1994) both mention that Norwalk-like viruses are a plausible cause of gastroenteritis. Enteroviruses, the commonest viruses in sewage effluent, can cause respiratory symptoms. As pointed out by Walker (1992), testing for viruses is potentially important. Not only are viruses potentially responsible for many of the symptoms associated with swimming in ocean water but they decay at a slower rate in sea water than bacteria and they can cause infection at a much lower dose.

In summary, we believe that the results of this study are valid for the purposes of addressing the two research questions we posed in the beginning. Distance from the storm drain, particularly swimming in front of the storm drains that we studied, is associated with an increased risk for a relatively broad range of adverse health effects, including HCGI and significant respiratory disease. A number of bacterial indicators, particularly the total coliforms to fecal coliforms ratio and enterococcus, measured in a manner similar to routine monitoring, are also associated with increased risk of adverse health effects. Both sets of results suggest that there is an increased risk of a relatively broad range of symptoms caused by swimming adjacent to the drains at the beach sites included in this study. The estimated attributable numbers, which reached into the 100's

per 10,000 exposed subjects, suggest these risks are not trivial when we consider the millions of persons who visit the beaches in Santa Monica Bay. In numerous discussions organized by the SMBRP, prior to the start of this study, an excess risk of 1 case per 100 exposed was generally considered a noteworthy health risk, so the study was designed to detect this level of risk (of course, the relative magnitude of these risks compared to other health risks will be a matter of judgement by interested parties). It is also probable that the risk is higher than we observed in this study since both distance and bacterial indicators are proxy measures of the actual pathogens causing these adverse health effects. It is worth recalling here that we excluded subjects who frequently entered the water at these beaches. We did this so we could link reported outcomes with a specific set of bacterial indicators for the one day and place a subject was in the water, which we needed to address the second research question we posed. If there is a dose-response relationship such that increasing exposure is associated with increasing risk, which seems plausible, then one may conclude that surfers, lifeguards, and other subjects who frequently enter the water and immerse their heads may be at an increased risk of adverse health outcomes (perhaps substantially so) than the relatively infrequent recreational swimmers included in this study. A counter-argument that has been raised is that frequent swimmers may develop an immunity to the pathogens and thereby have a lower risk. This would seem to be an important issue that warrants further study. Surfers would seem to be an appropriate group to study since there are not enough lifeguards at a given beach to achieve the statistical power one needs. The study design would have to be different than the one used here to address the issue of frequent use. Interested readers are referred to the original proposal for this study, where an adjunct study of surfers was presented. We consider the policy implications of the present study to be beyond the scope of this final report. They will be the subject of a separate report issued by the Santa Monica Bay Restoration Project.

V. REFERENCES

Balarajan R, Soni Raleigh V, et al. Health risks associated with bathing in sea water. Br Med J 303:1444 (1991).

Cabelli V. Swimming-associated illness and recreational water quality. Water Sci Tech 21: 13 (1989).

Cabelli V. Health effects criteria for marine recreational waters. US EPA, EPA 600/1-80-031, Washington DC (1983)

Cabelli V, Dufour A, et al. Swimming-associated gastroenteritis and water quality. Am J Epi 115: 606 (1982).

Cabelli V, et al. A marine recreational water quality criterion consistent with indicator concepts and risk analysis. J Water Poll Control Fed 55: 1306 (1984).

Cabelli V, Dufour A, et al. Relationship of microbial indicators to health effects at marine bathing breaches. Am J Pub Health 69: 690 (1979).

Centers for Disease Control. Viral agents of gastroenteritis. MMWR Rec and Reports 39: 1 (1990).

Cheung W, Chang K, et al. Variations in microbial indicator densities in beach waters and health-related assessment of bathing water quality. Epi and Inf 106: 329 (1991).

Craun G (ed). Methods for the investigation and prevention of waterborne disease outbreaks. Health Effects Res Lab, US EPA (Cinncinati, 1990).

Deitmer T, Scheffler R. Possible pathogenesis of swimming sinusitis. Larnygo- Rhino-Otologie 69: 221 (1990).

Dewailly E, Poirier C, et al. Health Hazards associaated with windsurfing on polluted water. Am J Pub Health 76: 690 (1986).

Dufour A. Bacterial indicators of recreational water quality. Can J Pub Health 78: 49 (1984).

Fleisher J. A reanalysis of data supporting U.S. federal bacteriological water quality criteria governing marine recreational waters. Res J Water Poll Control Fed 63: 259 (1991).

Fleisher J. The effects of measurement error on previously mathematical relationships between indicator organism density and swimming-associated illness: a quantitative estimate of the resulting bias. Int J Epi 19:1100 (1990).

Fleisher JM, Jones F, Kay D, Stanwell-Smith R, Wyer M, Morano R. Water and non-water related risk factors for gastroenteritis among bathers exposed to sewage contaminated marine waters. Int J of Epid 22:698-708 (1993).

Genthe B, Strauss N, Kfir R, Von Schirnding Y. Evaluation of health risks associated with recreational activities in South African marine waters.

Gerba C, Goyal S, et al. Failure of indicator bacteria to reflect the occurrence of enteroviruses in marine waters. Am J Pub Health 69:1116 (1979).

Gerba C, Rose J, et al. Waterborne gastroenteritis and viral hepatitis. CRC Crit Rev Env Control 15: 213 (1985).

Gold M, Bartlett M, et al. Storm drains as a source of surf zone bacterial indicators and human enteric viruses to Santa Monica Bay. Document prepared for the Santa Monica Bay Restoration Project, May 1991.

Howard R., S. Lieb. Soft-tissue infections caused by halophilic marine Vibrios. Arch Surg 123: 245 (1988).

Kay D, Fleisher JM, Salmon RL, Jones F, Wyer MD, Godfree AF, Zelenauch-Jacquotte Z, Shore R. Lancet 344:905-09 (1994).
Los Angeles County Department of Health Services, Toxics Epidemiology Program. Population estimation and projection system (PEPS); 1993 population release documention. May 1994. Unpublished.
Marine Monitoring in Santa Monica Bay: Annual Assessment Report July 1991-June 1992, Envir. Monitoring Division, Bureau of Sanitation, Dept. PW., City of Los Angeles, 1993.
New Jersey Dept. of Health, Ocean Health Study. Final report, Sept. 1990.
Philipp R, Evans E, et al. Health risks of snorkel swimming in untreated water. Int J Epi 14: 624 (1985).
Saliba L, Helmer R. Health risks associated with pollution of coastal bathing waters. WHO Stats Quarterly 43: 177 (1990).
Santa Monica Bay Beach Pilot Study. Final report. 1993. (Available from Santa Monica Bay Restoration Project).
Santa Monica Bay Restoration Project. Assessment of storm drain sources of contaminants to Santa Monica Bay. Volume 1 (1993).
Seyfried P, Tobin R, et al. A prospective study of swimming-related illness. I. Swimming-associated health risk. II. Morbidity and the microbiological quality of water. Am J Pub Health 75: 1068 (1985).
von Schirnding Y, Kfir R, Cabelli V, et al. Morbidity among bathers exposed to polluted seawater. A prospective epidemiologic study. S African Med J 81: 534 (1992).
Walker, A. Swimming - the hazards of taking a dip. Br Med J 304:242-5 (1992).
Am J of Public Health 83:-1706 (1993)

LIST OF VARIABLES

ITEM	RANGE	CODES
BEACH ID	A,M;W	A=ASHLAND,M=MALIBU,W=WILL ROGERS
PARTICIPANT #	1-12500	
RELATION	A,B,C,D,E,F,G,H,I,J	
PRE PRINTED #	1-12500	
BEACH INT MONTH	06-10	06=JUNE,07=JULY,08=AUG,09=SEPT,10=OCT
BEACH INT DAY	1-31	
PHONE INT MONTH	06-10	06=JUNE,07=JULY,08=AUG,09=SEPT,10=OCT
PHONE INT DAY	1-31	
WATER CLEAN?	1-2	1=NO,2=YES
GENDER	1-2	1=FEMALE,2=MALE
AGE	1-9	1=0-12,2=13-18,3=19-25,4=26-35,5=36-45,6=46-55,7=56-65,8=66-75,9=>75
EXACT AGE FOR UNDER 12	1-12	
MAP CODE	1-8	
BEACH INTR #	0-999	
PHONE INTR #	0-999	
Q1 FACE WET	1-2	1=NO FACE NOT WET,2 YES FACE GOT WET
Q2	1-3	1=NO CHILD DID NOT GET FACE WET,2=YES GOT FACE WET,3=DON'T KNOW/REMEBER
Q3.1.A FEVER	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.1.C FEVER	2	2=EVENT DUE TO BEACH VISIT
Q3.2.A CHILLS	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.2.C CHILLS	2	2=EVENT DUE TO BEACH VISIT
Q3.3.A EYE DISCHARGE	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.3.B EYE DISCHARGE	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.3.C EYE DISCHARGE	2	2=EVENT DUE TO BEACH VISIT
Q3.4.A EARACHE	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.4.B EARACHE	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.4.C EARACHE	2	2=EVENT DUE TO BEACH VISIT
Q3.5.A EAR DISCHARGE	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.5.B EAR DISCHARGE	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.5.C EAR DISHCARGE	2	2=EVENT DUE TO BEACH VISIT
Q3.6.A SKIN RASH	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.6.B SKIN RASH	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.6.C SKIN RASH	2	2=EVENT DUE TO BEACH VISIT
Q3.7.A INFECTED CUT	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.7.B INFECTED CUT	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.7.C INFECTED CUT	2	2=EVENT DUE TO BEACH VISIT

Q3.8.A NAUSEA	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.8.B NAUSEA	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.8.C NAUSEA	2	2=EVENT DUE TO BEACH VISIT
Q3.9.A VOMITING	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.9.B VOMITING	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.9.C VOMITING	2	2=EVENT DUE TO BEACH VISIT
Q3.10.A DIARRHEA	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.10.B DIARRHEA	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.10.C DIARRHEA	2	2=EVENT DUE TO BEACH VISIT
Q3.11.A DIARRHEA W/ BLOOD	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.11.B DIARRHEA W/ BLOOD	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.11.C DIARRHEA W/ BLOOD	2	2=EVENT DUE TO BEACH VISIT
Q3.12.A STOMACH PAIN	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.12.B STOMACH PAIN	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.12.C STOMACH PAIN	2	2=EVENT DUE TO BEACH VISIT
Q3.13.A COUGHING	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.13.B COUGHING	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.13.C COUGHING	2	2=EVENT DUE TO BEACH VISIT
Q3.14.A COUGH W/ PHLEGM	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.14.B COUGH W/ PHLEGM	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.14.C COUGH W/ PHLEGM	2	2=EVENT DUE TO BEACH VISIT
Q3.15.A RUNNY NOSE/CONGES	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.15.B RUNNY NOSE/CONGES	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.15.C RUNNY NOSE/CONGES	2	2=EVENT DUE TO BEACH VISIT
Q3.16.A SORE THROAT	1-3	1=NOT HAVE SYMPTON SINCE VISIT,2=YES HAD SYMPTON SINCE VISIT, 3=DK
Q3.16.B SORE THROAT	1-3	1=NOT HAD SYMPTON BEFORE VISIT,2=YES HAD SYMPTOM BFORE VISIT, 3=DK
Q3.16.C SORE THROAT	2	2=EVENT DUE TO BEACH VISIT
Q4 WORRIED ABOUT HAZARD	1-4	1=NOT AT ALL WORRIED,2=SOMEWHAT WORRIED,3=A LITTLE WORRIED,4=VERY WORRIED
Q5 ETHNIC BACKGROUND	1-6	1=WHITE,2=BLACK,3=LATINO,4=ASIAN,5=MULTI-ETHNIC,6=OTHER
Q6 ZIP CODE	0-99999	
MEDIAN INCOME FOR ZIP		MEDIAN HOUSEHOLD INCOME FOR RESPONDENTS ZIP CODE
RECODED AGE	1-2	1=0-12,2=>12
RECODED MAP AREA	1-2	1=DIRTY (AREAS 0/3/4/5/6),2=CLEAN (AREAS 1/8)
E COLI FROM SAMPLE AREA1		
E COLI FROM SAMPLE AREA2		
E COLI FROM SAMPLE AREA3		
E COLI FROM SAMPLE AREA4		

E COLI FROM SAMPLE AREA5		
ENTEROCOCCUS AREA1		
ENTEROCOCCUS AREA2		
ENTEROCOCCUS AREA3		
ENTEROCOCCUS AREA4		
ENTEROCOCCUS AREA5		
FECAL COLIFORMS AREA1		
FECAL COLIFORMS AREA2		
FECAL COLIFORMS AREA3		
FECAL COLIFORMS AREA4		
FECAL COLIFORMS AREA5		
TOTAL COLIFORMS AREA1		
TOTAL COLIFORMS AREA2		
TOTAL COLIFORMS AREA3		
TOTAL COLIFORMS AREA4		
TOTAL COLIFORMS AREA5		
FLOW		
FAMILY SIZE		1=INDIVIDUAL,2-9=FAMILY SIZE
HCGI_1		
HCGI_2		
SRD		

Table 1. Completed Interviews by Beach Interview Date

JUNE

BEACH	22	23	24	25	26	27	28	29	30	total
Ashland	15	4	61	103	16	19	22	34	20	294
Malibu	3	5	39	36	2	28	13	20	15	161
W Rogers	8	0	13	17	5	11	2	9	13	78
total	26	9	113	156	23	58	37	63	48	533

JULY

BEACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly total
Ashland	114	159	108	133	20	31	52	72	238	43	75	45	46	50	115	41	42	31	39	21	54	181	338	32	29	55	69	51	265	244	31	2824
Malibu	32	70	15	31	21	18	23	37	66	39	22	39	62	40	81	61	43	29	49	32	61	62	139	41	31	38	58	38	196	135	37	1614
W Rogers	38	43	39	31	10	10	21	18	34	34	37	27	37	30	69	26	13	2	20	28	26	45	84	57	13	9	8	30	58	138	18	1053
total	184	272	162	195	51	59	96	127	338	116	134	111	145	120	265	128	98	62	108	81	141	288	561	130	73	102	135	119	519	517	86	5523

AUGUST

BEACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly total
Ashland	17	13	29	20	72	203	16	29	12	47	40	166	287	24	22	11	17	21	121	99	18	16	25	18	32	116	151	49	18	37	8	1754
Malibu	51	21	19	18	57	117	20	52	77	35	74	139	101	43	25	19	32	60	117	71	26	21	31	56	21	66	134	30	31	2	45	1611
W Rogers	3		5	7	70	25	29	26	9	32	41	56	56	8	7	2	1	21	10	16	4	0	1	7	8	33	36	3	7	12	6	541
total	71	34	53	45	199	345	65	107	98	114	155	361	444	75	54	32	50	102	248	186	48	37	57	81	61	215	321	82	56	51	59	3906

SEPTEMBER

BEACH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	monthly total
Ashland	38	118	346	357					21	77						29	20						23	19								1048
Malibu	13	126	150	245					21	30						26	24							15								650
W Rogers	16	28	62	27																												133
total	67	272	558	629	0	0	0	0	42	107	0	0	0	0	0	55	44	0	0	0	0	0	23	34	0	0	0	0	0	0	0	1831
																																11793

Figure 1. Study Eligibles

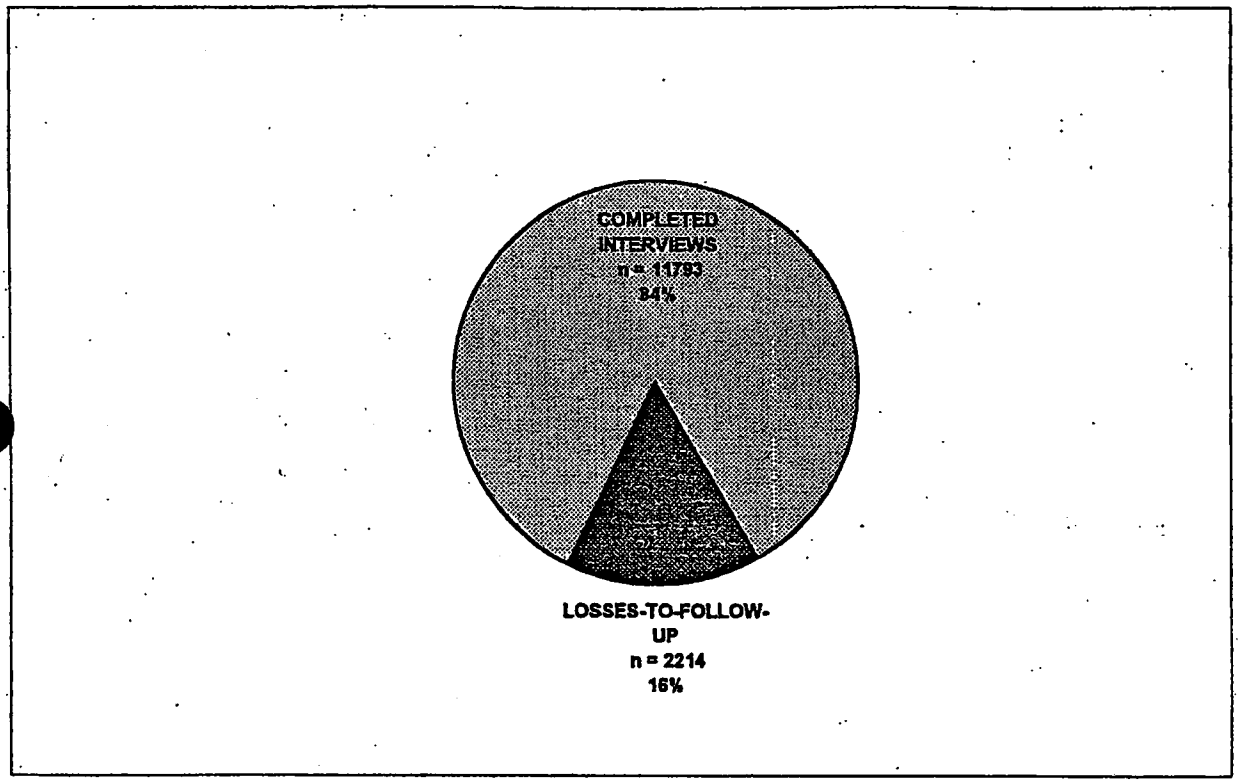
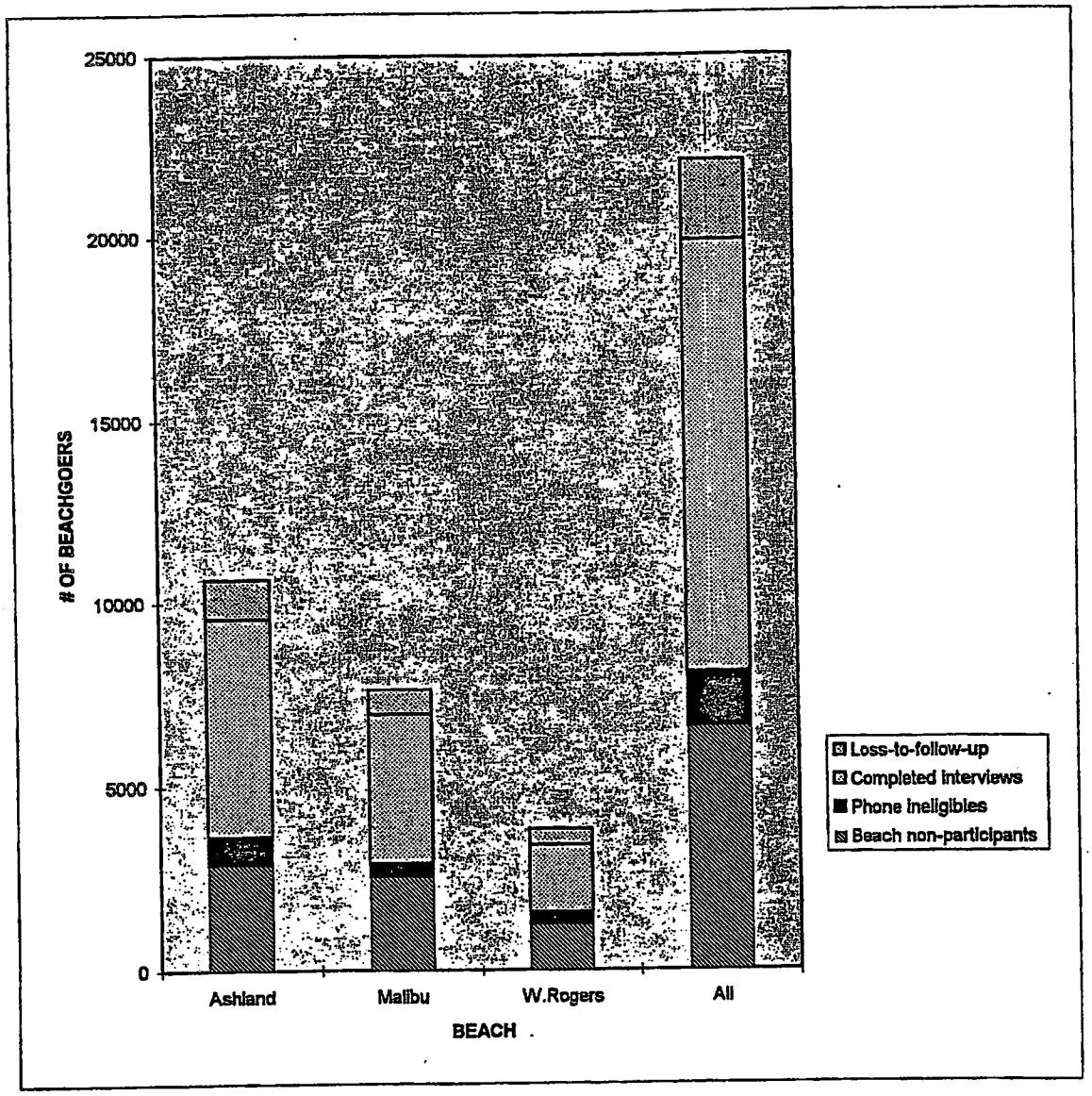


Figure 2. Beach Encounters by Beach



	Ashland	Malibu	W.Rogers	All
Beach non-participants (incl. ineligibles)	2862 (27%)	2508 (33%)	1223 (32%)	6593 (30%)
Phone ineligibles (back to beach)	766 (7%)	380 (5%)	339 (9%)	1485 (7%)
Completed interviews	5920 (56%)	4067 (53%)	1806 (47%)	11793 (53%)
Losses-to-follow-up	1078 (10%)	681 (9%)	455 (12%)	2214 (10%)
	10626	7636	3823	22085

Table 2. Reasons for Non-Participation at the Beach (All Beaches)

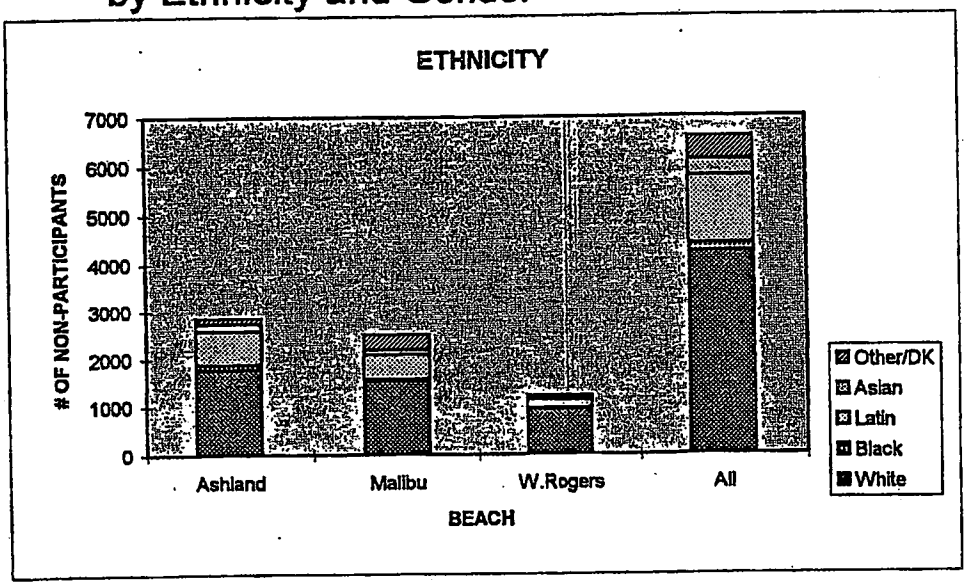
		%	*% of all beach encounters*
Ineligible (been to beach)	3681	56	*17*
Refusal	1761	27	*8*
Language difficulty	648	10	*3*
No telephone	503	8	*2*
	6593	101*	*30*

Table 3. Reasons for Non-Actualized Telephone Interviews (All Beaches)

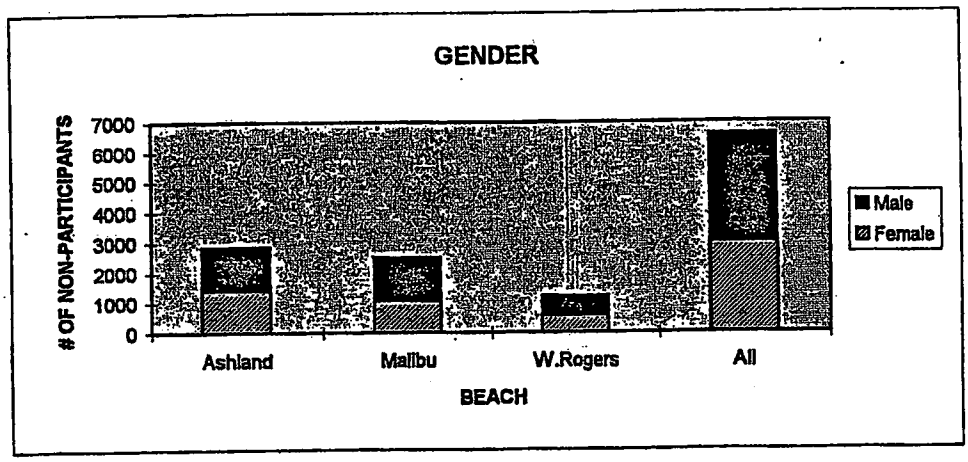
		%	*% of all beach interviews*
Ineligible (back to beach)	1485	40	*10*
Wrong number/disconnect	1170	32	*8*
Answering machine	504	14	*3*
No answer	283	8	*2*
Other reason (moved, etc.)	235	6	*1*
Refusal	22	1	*0*
	3699	101*	*24*

* Does not add to 100% due to rounding.

Figure 3. Non-Participation (Including Ineligibles) at 3 Beaches by Ethnicity and Gender*



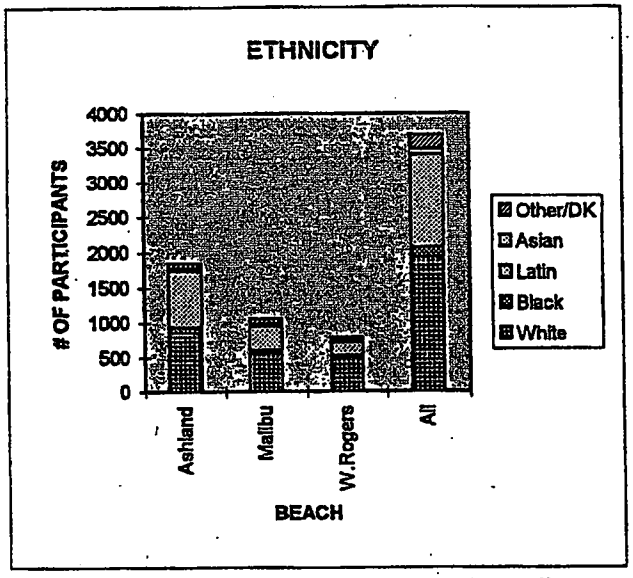
	Ashland	Malibu	W.Rogers	All
White	1768 (62%)	1530 (61%)	930 (76%)	4228 (64%)
Black	123 (4%)	31 (1%)	28 (2%)	182 (3%)
Latin	691 (24%)	509 (20%)	172 (14%)	1372 (21%)
Asian	151 (5%)	113 (5%)	55 (4%)	319 (5%)
Other/DK	129 (4%)	325 (13%)	38 (3%)	492 (7%)

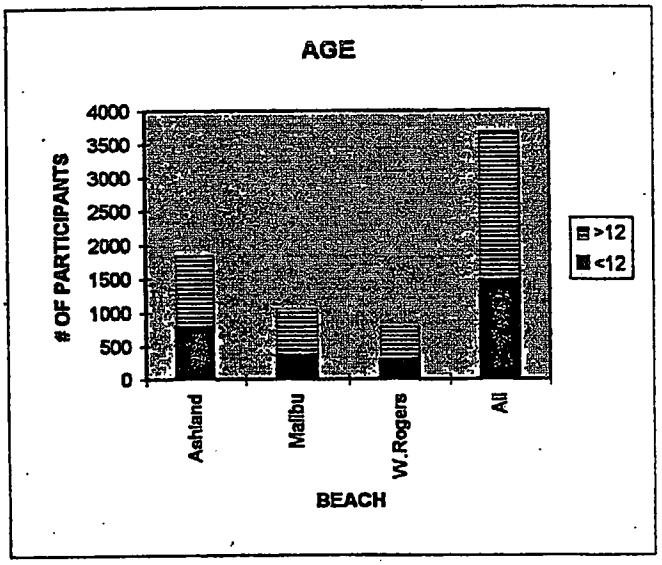


	Ashland	Malibu	W.Rogers	All
Female	1384 (48%)	1057 (42%)	559 (46%)	3000 (46%)
Male	1478 (52%)	1451 (58%)	664 (54%)	3593 (54%)

* Children younger than 12 were not tallied.

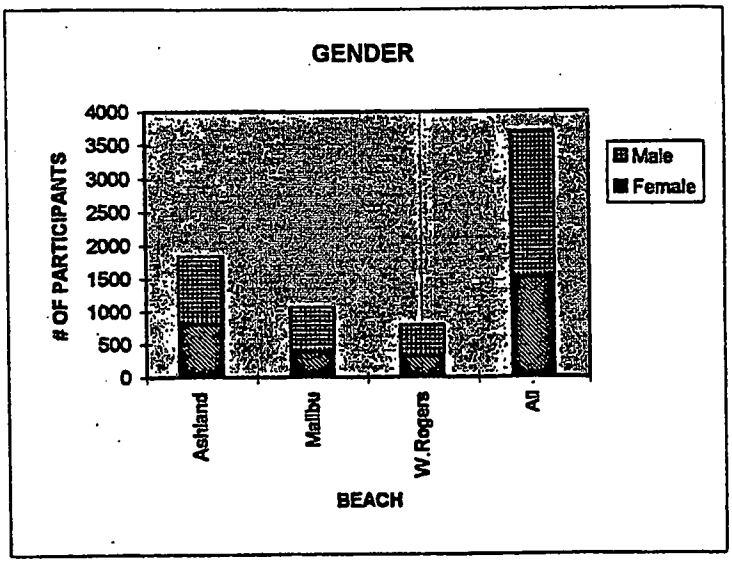
Figure 4. Non-Actualized Telephone Interviews from 3 Beaches by Ethnicity, Age and Gender





	Ashland	Malibu	W.Rogers	All
White	856 (46%)	569 (54%)	505 (64%)	1930 (52%)
Black	88 (5%)	29 (3%)	17 (2%)	134 (4%)
Latin	87 (43%)	353 (33%)	194 (24%)	1334 (36%)
Asian	38 (2%)	31 (3%)	19 (2%)	88 (2%)
Other/DK	75 (4%)	79 (7%)	59 (7%)	213 (6%)

	Ashland	Malibu	W.Rogers	All
≤12	812 (44%)	381 (36%)	299 (38%)	1492(40%)
>12	1032 (56%	680 (64%)	495 (62%)	2207(60%)



	Ashland	Malibu	W.Rogers	All
Female	803 (44%)	392 (37%)	316 (40%)	1511 (41%)
Male	1041(56%)	669 (63%)	478 (60%)	2188 (59%)

Table 4. Beach Study Respondent Characteristics

Proximity to Drain

BEACH	0-100 Yds	≥400 Yds	RATIO
Ashland	4388	1532	2.9:1
Malibu	3034	1033	2.9:1
W Rogers	1310	496	2.6:1
	8732	3061	2.9:1

Family Size

BEACH	Individuals			family members			totals		
Ashland	1115	(19%)	{43%}	4805	(81%)	{52%}	5920	(100%)	{50%}
Malibu	920	(23%)	{36%}	3147	(77%)	{34%}	4067	(100%)	{34%}
W Rogers	547	(30%)	{21%}	1259	(70%)	{14%}	1806	(100%)	{15%}
	2582	(22%)	{100%}	9211	(78%)	{100%}	11793	(100%) *	{100%} †

SES based on zip code (California only)

BEACH	<=25000			>25000			totals		
Ashland	655	(13%)	{64%}	4583	(87%)	{50%}	5238	(100%)	{51%}
Malibu	238	(7%)	{23%}	3142	(93%)	{34%}	3380	(100%)	{33%}
W Rogers	128	(8%)	{13%}	1464	(92%)	{16%}	1592	(100%)	{16%}
	1021	(10%)	{100%}	9189	(90%)	{100%}	10210	(100%)	{100%}

Residency based on zip code

BEACH	CA resident			Outside CA			totals		
Ashland	5341	(90%)	{51%}	579	(10%)	{42%}	5920	(100%)	{50%}
Malibu	3472	(85%)	{33%}	595	(15%)	{43%}	4067	(100%)	{34%}
W Rogers	1612	(89%)	{15%}	194	(11%)	{14%}	1806	(100%)	{15%}
	10425	(88%)	{100%}	1368	(12%)	{100%}	11793	(100%)	{100%}

* ( ) row percentages
† { } column percentages

Table 5. Beach Study Respondent Characteristics vs. PEPS

Beach Study Respondents

AGE		
0-12	5,718	48%
13-18	1,772	15%
19-25	1,213	10%
26-35	1,688	14%
36-45	994	8%
46-55	314	3%
56-65	61	1%
66-75	30	0%
>75	3	0%
	11,793	

PEPS*

AGE		
0-14	2,074,678	22%
14-19	539,427	6%
20-24	653,813	7%
25-34	1,746,236	19%
35-44	1,583,407	17%
45-54	1,043,714	11%
55-64	668,540	7%
65-74	538,028	6%
>75	392,559	4%
	9,240,402	

Beach Study Respondents

AGE		
<=12	5,718	48%
13-25	2,985	25%
>=26	3,090	26%

PEPS

AGE		
>=14	2,074,678	22%
15-24	1,193,240	13%
>=25	5,972,484	65%

*Population Estimation and Projection System (Los Angeles County, 1993)

Table 5, cont. Beach Study Respondent Characteristics vs. PEPS

Beach Study Respondents

GENDER		
female	5,319	45%
male	6,474	55%

PEPS*

GENDER		
female	4,726,498	50%
male	4,713,953	50%

Beach Study Respondents

ETHNICITY		
White	5,295	45%
Black	367	3%
Latino	5,103	43%
Asian/other	1,028	9%

PEPS

ETHNICITY		
White	3,414,147	36%
Black	938,202	10%
Latino	3,871,909	41%
Asian/other	1,216,192	13%

*Population Estimation and Projection System (Los Angeles County, 1993)

Table 6. Respondent Age by Map Area for Each Beach

Ashland								
Map Area*	0-12		13-25		>=26		totals	
drain	91 (59%)	(3%)	23 (15%)	(2%)	40 (26%)	(3%)	154 (100%)	(3%)
1-50 down	656 (54%)	(21%)	234 (19%)	(17%)	318 (26%)	(11%)	1208 (100%)	(20%)
1-50 up	688 (51%)	(22%)	353 (26%)	(25%)	309 (23%)	(12%)	1350 (100%)	(23%)
51-100 down	216 (48%)	(7%)	122 (27%)	(9%)	114 (25%)	(5%)	452 (100%)	(8%)
51-100 up	588 (48%)	(19%)	321 (26%)	(23%)	315 (26%)	(15%)	1224 (100%)	(21%)
400+ down	105 (57%)	(3%)	44 (24%)	(3%)	36 (19%)	(2%)	185 (100%)	(3%)
400+ up	714 (53%)	(23%)	309 (23%)	(22%)	324 (24%)	(17%)	1347 (100%)	(23%)
	3058 (52%)	(100%)	1406 (24%)	(100%)	1456 (25%)	(100%)	5920 (100%) †	(100%) ‡

Malibu								
Map Area	0-12		13-25		>=26		totals	
drain	390 (65%)	(21%)	119 (20%)	(11%)	94 (16%)	(9%)	603 (100%)	(15%)
1-50 down	124 (35%)	(7%)	117 (33%)	(11%)	111 (32%)	(5%)	352 (100%)	(9%)
1-50 up	412 (39%)	(22%)	337 (32%)	(31%)	310 (29%)	(16%)	1059 (100%)	(26%)
51-100 down	85 (39%)	(5%)	75 (35%)	(7%)	57 (26%)	(3%)	217 (100%)	(5%)
51-100 up	362 (45%)	(19%)	196 (24%)	(18%)	245 (31%)	(15%)	803 (100%)	(20%)
400+ down	457 (48%)	(24%)	237 (25%)	(21%)	252 (27%)	(19%)	946 (100%)	(23%)
400+ up	49 (56%)	(3%)	22 (25%)	(2%)	16 (18%)	(1%)	87 (100%)	(2%)
	1879 (46%)	(100%)	1103 (27%)	(100%)	1085 (27%)	(100%)	4067 (100%)	(100%)

Will Rogers								
Map Area	0-12		13-25		>=26		totals	
drain	50 (57%)	(6%)	22 (25%)	(5%)	16 (18%)	(3%)	88 (100%)	(5%)
1-50 down	155 (40%)	(20%)	102 (27%)	(21%)	127 (33%)	(23%)	384 (100%)	(21%)
1-50 up	80 (40%)	(10%)	46 (23%)	(10%)	76 (38%)	(14%)	202 (100%)	(11%)
51-100 down	182 (39%)	(23%)	138 (30%)	(29%)	145 (31%)	(26%)	465 (100%)	(26%)
51-100 up	57 (33%)	(7%)	41 (24%)	(9%)	73 (43%)	(13%)	171 (100%)	(9%)
400+ down	234 (52%)	(30%)	115 (26%)	(24%)	99 (22%)	(18%)	448 (100%)	(25%)
400+ up	23 (48%)	(3%)	12 (25%)	(3%)	13 (27%)	(2%)	48 (100%)	(3%)
	781 (43%)	(100%)	476 (26%)	(100%)	549 (30%)	(100%)	1806 (100%)	(100%)

* down = downcoast; up = upcoast

† ( ) row percentages

‡ { } column percentages

Table 7. Respondent Gender by Map Area for Each Beach

	Ashland					
Map Area*	female			male		totals
drain	87	(56%)	{3%}	67	(44%)	{2%}	154 (100%) {3%}
1-50 down	553	(46%)	{20%}	655	(54%)	{21%}	1208 (100%) {20%}
1-50 up	642	(48%)	{23%}	708	(52%)	{22%}	1350 (100%) {23%}
51-100 down	212	(47%)	{8%}	240	(53%)	{8%}	452 (100%) {8%}
51-100 up	548	(45%)	{20%}	676	(55%)	{21%}	1224 (100%) {21%}
400+ down	75	(41%)	{3%}	110	(59%)	{3%}	185 (100%) {3%}
400+ up	629	(47%)	{23%}	718	(53%)	{23%}	1347 (100%) {23%}
	2746	(46%)	{100%}	3174	(54%)	{100%}	5920 (100%) † {100%} ‡

	Malibu					
Map Area	female			male		totals
drain	271	(45%)	{15%}	332	(55%)	{15%}	603 (100%) {15%}
1-50 down	124	(35%)	{7%}	228	(65%)	{10%}	352 (100%) {9%}
1-50 up	457	(43%)	{25%}	602	(57%)	{26%}	1059 (100%) {26%}
51-100 down	86	(40%)	{5%}	131	(60%)	{6%}	217 (100%) {5%}
51-100 up	366	(46%)	{20%}	437	(54%)	{19%}	803 (100%) {20%}
400+ down	452	(48%)	{25%}	494	(52%)	{22%}	946 (100%) {23%}
400+ up	38	(44%)	{2%}	49	(56%)	{2%}	87 (100%) {2%}
	1794	(44%)	{100%}	2273	(56%)	{100%}	4067 (100%) {100%}

	Will Rogers					
Map Area	female			male		totals
drain	42	(48%)	{5%}	46	(52%)	{4%}	88 (100%) {5%}
1-50 down	164	(43%)	{21%}	220	(57%)	{21%}	384 (100%) {21%}
1-50 up	85	(42%)	{11%}	117	(58%)	{11%}	202 (100%) {11%}
51-100 down	186	(40%)	{24%}	279	(60%)	{27%}	465 (100%) {26%}
51-100 up	85	(50%)	{11%}	86	(50%)	{8%}	171 (100%) {9%}
400+ down	202	(45%)	{26%}	246	(55%)	{24%}	448 (100%) {25%}
400+ up	15	(31%)	{2%}	33	(69%)	{3%}	48 (100%) {3%}
	779	(43%)	{100%}	1027	(57%)	{100%}	1806 (100%) {100%}

* down = downcoast; up = upcoast

† ( ) row percentages

‡ { } column percentages

Table 8. Respondent Ethnicity by Map Area for Each Beach

Ashland

Map Area*	White			Black			Latino			Asian			multi			other			totals		
drain	28	(18%)	(1%)	8	(5%)	(3%)	108	(70%)	(4%)	4	(3%)	(2%)	4	(3%)	(2%)	2	(1%)	(2%)	154	(100%)	(3%)
1-50 down	464	(38%)	(21%)	52	(4%)	(19%)	558	(46%)	(20%)	65	(5%)	(31%)	39	(3%)	(21%)	30	(2%)	(23%)	1208	(100%)	(20%)
1-50 up	457	(34%)	(20%)	60	(4%)	(22%)	725	(54%)	(25%)	35	(3%)	(17%)	49	(4%)	(26%)	24	(2%)	(18%)	1350	(100%)	(23%)
51-100 down	207	(46%)	(9%)	20	(4%)	(7%)	186	(41%)	(7%)	21	(5%)	(10%)	8	(2%)	(4%)	10	(2%)	(8%)	452	(100%)	(8%)
51-100 up	471	(38%)	(21%)	55	(4%)	(20%)	590	(48%)	(21%)	38	(3%)	(18%)	46	(4%)	(24%)	24	(2%)	(18%)	1224	(100%)	(21%)
400+ down	71	(38%)	(3%)	12	(6%)	(4%)	82	(44%)	(3%)	1	(1%)	(0%)	13	(7%)	(7%)	6	(3%)	(5%)	185	(100%)	(3%)
400+ up	564	(42%)	(25%)	64	(5%)	(24%)	609	(45%)	(21%)	45	(3%)	(22%)	31	(2%)	(16%)	34	(3%)	(26%)	1347	(100%)	(23%)
	2262	(38%)	(100%)	271	(5%)	(100%)	2858	(48%)	(100%)	209	(4%)	(100%)	190	(3%)	(100%)	130	(2%)	(100%)	5920	(100%) †	(100%) ‡

Malibu

Map Area	White			Black			Latino			Asian			multi			other			totals		
drain	231	(38%)	(11%)	5	(1%)	(10%)	337	(56%)	(21%)	13	(2%)	(10%)	11	(2%)	(10%)	5	(1%)	(5%)	602	(100%)	(15%)
1-50 down	161	(46%)	(8%)	3	(1%)	(6%)	157	(45%)	(10%)	7	(2%)	(6%)	11	(3%)	(10%)	13	(4%)	(14%)	352	(100%)	(9%)
1-50 up	499	(47%)	(24%)	24	(2%)	(49%)	459	(43%)	(28%)	25	(2%)	(20%)	22	(2%)	(20%)	27	(3%)	(29%)	1056	(100%)	(26%)
51-100 down	132	(61%)	(6%)	0	(0%)	(0%)	67	(31%)	(4%)	4	(2%)	(3%)	7	(3%)	(6%)	7	(3%)	(8%)	217	(100%)	(5%)
51-100 up	450	(56%)	(22%)	2	(0%)	(4%)	271	(34%)	(17%)	50	(6%)	(40%)	11	(1%)	(10%)	19	(2%)	(20%)	803	(100%)	(20%)
400+ down	535	(57%)	(26%)	15	(2%)	(31%)	300	(32%)	(18%)	25	(3%)	(20%)	49	(5%)	(44%)	22	(2%)	(24%)	946	(100%)	(23%)
400+ up	36	(41%)	(2%)	0	(0%)	(0%)	50	(57%)	(3%)	1	(1%)	(1%)	0	(0%)	(0%)	0	(0%)	(0%)	87	(100%)	(2%)
	2044	(50%)	(100%)	49	(1%)	(100%)	1641	(40%)	(100%)	125	(3%)	(100%)	111	(3%)	(100%)	93	(2%)	(100%)	4063	(100%)	(100%)

Will Rogers

Map Area	White			Black			Latino			Asian			multi			other			totals		
drain	22	(25%)	(2%)	3	(3%)	(6%)	57	(65%)	(9%)	4	(5%)	(7%)	2	(2%)	(3%)	0	(0%)	(0%)	88	(100%)	(5%)
1-50 down	173	(45%)	(17%)	6	(2%)	(13%)	171	(45%)	(28%)	13	(3%)	(22%)	16	(4%)	(27%)	5	(1%)	(10%)	384	(100%)	(21%)
1-50 up	107	(53%)	(11%)	13	(6%)	(28%)	66	(33%)	(11%)	5	(2%)	(9%)	7	(3%)	(12%)	4	(2%)	(8%)	202	(100%)	(11%)
51-100 down	277	(60%)	(28%)	13	(3%)	(28%)	119	(26%)	(20%)	18	(4%)	(31%)	19	(4%)	(32%)	19	(4%)	(39%)	465	(100%)	(26%)
51-100 up	105	(61%)	(11%)	0	(0%)	(0%)	47	(27%)	(8%)	10	(6%)	(17%)	4	(2%)	(7%)	5	(3%)	(10%)	171	(100%)	(9%)
400+ down	277	(62%)	(28%)	11	(2%)	(23%)	127	(28%)	(21%)	7	(2%)	(12%)	10	(2%)	(17%)	16	(4%)	(33%)	448	(100%)	(25%)
400+ up	28	(58%)	(3%)	1	(2%)	(2%)	17	(35%)	(3%)	1	(2%)	(2%)	1	(2%)	(2%)	0	(0%)	(0%)	48	(100%)	(3%)
	989	(55%)	(100%)	47	(3%)	(100%)	604	(33%)	(100%)	58	(3%)	(100%)	59	(3%)	(100%)	49	(3%)	(100%)	1806	(100%)	(100%)

* down = downcoast; up = upcoast

† ( ) row percentages

‡ ( ) column percentages

Table 9. Age, Gender and Ethnicity by Map Area For All Beaches

	beach									
Map Area*	Ashland			Malibu			Will Rogers			totals
drain	154	(18%)	{3%}	603	(71%)	{15%}	88	(10%)	{5%}	845 (100%) {7%}
1-50 down	1208	(62%)	{20%}	352	(18%)	{9%}	384	(20%)	{21%}	1944 (100%) {16%}
1-50 up	1350	(52%)	{23%}	1059	(41%)	{26%}	202	(8%)	{11%}	2611 (100%) {22%}
51-100 down	452	(40%)	{8%}	217	(19%)	{5%}	465	(41%)	{26%}	1134 (100%) {10%}
51-100 up	1224	(56%)	{21%}	803	(37%)	{20%}	171	(8%)	{9%}	2198 (100%) {19%}
400+ down	185	(12%)	{3%}	946	(60%)	{23%}	448	(28%)	{25%}	1579 (100%) {13%}
400+ up	1347	(91%)	{23%}	87	(6%)	{2%}	48	(3%)	{3%}	1482 (100%) {13%}
	5920	(50%)	{100%}	4067	(34%)	{100%}	1806	(15%)	{100%}	11793 (100%) † {100%} ‡

	age									
Map Area*	0-12			13-25			>=26			totals
drain	531	(63%)	{9%}	164	(19%)	{5%}	150	(18%)	{5%}	845 (100%) {7%}
1-50 down	935	(48%)	{16%}	453	(23%)	{15%}	556	(29%)	{18%}	1944 (100%) {16%}
1-50 up	1180	(45%)	{21%}	736	(28%)	{25%}	695	(27%)	{22%}	2611 (100%) {22%}
51-100 down	483	(43%)	{8%}	335	(30%)	{11%}	316	(28%)	{10%}	1134 (100%) {10%}
51-100 up	1007	(46%)	{18%}	558	(25%)	{19%}	633	(29%)	{20%}	2198 (100%) {19%}
400+ down	796	(50%)	{14%}	396	(25%)	{13%}	387	(25%)	{13%}	1579 (100%) {13%}
400+ up	786	(53%)	{14%}	343	(23%)	{11%}	353	(24%)	{11%}	1482 (100%) {13%}
	5718	(48%)	{100%}	2985	(25%)	{100%}	3090	(26%)	{100%}	11793 (100%) {100%}

	gender						
Map Area*	female			male			totals
drain	400	(47%)	{8%}	445	(53%)	{7%}	845 (100%) {7%}
1-50 down	841	(43%)	{16%}	1103	(57%)	{17%}	1944 (100%) {16%}
1-50 up	1184	(45%)	{22%}	1427	(55%)	{22%}	2611 (100%) {22%}
51-100 down	484	(43%)	{9%}	650	(57%)	{10%}	1134 (100%) {10%}
51-100 up	999	(45%)	{19%}	1199	(55%)	{19%}	2198 (100%) {19%}
400+ down	729	(46%)	{14%}	850	(54%)	{13%}	1579 (100%) {13%}
400+ up	682	(46%)	{13%}	800	(54%)	{12%}	1482 (100%) {13%}
	5319	(45%)	{100%}	6474	(55%)	{100%}	11793 (100%) {100%}

* down = downcoast; up = upcoast
† ( ) row percentages
‡ { } column percentages

Table 9, cont. Age, Gender and Ethnicity by Map Area For All Beaches

	ethnicity																							
Map Area*	White			Black			Latino			Asian			multi			other			totals					
drain	281	(33%)	(5%)	16	(2%)	(4%)	502	(58%)	(10%)	21	(2%)	(5%)	17	(2%)	(5%)	7	(1%)	(3%)	844	(100%)		(7%)		
1-50 down	798	(41%)	(15%)	61	(3%)	(17%)	886	(46%)	(17%)	85	(4%)	(22%)	66	(3%)	(18%)	48	(2%)	(18%)	1944	(100%)		(16%)		
1-50 up	1063	(41%)	(20%)	97	(4%)	(26%)	1250	(48%)	(24%)	65	(2%)	(17%)	78	(3%)	(22%)	55	(2%)	(20%)	2608	(100%)		(22%)		
51-100 down	616	(54%)	(12%)	33	(3%)	(9%)	372	(33%)	(7%)	43	(4%)	(11%)	34	(3%)	(9%)	36	(3%)	(13%)	1134	(100%)		(10%)		
51-100 up	1026	(47%)	(19%)	57	(3%)	(16%)	908	(41%)	(18%)	98	(4%)	(25%)	61	(3%)	(17%)	48	(2%)	(18%)	2198	(100%)		(19%)		
400+ down	883	(56%)	(17%)	38	(2%)	(10%)	509	(32%)	(10%)	33	(2%)	(8%)	72	(5%)	(20%)	44	(3%)	(16%)	1579	(100%)		(13%)		
400+ up	628	(42%)	(12%)	65	(4%)	(18%)	676	(46%)	(13%)	47	(3%)	(12%)	32	(2%)	(9%)	34	(2%)	(13%)	1482	(100%)		(13%)		
	5295	(45%)	(100%)	367	(3%)	(100%)	5103	(43%)	(100%)	392	(3%)	(100%)	360	(3%)	(100%)	272	(2%)	(100%)	11789	(100%)	†	(100%)	‡	

* down = downcoast; up = upcoast
† ( ) row percentages
‡ { } column percentages

Table 10. Subgroup Specific Symptom Counts

	TOTAL	A) gender		B) age groups			C) ethnicity					
Symptom		Female	Male	<=12	13-25	>=26	White	Black	Latino	Asian	multi	other
Fever	567	257	310	323	121	123	259	21	231	18	27	11
Chills	296	140	156	139	70	87	150	8	114	7	11	6
Redness/discharge from eyes	212	108	104	118	39	55	72	8	112	2	12	6
Earache	407	192	215	185	119	103	212	15	152	6	9	12
Discharge/draining from ears	79	41	38	29	27	23	33	1	41	0	3	1
Skin rash	110	56	54	55	21	34	35	2	65	1	3	4
Cuts becoming infected	76	29	47	21	31	24	46	1	24	2	2	1
Nausea	432	219	213	206	106	119	223	16	155	10	18	10
Vomiting	204	91	113	144	33	27	80	7	98	5	11	3
Diarrhea	627	286	341	307	130	190	365	23	174	15	30	20
Diarrhea with blood	14	7	7	7	4	3	5	0	8	0	1	0
Stomach pain or cramps	736	351	385	370	194	171	387	28	250	23	30	18
Coughing	834	372	462	454	214	166	389	34	333	28	35	14
Coughing with phlegm	390	156	234	195	111	84	176	10	177	8	14	4
Nasal congestion or runny nose	1079	477	602	504	307	268	588	32	361	31	43	23
Sore throat	802	386	416	350	233	219	422	25	291	14	28	21
hcgi_1	355	166	189	223	65	67	164	16	141	9	20	5
hcgi_2	101	39	62	76	15	10	43	2	48	2	5	1
srd	589	264	325	307	158	124	276	20	241	14	26	11

Table 10, cont. Subgroup Specific Symptom Counts

	D) SES		E) residency		F) concern about hazards			
Symptom	<=$25,000	>$25,000	CA resident	non CA	not at all worried	somewhat worried	a little worried	very worried
Fever	64	447	526	40	46	68	122	227
Chills	30	236	272	24	20	39	59	140
Redness/discharge from eyes	15	176	194	16	23	26	46	77
Earache	22	336	363	39	28	56	83	172
Discharge/draining from ears	3	71	75	3	7	5	20	38
Skin rash	22	79	104	6	14	12	25	44
Cuts becoming infected	3	62	67	8	6	14	13	33
Nausea	32	347	387	39	18	55	82	195
Vomiting	12	172	187	13	11	20	47	83
Diarrhea	22	497	532	90	34	98	119	273
Diarrhea with blood	2	10	13	1	1	2	4	5
Stomach pain or cramps	41	598	652	78	53	98	151	295
Coughing	75	663	764	66	85	117	164	324
Coughing with phlegm	30	314	363	24	48	57	71	152
Nasal congestion or runny nose	72	863	964	103	93	171	238	424
Sore throat	61	634	721	75	73	134	178	301
hcgi_1	27	288	322	29	22	36	72	150
hcgi_2	6	89	97	3	5	10	21	47
srd	49	473	547	39	60	87	118	220

Table 11. Subgroup Specific Symptom Rates per 100 Persons

SYMPTOM	TOTALS	A) gender		B) age			C) ethnicity					
		female	male	0-12	13-25	>=26	White	Black	Latino	Asian	multi	other
1 Fever	4.8	4.8	4.8	5.6	4.1	4.0	4.9	5.7	4.5	4.6	7.5	4.0
2 Chills	2.5	2.6	2.4	2.4	2.3	2.8	2.8	2.2	2.2	1.8	3.1	2.2
3 Redness/discharge from eyes	1.8	2.0	1.6	2.1	1.3	1.8	1.4	2.2	2.2	0.5	3.3	2.2
4 Earache	3.5	3.6	3.3	3.2	4.0	3.3	4.0	4.1	3.0	1.5	2.5	4.3
5 Discharge/draining from ears	0.7	0.8	0.6	0.5	0.9	0.7	0.6	0.3	0.8	0.0	0.8	0.4
6 Skin rash	0.9	1.1	0.8	1.0	0.7	1.1	0.7	0.5	1.3	0.3	0.8	1.4
7 Cuts becoming infected	0.6	0.5	0.7	0.4	1.0	0.8	0.9	0.3	0.5	0.5	0.6	0.4
8 Nausea	3.7	4.1	3.3	3.6	3.6	3.9	4.2	4.4	3.0	2.6	5.0	3.6
9 Vomiting	1.7	1.7	1.7	2.5	1.1	0.9	1.5	1.9	1.9	1.3	3.1	1.1
10 Diarrhea	5.3	5.4	5.3	5.4	4.4	6.1	6.9	6.3	3.4	3.8	8.3	7.2
11 Diarrhea with blood	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.0	0.3	0.0
12 Stomach pain or cramps	6.2	6.6	5.9	6.5	6.5	5.5	7.3	7.6	4.9	5.9	8.3	6.5
13 Coughing	7.1	7.0	7.1	7.9	7.2	5.4	7.3	9.3	6.5	7.1	9.7	5.1
14 Coughing with phlegm	3.3	2.9	3.6	3.4	3.7	2.7	3.3	2.7	3.5	2.0	3.9	1.4
15 Nasal congestion or runny nose	9.1	9.0	9.3	8.8	10.3	8.7	11.1	8.7	7.1	7.9	11.9	8.3
16 Sore throat	6.8	7.3	6.4	6.1	7.8	7.1	8.0	6.8	5.7	3.6	7.8	7.6
HCGI_1	3.0	3.1	2.9	3.9	2.2	2.2	3.1	4.4	2.8	2.3	5.6	1.8
HCGI_2	0.9	0.7	1.0	1.3	0.5	0.3	0.8	0.5	0.9	0.5	1.4	0.4
SRD	5.0	5.0	5.0	5.4	5.3	4.0	5.2	5.4	4.7	3.6	7.2	4.0

Table 11, cont. Subgroup Specific Symptom Rates per 100 Persons

SYMPTOM	D) SES		E) residency		F) concern about environmental hazards at beach			
	<=25,000	>25,000	CA resident	outside CA	not at all worried	somewhat worried	a little worried	very worried
1 Fever	6.3	4.9	5.0	3.1	3.0	3.3	4.9	6.6
2 Chills	2.9	2.6	2.6	1.9	1.3	1.9	2.4	4.1
3 Redness/discharge from eyes	1.5	1.9	1.9	1.2	1.5	1.3	1.9	2.2
4 Earache	2.2	3.7	3.5	3.0	1.8	2.7	3.3	5.0
5 Discharge/draining from ears	0.3	0.8	0.7	0.2	0.5	0.2	0.8	1.1
6 Skin rash	2.2	0.9	1.0	0.5	0.9	0.6	1.0	1.3
7 Cuts becoming infected	0.3	0.7	0.6	0.6	0.4	0.7	0.5	1.0
8 Nausea	3.1	3.8	3.7	3.0	1.2	2.6	3.3	5.7
9 Vomiting	1.2	1.9	1.8	1.0	0.7	1.0	1.9	2.4
10 Diarrhea	2.2	5.4	5.1	7.0	2.2	4.7	4.8	7.9
11 Diarrhea with blood	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1
12 Stomach pain or cramps	4.0	6.5	6.3	6.0	3.4	4.7	6.1	8.5
13 Coughing	7.3	7.2	7.3	5.1	5.5	5.6	6.6	9.4
14 Coughing with phlegm	2.9	3.4	3.5	1.9	3.1	2.7	2.9	4.4
15 Nasal congestion or runny nose	7.1	9.4	9.2	8.0	6.0	8.2	9.6	12.3
16 Sore throat	6.0	6.9	6.9	5.8	4.7	6.4	7.2	8.7
HCGI_1	2.6	3.1	3.1	2.2	1.4	1.7	2.9	4.3
HCGI_2	0.6	1.0	0.9	0.2	0.3	0.5	0.8	1.4
SRD	4.8	5.1	5.2	3.0	3.9	4.2	4.8	6.4

Table 12. Percentage of Days in which Bacterial Indicators Exceeded the Standard Cutoff Levels

A. ASHLAND

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Upcoast (%)	Cutoff cfu
E. coli	30.8	7.8	9.1	11.7	35
E. coli	19.2	5.2	2.6	3.9	70
Entercoccus	19.0	6.3	5.1	5.1	35
Fecal Coliforms	11.4	3.8	3.8	1.3	200
Total Coliforms	44.3	12.7	12.8	3.8	1000

B. MALIBU

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	60.3	24.4	66.7	52.6	35
E. coli	55.1	15.4	53.8	25.6	70
Entercoccus	51.3	19.2	48.7	21.8	35
Fecal Coliforms	52.6	10.3	43.6	11.5	200
Total Coliforms	23.1	3.8	14.1	6.4	1000

C. WILL ROGERS

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	74.0	21.9	45.2	15.1	35
E. coli	58.9	13.7	17.8	1.4	70
Entercoccus	79.5	23.3	42.5	9.6	35
Fecal Coliforms	56.2	6.8	8.2	1.4	200
Total Coliforms	46.6	5.5	5.5	0.0	1000

Note: Samples collected once daily between 8 am and 11 am.

cfu = colony forming units

Table 13. Percentage of Days in which Bacterial Indicators Exceeded the Higher Cutoff Levels

A. ASHLAND

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Upcoast (%)	Cutoff cfu
E. coli	9.0	1.3	0.0	0.0	160
E. coli	6.4	1.3	0.0	0.0	320
Entercoccus	6.3	0.0	1.3	0.0	106
Fecal Coliforms	10.1	1.3	1.3	0.0	400
Total Coliforms	25.3	1.3	3.8	0.0	5,000
Total Coliforms	15.2	0.0	1.3	0.0	10,000

B. MALIBU

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	47.4	10.3	33.3	7.7	160
E. coli	39.7	7.7	19.2	1.3	320
Entercoccus	34.6	5.1	17.9	2.6	106
Fecal Coliforms	46.2	6.4	21.8	2.6	400
Total Coliforms	5.1	2.6	1.3	0.0	5,000
Total Coliforms	3.8	1.3	0.0	0.0	10,000

C. WILL ROGERS

	AREA				
Bacterial Indicator	Storm Drain 0 Yards (%)	1-100 Yards Upcoast (%)	1-100 Yards Downcoast (%)	400 + Yards Downcoast (%)	Cutoff cfu
E. coli	42.5	5.5	8.2	0.0	160
E. coli	28.8	1.4	1.4	0.0	320
Entercoccus	45.2	6.8	9.6	1.4	106
Fecal Coliforms	32.9	1.4	2.7	0.0	400
Total Coliforms	16.4	1.4	2.7	0.0	5,000
Total Coliforms	6.8	0.0	1.4	0.0	10,000

Note: Samples collected once daily between 8 am and 11 am.

cfu = colony forming units

Table 14. Total Coliforms/Enterococcus Within Specified Ranges

A. ASHLAND

	AREA			
Total Coliforms/Enterococcus	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Upcoast (% of days)
<=7	2.5	21.5	25.6	21.8
<=10	11.4	27.9	26.9	29.5
<=13	15.2	30.4	30.8	42.3

B. MALIBU

	AREA			
Total Coliforms/Enterococcus	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=7	44.9	66.7	50.0	51.3
<=10	59.0	78.2	74.4	74.4
<=13	68.0	84.6	80.8	83.3

C. WILL ROGERS

	AREA			
Total Coliforms/Enterococcus	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=7	46.6	65.8	69.9	83.6
<=10	60.3	78.1	79.5	91.8
<=13	69.9	82.2	89.0	95.9

Note: Samples collected once daily between 8 am and 11 am.

Table 15. Total Coliforms/Fecal Coliforms Within Specified Ranges

A. ASHLAND

	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Upcoast (% of days)
<=5	17.7	34.2	30.8	48.7
<=4	17.7	29.1	26.9	41.0
<=2	7.6	20.3	14.1	24.4

B. MALIBU

	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	82.1	85.9	88.5	89.7
<=4	80.8	82.1	82.1	84.6
<=2	51.3	68.0	55.1	60.3

C. WILL ROGERS

	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	52.1	76.7	75.3	84.9
<=4	41.1	72.6	63.0	75.3
<=2	13.7	27.4	24.7	30.1

Note: Samples collected once daily between 8 am and 11 am.

Table 16. Total Coliforms/Fecal Coliforms Within Specified Ranges On Days When Total Coliforms > 1000 and > 5000

A. ASHLAND

> 1000	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Upcoast (% of days)
<=5	0.0	0.0	0.0	0.0
<=4	0.0	0.0	0.0	0.0
<=2	0.0	0.0	0.0	0.0

> 5000

Total Coliforms/Fecal Coliforms				
<=5	0.0	0.0	0.0	-
<=4	0.0	0.0	0.0	-
<=2	0.0	0.0	0.0	-

B. MALIBU

> 1000	AREA			
Total Coliforms/Fecal Coliforms	Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	55.6	0.0	54.6	20.0
<=4	55.6	0.0	36.4	0.0
<=2	16.7	0.0	18.2	0.0

> 5000

Total Coliforms/Fecal Coliforms				
<=5	25.0	0.0	0.0	-
<=4	25.0	0.0	0.0	-
<=2	0.0	0.0	0.0	-

Note: Samples collected once daily between 8 am and 11 am.

Table 16 Continued. Total Coliforms/Fecal Coliforms Within Specified Ranges On Days When Total Coliforms > 1000 and > 5000

C. WILL ROGERS

> 1000

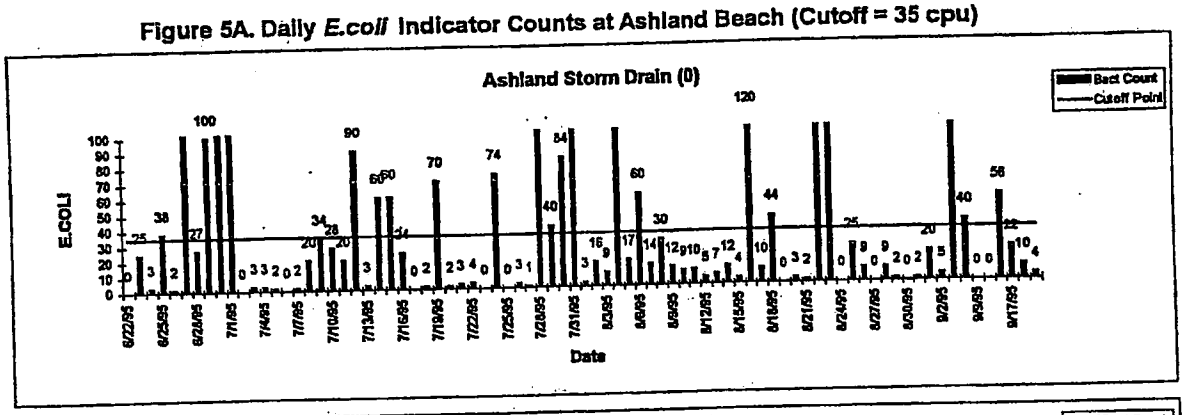
Total Coliforms/Fecal Coliforms	AREA: Storm Drain 0 Yards (% of days)	1-100 Yards Upcoast (% of days)	1-100 Yards Downcoast (% of days)	400 + Yards Downcoast (% of days)
<=5	50.0	25.0	75.0	-
<=4	41.2	25.0	75.0	-
<=2	14.7	0.0	0.0	-

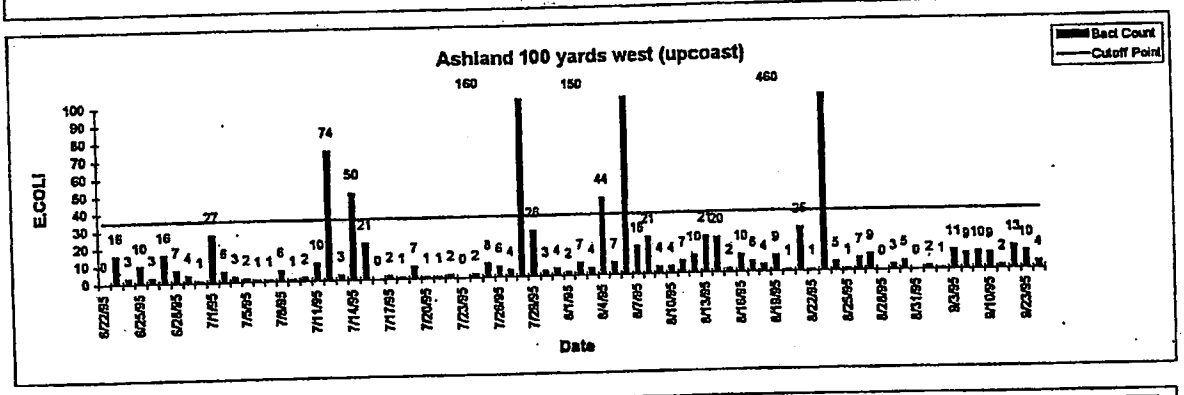
> 5000

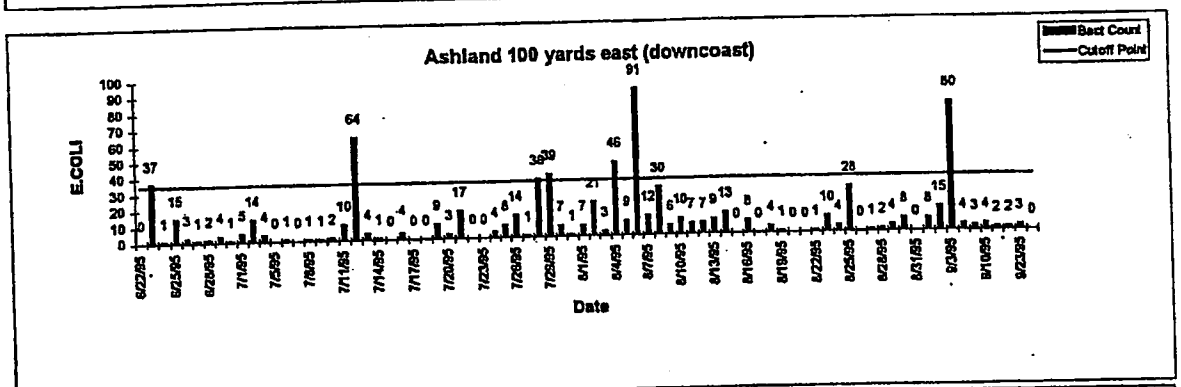
Total Coliforms/Fecal Coliforms				
<=5	33.3	0.0	50.0	-
<=4	33.3	0.0	50.0	-
<=2	16.7	0.0	0.0	-

Note: Samples collected once daily between 8 am and 11 am.

Figure 5A. Daily *E.coli* Indicator Counts at Ashland Beach (Cutoff = 35 cpu)







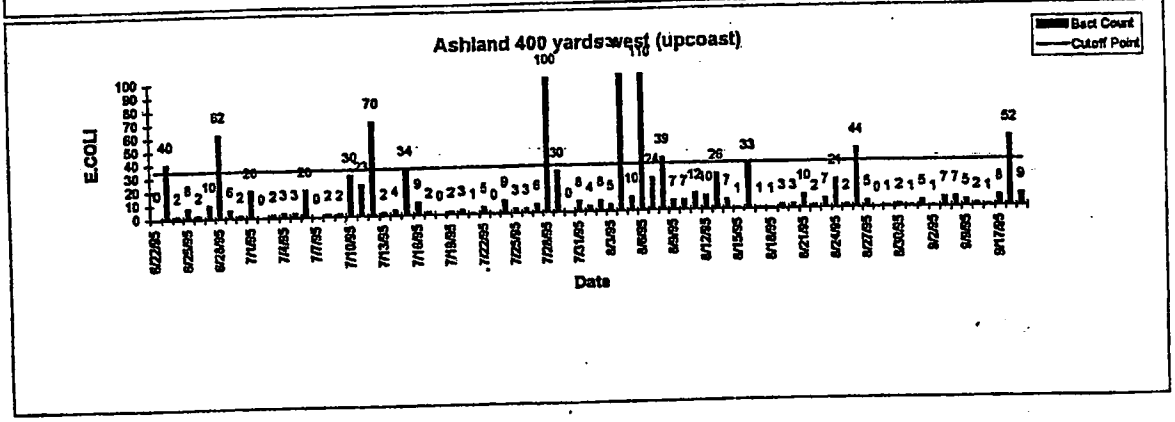
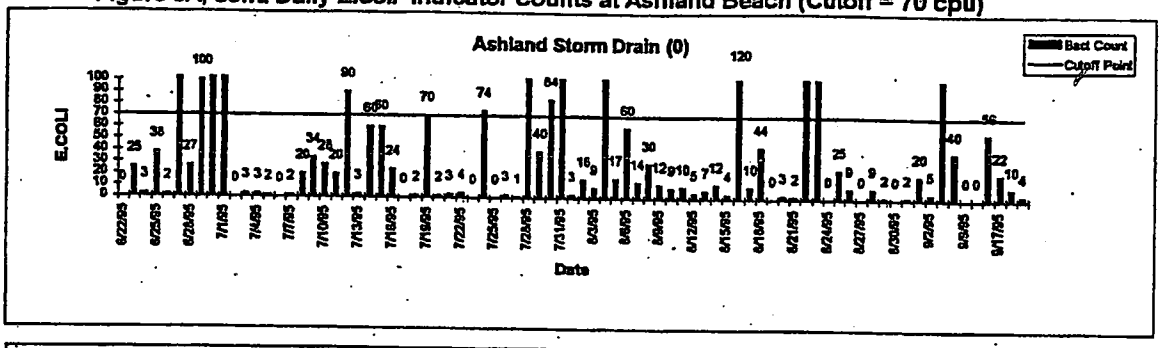
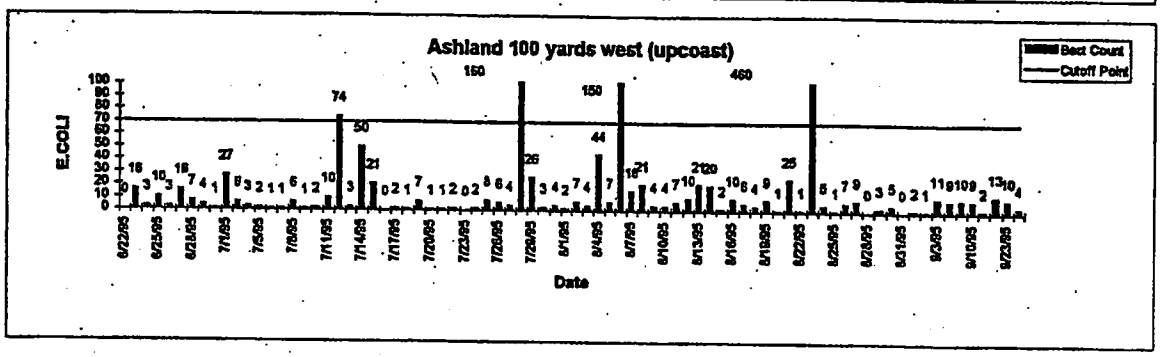
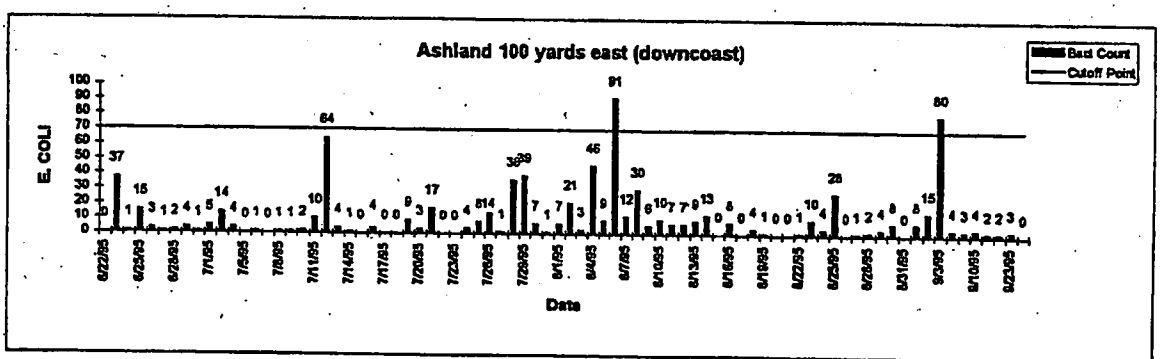


Figure 5A, cont. Daily *E.coli* Indicator Counts at Ashland Beach (Cutoff = 70 cpu)







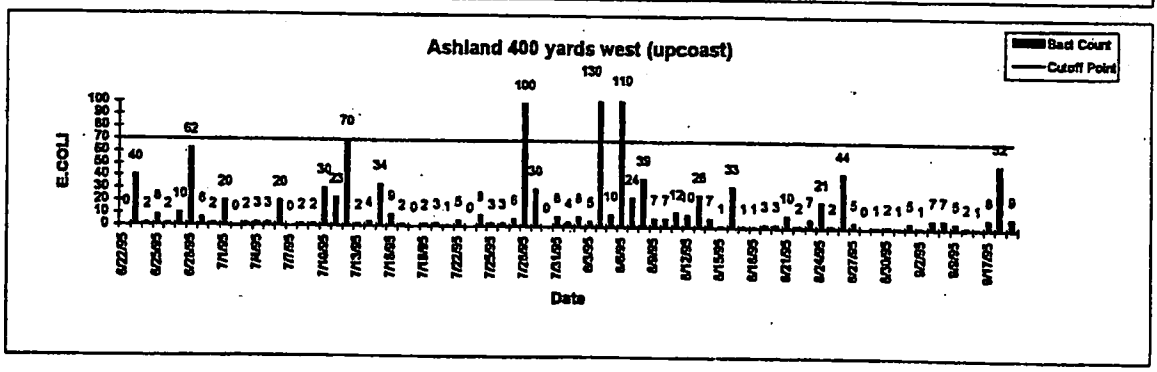
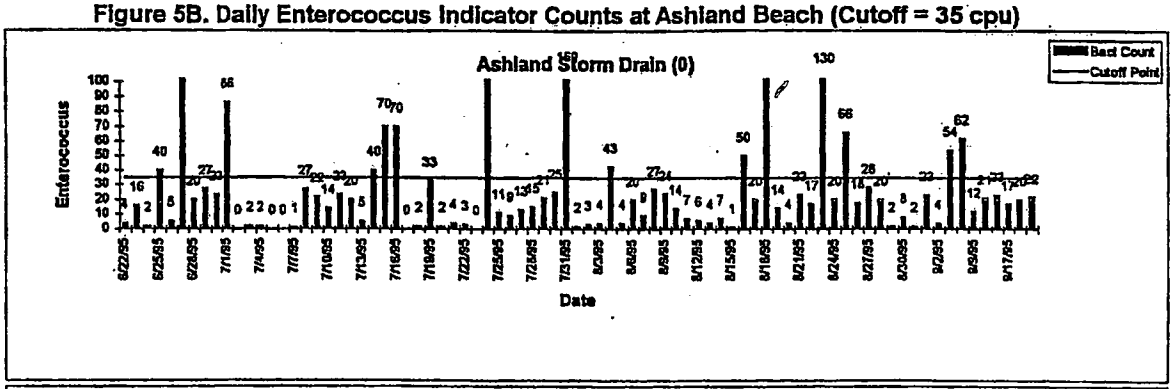
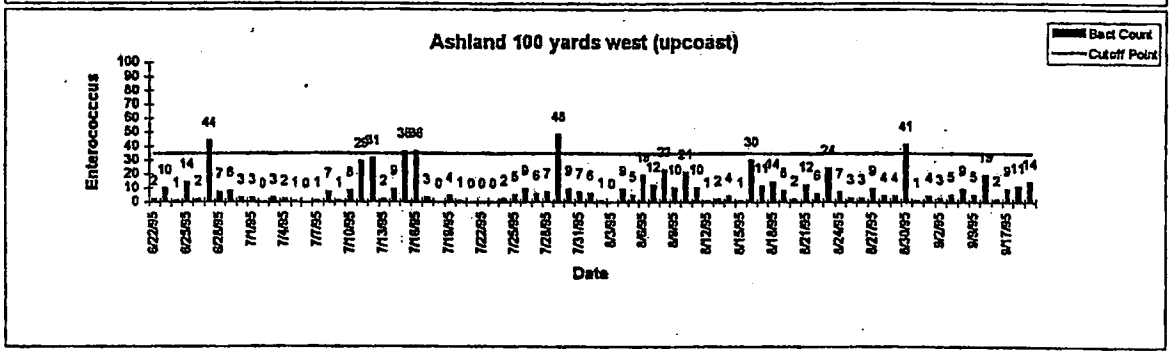
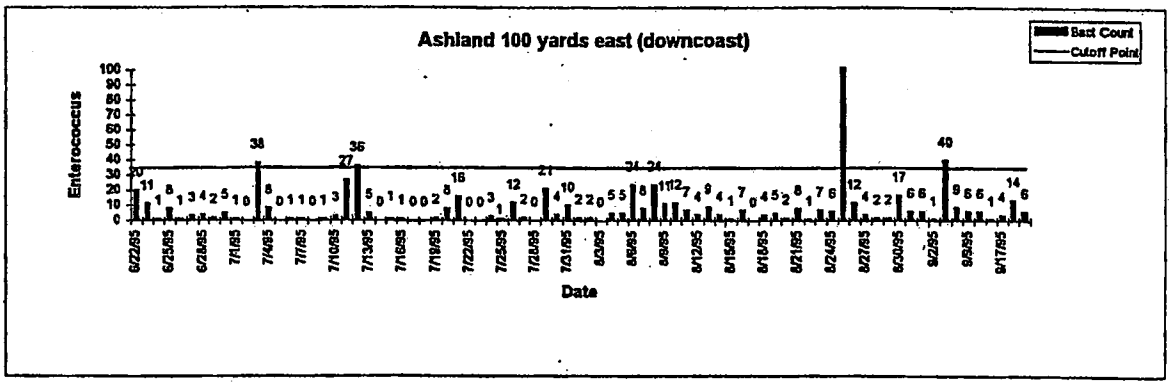


Figure 5B. Daily Enterococcus Indicator Counts at Ashland Beach (Cutoff = 35 cpu)







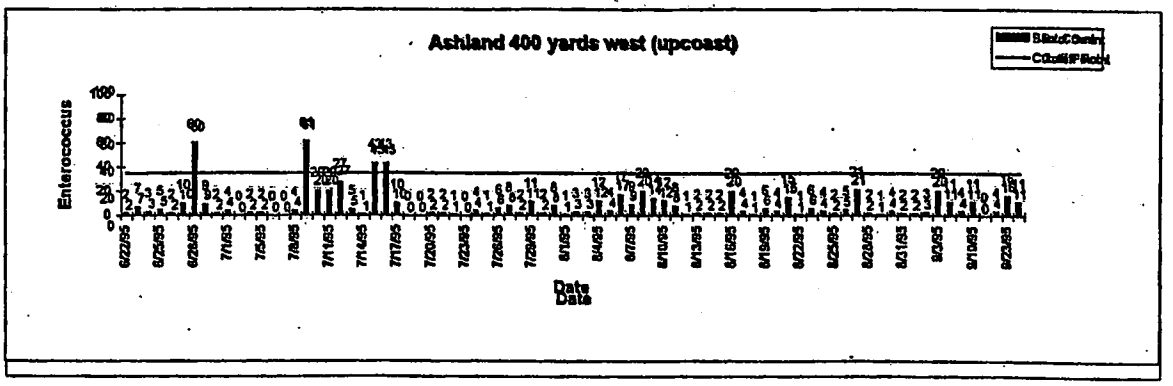
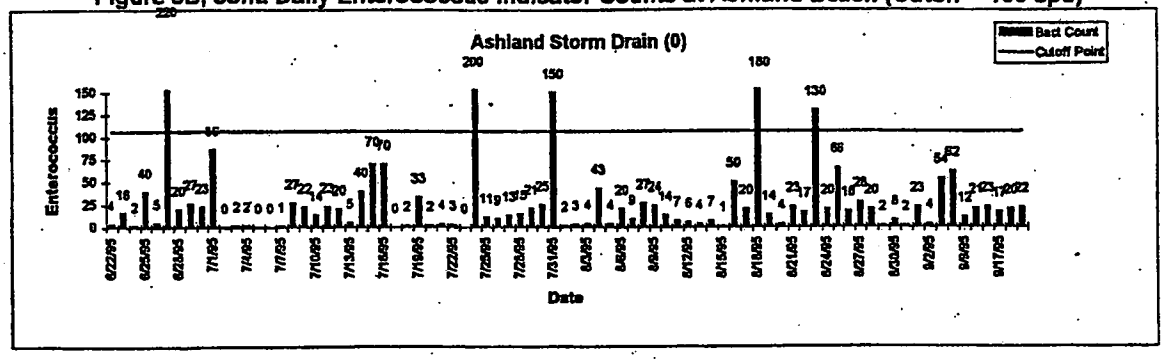
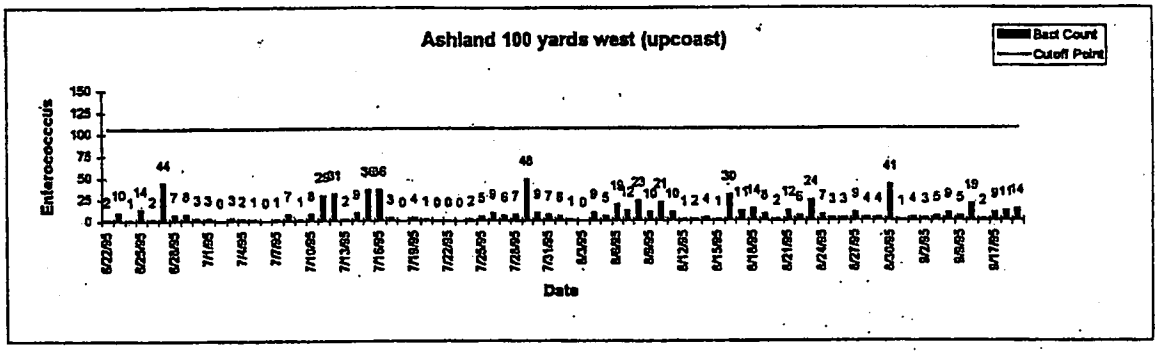
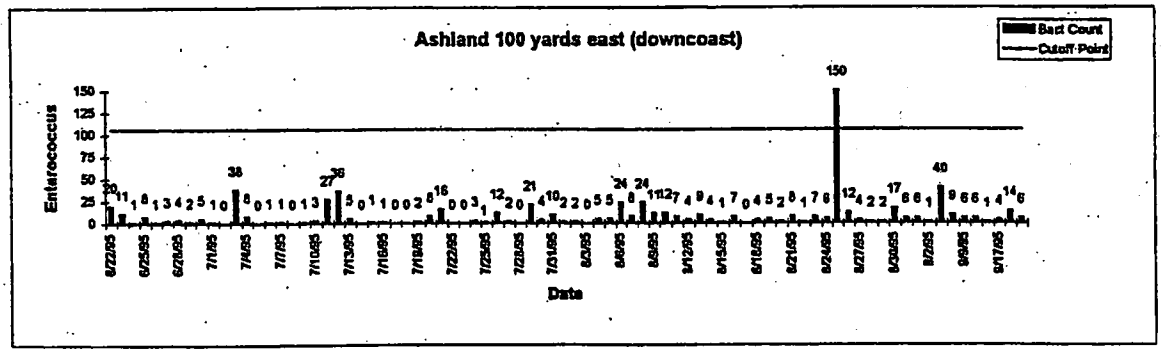


Figure 5B, cont. Daily Enterococcus Indicator Counts at Ashland Beach (Cutoff = 106 cpu)







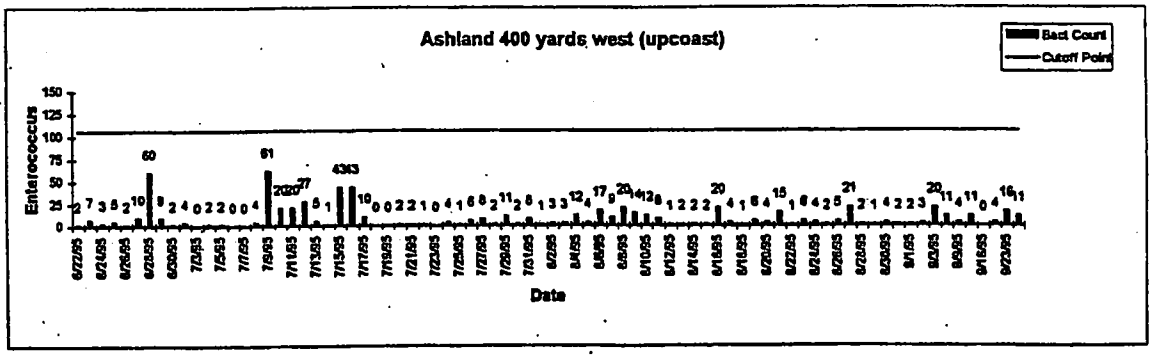
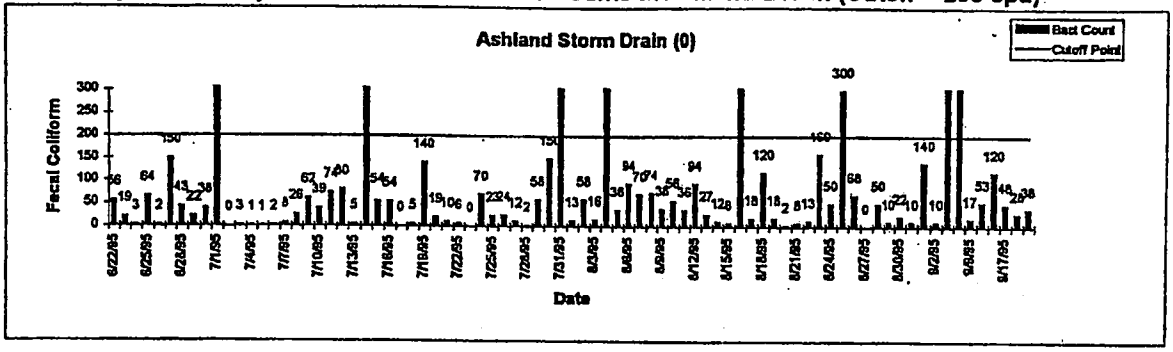
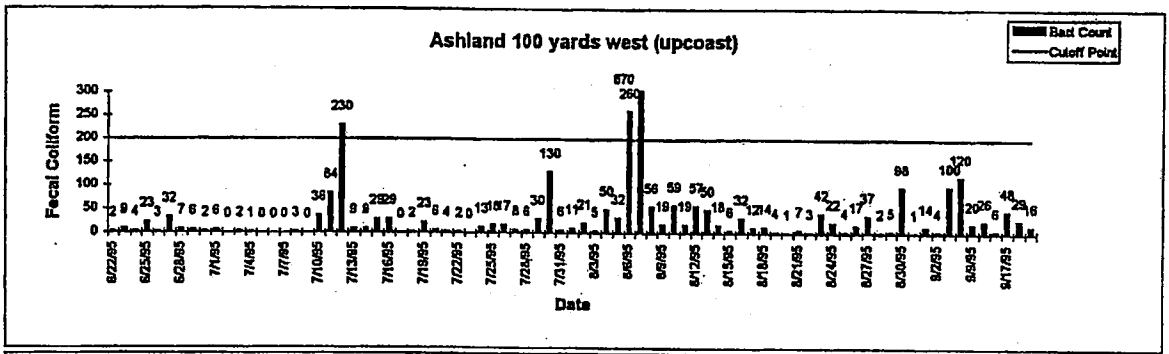
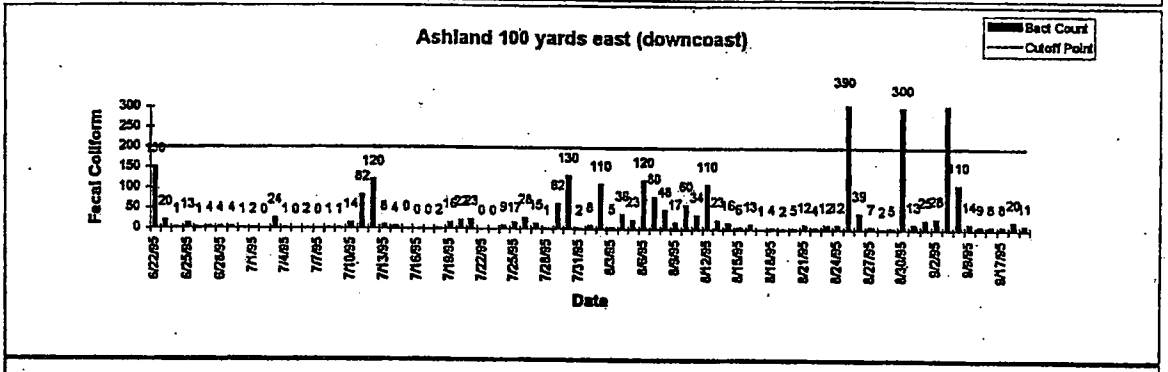


Figure 5C. Daily Fecal Coliform Indicator Counts at Ashland Beach (Cutoff = 200 cpu)







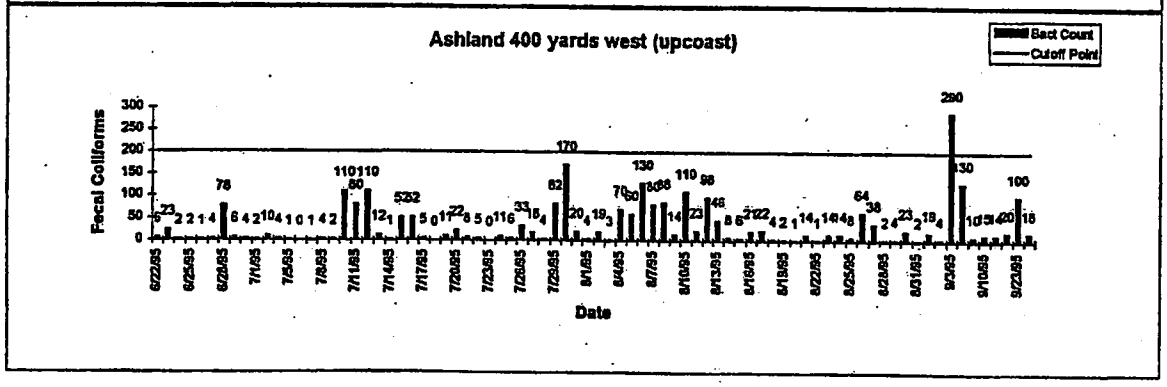
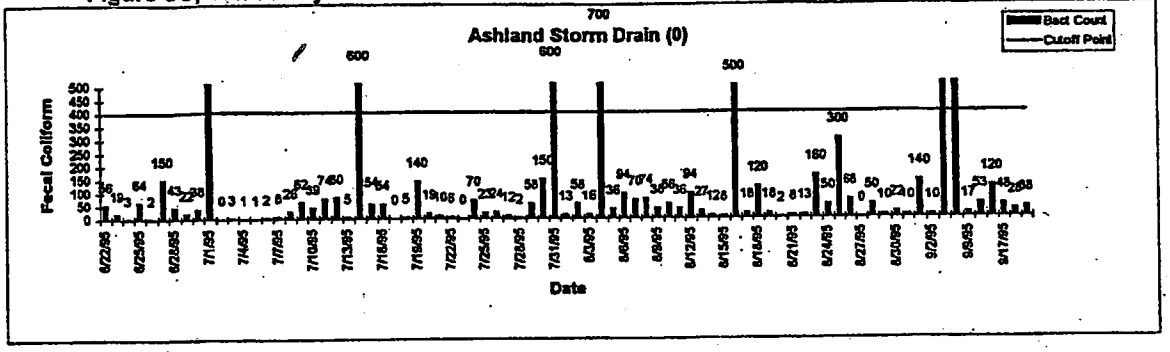
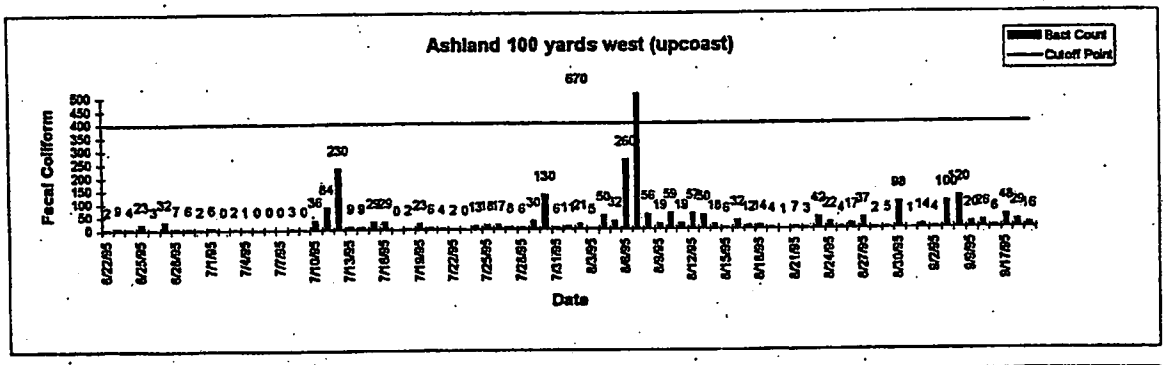
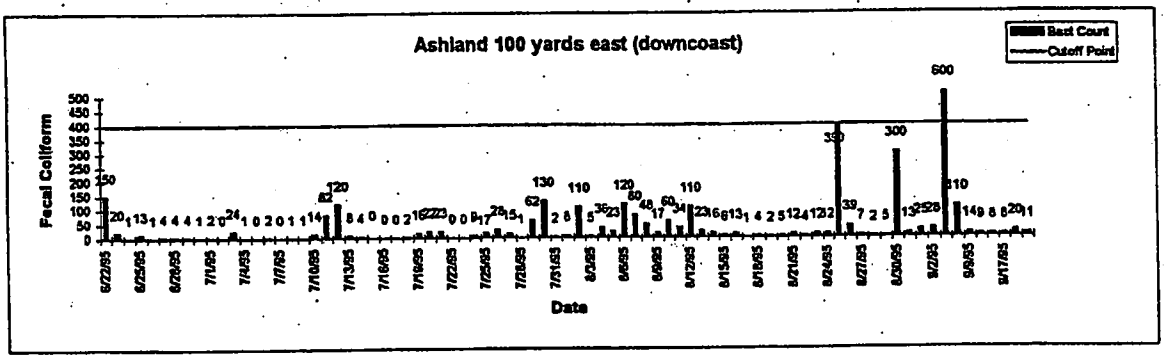


Figure 5C, cont. Daily Fecal Coliform Indicator Counts at Ashland Beach (Cutoff = 400 cpu)







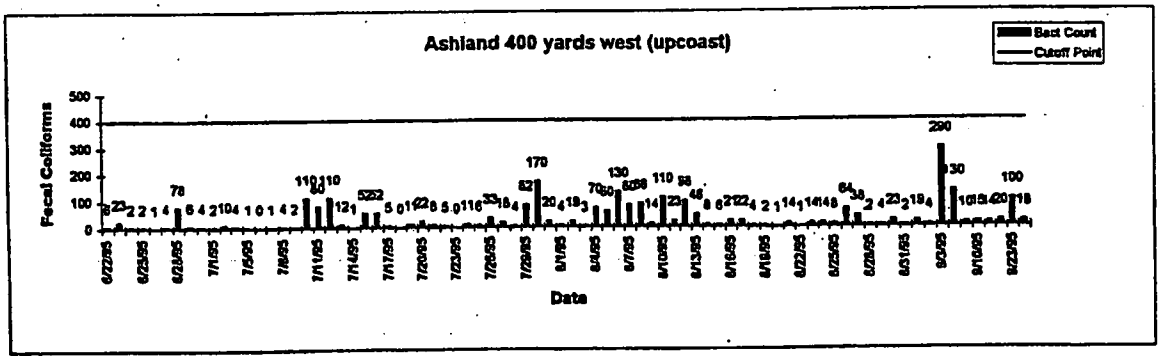
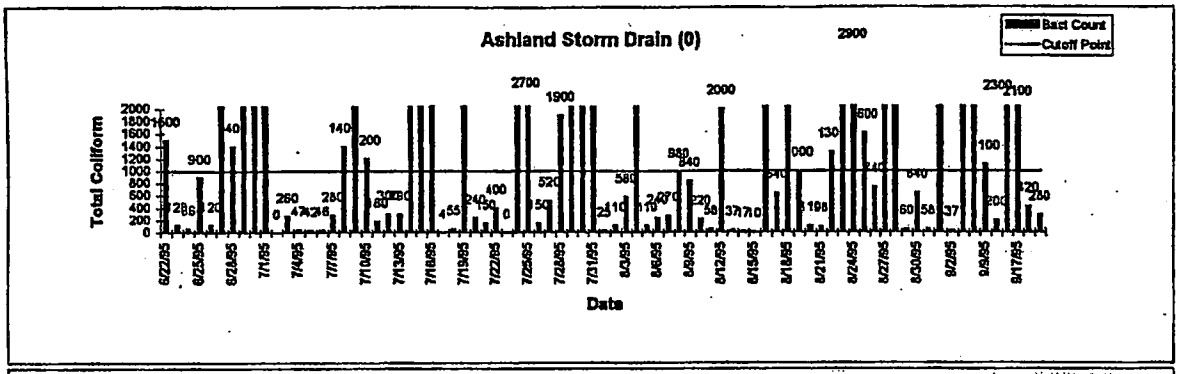
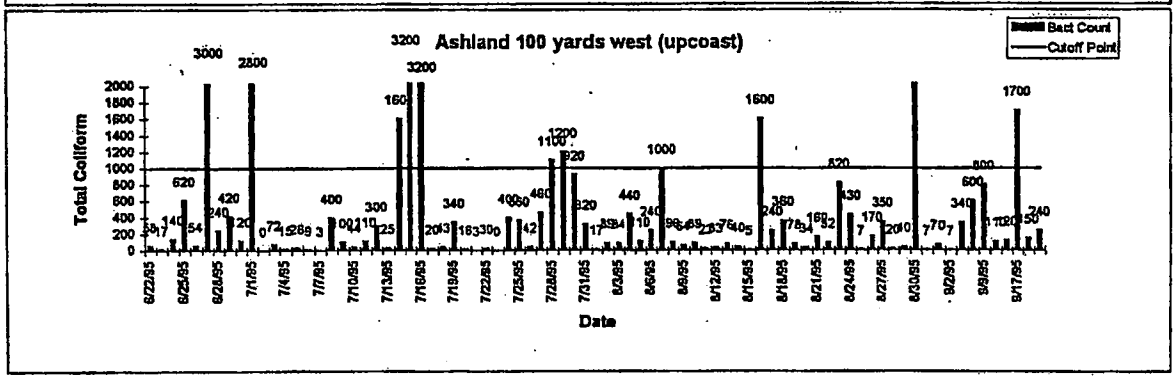
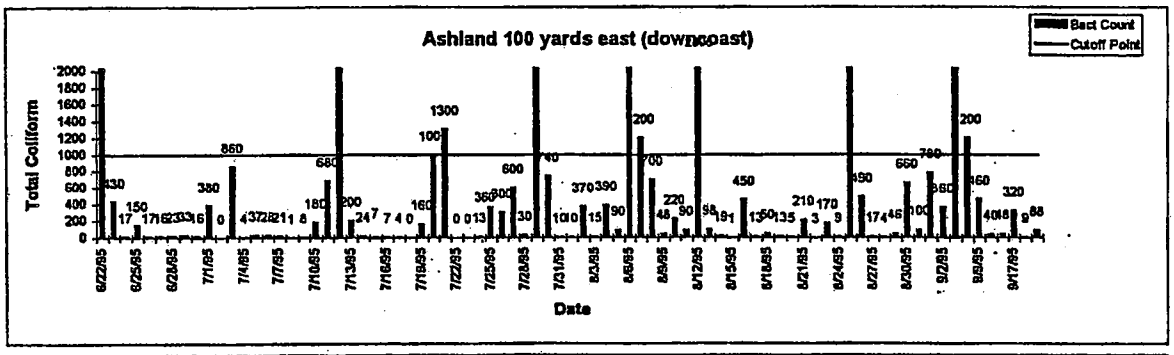


Figure 5D. Daily Total Coliform Indicator Counts at Ashland Beach (Cutoff = 1000 cpu)







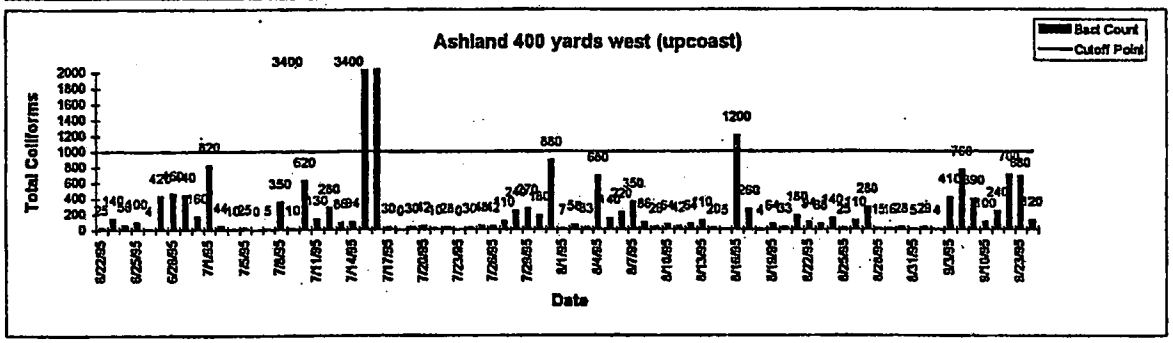
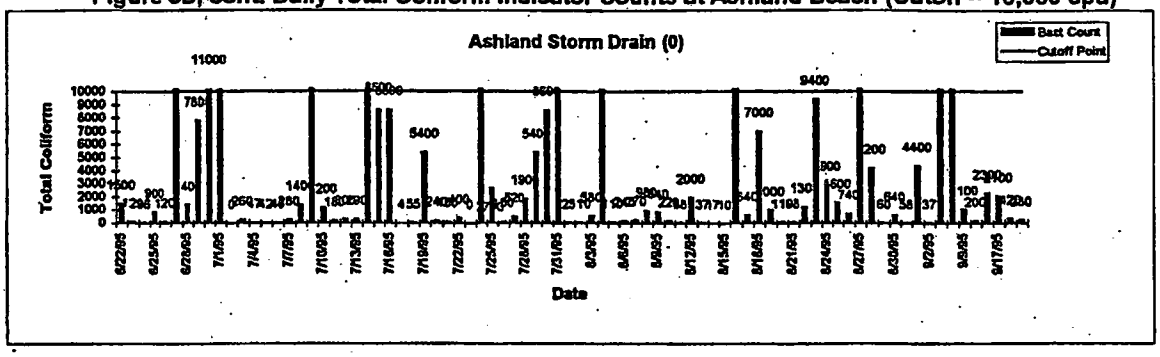
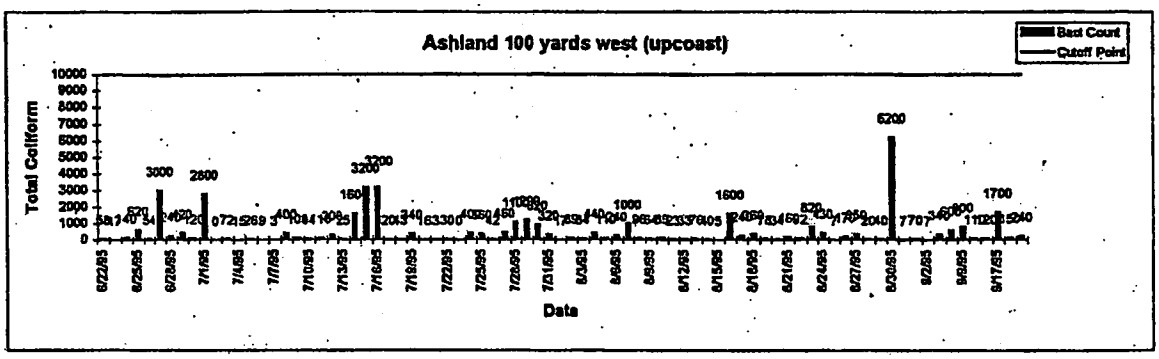
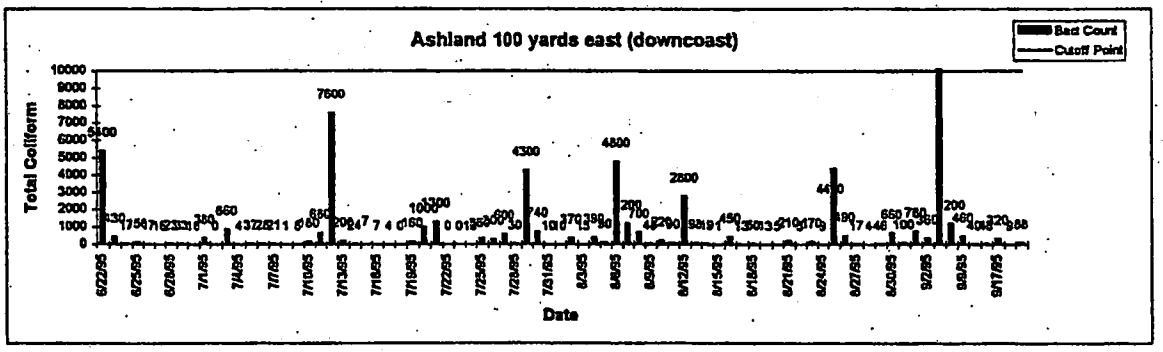


Figure 5D, cont. Daily Total Coliform Indicator Counts at Ashland Beach (Cutoff = 10,000 cpu)







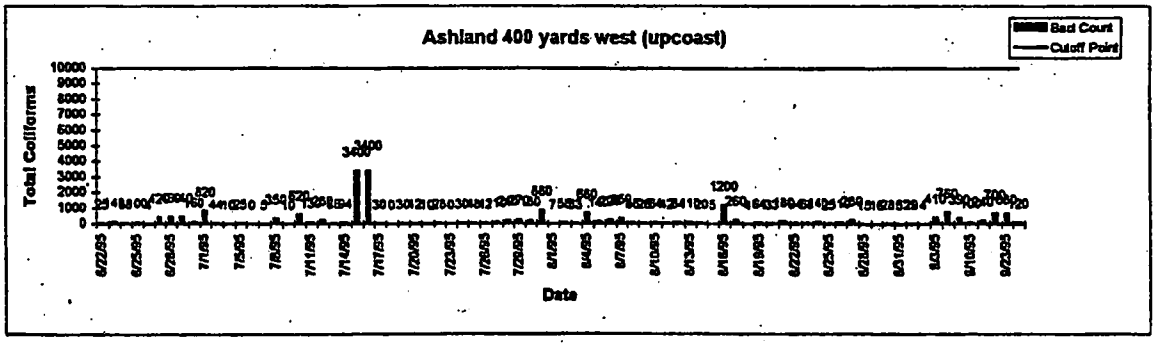
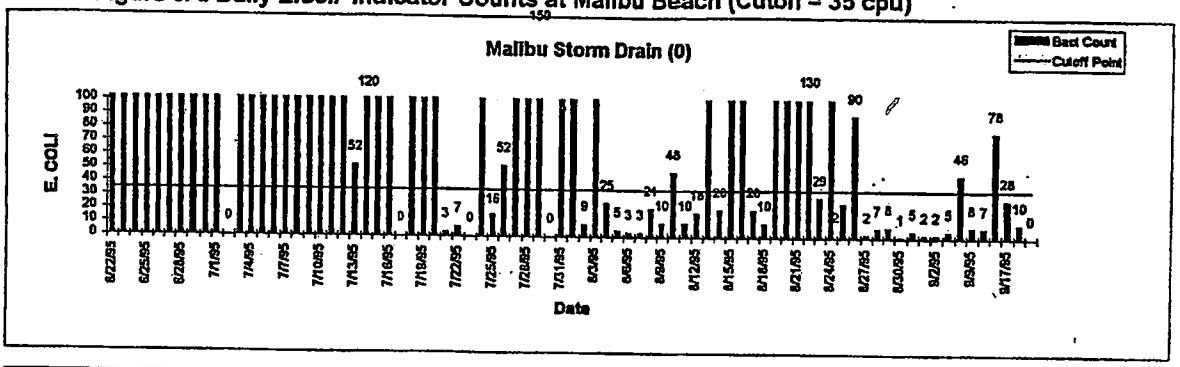
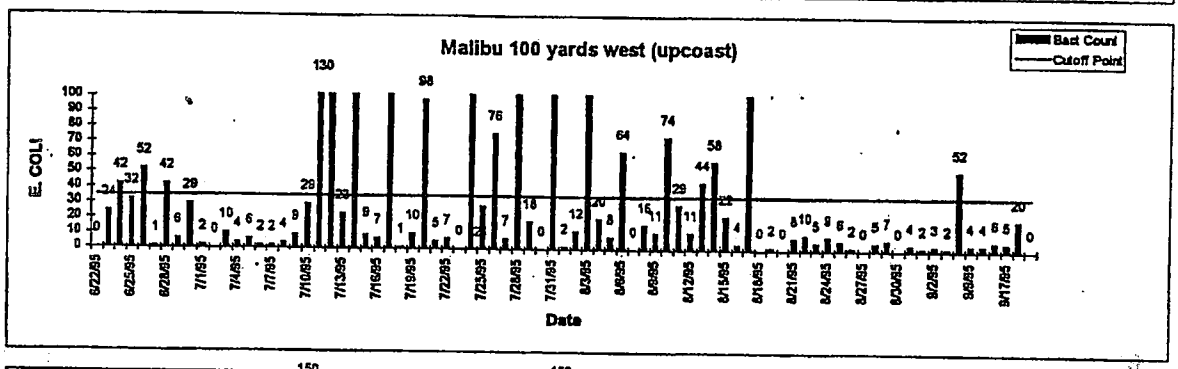
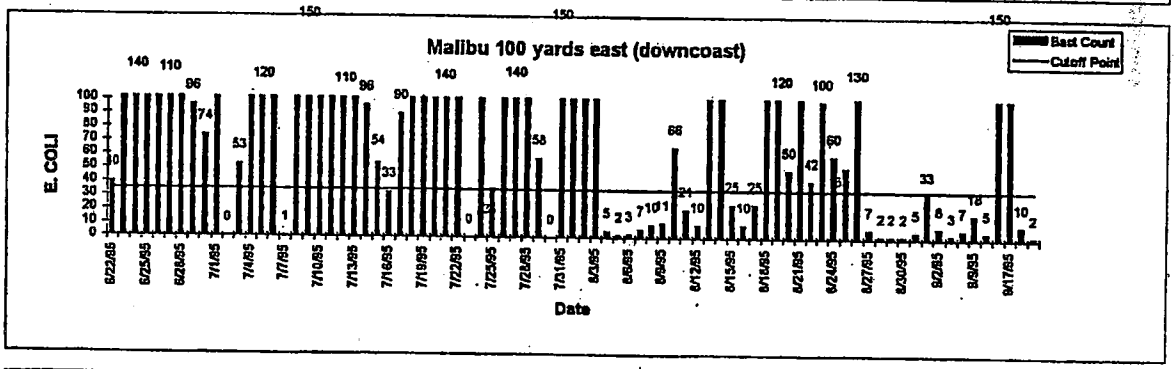


Figure 6A. Daily *E.coli* Indicator Counts at Malibu Beach (Cutoff = 35 cpu)







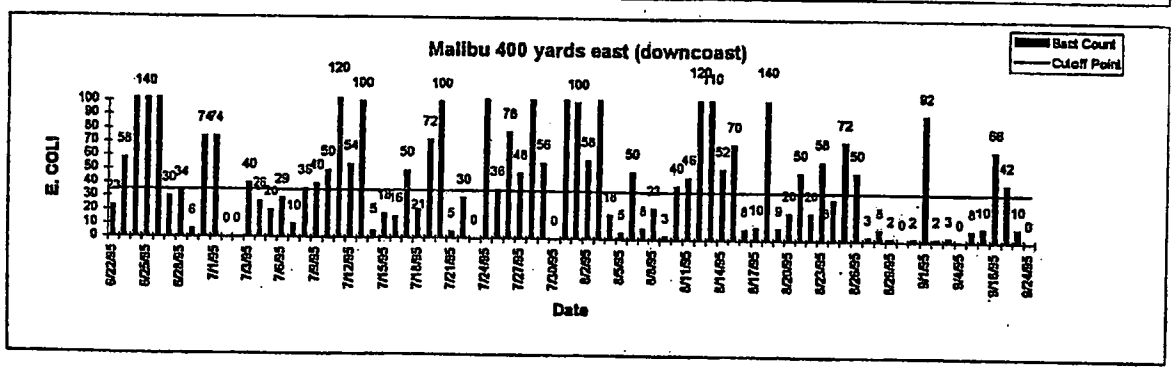
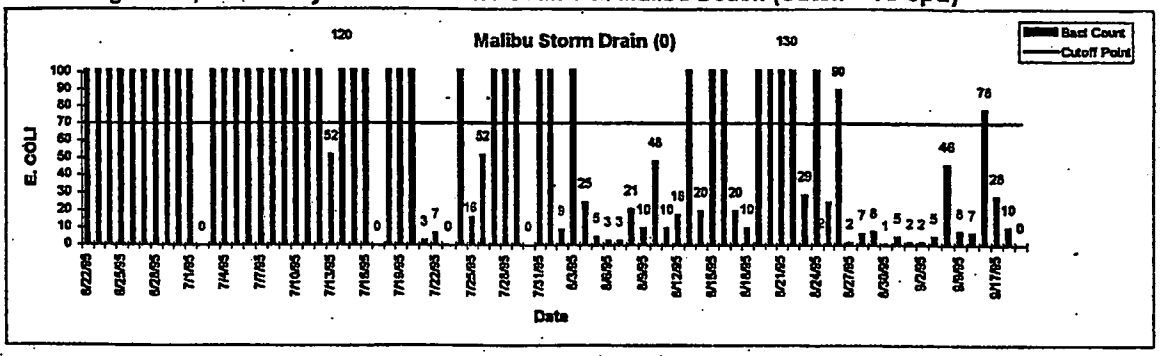
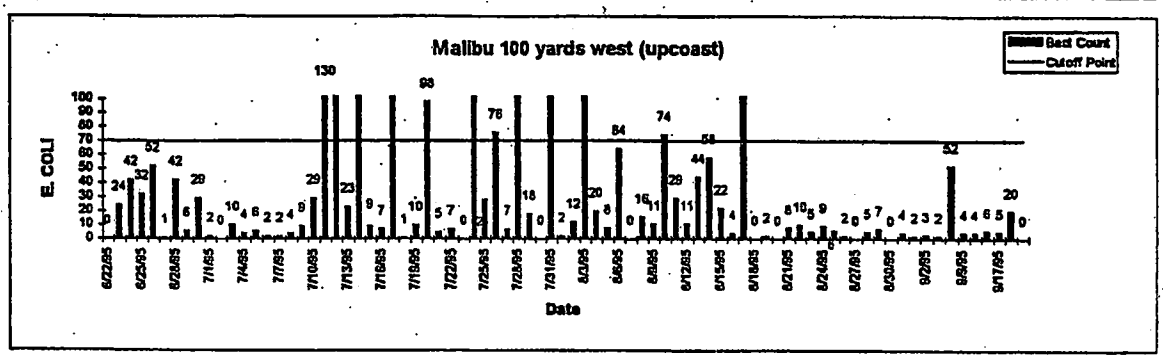
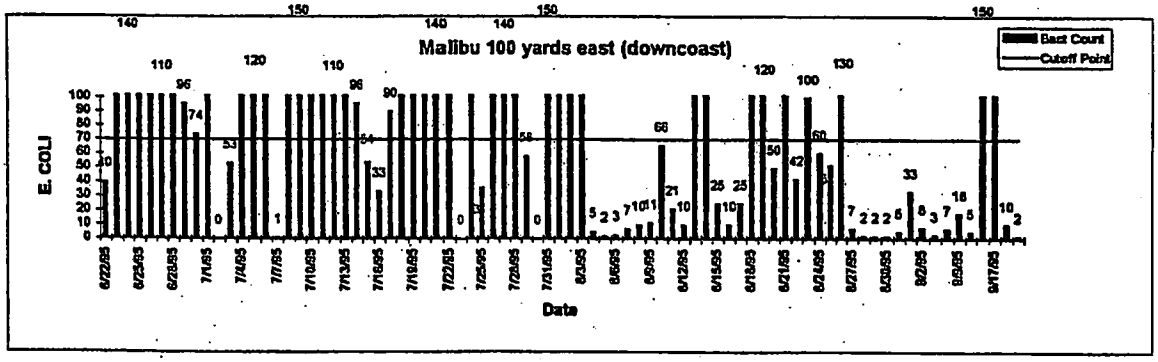


Figure 6A, cont. Daily *E.coli* Indicator Counts at Malibu Beach (Cutoff = 70 cpu)







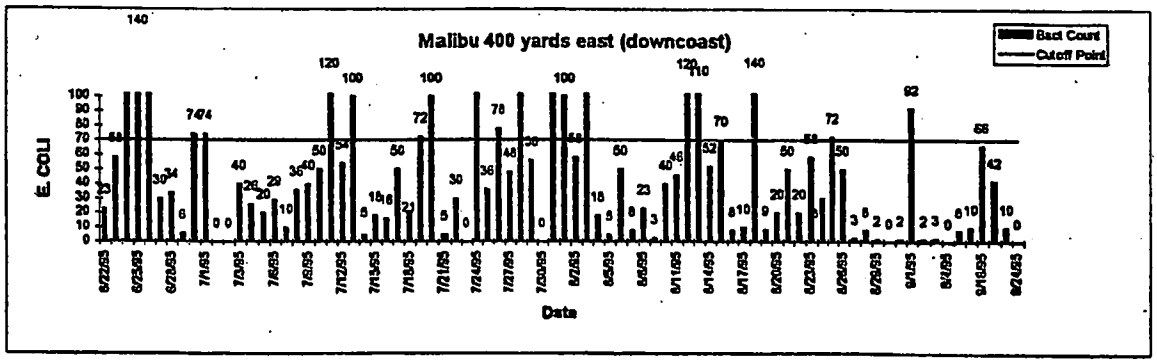
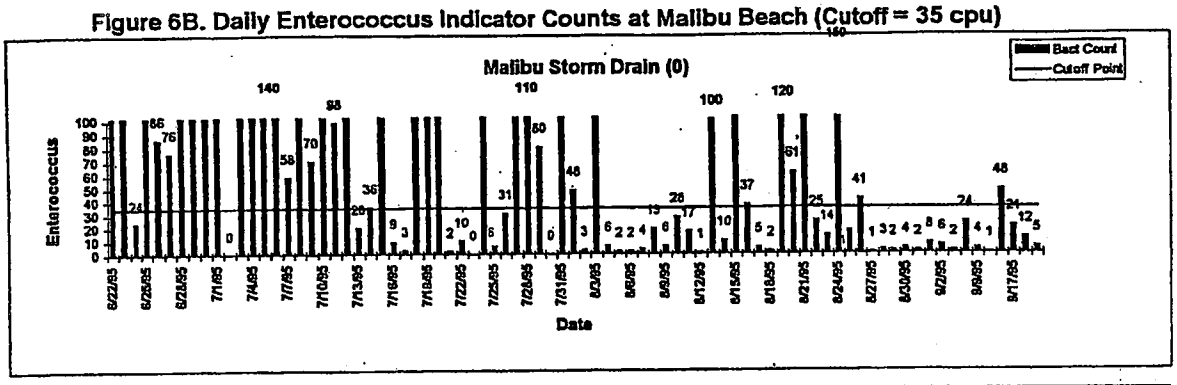
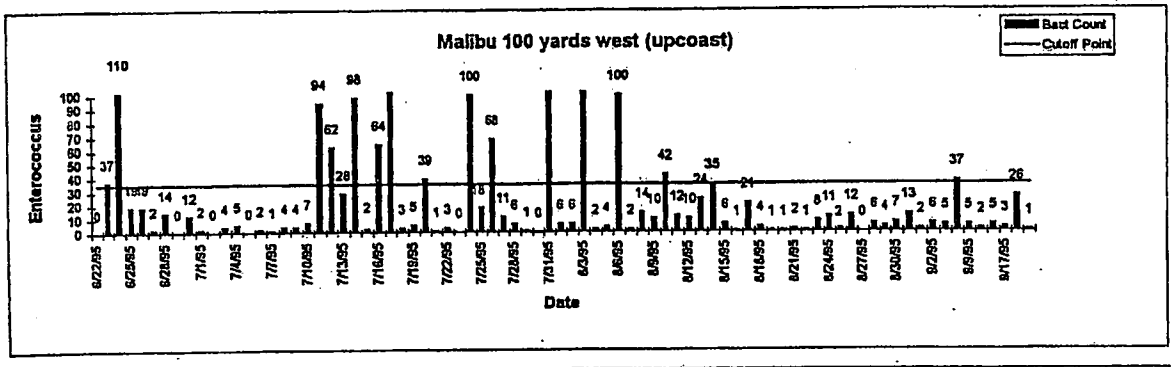
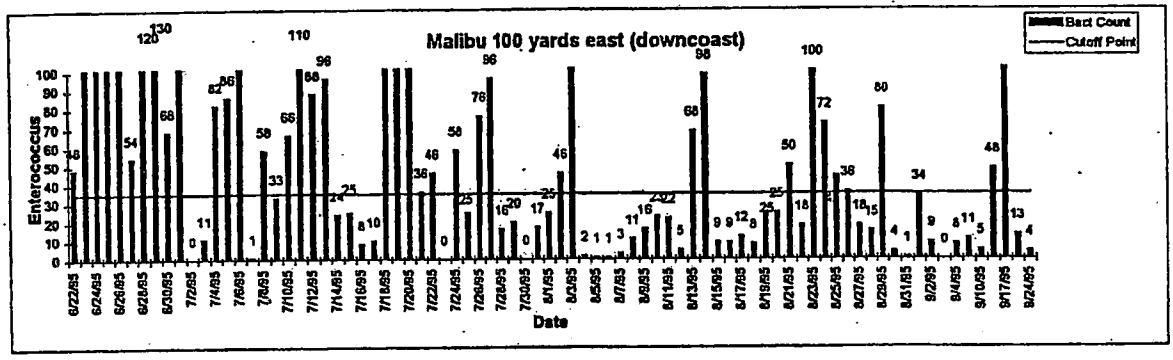


Figure 6B. Daily Enterococcus Indicator Counts at Malibu Beach (Cutoff = 35 cpu)







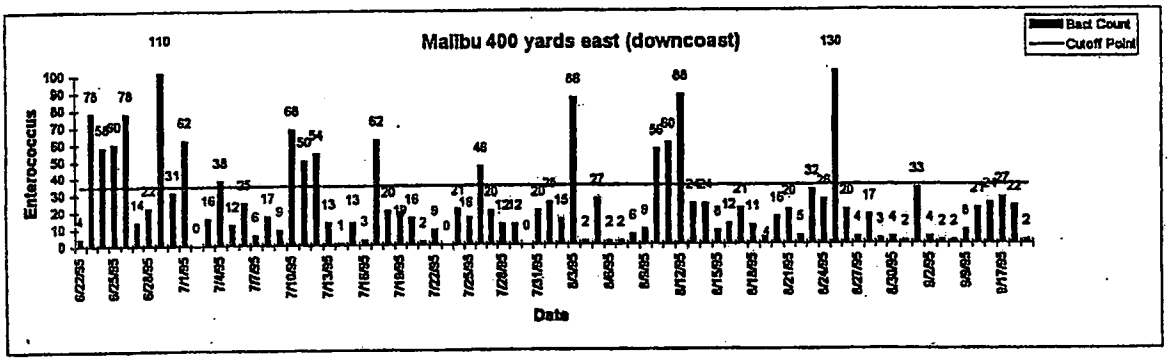
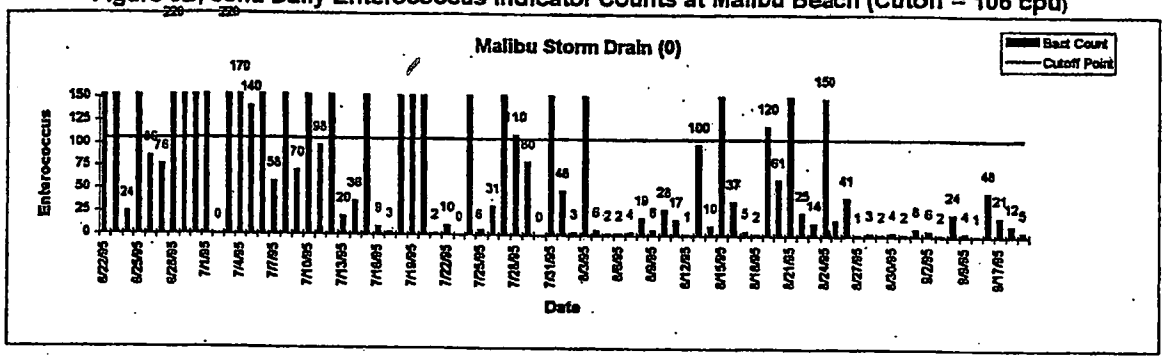
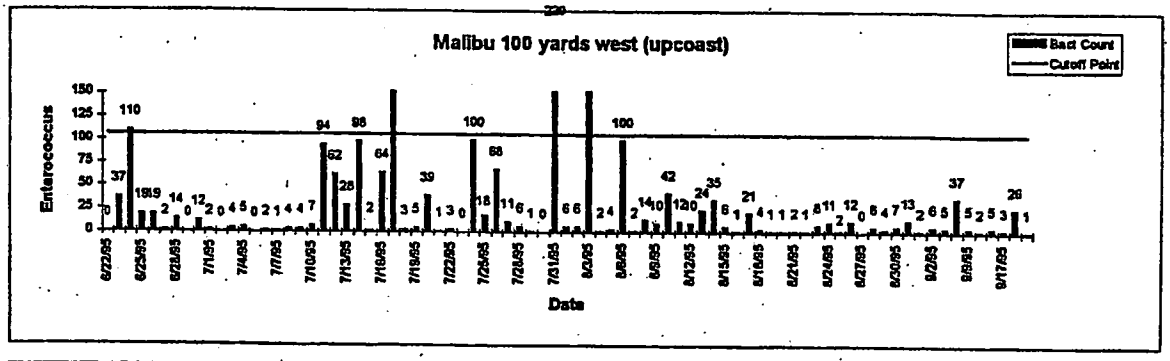
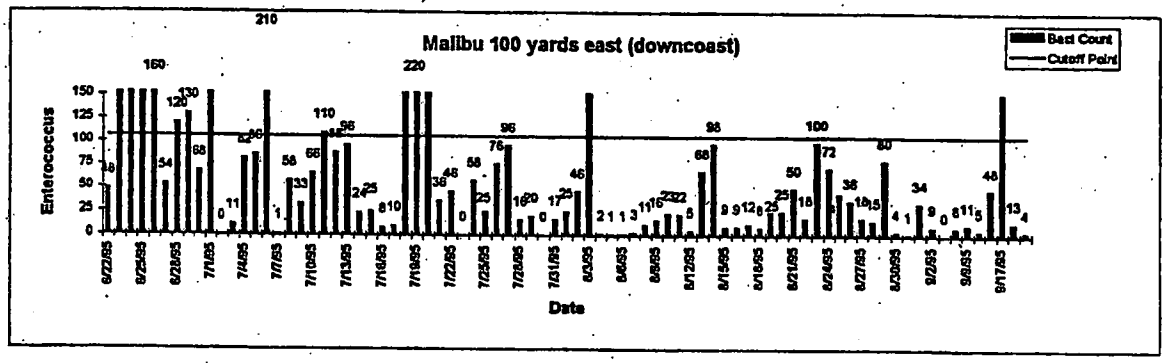


Figure 6B, cont. Daily Enterococcus Indicator Counts at Malibu Beach (Cutoff = 106 cpu)







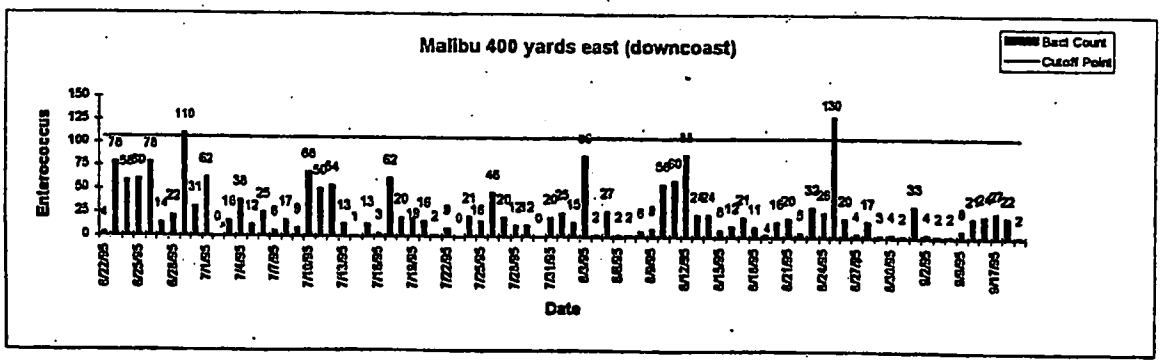
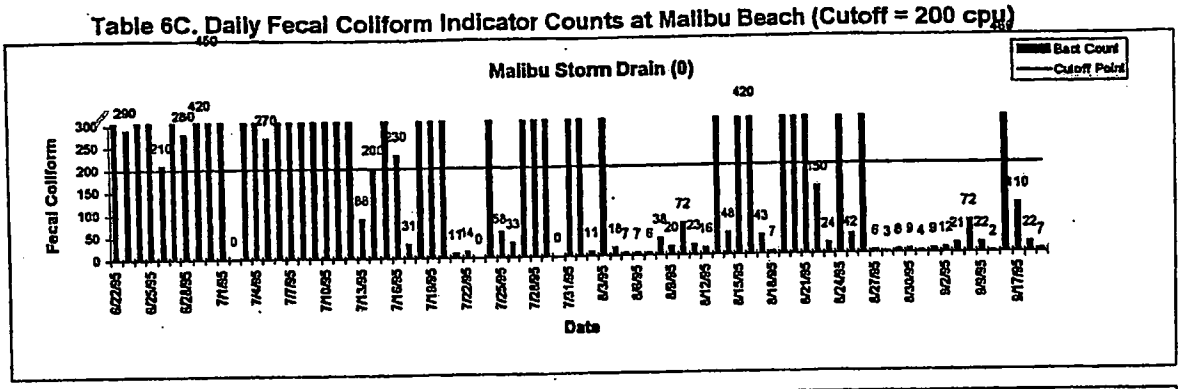
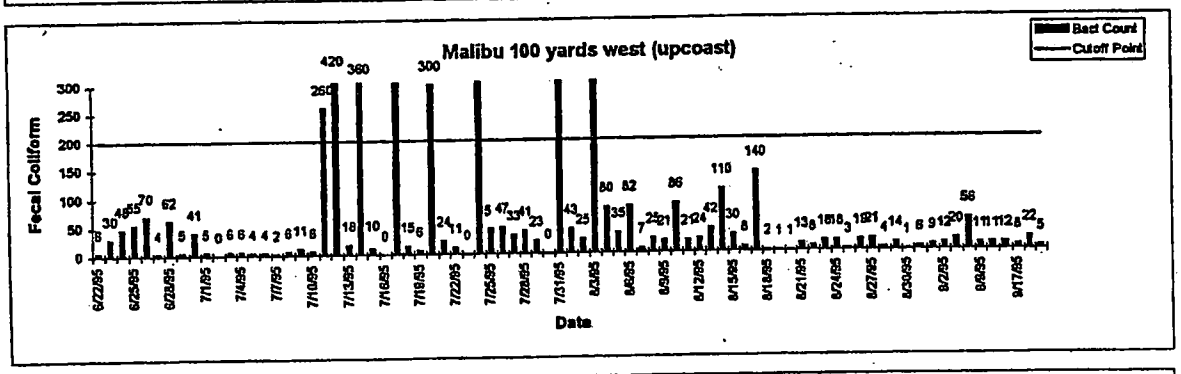
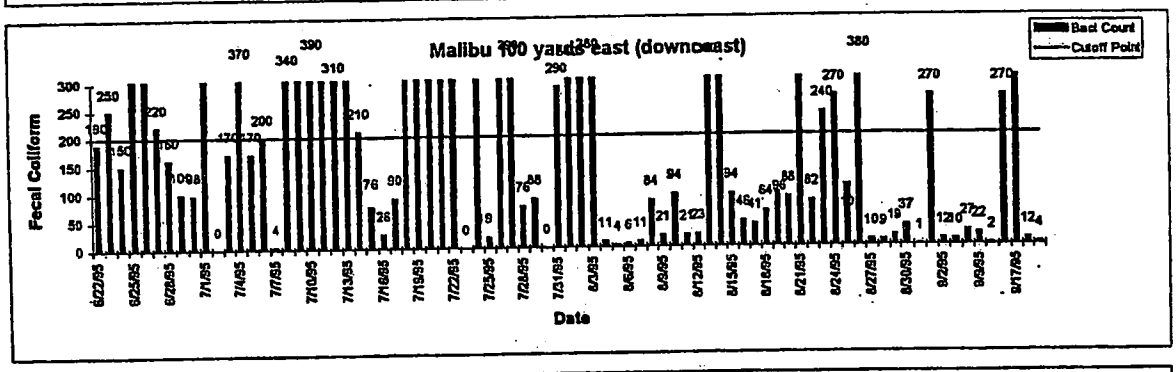


Table 6C. Daily Fecal Coliform Indicator Counts at Malibu Beach (Cutoff = 200 cpu)







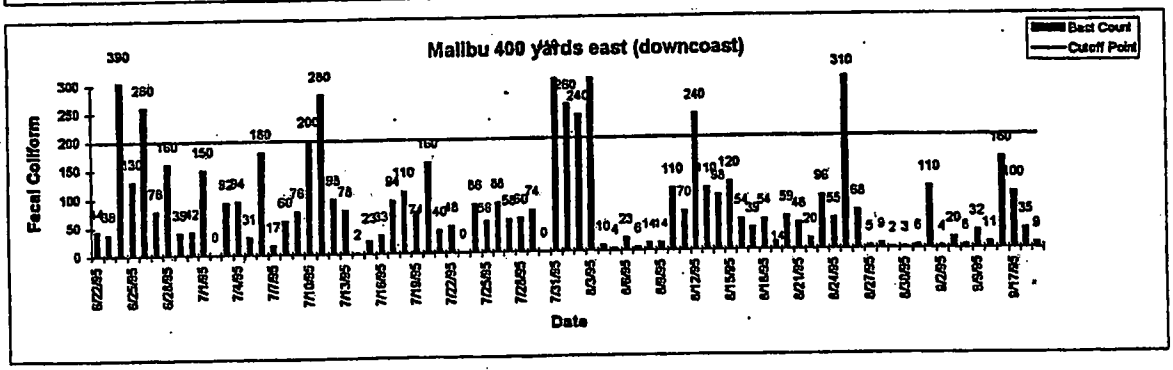
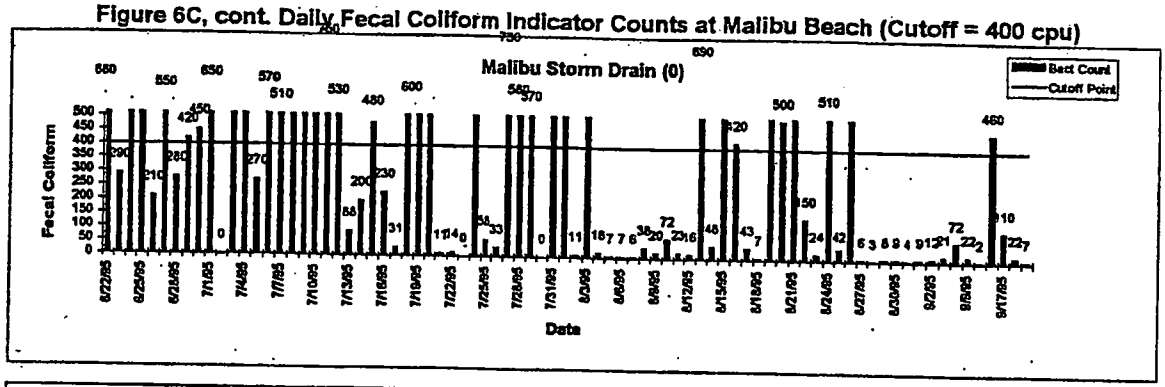
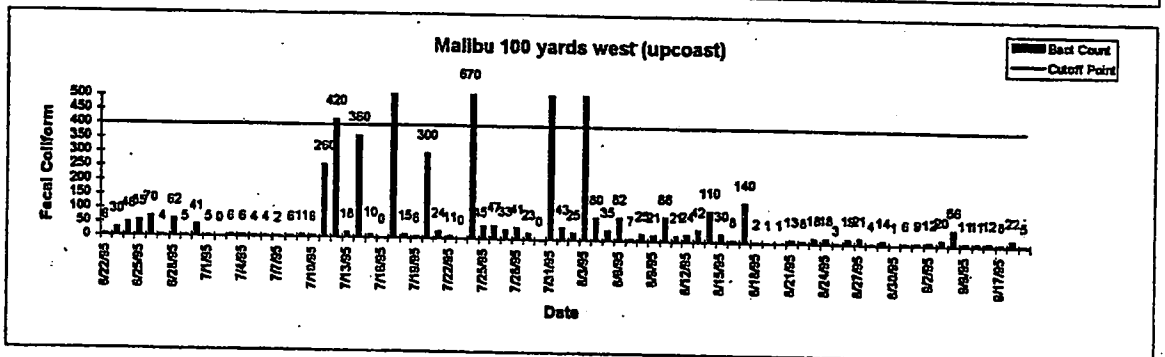
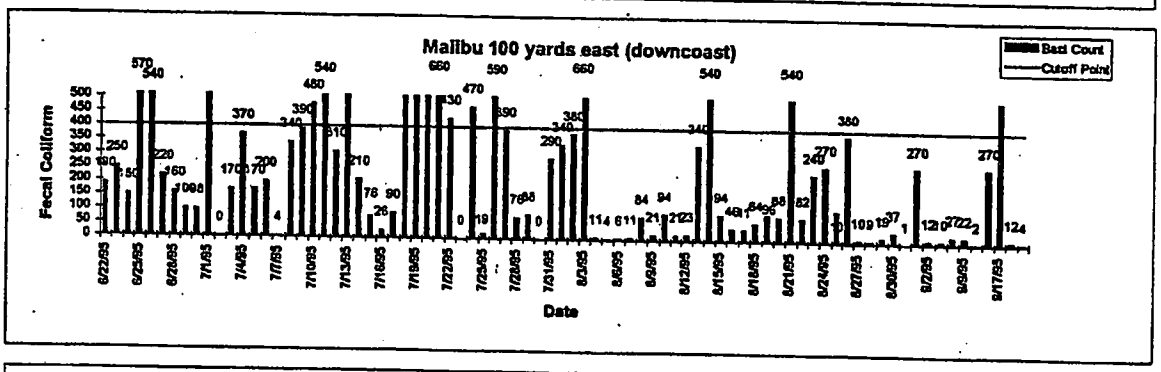


Figure 6C, cont. Daily Fecal Coliform Indicator Counts at Malibu Beach (Cutoff = 400 cpu)







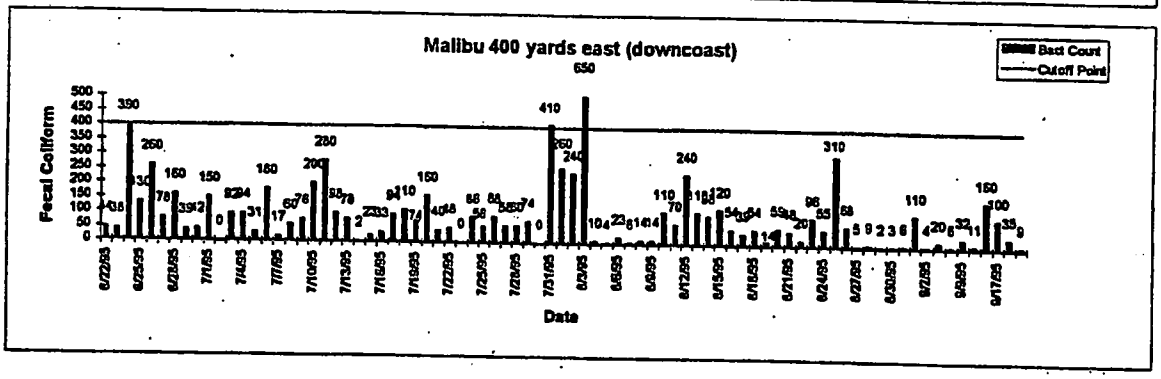
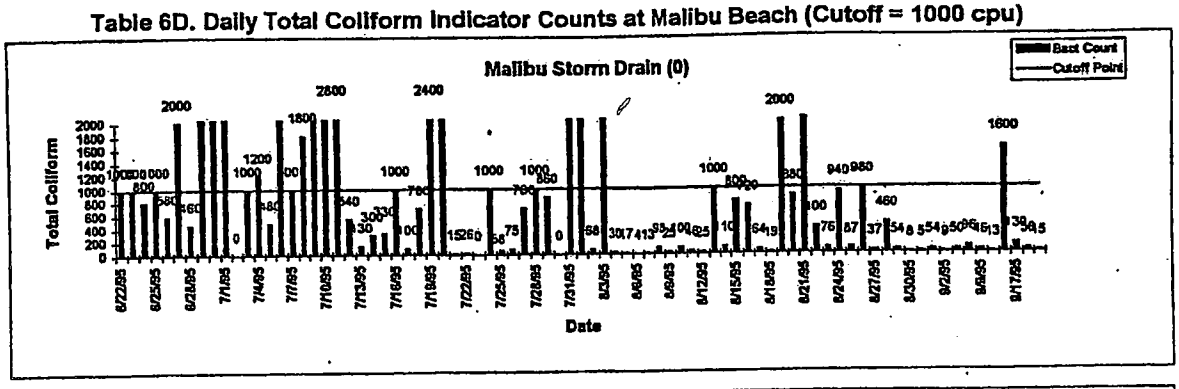
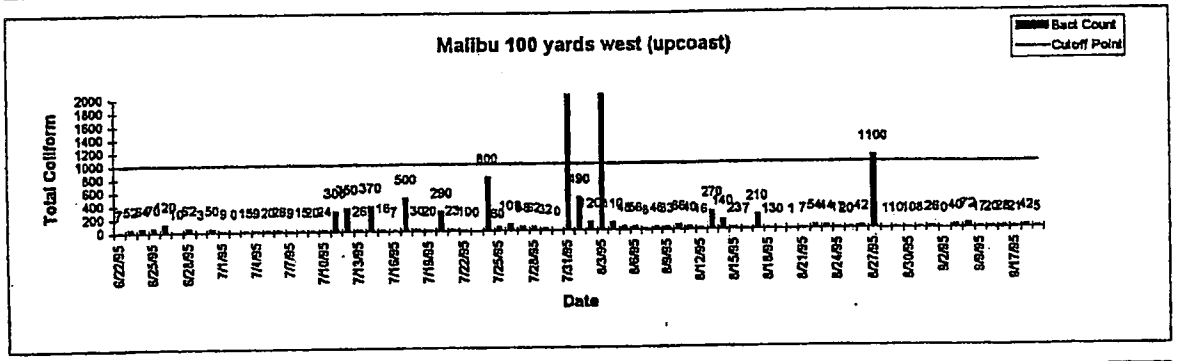
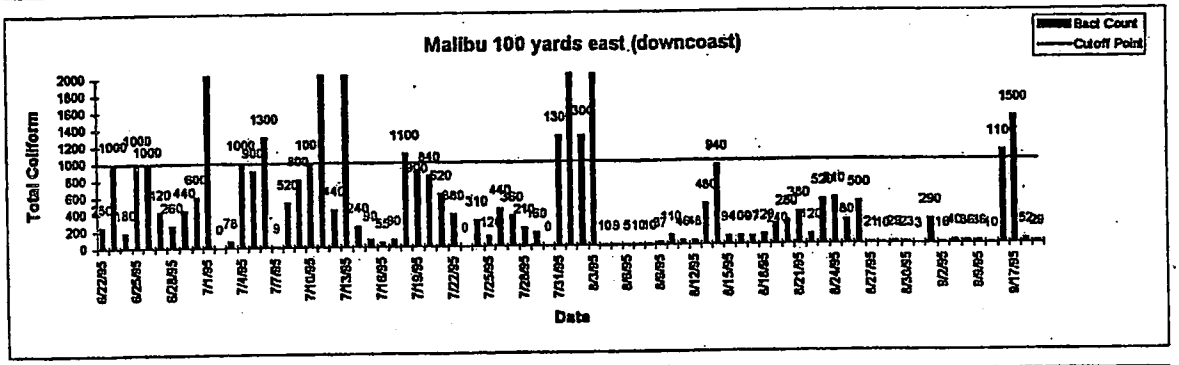


Table 6D. Daily Total Coliform Indicator Counts at Malibu Beach (Cutoff = 1000 cpu)







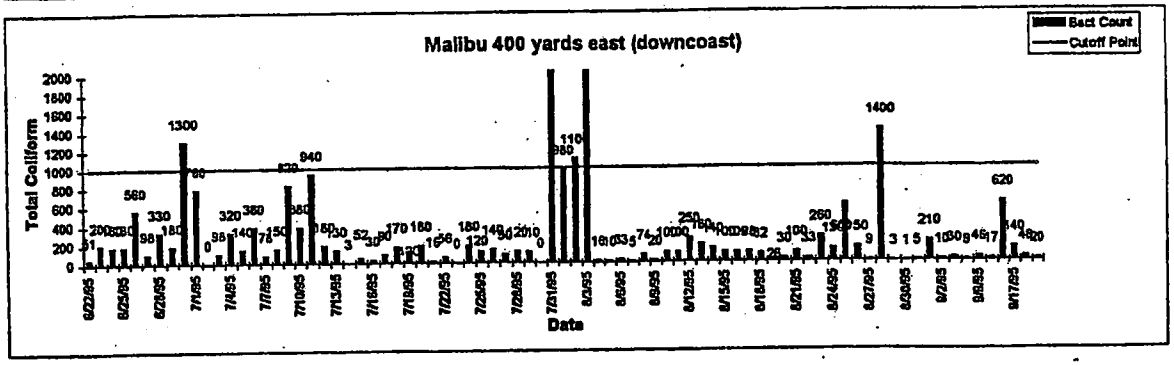
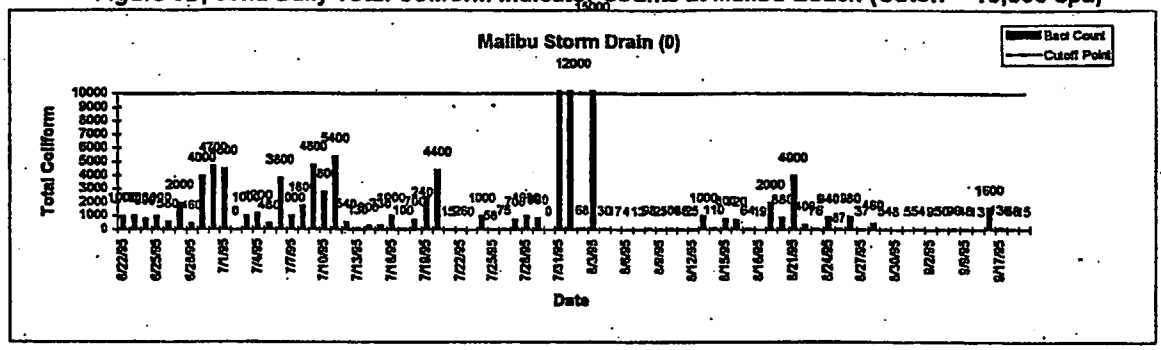
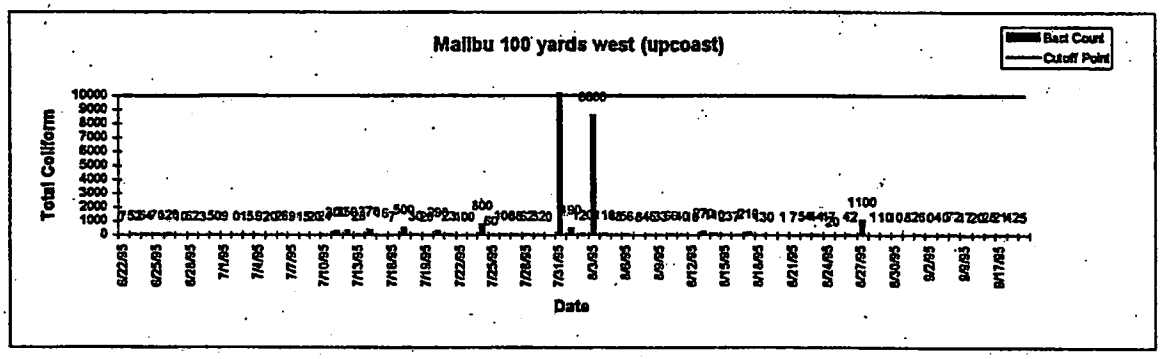
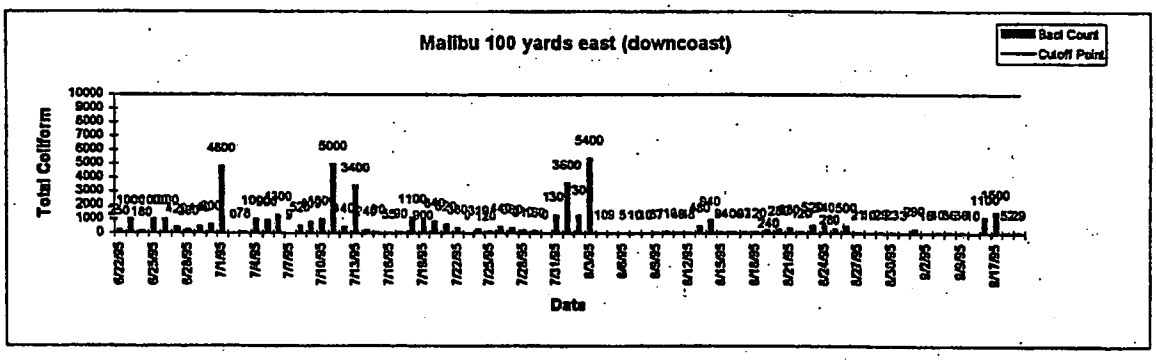


Figure 6D, cont. Daily Total Coliform Indicator Counts at Malibu Beach (Cutoff = 10,000 cpu)







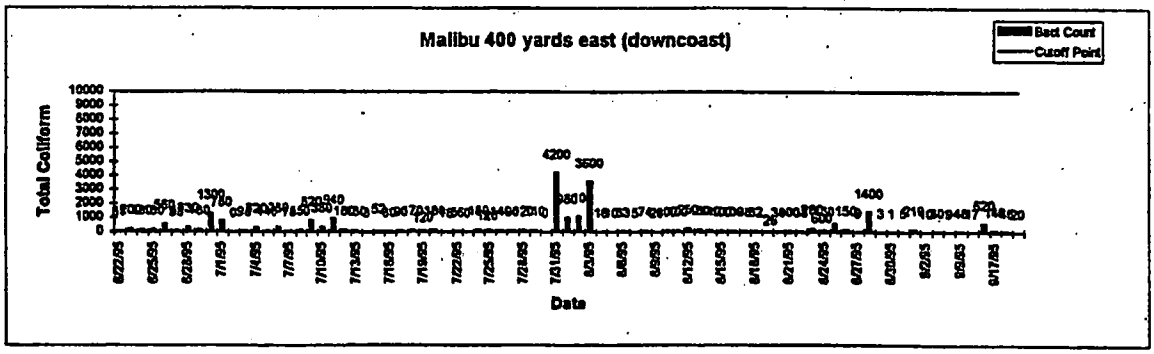
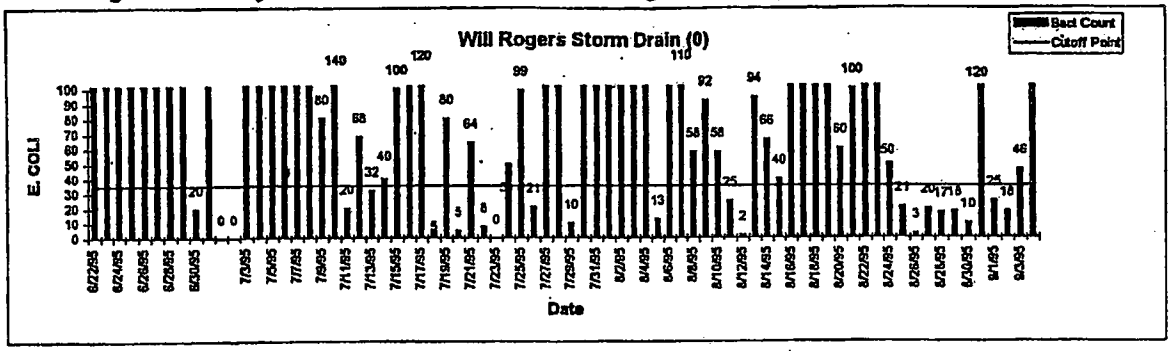
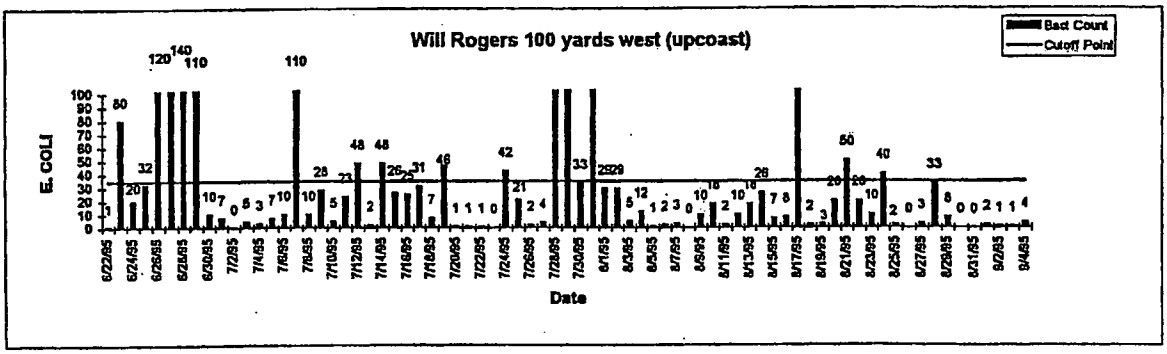
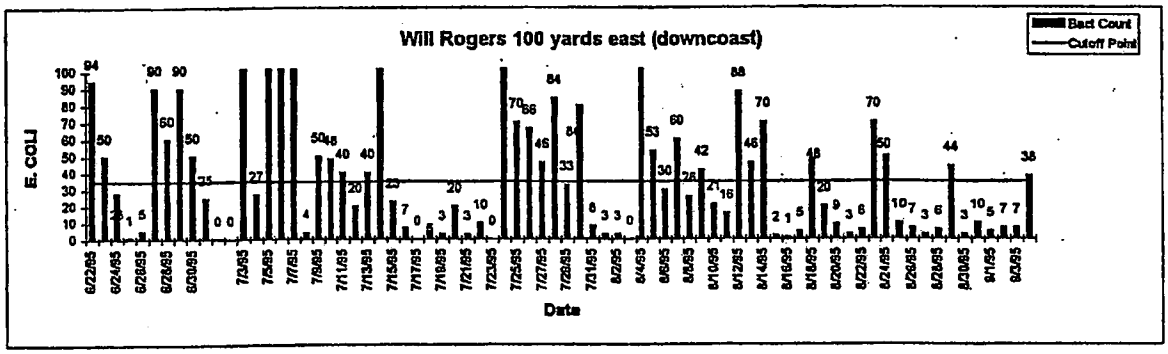


Figure 7A. Daily *E.coli* Indicator Counts at Will Rogers Beach (Cutoff = 35 cpu)







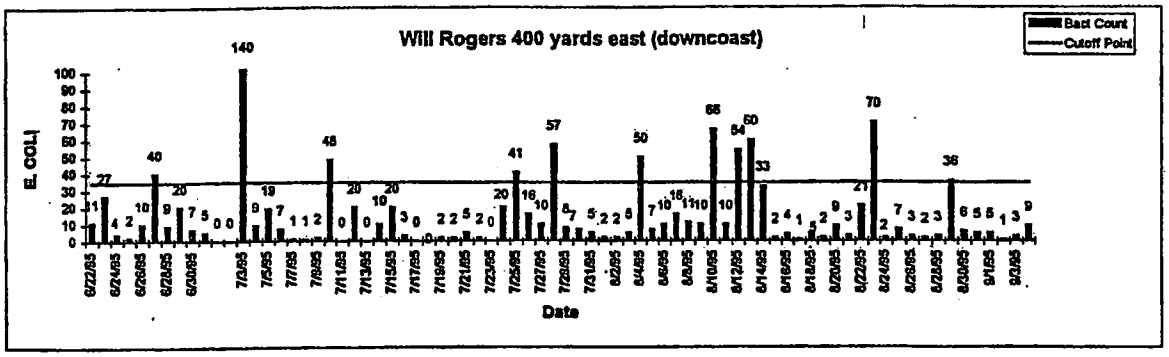
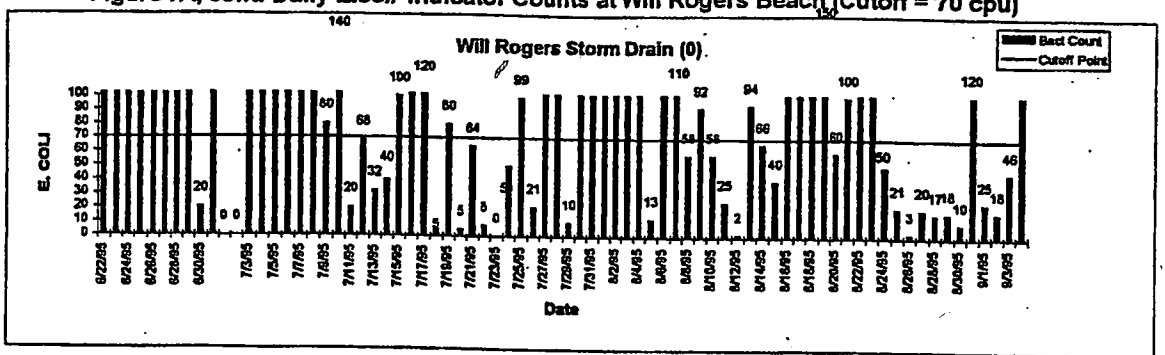
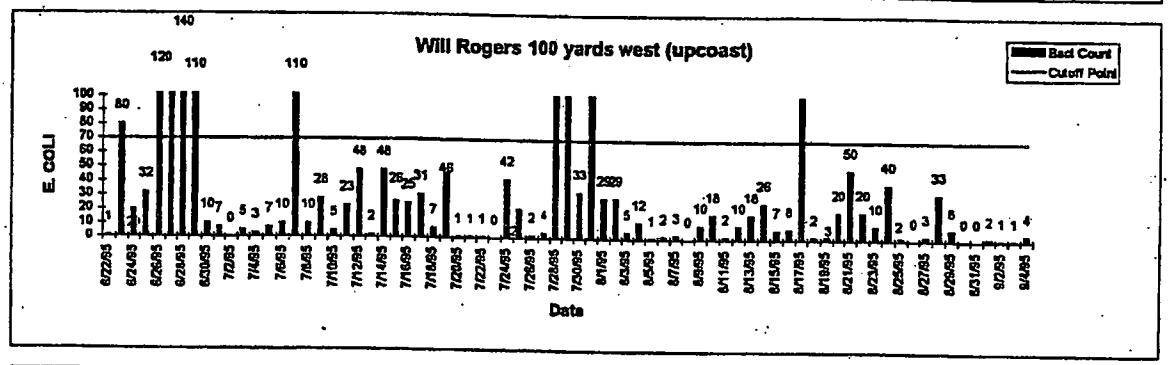
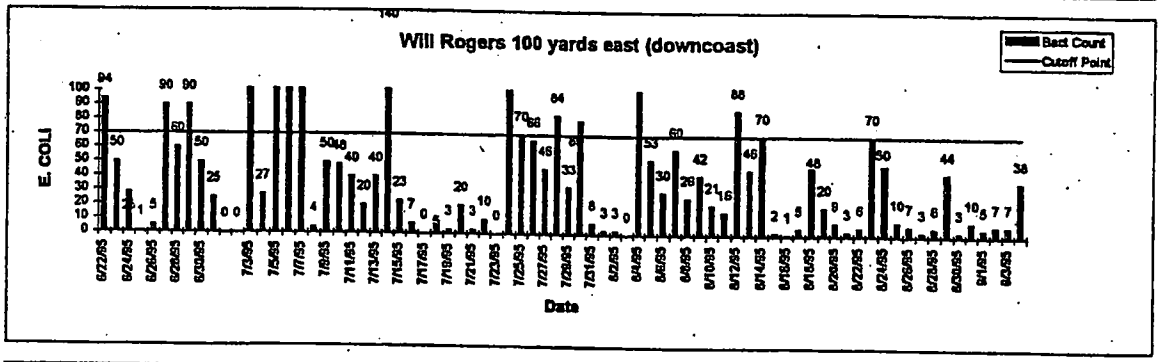


Figure 7A, cont. Daily *E.coli* Indicator Counts at Will Rogers Beach (Cutoff = 70 cpu)







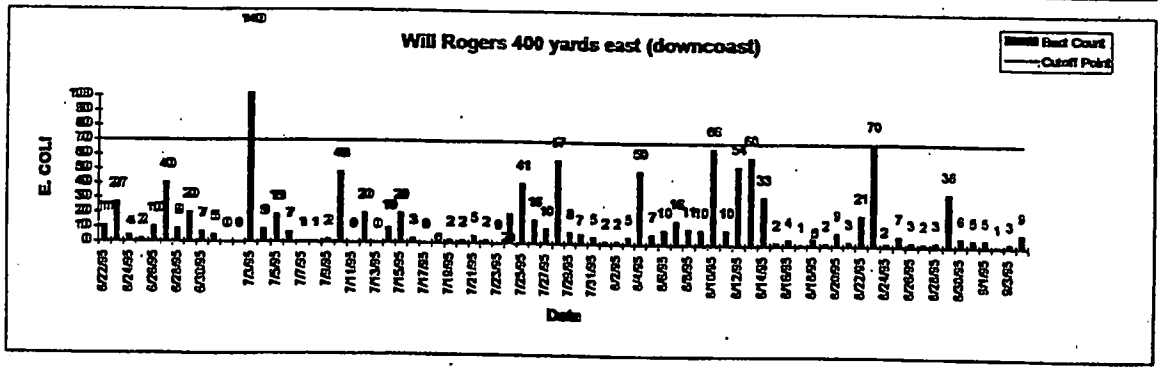
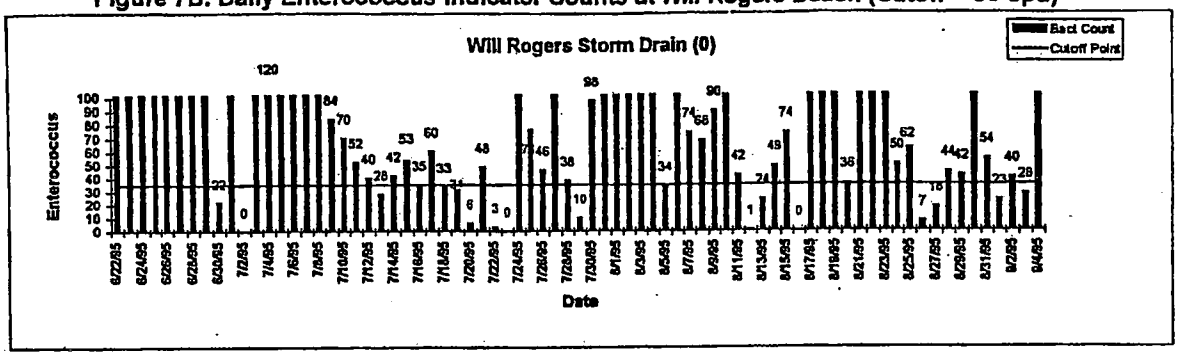
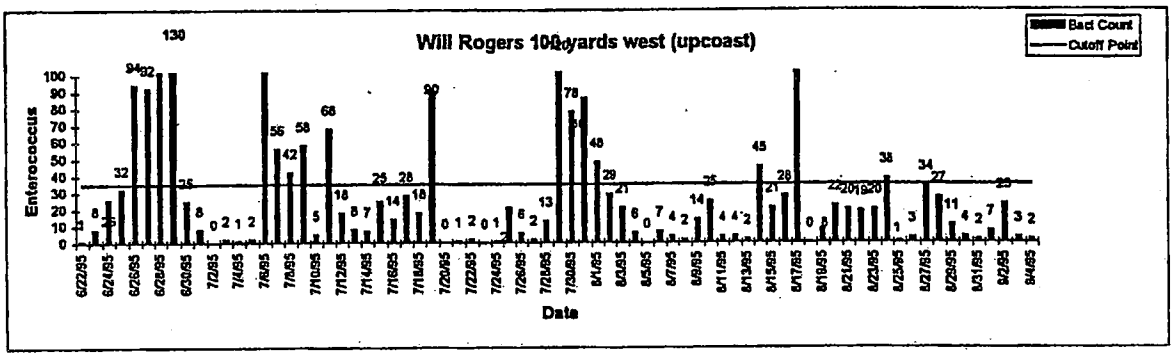
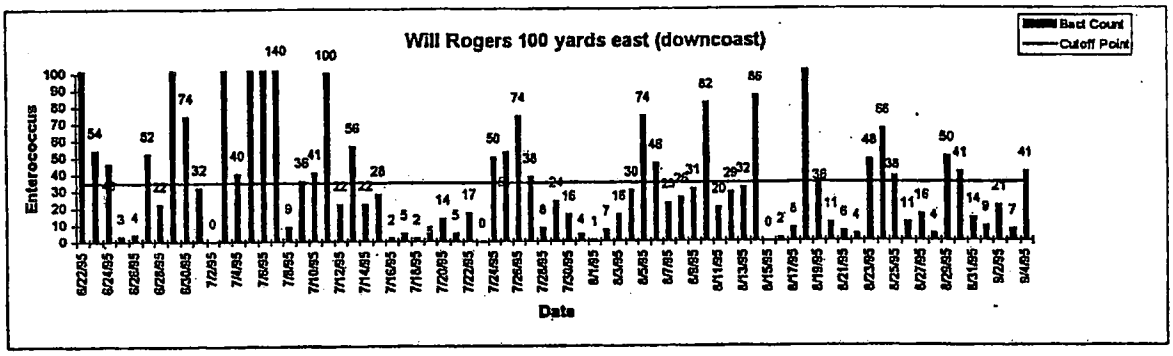


Figure 7B. Daily Enterococcus Indicator Counts at Will Rogers Beach (Cutoff = 35 cpu)







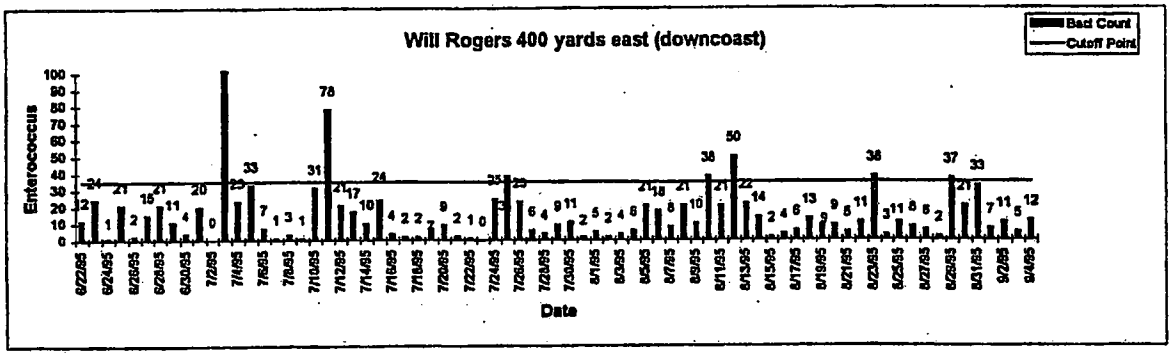
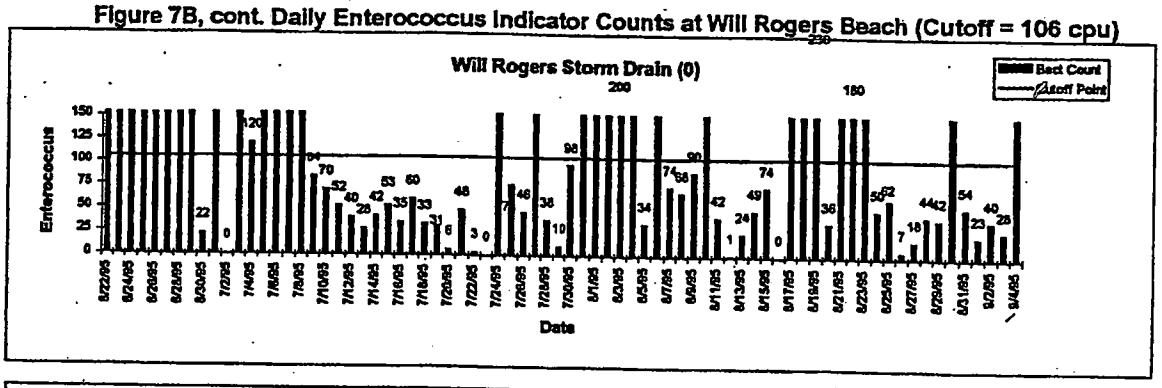
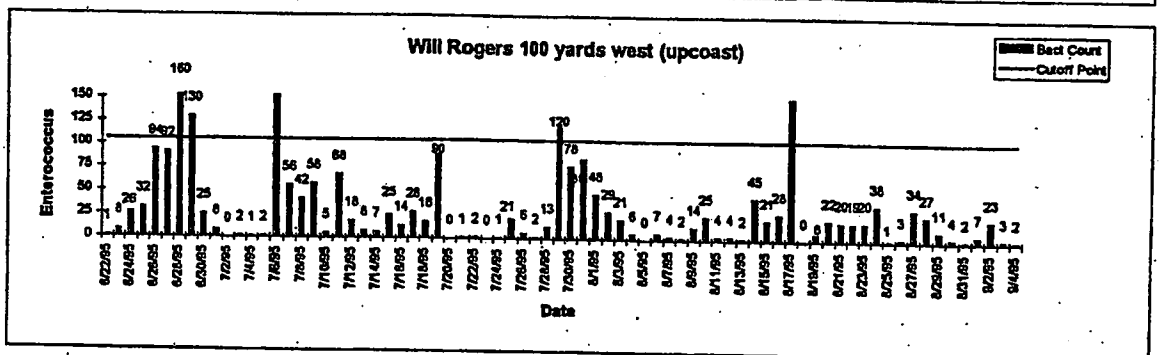
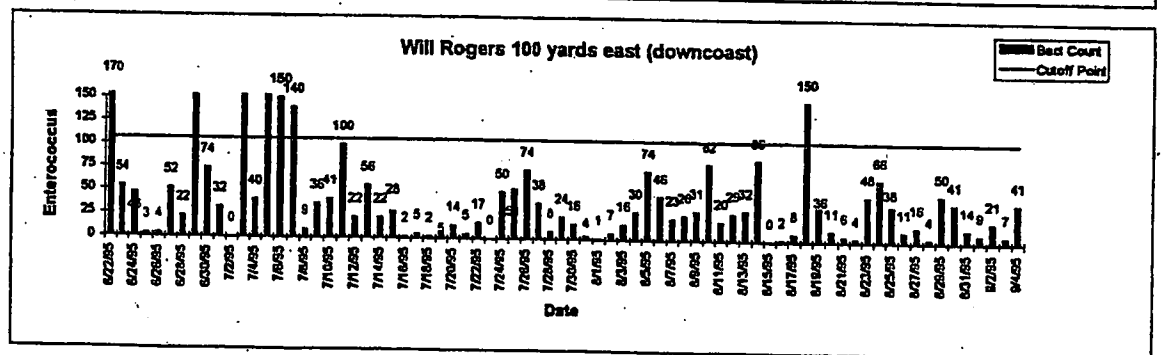


Figure 7B, cont. Daily Enterococcus Indicator Counts at Will Rogers Beach (Cutoff = 106 cpu)







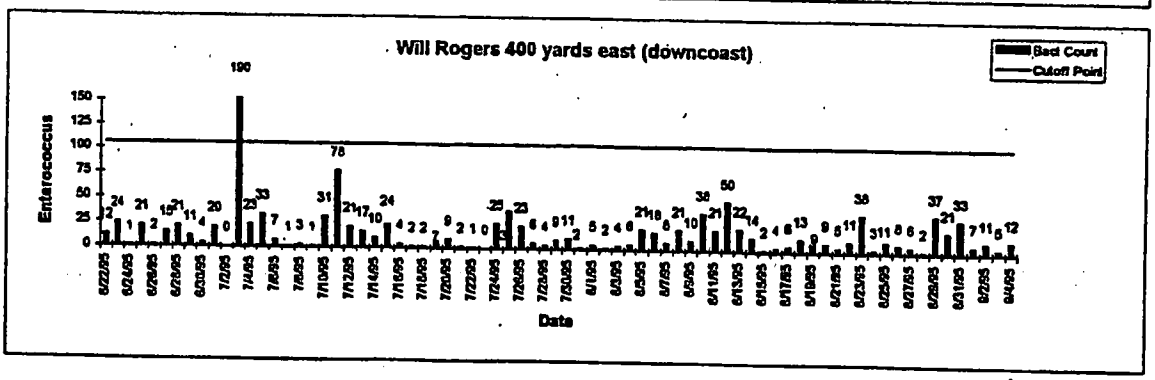
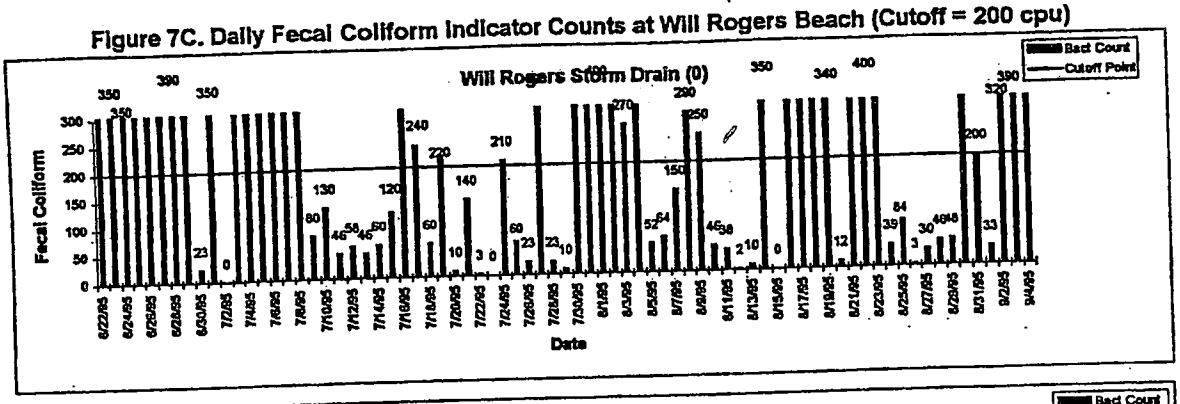
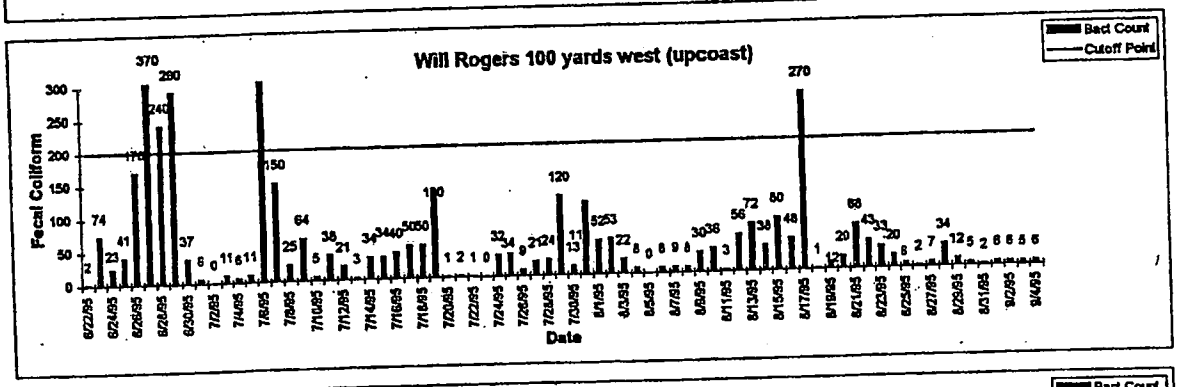
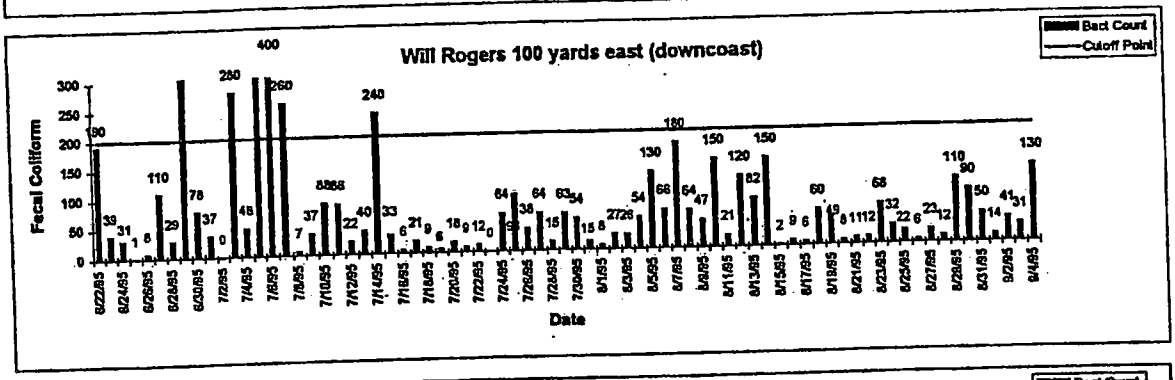


Figure 7C. Daily Fecal Coliform Indicator Counts at Will Rogers Beach (Cutoff = 200 cpu)







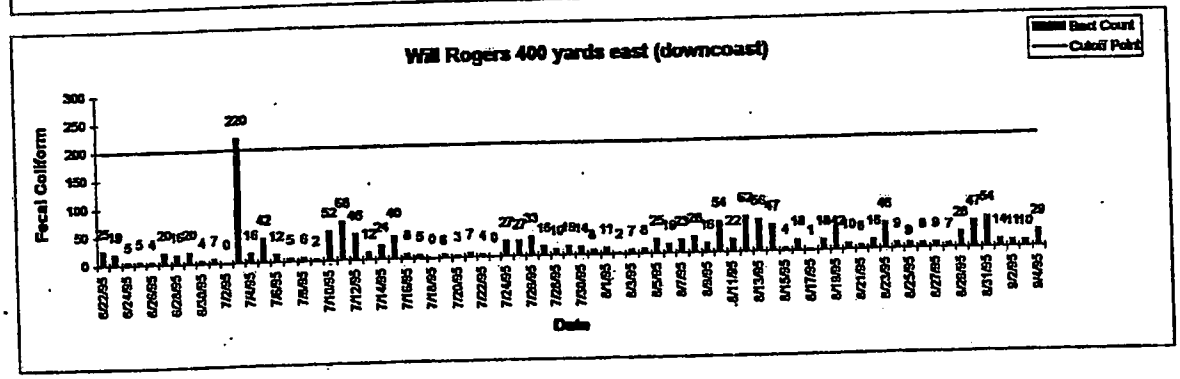
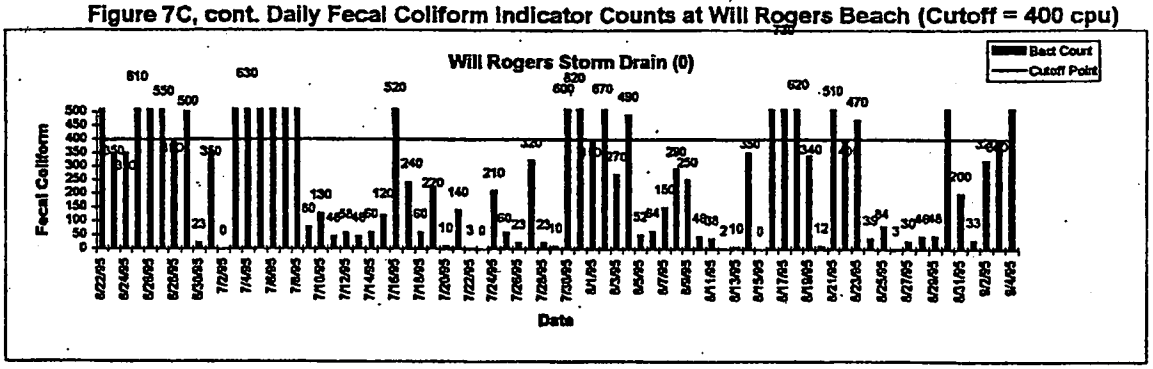
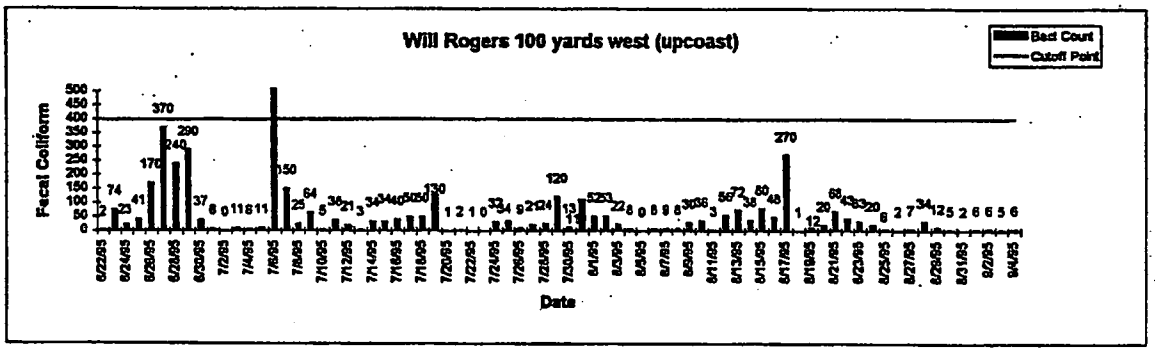
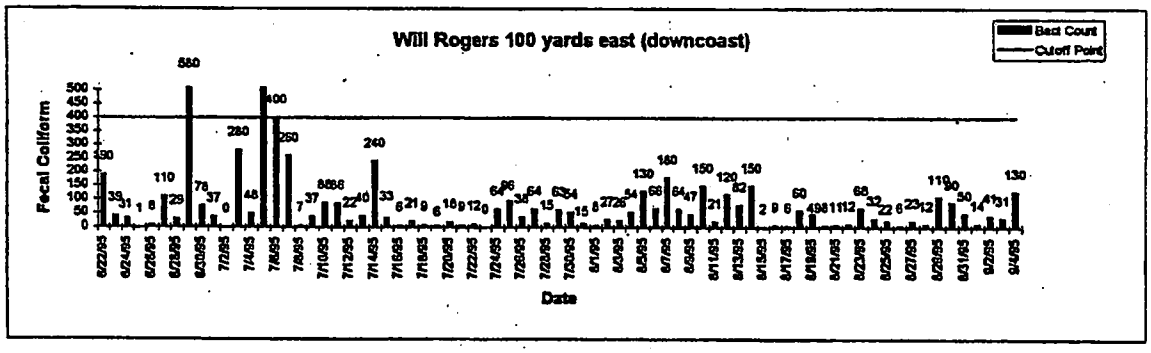


Figure 7C, cont. Daily Fecal Coliform Indicator Counts at Will Rogers Beach (Cutoff = 400 cpu)







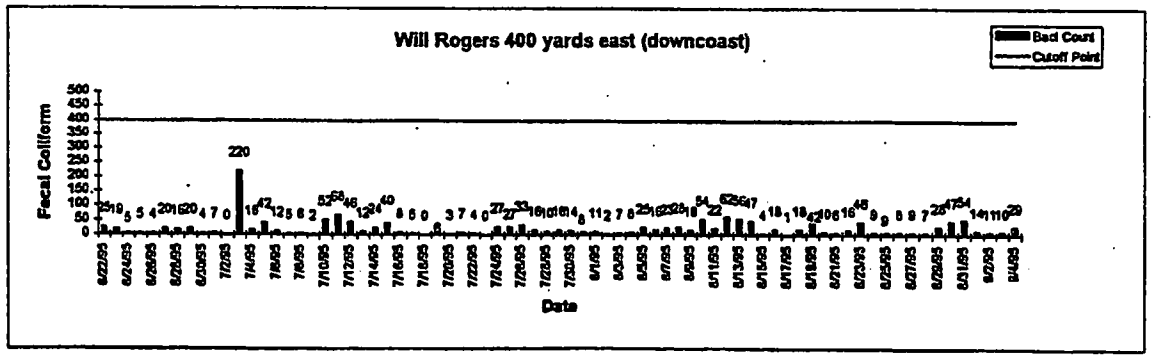
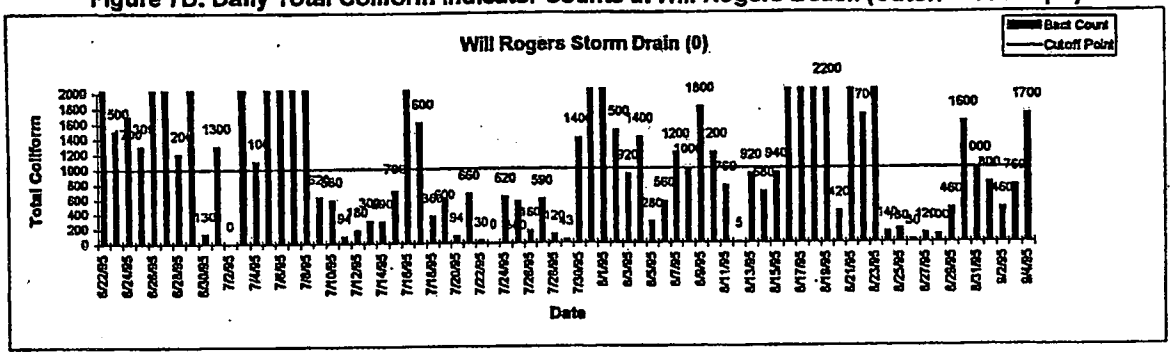
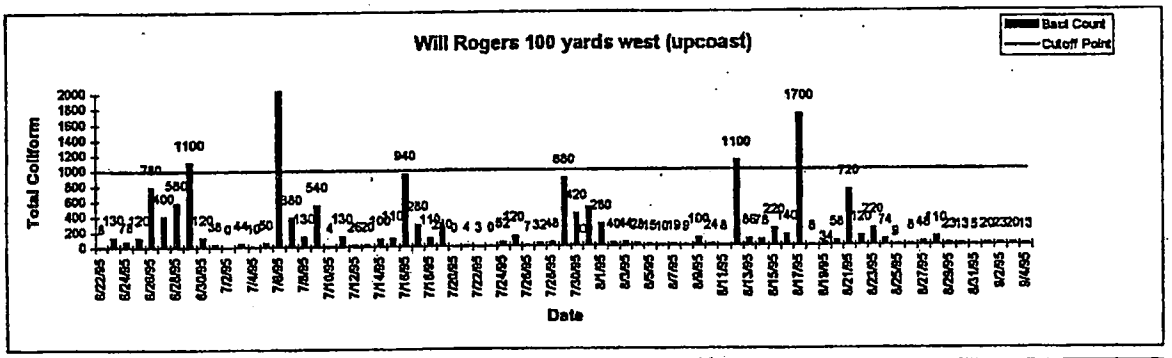
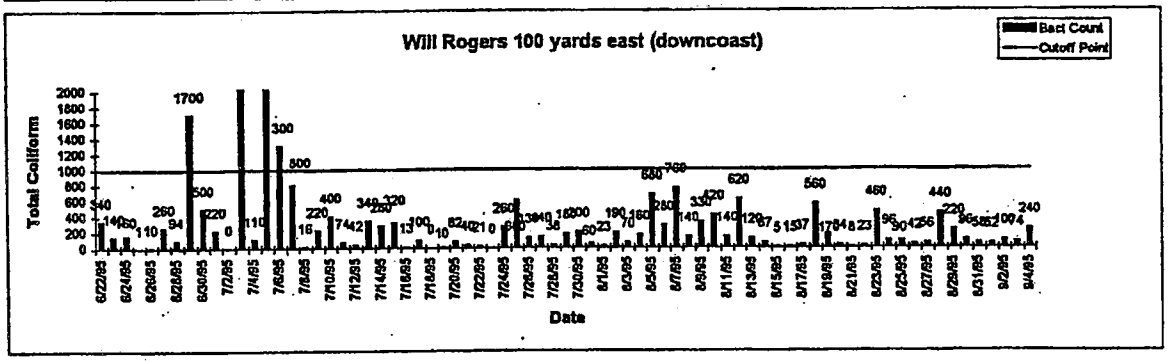


Figure 7D. Daily Total Coliform Indicator Counts at Will Rogers Beach (Cutoff = 1000 cpu)







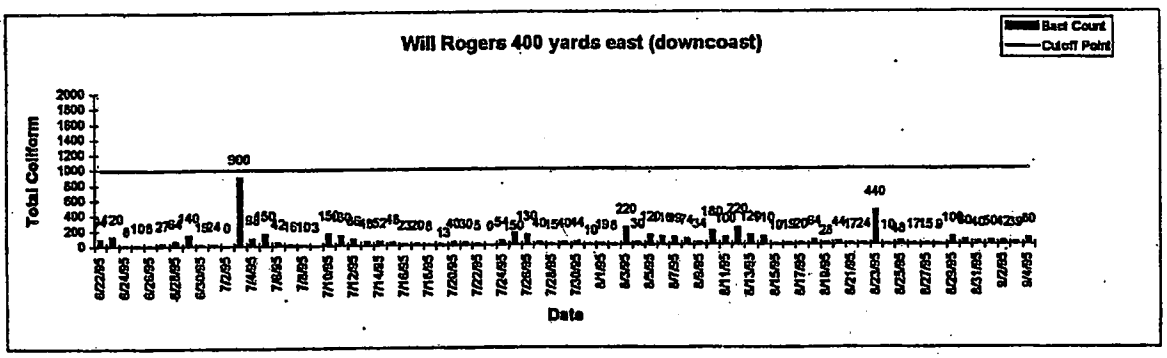
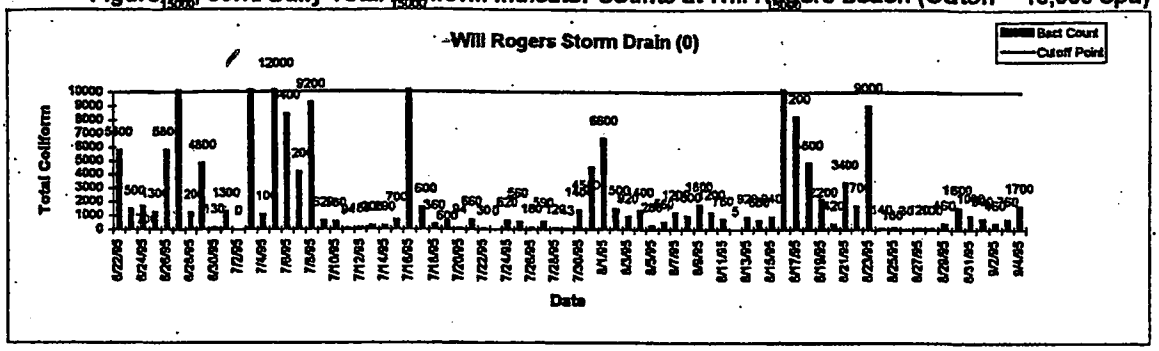
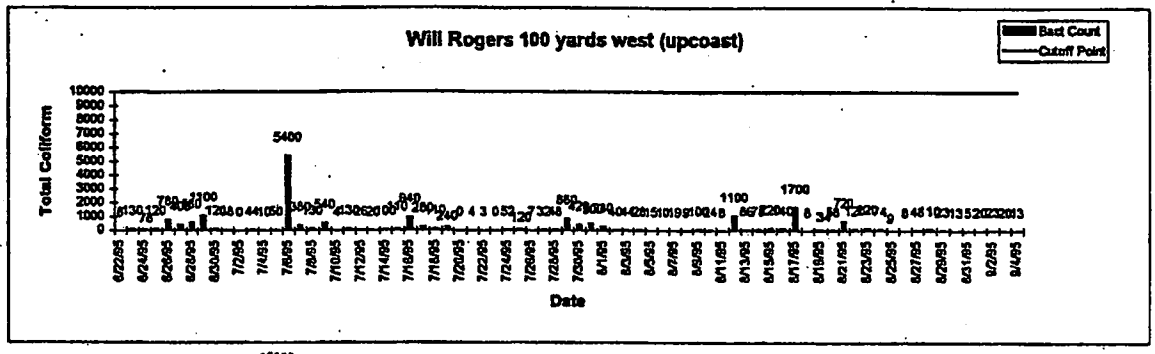
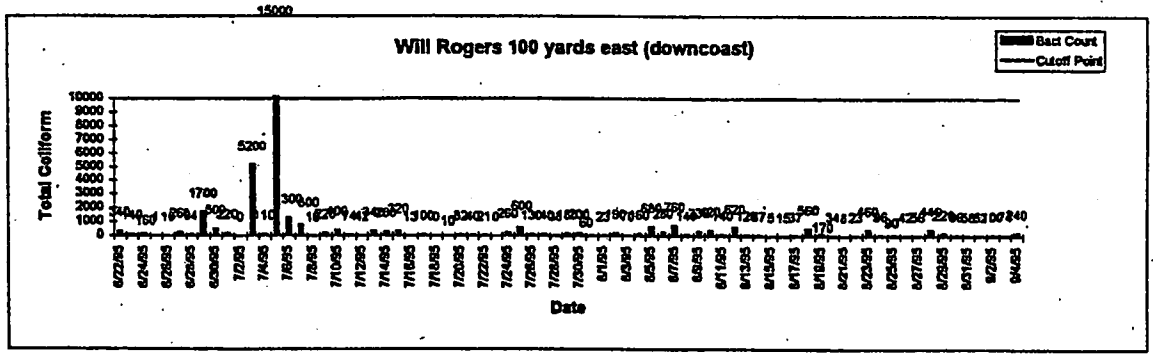


Figure 7D, cont. Daily Total Coliform Indicator Counts at Will Rogers Beach (Cutoff = 10,000 cpu)







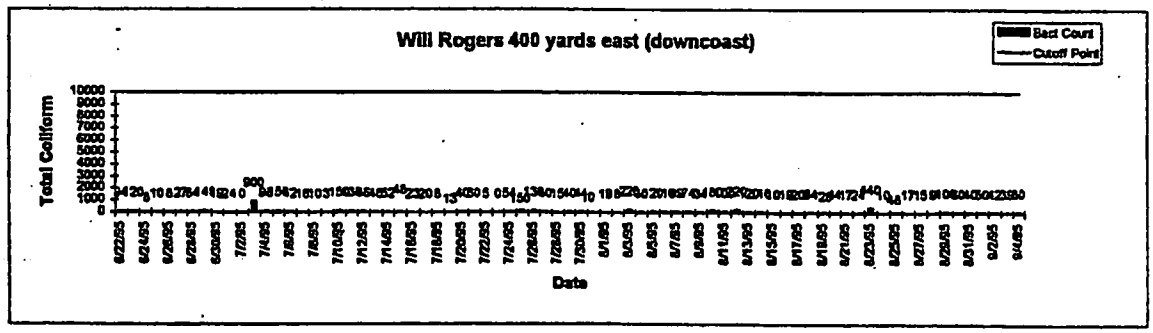


Table 17. Risks Among Swimmers at the Drain vs. Risks Among Controls

ALL BEACHES

SYMPTOMS	Total Exposed = 827 0 yds		Total Unexposed = 3030 400+ yds				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever*	59	0.071	138	0.046	1.57	1.17	2.10
Chills*	31	0.037	72	0.024	1.58	1.04	2.39
Eye discharge	19	0.023	61	0.020	1.14	0.69	1.90
Earache	38	0.046	116	0.038	1.20	0.84	1.72
Ear discharge*	13	0.016	21	0.007	2.27	1.14	4.51
Skin rash	4	0.005	23	0.008	0.64	0.22	1.84
Infected cut	6	0.007	17	0.006	1.29	0.51	3.27
Nausea	40	0.048	133	0.044	1.10	0.78	1.56
Vomiting*	25	0.030	57	0.019	1.61	1.01	2.56
Diarrhea	53	0.064	204	0.067	0.95	0.71	1.27
Diarrhea w/ blood	2	0.002	7	0.002	1.05	0.22	5.03
Stomach pain	61	0.074	206	0.068	1.08	0.82	1.43
Coughing	55	0.067	209	0.069	0.96	0.72	1.28
Phlegm*	39	0.047	90	0.030	1.59	1.10	2.29
Nasal congestion	74	0.089	273	0.090	0.99	0.78	1.27
Sore throat	59	0.071	190	0.063	1.14	0.86	1.51
HCGI 1	35	0.042	102	0.034	1.26	0.86	1.83
HCGI 2*	15	0.018	26	0.009	2.11	1.12	3.97
SRD*	63	0.076	139	0.046	1.66	1.25	2.21

*** statistically significant at p < 0.05**

3-395

Table 18. Risks Among Swimmers at 1-50 Yards Upcoast vs. Risks Among Controls

ALL BEACHES

SYMPTOMS	Total Exposed = 2592 1-50 yds		Total Unexposed = 3030 400+ yds				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	114	0.045	138	0.046	0.99	0.78	1.26
Chills	63	0.025	72	0.024	1.05	0.75	1.46
Eye discharge	50	0.020	61	0.020	0.98	0.68	1.42
Earache	81	0.032	116	0.038	0.84	0.63	1.11
Ear discharge	19	0.008	21	0.007	1.08	0.58	2.01
Skin rash*	35	0.014	23	0.008	1.82	1.08	3.08
Infected cut	23	0.009	17	0.006	1.62	0.87	3.03
Nausea	82	0.032	133	0.044	0.74	0.56	0.97
Vomiting	36	0.014	57	0.019	0.76	0.50	1.14
Diarrhea	120	0.047	204	0.067	0.70	0.57	0.88
Diarrhea w/ blood	1	0.000	7	0.002	0.17	0.02	1.39
Stomach pain	163	0.064	206	0.068	0.95	0.78	1.16
Coughing	173	0.068	209	0.069	0.99	0.82	1.20
Phlegm	80	0.032	90	0.030	1.06	0.79	1.43
Nasal congestion	205	0.081	273	0.090	0.90	0.76	1.07
Sore throat	177	0.070	190	0.063	1.12	0.92	1.36
HCGI 1	71	0.028	102	0.034	0.83	0.62	1.12
HCGI 2	20	0.008	26	0.009	0.92	0.52	1.65
SRD	112	0.044	139	0.046	0.97	0.76	1.23

* statistically significant at $p < 0.05$

Table 19. Risks Among Swimmers at 51-100 Yards Upcoast vs. Risks Among Controls

ALL BEACHES

SYMPTOMS	Total Exposed = 2186 51-100 yds		Total Unexposed = 3030 400+ yds				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	109.00	0.050	138	0.046	1.09	0.86	1.40
Chills	54	0.025	72	0.024	1.04	0.73	1.47
Eye discharge	45	0.021	61	0.020	1.02	0.70	1.50
Earache	81	0.037	116	0.038	0.97	0.73	1.28
Ear discharge	10	0.005	21	0.007	0.66	0.31	1.40
Skin rash	20	0.009	23	0.008	1.21	0.66	2.19
Infected cut	10	0.005	17	0.006	0.82	0.37	1.78
Nausea	75	0.034	133	0.044	0.78	0.59	1.03
Vomiting	40	0.018	57	0.019	0.97	0.65	1.45
Diarrhea	96	0.044	204	0.067	0.65	0.52	0.83
Diarrhea w/ blood	1	0.000	7	0.002	0.20	0.02	1.61
Stomach pain	126	0.058	206	0.068	0.85	0.68	1.05
Coughing	164	0.075	209	0.069	1.09	0.89	1.32
Phlegm	69	0.032	90	0.030	1.06	0.78	1.45
Nasal congestion	214	0.098	273	0.090	1.09	0.92	1.29
Sore throat	168	0.077	190	0.063	1.23	1.00	1.50
HCGI 1	63	0.029	102	0.034	0.86	0.63	1.17
HCGI 2	19	0.009	26	0.009	1.01	0.56	1.83
SRD	114	0.052	139	0.046	1.14	0.89	1.45

3-387

Table 20. Risks Among Swimmers at 1-50 Yards Downcoast vs. Risks Among Controls

ALL BEACHES

	Total Exposed = 1926		Total Unexposed = 3030				
	1-50 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	94	0.049	138	0.046	1.07	0.83	1.38
Chills	45	0.023	72	0.024	0.98	0.68	1.42
Eye discharge	23	0.012	61	0.020	0.59	0.37	0.95
Earache	55	0.029	116	0.038	0.75	0.54	1.02
Ear discharge	6	0.003	21	0.007	0.45	0.18	1.11
Skin rash	18	0.009	23	0.008	1.23	0.67	2.28
Infected cut	14	0.007	17	0.006	1.30	0.64	2.62
Nausea	61	0.032	133	0.044	0.72	0.54	0.97
Vomiting	27	0.014	57	0.019	0.75	0.47	1.17
Diarrhea	82	0.043	204	0.067	0.63	0.49	0.81
Diarrhea w/ blood	2	0.001	7	0.002	0.45	0.09	2.16
Stomach pain	108	0.056	206	0.068	0.82	0.66	1.03
Coughing	123	0.064	209	0.069	0.93	0.75	1.15
Phlegm	63	0.033	90	0.030	1.10	0.80	1.51
Nasal congestion	166	0.086	273	0.090	0.96	0.80	1.15
Sore throat	127	0.066	190	0.063	1.05	0.85	1.31
HCGI 1	50	0.026	102	0.034	0.77	0.55	1.08
HCGI 2	12	0.006	26	0.009	0.73	0.37	1.44
SRD	93	0.048	139	0.046	1.05	0.81	1.36

Table 21. Risks Among Swimmers at 51-100 Yards Downcoast vs. Risks Among Controls

ALL BEACHES

	Total Exposed = 1125		Total Unexposed = 3030				
	51-100 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	49	0.044	138	0.046	0.96	0.70	1.32
Chills	31	0.028	72	0.024	1.16	0.77	1.76
Eye discharge	14	0.012	61	0.020	0.62	0.35	1.10
Earache	35	0.031	116	0.038	0.81	0.56	1.18
Ear discharge	9	0.008	21	0.007	1.15	0.53	2.51
Skin rash	10	0.009	23	0.008	1.17	0.56	2.45
Infected cut	6	0.005	17	0.006	0.95	0.38	2.40
Nausea	40	0.036	133	0.044	0.81	0.57	1.15
Vomiting	18	0.016	57	0.019	0.85	0.50	1.44
Diarrhea	67	0.060	204	0.067	0.88	0.68	1.16
Diarrhea w/ blood	1	0.001	7	0.002	0.38	0.05	3.12
Stomach pain	68	0.060	206	0.068	0.89	0.68	1.16
Coughing*	99	0.088	209	0.069	1.28	1.01	1.60
Phlegm	45	0.040	90	0.030	1.35	0.95	1.91
Nasal congestion*	137	0.122	273	0.090	1.35	1.11	1.64
Sore throat	76	0.068	190	0.063	1.08	0.83	1.39
HCGI 1	33	0.029	102	0.034	0.87	0.59	1.28
HCGI 2	9	0.008	26	0.009	0.93	0.44	1.98
SRD	63	0.056	139	0.046	1.22	0.91	1.63

* statistically significant at $p < 0.05$

3-389

Table 22. Risks Among Swimmers At Each Distance vs. Risks Among Controls

ALL BEACHES – downcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.57	1.17	2.10	1.07	0.83	1.38	0.96	0.70	1.32
Chills	1.58	1.04	2.39	0.98	0.68	1.42	1.16	0.77	1.76
Eye discharge	1.14	0.69	1.90	0.59	0.37	0.95	0.62	0.35	1.10
Earache	1.20	0.84	1.72	0.75	0.54	1.02	0.81	0.56	1.18
Ear discharge	2.27	1.14	4.51	0.45	0.18	1.11	1.15	0.53	2.51
Skin rash	0.64	0.22	1.84	1.23	0.67	2.28	1.17	0.56	2.45
Infected cut	1.29	0.51	3.27	1.30	0.64	2.62	0.95	0.38	2.40
Nausea	1.10	0.78	1.56	0.72	0.54	0.97	0.81	0.57	1.15
Vomiting	1.61	1.01	2.56	0.75	0.47	1.17	0.85	0.50	1.44
Diarrhea	0.95	0.71	1.27	0.63	0.49	0.81	0.88	0.68	1.16
Diarrhea w/ blood	1.05	0.22	5.03	0.45	0.09	2.16	0.38	0.05	3.12
Stomach pain	1.08	0.82	1.43	0.82	0.66	1.03	0.89	0.68	1.16
Coughing	0.96	0.72	1.28	0.93	0.75	1.15	1.28	1.01	1.60
Phlegm	1.59	1.10	2.29	1.10	0.80	1.51	1.35	0.95	1.91
Nasal congestion	0.99	0.78	1.27	0.96	0.80	1.15	1.35	1.11	1.64
Sore throat	1.14	0.86	1.51	1.05	0.85	1.31	1.08	0.83	1.39
HCGI_1	1.26	0.86	1.83	0.77	0.55	1.08	0.87	0.59	1.28
HCGI_2	2.11	1.12	3.97	0.73	0.37	1.44	0.93	0.44	1.98
SRD	1.66	1.25	2.21	1.05	0.81	1.36	1.22	0.91	1.63

Table 23. Risks Among Swimmers At Each Distance vs. Risks Among Controls

ALL BEACHES -- upcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.57	1.17	2.10	0.99	0.78	1.26	1.09	0.86	1.40
Chills	1.58	1.04	2.39	1.05	0.75	1.46	1.04	0.73	1.47
Eye discharge	1.14	0.69	1.90	0.98	0.68	1.42	1.02	0.70	1.50
Earache	1.20	0.84	1.72	0.84	0.63	1.11	0.97	0.73	1.28
Ear discharge	2.27	1.14	4.51	1.08	0.58	2.01	0.66	0.31	1.40
Skin rash	0.64	0.22	1.84	1.82	1.08	3.08	1.21	0.66	2.19
Infected cut	1.29	0.51	3.27	1.62	0.87	3.03	0.82	0.37	1.78
Nausea	1.10	0.78	1.56	0.74	0.56	0.97	0.78	0.59	1.03
Vomiting	1.61	1.01	2.56	0.76	0.50	1.14	0.97	0.65	1.45
Diarrhea	0.95	0.71	1.27	0.70	0.57	0.88	0.65	0.52	0.83
Diarrhea w/ blood	1.05	0.22	5.03	0.17	0.02	1.39	0.20	0.02	1.61
Stomach pain	1.08	0.82	1.43	0.95	0.78	1.16	0.85	0.68	1.05
Coughing	0.96	0.72	1.28	0.99	0.82	1.20	1.09	0.89	1.32
Phlegm	1.59	1.10	2.29	1.06	0.79	1.43	2.60	2.03	3.34
Nasal congestion	0.99	0.78	1.27	0.90	0.76	1.07	1.09	0.92	1.29
Sore throat	1.14	0.86	1.51	1.12	0.92	1.36	1.23	1.00	1.50
HCGI 1	1.26	0.86	1.83	0.83	0.62	1.12	0.86	0.63	1.17
HCGI 2	2.11	1.12	3.97	0.92	0.52	1.65	1.01	0.56	1.83
SRD	1.66	1.25	2.21	0.97	0.76	1.23	1.14	0.89	1.45

Table 24. Risks Among Swimmers at the Drain vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

SYMPTOMS	Total Exposed = 827 0 yds		Total Unexposed = 624 400+ yds				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever*	59	0.071	27	0.043	1.65	1.06	2.57
Chills*	31	0.037	11	0.018	2.13	1.08	4.20
Eye discharge	19	0.023	19	0.030	0.75	0.40	1.41
Earache	38	0.046	26	0.042	1.10	0.68	1.80
Ear discharge	13	0.016	4	0.006	2.45	0.80	7.48
Skin rash	4	0.005	3	0.005	1.01	0.23	4.48
Infected cut	6	0.007	1	0.002	4.53	0.55	37.51
Nausea	40	0.048	27	0.043	1.12	0.69	1.80
Vomiting	25	0.030	10	0.016	1.89	0.91	3.90
Diarrhea	53	0.064	36	0.058	1.11	0.74	1.67
Diarrhea w/ blood	2	0.002	0	0.000	–	–	–
Stomach pain	61	0.074	44	0.071	1.05	0.72	1.52
Coughing	55	0.067	34	0.054	1.22	0.81	1.85
Phlegm*	39	0.047	11	0.018	2.68	1.38	5.18
Nasal congestion	74	0.089	46	0.074	1.21	0.85	1.73
Sore throat	59	0.071	33	0.053	1.35	0.89	2.04
HCGI 1	35	0.042	23	0.037	1.15	0.69	1.92
HCGI 2*	15	0.018	2	0.003	5.66	1.30	24.66
SRD*	63	0.076	17	0.027	2.80	1.65	4.73

* statistically significant at $p < 0.05$

Table 25. Risks Among Swimmers at 1-50 Yards Upcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed = 2592		Total Unexposed = 624				
	1-50 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	114	0.045	27	0.043	1.04	0.69	1.57
Chills	63	0.025	11	0.018	1.41	0.75	2.67
Eye discharge	50	0.020	19	0.030	0.65	0.39	1.09
Earache	81	0.032	26	0.042	0.77	0.50	1.19
Ear discharge	19	0.008	4	0.006	1.17	0.40	3.43
Skin rash	35	0.014	3	0.005	2.88	0.89	9.33
Infected cut	23	0.009	1	0.002	5.67	0.77	41.94
Nausea	82	0.032	27	0.043	0.75	0.49	1.15
Vomiting	36	0.014	10	0.016	0.89	0.44	1.78
Diarrhea	120	0.047	36	0.058	0.82	0.57	1.18
Diarrhea w/ blood	1	0.000	0	0.000	–	–	–
Stomach pain	163	0.064	163	0.261	0.25	0.20	0.30
Coughing	173	0.068	34	0.054	1.26	0.88	1.79
Phlegm	80	0.032	11	0.018	1.79	0.96	3.35
Nasal congestion	205	0.081	46	0.074	1.10	0.81	1.50
Sore throat	177	0.070	33	0.053	1.32	0.92	1.90
HCGI 1	71	0.028	23	0.037	0.76	0.48	1.21
HCGI 2	20	0.008	2	0.003	2.47	0.58	10.53
SRD	112	0.044	17	0.027	1.63	0.98	2.69

Table 26. Risks Among Swimmers at 51-100 Yards Upcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

SYMPTOMS	Total Exposed = 2186 51-100 yds		Total Unexposed = 624 400+ yds				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	109	0.050	27	0.043	1.15	0.76	1.74
Chills	54	0.025	11	0.018	1.40	0.74	2.66
Eye discharge	45	0.021	19	0.030	0.68	0.40	1.15
Earache	81	0.037	26	0.042	0.89	0.58	1.37
Ear discharge	10	0.005	4	0.006	0.71	0.22	2.27
Skin rash	20	0.009	3	0.005	1.90	0.57	6.38
Infected cut	10	0.005	1	0.002	2.85	0.37	22.26
Nausea	75	0.034	27	0.043	0.79	0.52	1.22
Vomiting	40	0.018	10	0.016	1.14	0.57	2.27
Diarrhea	96	0.044	36	0.058	0.76	0.52	1.10
Diarrhea w/ blood	1	0.000	0	0.000	–	–	–
Stomach pain	126	0.058	44	0.071	0.82	0.59	1.14
Coughing	164	0.075	34	0.054	1.38	0.96	1.97
Phlegm	69	0.032	11	0.018	1.79	0.95	3.36
Nasal congestion	214	0.098	46	0.074	1.33	0.98	1.80
Sore throat*	168	0.077	33	0.053	1.45	1.01	2.09
HCGI 1	63	0.029	23	0.037	0.78	0.49	1.25
HCGI 2	19	0.009	21	0.034	0.26	0.14	0.48
SRD*	114	0.052	17	0.027	1.91	1.16	3.16

* statistically significant at $p < 0.05$

Table 27. Risks Among Swimmers at 1-50 Yards Downcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed = 1926 1-50 yds		Total Unexposed = 624 400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	94	0.049	27	0.043	1.13	0.74	1.71
Chills	45	0.023	11	0.018	1.33	0.69	2.55
Eye discharge	23	0.012	19	0.030	0.39	0.22	0.72
Earache	55	0.029	26	0.042	0.69	0.43	1.08
Ear discharge	6	0.003	4	0.006	0.49	0.14	1.72
Skin rash	18	0.009	3	0.005	1.94	0.57	6.58
Infected cut	14	0.007	1	0.002	4.54	0.60	34.43
Nausea	61	0.032	27	0.043	0.73	0.47	1.14
Vomiting	27	0.014	10	0.016	0.87	0.43	1.80
Diarrhea	82	0.043	36	0.058	0.74	0.50	1.08
Diarrhea w/ blood	2	0.001	0	0.000	--	--	--
Stomach pain	108	0.056	44	0.071	0.80	0.57	1.12
Coughing	123	0.064	34	0.054	1.17	0.81	1.69
Phlegm	63	0.033	11	0.018	1.86	0.98	3.50
Nasal congestion	166	0.086	46	0.074	1.17	0.85	1.60
Sore throat	127	0.066	33	0.053	1.25	0.86	1.81
HCGI 1	50	0.026	23	0.037	0.70	0.43	1.14
HCGI 2	12	0.006	2	0.003	1.94	0.44	8.66
SRD*	93	0.048	17	0.027	1.77	1.07	2.95

* statistically significant at $p < 0.05$

SSC-393

Table 28. Risks Among Swimmers at 51-100 Yards Downcoast vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5

	Total Exposed = 1125		Total Unexposed = 624				
	51-100 yds		400+ yds				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	49	0.044	27	0.043	1.01	0.64	1.59
Chills	31	0.028	11	0.018	1.56	0.79	3.09
Eye discharge	14	0.012	19	0.030	0.41	0.21	0.81
Earache	35	0.031	26	0.042	0.75	0.45	1.23
Ear discharge	9	0.008	4	0.006	1.25	0.39	4.04
Skin rash	10	0.009	3	0.005	1.85	0.51	6.69
Infected cut	6	0.005	1	0.002	3.33	0.40	27.58
Nausea	40	0.036	27	0.043	0.82	0.51	1.33
Vomiting	18	0.016	10	0.016	1.00	0.46	2.15
Diarrhea	67	0.060	36	0.058	1.03	0.70	1.53
Diarrhea w/ blood	1	0.001	0	0.000	–	–	–
Stomach pain	68	0.060	44	0.071	0.86	0.59	1.24
Coughing*	99	0.088	34	0.054	1.62	1.11	2.35
Phlegm*	45	0.040	11	0.018	2.27	1.18	4.36
Nasal congestion*	137	0.122	46	0.074	1.65	1.20	2.27
Sore throat	76	0.068	33	0.053	1.28	0.86	1.90
HCGI 1	33	0.029	23	0.037	0.80	0.47	1.34
HCGI 2	9	0.008	2	0.003	2.50	0.54	11.52
SRD*	63	0.056	17	0.027	2.06	1.21	3.48

* statistically significant at $p < 0.05$

Table 29. Risks Among Swimmers At Each Distance vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5 -- downcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.65	1.06	2.57	1.13	0.74	1.71	1.01	0.64	1.59
Chills	2.13	1.08	4.20	1.33	0.69	2.55	1.56	0.79	3.09
Eye discharge	0.75	0.40	1.41	0.39	0.22	0.72	0.41	0.21	0.81
Earache	1.10	0.68	1.80	0.69	0.43	1.08	0.75	0.45	1.23
Ear discharge	2.45	0.80	7.48	0.49	0.14	1.72	1.25	0.39	4.04
Skin rash	1.01	0.23	4.48	1.94	0.57	6.58	1.85	0.51	6.69
Infected cut	4.53	0.55	37.51	4.54	0.60	34.43	3.33	0.40	27.58
Nausea	1.12	0.69	1.80	0.73	0.47	1.14	0.82	0.51	1.33
Vomiting	1.89	0.91	3.90	0.87	0.43	1.80	1.00	0.46	2.15
Diarrhea	1.11	0.74	1.67	0.74	0.50	1.08	1.03	0.70	1.53
Diarrhea w/ blood	--	--	--	--	--	--	--	--	--
Stomach pain	1.05	0.72	1.52	0.80	0.57	1.12	0.86	0.59	1.24
Coughing	1.22	0.81	1.85	1.17	0.81	1.69	1.62	1.11	2.35
Phlegm	2.68	1.38	5.18	1.86	0.98	3.50	2.27	1.18	4.36
Nasal congestion	1.21	0.85	1.73	1.17	0.85	1.60	1.65	1.20	2.27
Sore throat	1.35	0.89	2.04	1.25	0.86	1.81	1.28	0.86	1.90
HCGI_1	1.15	0.69	1.92	0.70	0.43	1.14	0.80	0.47	1.34
HCGI_2	5.66	1.30	24.66	1.94	0.44	8.66	2.50	0.54	11.52
SRD	2.80	1.65	4.73	1.77	1.07	2.95	2.06	1.21	3.48

3-397

Table 30. Risks Among Swimmers At Each Distance vs. Risks Among Controls

CONTROLS EXPOSED TO TOTAL/FECAL RATIOS > 5 -- upcoast

	drain (0 yds)			1 - 50 yards			51 - 100 yards		
SYMPTOMS	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI	RR	Lower 95% CI	Upper 95% CI
Fever	1.65	1.06	2.57	1.04	0.69	1.57	1.15	0.76	1.74
Chills	2.13	1.08	4.20	1.41	0.75	2.67	1.40	0.74	2.66
Eye discharge	0.75	0.40	1.41	0.65	0.39	1.09	0.68	0.40	1.15
Earache	1.10	0.68	1.80	0.77	0.50	1.19	0.89	0.58	1.37
Ear discharge	2.45	0.80	7.48	1.17	0.40	3.43	0.71	0.22	2.27
Skin rash	1.01	0.23	4.48	2.88	0.89	9.33	1.90	0.57	6.38
Infected cut	4.53	0.55	37.51	5.67	0.77	41.94	2.85	0.37	22.26
Nausea	1.12	0.69	1.80	0.75	0.49	1.15	0.79	0.52	1.22
Vomiting	1.89	0.91	3.90	0.89	0.44	1.78	1.14	0.57	2.27
Diarrhea	1.11	0.74	1.67	0.82	0.57	1.18	0.76	0.52	1.10
Diarrhea w/ blood	--	--	--	--	--	--	--	--	--
Stomach pain	1.05	0.72	1.52	0.25	0.20	0.30	0.82	0.59	1.14
Coughing	1.22	0.81	1.85	1.26	0.88	1.79	1.38	0.96	1.97
Phlegm	2.68	1.38	5.18	1.79	0.96	3.35	1.79	0.95	3.36
Nasal congestion	1.21	0.85	1.73	1.10	0.81	1.50	1.33	0.98	1.80
Sore throat	1.35	0.89	2.04	1.32	0.92	1.90	1.45	1.01	2.09
HCGI 1	1.15	0.69	1.92	0.76	0.48	1.21	0.78	0.49	1.25
HCGI 2	5.66	1.30	24.66	2.47	0.58	10.53	0.26	0.14	0.48
SRD	2.80	1.65	4.73	1.63	0.98	2.69	1.91	1.16	3.16

Table 31. Adjusted Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain.†

	Distance from drain (in yards)				
# exposed:	400 3030	100-50 3311	50-1 4518	0 827	trend P
Fever *	138 1.00	158 1.06 0.83-1.34	208 1.04 0.84-1.30	59 1.53 1.10-2.12	0.10
Chills	72 1.00	85 1.06 0.77-1.46	108 1.03 0.76-1.40	31 1.54 0.99-2.40	0.24
Eye discharge	61 1.00	59 0.88 0.61-1.27	73 0.79 0.56-1.12	19 1.20 0.70-2.06	0.61
Earache	116 1.00	116 0.89 0.68-1.16	136 0.80 0.62-1.03	38 1.32 0.89-1.94	0.70
Ear discharge *	21 1.00	19 0.78 0.42-1.46	25 0.82 0.46-1.47	13 2.28 1.10-4.71	0.26
Skin rash	23 1.00	30 1.15 0.66-1.98	53 1.51 0.92-2.47	4 0.62 0.21-1.83	0.41
Infected cut	17 1.00	16 0.80 0.40-1.59	37 1.50 0.84-2.68	6 1.55 0.59-4.05	0.08
Nausea	133 1.00	115 0.77 0.60-1.00	143 0.74 0.58-0.94	40 1.10 0.75-1.60	0.22
Vomiting	57 1.00	58 0.97 0.67-1.40	63 0.76 0.53-1.09	25 1.40 0.85-2.31	0.86
Diarrhea	204 1.00	163 0.70 0.57-0.87	202 0.67 0.55-0.82	53 0.95 0.69-1.32	0.01
Diarrhea with blood	7 1.00	2 0.26 0.05-1.23	3 0.26 0.07-1.02	2 0.80 0.15-4.20	0.19
Stomach pain	206 1.00	194 0.85 0.70-1.05	271 0.91 0.75-1.09	61 1.06 0.78-1.43	0.78
Cough	209 1.00	263 1.18 0.97-1.42	296 0.97 0.81-1.17	55 0.99 0.72-1.35	0.53
Cough & phlegm *	90 1.00	114 1.15 0.87-1.53	143 1.08 0.82-1.41	39 1.65 1.11-2.46	0.11

Table 31 (continued)

Runny nose	273 1.00	351 1.18 1.00-1.40	371 0.92 0.78-1.09	74 1.04 0.79-1.38	0.33
Sore throat	190 1.00	244 1.17 0.96-1.42	304 1.09 0.90-1.32	59 1.19 0.87-1.63	0.33
HCGI 1*	102 1.00	188 1.03 0.83-1.28	239 0.97 0.79-1.19	69 1.48 1.09-2.00	0.23
HCGI 2	26 1.00	28 1.03 0.60-1.76	32 0.88 0.52-1.49	15 1.58 0.81-3.08	0.57
Signif.* resp. disease	161 1.00	198 1.12 0.90-1.39	239 1.01 0.82-1.24	67 1.64 1.21-2.23	0.10

* Statistically significant at $p<05$.

† All results adjusted for: age, beach, gender, race, tourist versus local residence, socioeconomic status, and worry about potential hazards of swimming in the Santa Monica Bay. The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 32. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers at Ashland Beach.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	1523	1667	2534	154	
Fever	71	77	111	11	
	1.00	0.99	0.94	1.57	0.92
		0.71-1.38	0.69-1.27	0.81-3.04	
Chills*	27	42	57	7	
	1.00	1.43	1.28	2.64	0.15
		0.88-2.33	0.80-2.02	1.13-6.16	
Eye discharge*	38	32	39	11	
	1.00	0.76	0.61	3.01	0.67
		0.48-1.23	0.39-0.96	1.50-6.01	
Earache	66	57	62	7	
	1.00	0.78	0.55	1.05	0.01
		0.54-1.12	0.39-0.79	0.47-2.33	
Ear discharge	8	8	13	1	
	1.00	0.91	0.98	1.24	0.95
		0.34-2.44	0.40-2.36	0.15-9.96	
Skin rash	12	13	34	1	
	1.00	0.99	1.71	0.82	0.11
		0.45-2.18	0.88-3.32	0.11-6.37	
Infected cut	6	8	16	0	
	1.00	1.22	1.61	0.00	0.49
		0.42-3.52	0.63-4.11	0.00-+INF	
Nausea	66	57	67	4	
	1.00	0.78	0.60	0.59	0.00
		0.54-1.12	0.42-0.85	0.21-1.64	
Vomiting	34	32	35	3	
	1.00	0.86	0.61	0.87	0.06
		0.53-1.40	0.38-0.99	0.26-2.87	
Diarrhea	94	60	103	5	
	1.00	0.57	0.64	0.51	0.00
		0.41-0.79	0.48-0.86	0.20-1.27	
Diarrhea with blood	5	1	1	0	
	1.00	0.18	0.12	0.00	0.03
		0.02-1.56	0.01-1.03	0.00-+INF	
Stomach pain	93	90	144	6	
	1.00	0.88	0.93	0.62	0.44
		0.65-1.18	0.71-1.21	0.27-1.45	
Cough	111	133	176	9	
	1.00	1.10	0.95	0.79	0.44
		0.85-1.43	0.74-1.21	0.39-1.59	
Cough & phlegm	47	57	86	5	
	1.00	1.11	1.10	1.05	0.66
		0.75-1.65	0.77-1.58	0.41-2.69	

Table 32 (continued)

Runny nose	140 1.00	169 1.11 0.88-1.41	200 0.85 0.68-1.06	12 0.83 0.45-1.54	0.08
Sore throat	99 1.00	127 1.19 0.90-1.56	156 0.94 0.73-1.22	6 0.58 0.25-1.35	0.27
HCGI 1	54 1.00	50 0.84 0.57-1.24	63 0.69 0.48-1.00	5 0.91 0.36-2.32	0.08
HCGI 2	13 1.00	14 0.98 0.46-2.10	16 0.74 0.35-1.54	0 0.00 0.00-+INF	0.24
Signif. resp. disease	84 1.00	99 1.08 0.80-1.46	140 1.00 0.76-1.32	10 1.19 0.60-2.34	0.93

* Statistically significant at p<.05

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 33. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers at Malibu Beach.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	1013	1012	1399	587	
Fever*	48 1.00	45 0.94 0.62-1.42	61 0.92 0.62-1.35	42 1.55 1.01-2.38	0.14
Chills	37 1.00	23 0.61 0.36-1.04	37 0.72 0.45-1.14	21 0.98 0.57-1.69	0.72
Eye discharge	15 1.00	14 0.93 0.45-1.94	24 1.16 0.61-2.23	7 0.80 0.33-1.98	0.97
Earache*	26 1.00	35 1.36 0.81-2.28	49 1.38 0.85-2.23	30 2.04 1.20-3.49	0.02
Ear discharge*	7 1.00	4 0.57 0.17-1.95	11 1.14 0.44-2.95	12 3.00 1.17-7.66	0.01
Skin rash	6 1.00	6 1.00 0.32-3.11	12 1.45 0.54-3.88	3 0.86 0.21-3.46	0.78
Infected cut	7 1.00	4 0.57 0.17-1.95	14 1.45 0.58-3.61	6 1.48 0.50-4.44	0.22
Nausea	46 1.00	36 0.78 0.50-1.21	53 0.83 0.55-1.24	34 1.29 0.82-2.04	0.47
Vomiting*	17 1.00	16 0.94 0.47-1.87	21 0.89 0.47-1.70	22 2.28 1.20-4.33	0.04
Diarrhea	67 1.00	61 0.91 0.63-1.30	67 0.71 0.50-1.01	48 1.26 0.86-1.85	0.92
Diarrhea with blood	2 1.00	1 0.50 0.05-5.52	1 0.36 0.03-3.99	2 1.73 0.24-12.30	0.79
Stomach pain	7 1.00	65 0.91 0.64-1.29	95 0.97 0.70-1.33	52 1.29 0.89-1.87	0.28
Cough	61 1.00	79 1.32 0.93-1.87	88 1.05 0.75-1.47	40 1.14 0.76-1.72	0.86
Cough & phlegm*	25 1.00	38 1.54 0.92-2.57	41 1.19 0.72-1.98	29 2.05 1.19-3.54	0.05

Table 33 (continued)

Runny nose	88 1.00	103 1.19 0.88-1.61	122 1.00 0.75-1.34	58 1.15 0.81-1.63	0.76
Sore throat	59 1.00	76 1.31 0.92-1.87	100 1.24 0.89-1.74	44 1.31 0.87-1.96	0.21
HCGI 1	33 1.00	27 0.81 0.49-1.36	41 0.90 0.56-1.43	28 1.49 0.89-2.49	0.22
HCGI-2*	10 1.00	10 1.00 0.41-2.42	9 0.65 0.26-1.60	15 2.63 1.17-5.89	0.08
Signif. resp. disease*	49 1.00	63 1.31 0.89-1.92	70 1.04 0.71-1.51	49 1.79 1.19-2.70	0.05

* Statistically significant at $p<.05$.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 34. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers at Will Roger's Beach.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	494	632	585	86	
Fever	19 1.00	36 1.51 0.86-2.67	36 1.64 0.93-2.90	6 1.87 0.73-4.84	0.08
Chills	8 1.00	20 1.99 0.87-4.55	14 1.49 0.62-3.58	3 2.20 0.57-8.44	0.35
Eye discharge	8 1.00	13 1.28 0.52-3.10	10 1.06 0.41-2.70	1 0.71 0.09-5.78	0.89
Earache	24 1.00	24 0.77 0.43-1.38	25 0.87 0.49-1.55	1 0.23 0.03-1.73	0.29
Ear discharge	6 1.00	7 0.91 0.30-2.73	1 0.14 0.02-1.16	0 0.00 0.00-+INF	0.04
Skin rash	5 1.00	11 1.73 0.60-5.02	7 1.18 0.37-3.76	0 0.00 0.00-+INF	0.74
Infected cut	4 1.00	4 0.78 0.19-3.14	7 1.48 0.43-5.10	0 0.00 0.00-+INF	0.81
Nausea	21 1.00	22 0.81 0.44-1.49	23 0.92 0.50-1.69	2 0.54 0.12-2.33	0.58
Vomiting	6 1.00	10 1.31 0.47-3.62	7 0.99 0.33-2.95	0 0.00 0.00-+INF	0.57
Diarrhea	43 1.00	42 0.75 0.48-1.16	32 0.61 0.38-0.98	0 0.00 0.00-+INF	0.00
Stomach pain	42 1.00	39 0.71 0.45-1.11	32 0.62 0.39-1.00	3 0.39 0.12-1.28	0.02
Cough	37 1.00	51 1.08 0.70-1.68	32 0.71 0.44-1.17	6 0.93 0.38-2.27	0.23
Cough & phlegm	18 1.00	19 0.82 0.43-1.58	16 0.74 0.38-1.47	5 1.63 0.59-4.52	0.94

Table 34 (continued)

Runny nose	45 1.00	79 1.43 0.97-2.10	49 0.91 0.60-1.39	4 0.49 0.17-1.39	0.21
Sore throat	32 1.00	41 1.00 0.62-1.62	48 1.29 0.81-2.05	9 1.69 0.78-3.67	0.12
HCGI 1	15 1.00	19 0.99 0.50-1.97	17 0.96 0.47-1.93	2 0.76 0.17-3.39	0.78
HCGI 2	3 1.00	4 1.04 0.23-4.68	7 1.98 0.51-7.71	0 0.00 0.00-+INF	0.55
Signif. resp. disease	28 1.00	36 1.01 0.60-1.67	29 0.87 0.51-1.48	8 1.71 0.75-3.88	0.80

* Statistically significant at p<.05.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 35. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Children Under 12 Years Old.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	1551	1470	2079	514	
Fever*	86 1.00	78 0.95 0.70-1.31	113 0.98 0.73-1.31	42 1.52 1.03-2.22	0.18
Chills	38 1.00	37 1.03 0.65-1.63	44 0.86 0.55-1.34	20 1.61 0.93-2.80	0.51
Eye discharge	43 1.00	27 0.66 0.40-1.07	36 0.62 0.39-0.97	12 0.84 0.44-1.60	0.13
Earache	54 1.00	50 0.98 0.66-1.44	58 0.80 0.55-1.16	22 1.24 0.75-2.06	0.82
Ear discharge*	8 1.00	6 0.79 0.27-2.28	7 0.65 0.24-1.80	7 2.66 0.96-7.38	0.31
Skin rash	13 1.00	14 1.14 0.53-2.43	26 1.50 0.77-2.93	2 0.46 0.10-2.05	0.81
Infected cut	6 1.00	5 0.88 0.27-2.89	8 0.99 0.34-2.87	2 1.01 0.20-5.00	0.97
Nausea	75 1.00	45 0.62 0.43-0.91	61 0.59 0.42-0.84	25 1.01 0.63-1.60	0.12
Vomiting*	42 1.00	31 0.77 0.48-1.24	47 0.83 0.55-1.27	23 1.68 1.00-2.83	0.32
Diarrhea	110 1.00	69 0.65 0.47-0.88	85 0.56 0.42-0.75	38 1.05 0.71-1.53	0.05
Diarrhea with blood	2 1.00	1 0.53 0.05-5.82	2 0.75 0.10-5.30	2 3.03 0.43-21.53	0.42
Stomach pain	114 1.00	81 0.74 0.55-0.99	133 0.86 0.66-1.12	39 1.03 0.71-1.51	0.79
Cough	127 1.00	137 1.15 0.90-1.48	139 0.80 0.63-1.03	40 0.95 0.65-1.37	0.12
Cough & phlegm*	54 1.00	56 1.10 0.75-1.61	53 0.73 0.49-1.07	28 1.60 1.00-2.55	0.88

Table 35 (continued)

Runny nose	146 1.00	148 1.08 0.85-1.37	152 0.76 0.60-0.96	48 0.99 0.70-1.40	0.09
Sore throat	100 1.00	102 1.08 0.81-1.44	106 0.78 0.59-1.03	37 1.13 0.76-1.66	0.37
HCGI 1	71 1.00	50 0.73 0.51-1.06	72 0.75 0.54-1.04	29 1.25 0.80-1.94	0.86
HCGI 2	22 1.00	14 0.67 0.34-1.31	26 0.88 0.50-1.56	14 1.95 0.99-3.83	0.19
Signif. resp. disease*	86 1.00	88 1.08 0.80-1.47	88 0.75 0.56-1.02	47 1.71 1.18-2.48	0.53

* Statistically significant at p<.05.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 36. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Swimmers Aged 12-25 Years Old.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	739	892	1188	163	
Fever*	25	39	46	11	
	1.00	1.31	1.15	2.07	0.23
		0.78-2.18	0.70-1.89	1.00-4.29	
Chills	14	22	28	6	
	1.00	1.31	1.25	1.98	0.29
		0.67-2.58	0.65-2.39	0.75-5.23	
Eye discharge	7	14	15	3	
	1.00	1.67	1.34	1.96	0.49
		0.67-4.15	0.54-3.30	0.50-7.66	
Earache	33	38	38	10	
	1.00	0.95	0.71	1.40	0.53
		0.59-1.53	0.44-1.14	0.67-2.90	
Ear discharge	7	6	12	2	
	1.00	0.71	1.07	1.30	0.67
		0.24-2.12	0.42-2.72	0.27-6.31	
Skin rash	5	3	13	0	
	1.00	0.50	1.62	0.00	0.53
		0.12-2.08	0.58-4.57	0.00-+INF	
Infected cut	8	6	15	2	
	1.00	0.62	1.17	1.14	0.55
		0.21-1.79	0.49-2.77	0.24-5.40	
Nausea	25	40	34	7	
	1.00	1.34	0.84	1.28	0.61
		0.81-2.23	0.50-1.42	0.54-3.02	
Vomiting	7	19	5	2	
	1.00	2.28	0.44	1.30	0.20
		0.95-5.44	0.14-1.40	0.27-6.31	
Diarrhea	43	31	46	10	
	1.00	0.58	0.65	1.06	0.28
		0.36-0.93	0.43-1.00	0.52-2.15	
Diarrhea with blood	3	1	0	0	
	1.00	0.28	0.00	0.00	0.07
		0.03-2.65	0.00-+INF	0.00-+INF	
Stomach pain	52	54	77	11	
	1.00	0.85	0.92	0.96	0.78
		0.57-1.26	0.64-1.32	0.49-1.88	
Cough	43	71	87	13	
	1.00	1.40	1.28	1.40	0.25
		0.95-2.07	0.88-1.87	0.74-2.67	
Cough & phlegm*	21	32	48	10	
	1:00	1.27	1.44	2.23	0.05
		0.73-2.23	0.85-2.42	1.03-4.84	

Table 36 (continued)

Runny nose	72 1.00 0.87-1.65	102 1.20 0.74-1.37	116 1.00 0.62-1.88	17 1.08	0.90
Sore throat	46 1.00	67 1.22 0.83-1.80	105 1.46 1.02-2.09	15 1.53 0.83-2.81	0.03
HCGI 1	16 1.00	24 1.25 0.66-2.37	21 0.81 0.42-1.57	4 1.14 0.38-3.45	0.58
HCGI 2	1 1.00	10 8.37 1.07-65.51	3 1.87 0.19-17.99	1 4.56 0.28-73.21	0.98
Signif. resp. disease	46 1.00	55 0.99 0.66-1.48	81 1.10 0.76-1.60	16 1.64 0.90-2.98	0.20

* Statistically significant at p<.05.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 37. Crude Odds Ratios and 95% Confidence Intervals for Outcomes of Interest by Distance from Drain Among Adults Over 25 Years Old.†

	Distance from drain (in yards)				
	400	100-50	50-1	0	trend P
# exposed:	740	949	1251	150	
Fever	27 1.00	41 1.19 0.73-1.96	49 1.08 0.67-1.74	6 1.10 0.45-2.71	0.86
Chills	20 1.00	26 1.01 0.56-1.83	36 1.07 0.61-1.86	5 1.24 0.46-3.36	0.69
Eye discharge	11 1.00	18 1.28 0.60-2.73	22 1.19 0.57-2.46	4 1.82 0.57-5.78	0.48
Earache	29 1.00	28 0.75 0.44-1.26	40 0.81 0.50-1.32	6 1.02 0.42-2.51	0.65
Ear discharge	6 1.00	7 0.91 0.30-2.72	6 0.59 0.19-1.83	4 3.35 0.93-12.02	0.64
Skin rash	5 1.00	13 2.04 0.72-5.75	14 1.66 0.60-4.64	2 1.99 0.38-10.34	0.42
Infected cut	3 1.00	5 1.30 0.31-5.46	14 2.78 0.80-9.71	2 3.32 0.55-20.04	0.04
Nausea	33 1.00	30 0.70 0.42-1.16	48 0.85 0.54-1.34	8 1.21 0.55-2.67	0.98
Vomiting	8 1.00	8 0.78 0.29-2.08	11 0.81 0.32-2.03	0 0.00 0.00-+INF	0.37
Diarrhea	51 1.00	63 0.96 0.66-1.41	71 0.81 0.56-1.18	5 0.47 0.18-1.19	0.09
Diarrhea with blood	2 1.00	0 0.00 0.00-+INF	1 0.30 0.03-3.26	0 0.00 0.00-+INF	0.26
Stomach pain	40 1.00	59 1.16 0.77-1.75	61 0.90 0.60-1.35	11 1.38 0.69-2.77	0.87
Cough	39 1.00	55 1.11 0.73-1.69	70 1.07 0.71-1.59	2 0.24 0.06-1.02	0.44
Cough & phlegm	15 1.00	26 1.36 0.72-2.59	42 1.68 0.92-3.05	1 0.32 0.04-2.47	0.38
Runny nose	55 1.00	101 1.48 1.05-2.09	103 1.12 0.79-1.57	9 0.79 0.38-1.65	0.75

Table 37 (continued)

Sore throat	44 1.00	75 1.36 0.92-2.00	93 1.27 0.88-1.84	7 0.77 0.34-1.75	0.66
HCGI 1	15 1.00	22 1.15 0.59-2.23	28 1.11 0.59-2.09	2 0.65 0.15-2.89	0.93
HCGI 2	3 1.00	4 1.04 0.23-4.66	3 0.59 0.12-2.93	0 0.00 0.00-+INF	0.35
Signif. resp. disease	29 1.00	55 1.51 0.95-2.39	70 1.45 0.93-2.26	4 0.67 0.23-1.94	0.48

* Statistically significant at p<.05.

† The number of diseased subjects are given on the first line for each outcome. Trend P is from a linear model.

Table 38. Risks For High vs. Low E.Coli Indicator Counts

ALL BEACHES

	Total Exposed = 2654		Total Unexposed = 7724				
	> 70 cfu		≤ 70 cfu				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	135	0.051	363	0.047	1.08	0.89	1.31
Chills	68	0.026	186	0.024	1.06	0.81	1.40
Eye discharge	43	0.016	146	0.019	0.86	0.61	1.20
Earache	98	0.037	259	0.034	1.10	0.88	1.38
Ear discharge	17	0.006	50	0.006	0.99	0.57	1.71
Skin rash	28	0.011	72	0.009	1.13	0.73	1.75
Infected cut	15	0.006	49	0.006	0.89	0.50	1.59
Nausea	94	0.035	290	0.038	0.94	0.75	1.19
Vomiting	44	0.017	138	0.018	0.93	0.66	1.30
Diarrhea	144	0.054	411	0.053	1.02	0.85	1.23
Diarrhea w/ blood	3	0.001	8	0.001	1.09	0.29	4.11
Stomach pain	171	0.064	477	0.062	1.04	0.88	1.24
Coughing	197	0.074	540	0.070	1.06	0.91	1.24
Phlegm	88	0.033	267	0.035	0.96	0.76	1.22
Nasal congestion	251	0.095	702	0.091	1.04	0.91	1.19
Sore throat	186	0.070	516	0.067	1.05	0.89	1.23
HCGI 1	83	0.031	234	0.030	1.03	0.81	1.32
HCGI 2	24	0.009	69	0.009	1.01	0.64	1.61
SRD	135	0.051	390	0.050	1.01	0.83	1.22

Table 39. Risks For High vs. Low Bacterial Indicators

E. coli

	> 35 cfu		> 70 cfu	
Symptoms	**RR**	**95% CI**	**RR**	**95% CI**
Fever	1.16	0.98, 1.38	1.07	0.89 , 1.30
Chills	1.07	0.84, 1.37	1.06	0.80 , 1.39
Eye discharge	0.89	0.67, 1.20	0.85	0.61 , 1.19
Earache	0.94	0.77, 1.16	1.09	0.87 , 1.37
Ear discharge	0.83	0.51, 1.35	0.96	0.56 , 1.67
Skin rash	1.07	0.72, 1.59	1.13	0.73 , 1.74
Infected cut	0.74	0.44, 1.24	0.89	0.50 , 1.58
Nausea	1.10	0.90, 1.34	0.93	0.74 , 1.17
Vomiting	1.01	0.75, 1.35	0.92	0.65 , 1.28
Diarrhea	1.12	0.95, 1.31	1.00	0.83 , 1.21
Diarrhea w/ blood	1.70	0.52, 5.58	1.08	0.29 , 4.09
Stomach pain	1.18	1.01, 1.37	1.03	0.87 , 1.22
Coughing	0.94	0.81, 1.08	1.06	0.91 , 1.24
Phlegm	0.82	0.66, 1.01	0.97	0.77 , 1.22
Nasal congestion	0.97	0.86, 1.10	1.04	0.91 , 1.19
Sore throat	0.97	0.83, 1.12	1.04	0.89 , 1.22
HCGI 1	1.05	0.84, 1.30	1.02	0.80 , 1.31
HCGI 2	1.34	0.89 , 2.01	1.01	0.64 , 1.61
SRD	0.93	0.78, 1.10	1.01	0.83 , 1.22

3-414

Table 40. Odds Ratios and 95% Confidence Intervals for E. Coli Dichotomized First at 160 cfu, then at 320 cfu. The Number of Diseased Subjects are Given on the First Line for Each Outcome.

	Cutpoint	
# exposed:	160 cfu 1509	320 cfu 991
Fever	74.00 1.03 0.80-1.32	45.00 0.94 0.69-1.28
Chills	40.00 1.10 0.78-1.55	22.00 0.90 0.58-1.39
Eye discharge	29.00 1.07 0.72-1.59	23.00 1.32 0.85-2.05
Earache*	65.00 1.32 1.00-1.74*	47.00 1.46 1.06-2.00*
Ear discharge	12.00 1.28 0.69-2.40	6.00 0.93 0.40-2.16
Skinrash	21.00 1.57 0.97-2.55	15.00 1.68 0.97-2.92
Infected cut	12.00 1.36 0.72-2.55	9.00 1.56 9.77-3.16
Nausea	60.00 1.09 0.82-1.45	42.00 1.17 0.84-1.62
Vomiting	28.00 1.07 0.71-1.61	20.00 1.17 0.73-1.88
Diarrhea	81.00 1.00 0.79-1.28	56.00 1.07 0.80-1.42
Diarrhea with blood	2.00 1.31 0.28-6.05	0.00 0.00 0.00-+INF
Stomache pain	101.00 1.09 0.88-1.36	70.00 1.16 0.90-1.50
Cough	111.00 1.05 0.85-1.29	82.00 1.20 0.95-1.53
Cough & phlegm	54.00 1.06 0.79-1.42	43.00 1.32 0.95-1.83

Table 40 (continued)

Runny nose*	146.00 1.07 0.89-1.29	108.00 1.24 1.00-1.53*
Sorethroat	104.00 1.02 0.83-1.27	75.00 1.14 0.89-1.47
HCGI-1	53.00 1.19 0.88-1.60	36.00 1.22 0.86-1.74
HCGI-2	16.00 1.22 0.71-2.10	10.00 1.14 0.59-2.21
Signif. resp. disease	83.00 0.95 0.75-1.21	61.00 1.09 0.83-1.44

* Statistically significant at p<.05.

Table 41. Crude Odds Ratios and 95% Confidence Intervals for E. Coli by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints:	2.00	7.50	23.00	56.00	310.00	
# exposed:	2122	2096	2141	2052	2082	
Fever	99	104	85	119	98	
	1.00	1.07	0.84	1.26	1.01	0.99
		0.80-1.41	0.63-1.14	0.96-1.65	0.76-1.34	0.94-1.04
Chills	56	48	48	56	50	
	1.00	0.86	0.85	1.04	0.91	0.99
		0.59-1.28	0.57-1.25	0.71-1.51	0.62-1.34	0.92-1.07
Eye discharge	36	43	41	33	37	
	1.00	1.21	1.13	0.95	1.05	1.04
		0.78-1.90	0.72-1.78	0.59-1.52	0.66-1.67	0.98-1.10
Earache	83	67	71	57	82	
	1.00	0.81	0.84	0.70	1.01	1.03
		0.58-1.13	0.61-1.16	0.50-0.99	0.74-1.38	0.98-1.08
Ear discharge	16	14	16	9	14	
	1.00	0.89	0.99	0.58	0.89	0.98
		0.43-1.82	0.49-1.99	0.26-1.32	0.43-1.83	0.84-1.14
Skin rash*	16	18	25	18	23	
	1.00	1.14	1.56	1.16	1.47	1.07
		0.58-2.24	0.83-2.92	0.59-2.29	0.77-2.79	1.01-1.14
Infected cut	1	13	19	7	14	
	1.00	1.20	1.72	0.66	1.30	1.02
		0.54-2.68	0.82-3.62	0.25-1.70	0.59-2.87	0.91-1.15
Nausea*	85	68	72	78	82	
	1.00	0.80	0.83	0.95	0.98	1.04
		0.58-1.11	0.61-1.15	0.69-1.30	0.72-1.34	1.00-1.08
Vomiting	47	30	33	36	36	
	1.00	0.64	0.69	0.79	0.78	1.02
		0.40-1.02	0.44-1.08	0.51-1.22	0.50-1.20	0.95-1.10
Diarrhea	125	86	122	115		
	1.00	1.17	0.77	1.17	1.08	1.03
		0.90-1.53	0.58-1.03	0.89-1.52	0.82-1.41	0.99-1.07
Diarrhea with blood	2	1	2	3	3	
	1.00	0.51	0.99	1.55	1.53	0.85
		0.05-5.58	0.14-7.04	0.26-9.30	0.26-9.16	0.38-1.87
Stomach pain*	141	119	109	145	135	
	1.00	0.85	0.75	1.07	0.97	1.04
		0.66-1.09	0.58-0.98	0.84-1.36	0.76-1.24	1.00-1.07
Cough	150	157	140	141	149	
	1.00	1.06	0.92	0.97	1.01	1.02
		0.84-1.34	0.72-1.17	0.76-1.23	0.80-1.28	0.98-1.06
Cough & phlegm	67	91	69	61	67	
	1.00	1.39	1.02	0.94	1.02	1.02
		1.01-1.92	0.73-1.44	0.66-1.34	0.72-1.44	0.97-1.07

Table 41 (continued)

Runny nose	197 1.00	204 1.05 0.86-1.29	173 0.86 0.69-1.06	189 0.99 0.80-1.22	192 0.99 0.81-1.22	1.02 0.99-1.06
Sore throat	145 1.00	154 1.08 0.85-1.37	131 0.89 0.70-1.13	138 0.98 0.77-1.25	139 0.98 0.77-1.24	1.01 0.97-1.05
HCGI 1	83 1.00	56 0.67 0.48-0.95	48 0.56 0.39-0.81	66 0.82 0.59-1.13	64 0.78 0.56-1.09	1.02 0.97-1.08
HCGI 2	22 1.00	14 0.64 0.33-1.26	14 0.63 0.32-1.23	24 1.13 0.63-2.02	19 0.88 0.47-1.63	1.02 0.93-1.12
Signif. resp. disease	114 1.00	147 1.33 1.03-1.71	113 0.98 0.75-1.28	116 1.06 0.81-1.38	107 0.95 0.73-1.25	1.01 0.97-1.06

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

Table 42. Adjusted Odds Ratios and 95% Confidence Intervals for E. Coli by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints:	2.00	7.50	23.00	56.00	310.00	
# exposed:	2122	2096	2141	2052	2082	
Fever	99	104	85	119	98	
	1.00	1.06	0.81	1.21	0.97	0.99
		0.80-1.41	0.60-1.09	0.92-1.60	0.72-1.31	0.94-1.05
Chills	56	48	48	56	50	
	1.00	0.86	0.83	0.99	0.80	0.98
		0.58-1.27	0.56-1.22	0.67-1.45	0.54-1.20	0.90-1.06
Eye discharge	36	43	41	33	37	
	1.00	1.21	1.10	0.97	1.13	1.05
		0.77-1.90	0.70-1.74	0.59-1.57	0.70-1.83	0.99-1.11
Earache	83	67	71	57	82	
	1.00	0.80	0.82	0.64	0.91	1.03
		0.57-1.10	0.59-1.13	0.45-0.92	0.66-1.27	0.98-1.08
Ear discharge	16	14	16	9	14	
	1.00	0.84	0.93	0.48	0.68	0.95
		0.41-1.74	0.46-1.87	0.21-1.10	0.33-1.44	0.79-1.15
Skin rash*	16	18	25	18	23	
	1.00	1.08	1.38	1.11	1.58	1.09
		0.55-2.13	0.73-2.60	0.56-2.21	0.81-3.06	1.02-1.16
Infected cut	11	13	19	7	14	
	1.00	1.16	1.67	0.54	1.02	1.02
		0.52-2.60	0.79-3.54	0.21-1.42	0.45-2.31	0.90-1.15
Nausea	85	68	72	78	82	
	1.00	0.80	0.82	0.88	0.87	1.04
		0.58-1.11	0.60-1.13	0.63-1.21	0.63-1.20	0.99-1.08
Vomiting	47	30	33	36	36	
	1.00	0.64	0.68	0.79	0.75	1.02
		0.40-1.02	0.43-1.06	0.51-1.24	0.48-1.19	0.95-1.10
Diarrhea	109	125	860	122	115	
	1.00	1.14	0.75	1.03	0.89	1.02
		0.88-1.49	0.56-1.00	0.79-1.36	0.67-1.17	0.97-1.06
Diarrhea with blood	2	1	2	3	3	
	1.00	0.48	0.84	1.42	1.15	0.75
		0.04-5.27	0.12-6.03	0.23-8.74	0.18-7.38	0.28-1.99
Stomach pain	141	119	109	145	135	
	1.00	0.84	0.75	1.00	0.87	1.03
		0.65-1.09	0.58-0.97	0.78-1.28	0.68-1.12	0.99-1.07
Cough	150	157	140	141	149	
	1.00	1.07	0.91	0.97	1.03	1.03
		0.85-1.35	0.72-1.16	0.76-1.24	0.81-1.32	0.99-1.07
Cough & phlegm	67	91	69	61	67	
	1.00	1.38	1.01	0.92	0.98	1.03
		1.00-1.91	0.71-1.42	0.64-1.31	0.68-1.39	0.97-1.08

Table 42 (continued)

Runny nose	197 1.00	204 1.04 0.84-1.27	173 0.84 0.68-1.04	189 0.95 0.77-1.18	192 0.94 0.76-1.17	1.02 0.99-1.06
Sore throat	145 1.00	154 1.07 0.84-1.35	131 0.87 0.68-1.11	138 0.94 0.74-1.21	139 0.92 0.72-1.18	1.01 0.97-1.05
HCGI 1	83 1.00	56 0.68 0.48-0.96	48 0.55 0.38-0.79	66 0.79 0.56-1.11	64 0.74 0.52-1.05	1.02 0.97-1.08
HCGI 2	22 1.00	14 0.63 0.32-1.24	14 0.60 0.31-1.18	24 1.04 0.58-1.89	19 0.75 0.40-1.42	1.02 0.92-1.13
Signif. resp. disease	114 1.00	147 1.32 1.03-1.70	113 0.97 0.74-1.26	116 1.03 0.79-1.36	107 0.92 0.69-1.22	1.02 0.98-1.06

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

Table 43. Risks For High vs. Low Enterococcus Indicator Counts

ALL BEACHES

SYMPTOMS	Total exposed = 848 > 106 cfu		Total unexposed = 9561 ≤ 106 cfu				
	Ill	Risk	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	45	0.053	455	0.048	1.12	0.83	1.50
Chills	24	0.028	231	0.024	1.17	0.77	1.77
Eye discharge	16	0.019	174	0.018	1.04	0.62	1.72
Earache	31	0.037	327	0.034	1.07	0.74	1.53
Ear discharge	4	0.005	64	0.007	0.70	0.26	1.93
Skin rash	13	0.015	87	0.009	1.68	0.94	3.00
Infected cut	68	0.080	58	0.006	13.22	9.38	18.63
Nausea	40	0.047	344	0.036	1.31	0.95	1.81
Vomiting	18	0.021	164	0.017	1.24	0.76	2.00
Diarrhea	57	0.067	499	0.052	1.29	0.99	1.68
Diarrhea w/ blood *	3	0.004	8	0.001	4.23	1.12	15.91
Stomach pain	59	0.070	590	0.062	1.13	0.87	1.46
Coughing	63	0.074	675	0.071	1.05	0.82	1.35
Phlegm	31	0.037	325	0.034	1.08	0.75	1.54
Nasal congestion	85	0.100	869	0.091	1.10	0.89	1.36
Sore throat	52	0.061	651	0.068	0.90	0.69	1.18
HCGI 1 *	36	0.042	281	0.029	1.44	1.03	2.03
HCGI 2	12	0.014	81	0.008	1.67	0.91	3.05
SRD	45	0.053	481	0.050	1.05	0.78	1.42

* statistically significant at $p < 0.05$

3-421

Table 44. Risks For High vs. Low Bacterial Indicators

enterococcus

	> 35 cfu		> 106 cfu	
Symptoms	**RR**	**95% CI**	**RR**	**95% CI**
Fever	0.97	0.80 , 1.18	1.08	0.80 , 1.46
Chills	0.81	0.61 , 1.08	1.15	0.76 , 1.74
Eye discharge	0.77	0.55 , 1.09	1.01	0.61 , 1.68
Earache	0.91	0.72 , 1.16	1.04	0.73 , 1.50
Ear discharge	0.85	0.49 , 1.48	0.68	0.25 , 1.86
Skin rash	0.99	0.63 , 1.54	1.65	0.92 , 2.94
Infected cut	1.10	0.64 , 1.90	1.14	0.49 , 2.64
Nausea	1.17	0.94 , 1.45	1.28	0.93 , 1.76
Vomiting	1.15	0.84 , 1.57	1.20	0.74 , 1.95
Diarrhea	1.12	0.93 , 1.33	1.25	0.96 , 1.63
Diarrhea w/ blood*	1.06	0.28 , 3.97	4.14	1.10 , 15.57
Stomach pain	1.11	0.95 , 1.31	1.10	0.85 , 1.42
Coughing	0.93	0.79 ,1.09	1.05	0.82 , 1.34
Phlegm	0.97	0.77 , 1.22	1.11	0.78 , 1.58
Nasal congestion	1.00	0.87 , 1.14	1.10	0.89 , 1.35
Sore throat	0.90	0.76 , 1.06	0.89	0.68 , 1.17
HCGI 1*	1.08	0.85 , 1.37	1.41	1.00 , 1.98
HCGI 2*	1.10	0.70 , 1.72	1.68	1.08 , 2.61
SRD	0.92	0.76 , 1.12	1.67	0.91 , 3.05

*** statistically significant at $p < 0.05$**

3-422

Table 45. Crude Odds Ratios and 95% Confidence Intervals for Enterococcus by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints:	2.00	6.50	17.25	27.75	90.25	
# exposed:	2284	1928	2167	2065	1965	
Fever*	111 1.00	80 0.85 0.63-1.14	117 1.12 0.86-1.46	99 0.99 0.75-1.30	93 0.97 0.73-1.29	1.04 1.01-1.06
Chills	62 1.00	44 0.84 0.57-1.24	56 0.95 0.66-1.37	46 0.82 0.55-1.20	47 0.88 0.60-1.29	0.96 0.88-1.06
Eye discharge	41 1.00	38 1.10 0.70-1.72	40 1.03 0.66-1.60	37 1.00 0.64-1.56	34 0.96 0.61-1.52	1.03 0.99-1.07
Earache	79 1.00	75 1.13 0.82-1.56	63 0.84 0.60-1.17	76 1.07 0.77-1.47	65 0.95 0.68-1.33	0.99 0.93-1.04
Ear discharge	22 1.00	10 0.54 0.25-1.13	14 0.67 0.34-1.31	9 0.45 0.21-0.98	13 0.68 0.34-1.36	0.95 0.76-1.18
Skin rash*	20 1.00	9 0.53 0.24-1.17	29 1.54 0.87-2.72	20 1.11 0.59-2.06	22 1.28 0.70-2.36	1.06 1.03-1.09
Infected cut	16 1.00	10 0.74 0.33-1.63	8 0.53 0.22-1.23	15 1.04 0.51-2.10	15 1.09 0.54-2.21	1.00 0.90-1.11
Nausea*	74 1.00	65 1.04 0.74-1.46	83 1.19 0.86-1.64	82 1.23 0.90-1.70	80 1.27 0.92-1.75	1.04 1.02-1.06
Vomiting	35 1.00	30 1.02 0.62-1.66	43 1.30 0.83-2.04	36 1.14 0.71-1.82	38 1.27 0.80-2.01	1.02 0.98-1.07
Diarrhea*	106 1.00	116 1.32 1.00-1.72	113 1.13 0.86-1.48	103 1.08 0.82-1.42	118 1.31 1.00-1.72	1.04 1.02-1.06
Diarrhea with blood	3 1.00	1 0.39 0.04-3.80	2 0.70 0.12-4.21	2 0.74 0.12-4.42	3 1.16 0.23-5.77	1.04 0.92-1.17
Stomach pain*	128 1.00	121 1.13 0.87-1.46	139 1.15 0.90-1.48	119 1.03 0.80-1.33	142 1.31 1.02-1.68	1.02 1.00-1.05
Cough*	145 1.00	128 1.05 0.82-1.34	168 1.24 0.98-1.56	167 1.30 1.03-1.64	130 1.05 0.82-1.33	1.03 1.00-1.05
Cough & phlegm	72 1.00	67 1.11 0.79-1.55	74 1.09 0.78-1.51	77 1.19 0.86-1.65	66 1.07 0.76-1.50	1.02 0.99-1.05

Table 45 (continued)

Runny nose*	198 1.00	175 1.05 0.85-1.30	206 1.11 0.90-1.36	185 1.04 0.84-1.28	190 1.13 0.92-1.39	1.03 1.00-1.05
Sore throat	136 1.00	133 1.17 0.91-1.50	158 1.24 0.98-1.57	161 1.34 1.05-1.69	115 0.98 0.76-1.27	1.01 0.99-1.04
HCGI 1*	70 1.00	52 0.88 0.61-1.26	73 1.10 0.79-1.54	58 0.91 0.64-1.30	64 1.06 0.75-1.50	1.04 1.02-1.07
HCGI 2	15 1.00	11 0.87 0.40-1.90	29 2.05 1.10-3.84	17 1.26 0.63-2.52	21 1.63 0.84-3.18	1.04 0.99-1.08
Signif. resp. disease	128 1.00	106 0.98 0.75-1.28	127 1.05 0.81-1.35	130 1.13 0.88-1.46	103 0.93 0.71-1.22	1.00 0.97-1.04

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

Table 46. Adjusted Odds Ratios and 95% Confidence Intervals for Enterococcus by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints:	2.00	6.50	17.25	27.75	90.25	
# exposed:	2284	1928	2167	2065	1965	
Fever*	111	80	117	99	93	
	1.00	0.85	1.10	0.93	0.90	1.03
		0.63-1.14	0.84-1.44	0.70-1.23	0.67-1.21	1.01-1.06
Chills	62	44	56	46	47	
	1.00	0.86	0.96	0.78	0.79	0.94
		0.58-1.28	0.66-1.39	0.53-1.16	0.53-1.19	0.83-1.06
Eye discharge	41	38	40	37	34	
	1.00	1.12	1.01	0.99	1.02	1.03
		0.71-1.75	0.65-1.57	0.63-1.57	0.63-1.66	0.99-1.07
Earache	79	75	63	76	65	
	1.00	1.11	0.83	0.98	0.84	0.97
		0.80-1.54	0.59-1.16	0.71-1.37	0.59-1.20	0.90-1.04
Ear discharge	22	10	14	9	13	
	1.00	0.53	0.66	0.39	0.53	0.89
		0.25-1.14	0.33-1.29	0.18-0.87	0.26-1.10	0.66-1.19
Skin rash*	20	9	29	20	22	
	1.00	0.52	1.41	0.99	1.27	1.06
		0.23-1.15	0.79-2.50	0.53-1.88	0.66-2.45	1.03-1.10
Infected cut	16	10	8	15	15	
	1.00	0.71	0.53	0.91	0.88	0.98
		0.32-1.59	0.22-1.24	0.44-1.89	0.41-1.85	0.86-1.12
Nausea*	74	65	83	82	80	
	1.00	1.06	1.20	1.17	1.14	1.04
		0.75-1.48	0.87-1.66	0.85-1.63	0.81-1.59	1.01-1.06
Vomiting	35	30	43	36	38	
	1.00	1.08	1.33	1.18	1.34	1.03
		0.66-1.76	0.84-2.08	0.74-1.90	0.82-2.17	0.99-1.08
Diarrhea*	106	116	113	103	118	
	1.00	1.26	1.12	0.96	1.05	1.03
		0.96-1.66	0.85-1.47	0.72-1.28	0.79-1.40	1.01-1.05
Diarrhea with blood	3	1	2	2	3	
	1.00	0.42	0.71	0.69	1.01	1.05
		0.04-4.07	0.12-4.27	0.11-4.24	0.19-5.39	0.91-1.22
Stomach pain	128	121	139	119	142	
	1.00	1.13	1.17	0.99	1.18	1.02
		0.87-1.46	0.91-1.50	0.76-1.28	0.91-1.53	0.99-1.05
Cough*	145	128	168	7	130	
	1.00	1.07	1.25	1.29	1.06	1.03
		0.84-1.38	0.99-1.57	1.02-1.63	0.82-1.38	1.01-1.05
Cough & phlegm	72	67	74	77	66	
	1.00	1.15	1.09	1.18	1.08	1.02
		0.82-1.62	0.79-1.52	0.85-1.65	0.76-1.55	0.99-1.06

Table 46 (continued)

Runny* Nose	198 1.00	175 1.05 0.84-1.30	206 1.11 0.90-1.36	185 0.99 0.80-1.23	190 1.07 0.85-1.33	 1.02 1.00-1.05
Sore Throat	136 1.00	133 1.18 0.92-1.51	158 1.25 0.98-1.59	161 1.29 1.01-1.64	115 0.92 0.70-1.20	 1.01 0.98-1.04
HCGI 1*	70 1.00	52 0.90 0.62-1.29	73 1.11 0.79-1.55	58 0.89 0.62-1.28	64 1.02 0.71-1.46	 1.04 1.02-1.07
HCGI 2*	15 1.00	11 0.93 0.42-2.04	29 2.11 1.12-3.96	17 1.22 0.60-2.47	21 1.49 0.74-2.97	 1.04 1.00-1.09
Signif. resp. disease	128 1.00	106 1.01 0.77-1.32	127 1.06 0.82-1.36	130 1.11 0.86-1.44	103 0.92 0.70-1.22	 1.01 0.97-1.04

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

Table 47. Risks For High vs. Low Total Coliform Indicator Counts

ALL BEACHES

SYMPTOMS	Total Exposed = 847 > 10,000 cfu		Total Unexposed = 9562 ≤ 10,000 cfu				
	Ill	Risk	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	44	0.052	456	0.048	1.09	0.81	1.47
Chills	11	0.013	244	0.026	0.51	0.28	0.93
Eye discharge	18	0.021	172	0.018	1.18	0.73	1.91
Earache	22	0.026	336	0.035	0.74	0.48	1.13
Ear discharge	2	0.002	66	0.007	0.34	0.08	1.39
Skin rash*	21	0.025	79	0.008	3.00	1.86	4.83
Infected cut	4	0.005	60	0.006	0.75	0.27	2.07
Nausea	23	0.027	361	0.038	0.72	0.47	1.09
Vomiting	11	0.013	171	0.018	0.73	0.40	1.33
Diarrhea	37	0.044	519	0.054	0.80	0.58	1.12
Diarrhea w/ blood	1	0.001	10	0.001	1.13	0.14	8.81
Stomach pain	37	0.044	612	0.064	0.68	0.49	0.94
Coughing	59	0.070	679	0.071	0.98	0.76	1.27
Phlegm	31	0.037	325	0.034	1.08	0.75	1.55
Nasal congestion	81	0.096	873	0.091	1.05	0.84	1.30
Sore throat	53	0.063	650	0.068	0.92	0.70	1.21
HCGI 1	21	0.025	296	0.031	0.80	0.52	1.24
HCGI 2	5	0.006	88	0.009	0.64	0.26	1.58
SRD	46	0.054	480	0.050	1.08	0.81	1.45

* statistically significant at $p < 0.05$

Table 48. Risks For High vs. Low Bacterial Indicators

total coliforms

	> 1000 cfu		> 10,000 cfu	
Symptoms	**RR**	**95% CI**	**RR**	**95% CI**
Fever	0.97	0.80 , 1.17	1.11	0.82 , 1.49
Chills	0.86	0.65 , 1.14	0.51	0.28 , 0.93
Eye discharge	0.69	0.49 , 0.98	1.18	0.73 , 1.91
Earache	0.87	0.69 , 1.10	0.74	0.48 , 1.13
Ear discharge	0.87	0.51 , 1.51	0.34	0.08 , 1.37
Skin rash*	1.44	0.96 , 2.17	3.00	1.87 , 4.84
Infected cut	0.82	0.46 , 1.46	0.75	0.27 , 2.07
Nausea	0.84	0.67 , 1.06	0.72	0.47 , 1.09
Vomiting	0.87	0.62 , 1.22	0.72	0.39 , 1.32
Diarrhea	0.75	0.62 , 0.92	0.80	0.58 , 1.11
Diarrhea w/ blood	1.00	0.27 , 3.78	1.13	0.14 , 8.82
Stomach pain	0.88	0.74 , 1.05	0.68	0.49 , 0.94
Coughing	0.95	0.82 , 1.12	0.98	0.76 , 1.27
Phlegm	0.88	0.69 , 1.11	1.06	0.74 , 1.53
Nasal congestion	0.96	0.84 , 1.10	1.04	0.84 , 1.29
Sore throat	0.84	0.71 , 1.00	0.91	0.70 , 1.20
HCGI_1	0.83	0.64, 1.07	0.80	0.52, 1.24
HCGI_2	0.78	0.48 , 1.26	0.64	0.26 , 1.58
SRD	0.88	0.72, 1.06	1.07	0.80, 1.43

*** statistically significant at $p < 0.05$**

3-428

Table 49. Crude Odds Ratios and 95% Confidence Intervals for Total Coliform by Quintiles and From a Linear Model.

	Quintile					linear model*
	1	2	3	4	5	
midpoints:	22.75	86.00	259.75	834.25	6680.00	
# exposed:	2108	2102	2059	2062	2078	
Fever	96.00	103.00	115.00	84.00	102.00	
	1.00	1.08	1.24	0.89	1.08	0.99
		0.81-1.44	0.94-1.64	0.66-1.20	0.81-1.44	0.96-1.02
Chills	53.00	62.00	52.00	46.00	42.00	
	1.00	1.18	1.00	0.88	0.80	0.98
		0.81-1.71	0.68-1.48	0.59-1.32	0.53-1.20	0.94-1.03
Eye discharge	24.00	55.00	51.00	28.00	32.00	
	1.00	2.33	2.21	1.20	1.36	1.01
		1.44-3.78	1.35-3.60	0.69-2.07	0.80-2.31	0.98-1.04
Earache	77.00	73.00	82.00	64.00	62.00	
	1.00	0.95	1.09	0.84	0.81	0.96
		0.68-1.31	0.80-1.50	0.60-1.18	0.58-1.14	0.90-1.01
Ear discharge	16.00	13.00	18.00	9.00	12.00	
	1.00	0.81	1.15	0.57	0.76	0.76
		0.39-1.70	0.59-2.27	0.25-1.30	0.36-1.61	0.51-1.13
Skin rash*	13.00	14.00	30.00	14.00	29.00	
	1.00	1.08	2.38	1.10	2.28	1.01
		0.51-2.30	1.24-4.58	0.52-2.35	1.18-4.40	0.97-1.05
Infected cut	18.00	10.00	12.00	12.00	12.00	
	1.00	0.56	0.68	0.68	0.67	1.02
		0.26-1.21	0.33-1.42	0.33-1.41	0.32-1.40	0.98-1.05
Nausea	69.00	93.00	92.00	65.00	65.00	
	1.00	1.37	1.38	0.96	0.95	1.00
		1.00-1.88	1.01-1.90	0.68-1.36	0.68-1.35	0.98-1.03
Vomiting	31.00	37.00	45.00	36.00	33.00	
	1.00	1.20	1.50	1.19	1.08	1.01
		0.74-1.94	0.94-2.38	0.73-1.93	0.66-1.77	0.98-1.04
Diarrhea	110.00	130.00	139.00	92.00	85.00	
	1.00	1.20	1.31	0.85	0.77	0.99
		0.92-1.56	1.02-1.70	0.64-1.13	0.58-1.04	0.97-1.02
Diarrhea with blood	2.00	2.00	3.00	2.00	2.00	
	1.00	1.00	1.54	1.02	1.01	0.88
		0.14-7.13	0.26-9.21	0.14-7.26	0.14-7.21	0.47-1.64
Stomach pain	134.00	132.00	139.00	131.00	113.00	
	1.00	0.99	1.07	1.00	0.85	1.00
		0.77-1.27	0.83-1.36	0.78-1.28	0.65-1.10	0.99-1.02
Cough	142.00	150.00	177.00	121.00	148.00	
	1.00	1.06	1.30	0.86	1.06	1.01
		0.84-1.35	1.03-1.64	0.67-1.11	0.84-1.35	0.99-1.02
Cough & phlegm	72.00	74.00	83.00	53.00	74.00	
	1.00	1.03	1.19	0.75	1.04	1.00
		0.74-1.44	0.86-1.64	0.52-1.07	0.75-1.45	0.98-1.03

Table 49 (continued)

Runny nose	196.00 1.00	191.00 0.97 0.79-1.20	207.00 1.09 0.89-1.34	167.00 0.86 0.69-1.07	193.00 1.00 0.81-1.23	 1.01 1.00-1.02
Sore throat	134.00 1.00	159.00 1.21 0.95-1.53	157.00 1.22 0.96-1.54	129.00 0.98 0.77-1.26	124.00 0.93 0.73-1.20	 1.00 0.98-1.02
HCGI 1	63.00 1.00	67.00 1.07 0.75-1.52	73.00 1.19 0.85-1.68	59.00 0.96 0.67-1.37	55.00 0.88 0.61-1.27	 1.01 0.99-1.03
HCGI 2	12.00 1.00	20.00 1.68 0.82-3.44	30.00 2.58 1.32-5.06	15.00 1.28 0.60-2.74	16.00 1.36 0.64-2.87	 0.90 0.75-1.09
Signif. resp. disease	117.00 1.00	131.00 1.13 0.87-1.46	137.00 1.21 0.94-1.56	91.00 0.79 0.59-1.04	118.00 1.02 0.79-1.33	 1.00 0.98-1.02

* Noteworthy results.

Table 50. Adjusted odds ratios and 95% confidence intervals for total coliform by quintiles and from a linear model. Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

	Quintile					linear model*
	1	2	3	4	5	
midpoints:	22.75	86.00	259.75	834.25	6680.00	
# exposed:	2108	2102	2059	2062	2078	
Fever	96.00 1.00	103.00 1.08 0.81-1.44	115.00 1.26 0.95-1.67	84.00 0.91 0.67-1.23	102.00 1.11 0.82-1.50	0.99 0.96-1.02
Chills	53.00 1.00	62.00 1.20 0.82-1.74	52.00 1.07 0.72-1.59	46.00 0.94 0.63-1.40	42.00 0.86 0.56-1.32	0.99 0.95-1.03
Eye discharge	24.00 1.00	55.00 2.24 1.38-3.64	51.00 2.15 1.31-3.54	28.00 1.19 0.68-2.06	32.00 1.20 0.69-2.08	1.01 0.98-1.03
Earache	77.00 1.00	73.00 0.94 0.68-1.31	82.00 1.08 0.78-1.49	64.00 0.85 0.60-1.19	62.00 0.84 0.59-1.21	0.96 0.91-1.02
Ear discharge	16.00 1.00	13.00 0.84 0.40-1.76	18.00 1.26 0.63-2.52	9.00 0.63 0.27-1.43	12.00 0.91 0.41-2.04	0.80 0.54-1.17
Skin rash*	13.00 1.00	14.00 1.07 0.50-2.29	30.00 2.32 1.19-4.53	14.00 1.10 0.51-2.36	29.00 2.10 1.05-4.21	1.01 0.97-1.04
Infected cut	18.00 1.00	10.00 0.57 0.26-1.23	12.00 0.66 0.31-1.40	12.00 0.70 0.33-1.46	12.00 0.81 0.37-1.76	1.03 0.99-1.06
Nausea	69.00 1.00	93.00 1.38 1.00-1.90	92.00 1.43 1.04-1.98	65.00 1.00 0.71-1.41	65.00 1.06 0.74-1.52	1.01 0.99-1.03
Vomiting	31.00 1.00	37.00 1.20 0.74-1.95	45.00 1.61 1.01-2.58	36.00 1.26 0.77-2.05	33.00 1.08 0.64-1.81	1.01 0.99-1.04
Diarrhea	110.00 1.00	130.00 1.23 0.94-1.60	139.00 1.33 1.03-1.74	92.00 0.86 0.65-1.15	85.00 0.90 0.66-1.22	1.00 0.98-1.03
Diarrhea with blood	2.00 1.00	2.00 1.13 0.16-8.09	3.00 2.10 0.34-13.00	2.00 1.21 0.17-8.68	2.00 1.42 0.18-11.37	0.92 0.51-1.65
Stomach pain	134.00 1.00	132.00 1.00 0.78-1.28	139.00 1.10 0.86-1.41	131.00 1.03 0.80-1.32	113.00 0.94 0.72-1.23	1.01 0.99-1.03
Cough	142.00 1.00	150.00 1.04 0.82-1.33	177.00 1.30 1.03-1.64	121.00 0.87 0.68-1.12	148.00 1.03 0.80-1.32	1.01 0.99-1.02

Table 50 (continued)

Cough & phlegm	72.00 1.00	74.00 1.04 0.74-1.45	83.00 1.21 0.87-1.68	53.00 0.78 0.54-1.12	74.00 1.06 0.74-1.50	1.00 0.98-1.03
Runny nose	196.00 1.00	191.00 0.97 0.78-1.19	207.00 1.08 0.87-1.33	167.00 0.86 0.69-1.07	193.00 1.02 0.82-1.27	1.02 1.00-1.03
Sore throat	134.00 1.00	159.00 1.20 0.94-1.53	157.00 1.22 0.96-1.56	129.00 1.00 0.77-1.28	124.00 0.95 0.73-1.24	1.00 0.99-1.02
HCGI 1	63.00 1.00	67.00 1.06 0.75-1.51	73.00 1.23 0.87-1.75	59.00 0.99 0.69-1.42	55.00 0.90 0.61-1.32	1.01 0.99-1.03
HCGI 2	12.00 1.00	20.00 1.80 0.87-3.71	30.00 3.02 1.52-5.99	15.00 1.45 0.67-3.11	16.00 1.68 0.76-3.69	0.93 0.77-1.11
Signif. resp. disease	117.00 1.00	131.00 1.13 0.87-1.46	137.00 1.24 0.95-1.60	91.00 0.81 0.61-1.07	118.00 1.03 0.78-1.37	1.00 0.99-1.02

* Noteworthy results.

Table 51. Risks For High vs. Low Fecal Coliform Indicator Counts

ALL BEACHES

	Total Exposed = 1636		Total Unexposed = 8773				
	> 400 cfu		≤ 400 cfu				
SYMPTOMS	Ill	Risks	Ill	Risks	RR	Lower 95% CI	Upper 95% CI
Fever	80	0.049	420	0.048	1.02	0.81	1.29
Chills	34	0.021	221	0.025	0.82	0.58	1.18
Eye discharge	30	0.018	160	0.018	1.01	0.68	1.48
Earache	57	0.035	301	0.034	1.02	0.77	1.34
Ear discharge	7	0.004	61	0.007	0.62	0.28	1.34
Skin rash*	26	0.016	74	0.008	1.88	1.21	2.94
Infected cut	15	0.009	49	0.006	1.64	0.92	2.92
Nausea	57	0.035	327	0.037	0.93	0.71	1.23
Vomiting	31	0.019	151	0.017	1.10	0.75	1.61
Diarrhea	81	0.050	475	0.054	0.91	0.73	1.15
Diarrhea w/ blood	3	0.002	8	0.001	2.01	0.53	7.57
Stomach pain	103	0.063	546	0.062	1.01	0.83	1.24
Coughing	117	0.072	621	0.071	1.01	0.84	1.22
Phlegm	60	0.037	296	0.034	1.09	0.83	1.43
Nasal congestion	160	0.098	794	0.091	1.08	0.92	1.27
Sore throat	106	0.065	597	0.068	0.95	0.78	1.16
HCGI 1	50	0.031	267	0.030	1.00	0.75	1.35
HCGI 2	17	0.010	76	0.009	1.20	0.71	2.02
SRD	85	0.052	441	0.050	1.03	0.82	1.30

* statistically significant at $p < 0.05$

Table 52. Risks For High vs. Low Bacterial Indicators

fecal coliforms

	> 200 cfu		> 400 cfu	
Symptoms	**RR**	**95% CI**	**RR**	**95% CI**
Fever	1.04	0.85 , 1.26	1.02	0.81 , 1.29
Chills	0.98	0.73 , 1.30	0.82	0.57 , 1.17
Eye discharge	0.91	0.65 , 1.28	1.00	0.68 , 1.47
Earache	1.00	0.78 , 1.27	1.01	0.76 , 1.33
Ear discharge	0.92	0.52 , 1.63	0.60	0.28 , 1.31
Skin rash*	1.49	0.98 , 2.27	1.87	1.20 , 2.92
Infected cut	1.20	0.69 , 2.08	1.63	0.92 , 2.91
Nausea	1.09	0.86 , 1.36	0.93	0.70 , 1.22
Vomiting	1.21	0.88 , 1.68	1.09	0.74 , 1.60
Diarrhea	1.01	0.84 , 1.22	0.90	0.72 , 1.14
Diarrhea w/ blood	1.89	0.55 , 6.46	2.00	0.53 , 7.53
Stomach pain	1.02	0.86 , 1.22	1.00	0.82 , 1.23
Coughing	1.13	0.97 , 1.33	1.02	0.84 , 1.23
Phlegm	1.15	0.92 , 1.46	1.11	0.85 , 1.45
Nasal congestion	1.07	0.93 , 1.23	1.08	0.92 , 1.27
Sore throat	1.10	0.94 , 1.30	0.94	0.77 , 1.15
HCGI 1	1.08	0.84 , 1.38	1.00	0.74 , 1.34
HCGI 2	1.43	0.92 , 2.23	1.20	0.71 , 2.02
SRD	1.06	0.88 , 1.29	1.05	0.84 , 1.31

*** statistically significant at $p < 0.05$**

Table 53. Crude Odds Ratios and 95% Confidence Intervals for Fecal Coliform by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints:	5.00	20.25	51.25	130.00	642.25	
# exposed:	2093	2075	2106	2133	2002	
Fever*	105 1.00	82 0.78 0.58-1.05	107 1.01 0.77-1.34	110 1.03 0.78-1.35	96 0.95 0.72-1.27	1.05 1.00-1.10
Chills	63 1.00	47 0.75 0.51-1.09	46 0.72 0.49-1.06	57 0.88 0.62-1.27	42 0.69 0.47-1.03	0.91 0.80-1.04
Eye discharge	46 1.00	27 0.59 0.36-0.95	42 0.91 0.59-1.38	40 0.85 0.55-1.30	35 0.79 0.51-1.23	1.04 0.96-1.12
Earache	90 1.00	64 0.71 0.51-0.98	67 0.73 0.53-1.01	69 0.74 0.54-1.02	68 0.78 0.57-1.08	0.89 0.79-1.00
Ear discharge	20 1.00	11 0.55 0.26-1.16	17 0.84 0.44-1.61	10 0.49 0.23-1.05	10 0.52 0.24-1.11	0.90 0.69-1.17
Skin rash*	15 1.00	13 0.87 0.41-1.84	30 2.00 1.07-3.73	13 0.85 0.40-1.79	29 2.04 1.09-3.81	1.10 1.03-1.17
Infected cut	11 1.00	18 1.66 0.78-3.52	13 1.18 0.53-2.63	5 0.44 0.15-1.28	17 1.62 0.76-3.47	1.01 0.85-1.19
Nausea	82 1.00	79 0.97 0.71-1.33	68 0.82 0.59-1.14	82 0.98 0.72-1.34	73 0.93 0.67-1.28	1.04 0.98-1.10
Vomiting	35 1.00	32 0.92 0.57-1.49	39 1.11 0.70-1.76	35 0.98 0.61-1.57	41 1.23 0.78-1.94	1.05 0.98-1.13
Diarrhea	120 1.00	105 0.88 0.67-1.15	109 0.90 0.69-1.17	125 1.02 0.79-1.32	97 0.84 0.64-1.10	1.04 0.99-1.09
Diarrhea with blood	2 1.00	0 0.00 0.00-+INF	2 0.99 0.14-7.06	4 1.96 0.36-10.74	3 1.57 0.26-9.40	0.94 0.54-1.65
Stomach pain	145 1.00	118 0.81 0.63-1.04	122 0.83 0.64-1.06	137 0.92 0.72-1.17	127 0.91 0.71-1.16	1.01 0.96-1.07
Cough	134 1.00	146 1.11 0.87-1.41	142 1.06 0.83-1.35	172 1.28 1.01-1.62	144 1.13 0.89-1.45	1.03 0.99-1.08
Cough & phlegm	63 1.00	78 1.26 0.90-1.76	69 1.09 0.77-1.54	76 1.19 0.85-1.67	70 1.17 0.83-1.65	1.01 0.94-1.08

Table 53 (continued)

Runny nose	199 1.00	192 0.97 0.79-1.20	170 0.84 0.67-1.04	206 1.02 0.83-1.25	187 0.98 0.80-1.21	 1.03 0.99-1.08
Sore throat	138 1.00	143 1.05 0.82-1.34	143 1.03 0.81-1.31	145 1.03 0.81-1.32	134 1.02 0.79-1.30	 1.01 0.96-1.06
HCGI 1*	72 1.00	59 0.82 0.58-1.17	59 0.81 0.57-1.15	61 0.83 0.58-1.17	66 0.96 0.68-1.34	 1.06 1.00-1.12
HCGI 2	16 1.00	12 0.76 0.36-1.60	21 1.31 0.68-2.51	23 1.42 0.75-2.69	21 1.38 0.72-2.64	 1.06 0.97-1.16
Signif. resp. disease	114 1.00	120 1.07 0.82-1.39	124 1.09 0.84-1.41	127 1.10 0.85-1.43	109 1.00 0.76-1.31	 1.00 0.95-1.06

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

Table 54. Adjusted Odds Ratios and 95% Confidence Intervals for Fecal Coliform by Quintiles and from a Linear Model.†

	Quintile (cfu)					linear model
	1	2	3	4	5	
midpoints:	5.00	20.25	51.25	130.00	642.25	
# exposed:	2093	2075	2106	2133	2002	
Fever	105 1.00	82 0.78 0.58-1.04	107 1.00 0.76-1.32	110 1.03 0.78-1.35	96 0.91 0.68-1.22	1.05 1.00-1.10
Chills	63 1.00	47 0.73 0.50-1.07	46 0.72 0.49-1.05	57 0.88 0.61-1.27	42 0.62 0.42-0.93	0.90 0.79-1.04
Eye discharge	46 1.00	27 0.60 0.37-0.98	42 0.90 0.59-1.38	40 0.86 0.56-1.32	35 0.80 0.51-1.25	1.03 0.95-1.12
Earache	90 1.00	64 0.69 0.50-0.96	67 0.72 0.52-1.00	69 0.72 0.52-0.99	68 0.74 0.54-1.03	0.89 0.79-1.01
Ear discharge	20 1.00	11 0.52 0.25-1.08	17 0.81 0.42-1.56	10 0.46 0.22-0.99	10 0.44 0.20-0.95	0.89 0.67-1.18
Skin rash*	15 1.00	13 0.90 0.43-1.91	30 1.94 1.04-3.63	13 0.83 0.39-1.76	29 2.02 1.07-3.81	1.11 1.04-1.19
Infected cut	11 1.00	18 1.58 0.74-3.37	13 1.16 0.52-2.60	5 0.41 0.14-1.19	17 1.51 0.70-3.26	1.01 0.86-1.19
Nausea	82 1.00	79 0.95 0.69-1.30	68 0.81 0.58-1.12	82 0.95 0.70-1.31	73 0.86 0.62-1.19	1.04 0.98-1.10
Vomiting	35 1.00	32 0.93 0.57-1.51	39 1.11 0.70-1.77	35 1.01 0.63-1.62	41 1.17 0.74-1.85	1.06 0.98-1.14
Diarrhea	120 1.00	105 0.83 0.63-1.09	109 0.87 0.67-1.14	125 0.97 0.75-1.26	97 0.75 0.57-0.99	1.04 0.99-1.09
Diarrhea with blood	2 1.00	0 0.00 0.00-+INF	2 0.92 0.13-6.61	4 2.09 0.38-11.48	3 1.22 0.20-7.44	0.92 0.49-1.75
Stomach pain	145 1.00	118 0.78 0.61-1.01	122 0.81 0.63-1.05	137 0.90 0.70-1.14	127 0.84 0.65-1.08	1.01 0.96-1.07
Cough	134 1.00	146 1.13 0.88-1.44	142 1.07 0.84-1.36	172 1.29 1.02-1.64	144 1.14 0.89-1.46	1.03 0.99-1.08
Cough & phlegm	63 1.00	78 1.27 0.91-1.79	69 1.11 0.78-1.57	76 1.20 0.85-1.69	70 1.15 0.81-1.63	1.01 0.94-1.09

Table 54 (continued)

Runny nose	199 1.00	192 0.97 0.78-1.19	170 0.83 0.67-1.03	206 1.00 0.81-1.23	187 0.96 0.77-1.18	1.04 1.00-1.08
Sore throat	138 1.00	143 1.05 0.82-1.34	143 1.03 0.81-1.31	145 1.02 0.80-1.30	134 0.99 0.77-1.27	1.01 0.96-1.06
HCGI 1*	72 1.00	59 0.82 0.57-1.16	59 0.80 0.57-1.14	61 0.83 0.58-1.17	66 0.91 0.64-1.28	1.06 1.01-1.12
HCGI 2	16 1.00	12 0.73 0.34-1.55	21 1.30 0.67-2.50	23 1.43 0.75-2.72	21 1.22 0.63-2.35	1.07 0.97-1.18
Signif. resp. disease	114 1.00	120 1.08 0.83-1.40	124 1.09 0.84-1.42	127 1.10 0.85-1.43	109 0.98 0.75-1.29	1.00 0.94-1.06

* Statistically significant at $p<.05$.

† Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

Table 55. Risks For Total/Fecal Coliform Ratios < 5 vs. Ratios ≥ 5

ALL BEACHES

SYMPTOMS	Total exposed = 5769 T/F ratio < 5		Total unexposed = 4640 T/F ratio ≥ 5				
	Ill	Risk	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	289	0.050	211	0.045	1.10	0.93	1.31
Chills	153	0.027	102	0.022	1.21	0.94	1.55
Eye discharge	103	0.018	87	0.019	0.95	0.72	1.26
Earache	211	0.037	147	0.032	1.15	0.94	1.42
Ear discharge	40	0.007	28	0.006	1.15	0.71	1.86
Skin rash	54	0.009	46	0.010	0.94	0.64	1.40
Infected cut	40	0.007	24	0.005	1.34	0.81	2.22
Nausea	216	0.037	168	0.036	1.03	0.85	1.26
Vomiting	107	0.019	75	0.016	1.15	0.86	1.54
Diarrhea*	341	0.059	215	0.046	1.28	1.08	1.51
Diarrhea w/ blood	8	0.001	3	0.001	2.14	0.57	8.08
Stomach pain	369	0.064	280	0.060	1.06	0.91	1.23
Coughing	427	0.074	311	0.067	1.10	0.96	1.27
Phlegm	200	0.035	156	0.034	1.03	0.84	1.27
Nasal congestion	538	0.093	416	0.090	1.04	0.92	1.18
Sore throat	409	0.071	294	0.063	1.12	0.97	1.29
HCGI 1	185	0.032	132	0.028	1.13	0.90	1.40
HCGI 2*	65	0.011	28	0.006	1.87	1.20	2.90
SRD	299	0.052	227	0.049	1.06	0.90	1.25

* statistically significant at $p < 0.05$

EGT-139

Table 56. Risks For Total/Fecal Coliform Ratios < 5 vs. Ratios ≥ 5

TOTAL COLIFORMS > 5000

SYMPTOMS	Total exposed = 34 T/F ratio < 5		Total unexposed = 1362 T/F ratio ≥ 5				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever *	5	0.147	71	0.052	2.82	1.22	6.54
Chills	0	0.000	25	0.018	0.00	--	--
Eye discharge *	3	0.088	24	0.018	5.01	1.58	15.83
Earache	0	0.000	35	0.026	0.00	--	--
Ear discharge	1	0.029	6	0.004	6.68	0.83	53.95
Skin rash *	3	0.088	22	0.016	5.46	1.72	17.38
Infected cut	0	0.000	7	0.005	0.00	--	--
Nausea *	4	0.118	34	0.025	4.71	1.77	12.54
Vomiting	1	0.029	19	0.014	2.11	0.29	15.30
Diarrhea *	4	0.118	53	0.039	3.02	1.16	7.88
Diarrhea w/ blood	0	0.000	2	0.001	0.00	--	--
Stomach pain *	5	0.147	72	0.053	2.78	1.20	6.44
Coughing	5	0.147	112	0.082	1.79	0.78	4.10
Phlegm	3	0.088	54	0.040	2.23	0.73	6.76
Nasal congestion *	7	0.206	132	0.097	2.12	1.08	4.19
Sore throat	3	0.088	88	0.065	1.37	0.45	4.10
HCGI 1 *	3	0.088	33	0.024	3.64	1.17	11.29
HCGI 2	1	0.029	6	0.004	6.68	0.83	53.95
SRD *	5	0.147	74	0.054	2.71	1.17	6.27

* statistically significant at $p < 0.05$

Table 57. Risks For Total/Fecal Coliform Ratios < 5 vs. Ratios ≥ 5

TOTAL COLIFORMS > 10,000

SYMPTOMS	Total exposed 21 T/F ratio < 5		Total unexposed 826 T/F ratio ≥ 5				
	Ill	Risks	Ill	Risks	RR	Lower 95%CI	Upper 95% CI
Fever	3	0.143	41	0.050	2.88	0.97	8.55
Chills	0	0.000	11	0.013	0.00	--	--
Eye discharge *	3	0.143	15	0.018	7.87	2.46	25.13
Earache	0	0.000	22	0.027	0.00	--	--
Ear discharge *	1	0.048	1	0.001	39.33	2.55	607.82
Skin rash *	3	0.143	18	0.022	6.56	2.09	20.56
Infected cut	0	0.000	4	0.005	0.00	--	--
Nausea *	3	0.143	20	0.024	5.90	1.90	18.33
Vomiting	1	0.048	10	0.012	3.93	0.53	29.34
Diarrhea *	4	0.190	33	0.040	4.77	1.86	12.24
Diarrhea w/ blood	0	0.000	1	0.001	0.00	--	--
Stomach pain *	4	0.190	33	0.040	4.77	1.86	12.24
Coughing	3	0.143	56	0.068	2.11	0.72	6.19
Phlegm	1	0.048	30	0.036	1.31	0.19	9.17
Nasal congestion *	5	0.238	76	0.092	2.59	1.17	5.73
Sore throat	1	0.048	52	0.063	0.76	0.11	5.22
HCGI 1 *	3	0.143	18	0.022	6.56	2.09	20.56
HCGI 2 *	1	0.048	4	0.005	9.83	1.15	84.26
SRD	3	0.143	43	0.052	2.74	0.93	8.14

* statistically significant at $p < 0.05$

Table 58. Risks For Total/Fecal Indicator Ratios < 5 vs. Ratios ≥ 5

ALL BEACHES

	all total coliforms		total coliforms > 5000		total coliforms > 10,000	
Symptoms	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
Fever*	1.09	0.92 , 1.29	2.64	1.14 , 6.15	2.83	0.95 , 8.41
Chills	1.12	0.94 , 1.54	0.00	--	0.00	--
Eye discharge*	0.95	0.72 , 1.26	4.76	1.50 , 15.1	7.93	2.48 , 25.3
Earache	1.16	0.94 ,1.43	0.00	--	0.00	--
Ear discharge*	1.18	0.73 , 1.90	6.35	0.78 , 51.4	39.67	2.57 , 612
Skin rash*	0.94	0.64 , 1.40	5.19	1.63 , 16.6	6.61	2.11 , 20.7
Infected cut	1.34	0.81 , 2.22	0.00	--	0.00	--
Nausea*	1.03	0.84 , 1.25	4.48	1.68 , 12.0	5.95	1.92 , 18.5
Vomiting	1.16	0.86 , 1.55	2.00	0.28 , 14.6	3.97	0.53 , 29.6
Diarrhea*	1.28	1.08 , 1.51	2.87	1.10 , 7.51	4.81	1.87 , 12.4
Diarrhea w/ blood	2.14	0.57 , 8.08	0.00	--	0.00	--
Stomach pain*	1.07	0.92 , 1.24	2.64	1.14 , 6.15	4.81	1.87 , 12.4
Coughing	1.09	0.95 , 1.25	1.69	0.73 , 3.87	2.09	0.71 , 6.13
Phlegm	1.03	0.84 , 1.26	2.12	0.69 , 6.45	1.32	0.19 , 9.24
Nasal congestion*	1.04	0.92 , 1.17	2.02	1.02 , 4.00	2.61	1.18 , 5.78
Sore throat	1.11	0.96 , 1.29	1.30	0.43 , 3.91	0.76	0.11 , 5.26
HCGI 1*	1.13	0.91 , 1.41	3.46	1.11 , 10.8	6.61	2.11 , 20.7
HCGI 2*	1.87	1.20 , 2.90	6.68	0.83 , 54.0	9.83	1.15 , 84.3
SRD*	1.05	0.89 , 1.24	2.57	1.11 , 5.98	2.77	0.93 , 8.21

*** statistically significant at $p < 0.05$ in at least one set of results**

Table 59a. Odds Ratios and 95% Confidence Intervals for Ratio of Total to Fecal Coliform, Dichotomizing by Cutpoints at 2, 4, 6, and 8. The Number of Diseased Subjects are Given on the First Line for Each Outcome.

	Cutpoint			
	2	4	6	8
# exposed:	3450	5425	6267	6783
Fever	168.00 1.02 9.84-1.24	272.00 1.10 0.92-1.32	315.00 1.13 0.94-1.36	337.00 1.11 0.92-1.35
Chills	80.00 0.92 0.70-1.20	144.00 1.20 0.93-1.54	163.00 1.18 0.91-1.52	173.00 1.13 0.87-1.48
Eye discharge	64.00 1.03 0.76-1.39	97.00 0.96 0.72-1.28	108.00 0.87 0.65-1.16	125.00 1.03 0.76-1.39
Earache	124.00 1.07 0.86-1.34	197.00 1.13 0.91-1.40	228.00 1.17 0.94-1.45	245.00 1.16 0.93-1.46
Ear discharge	26.00 1.25 0.77-2.04	37.00 1.10 0.68-1.77	42.00 1.07 0.65-1.74	45.00 1.05 0.63-1.73
Skinrash	29.00 0.82 0.53-1.27	50.00 0.92 0.62-1.36	60.00 0.99 0.66-1.48	65.00 0.99 0.66-1.50
Infected cut	23.00 1.13 0.68-1.89	36.00 1.18 0.72-1.94	43.00 1.36 0.80-2.29	47.00 1.48 0.85-2.58
Nausea	129.00 1.02 0.82-1.27	209.00 1.10 0.90-1.35	243.00 1.14 0.93-1.41	266.00 1.21 0.97-1.51
Vomiting	63.00 1.07 0.79-1.45	100.00 1.12 0.84-1.51	119.00 1.25 0.92-1.71	123.00 1.12 0.82-1.53
Diarrhea*	200.00 1.14 0.96-1.36	321.00 1.27 1.07-1.51*	367.00 1.30 1.09-1.56*	400.00 1.39* 1.15-1.68*
Diarrhea with blood*	7.00 3.54 1.03-12.08*	8.00 2.45 0.65-9.25	8.00 1.76 0.47-6.65	8.00 1.43 0.38-5.38*
Stomach pain	232.00 1.13 0.96-1.34	347.00 1.06 0.90-1.24	394.00 1.02 0.87-1.20	426.00 1.02 0.87-1.21
Cough	269.00 1.17 1.00-1.37	403.00 1.11 0.96-1.29	461.00 1.11 0.95-1.29	496.00 1.10 0.94-1.29
Cough & phlegm	132.00 1.20 0.96-1.49	193.00 1.09 0.88-1.35	222.00 1.10 0.88-1.37	235.00 1.04 0.83-1.30

Table 59A (continued)

Runny nose	322.00 1.03 0.90-1.19	501.00 1.02 0.89-1.16	576.00 1.01 0.88-1.15	628.00 1.03 0.90-1.19
Sorethroat	257.00 1.18 1.00-1.38	386.00 1.13 0.97-1.32	441.00 1.12 0.96-1.31	476.00 1.13 0.96-1.33
HCGI-1	111.00 1.09 0.86-1.38	173.00 1.11 0.88-1.39	201.00 1.15 0.91-1.45	215.00 1.13 0.89-1.44
HCGI-2*	36.00 1.28 0.84-1.94	61.00 1.76 1.15-2.70*	70.00 2.02 1.26-3.25*	70.00 1.63 1.02-2.62*
Signif. resp disease	207.00 1.08 0.91-1.29	320.00 1.08 0.91-1.27	368.00 1.08 0.91-1.28	391.00 1.03 0.87-1.23

* Statistically significant at p<.05.

Table 59b. Crude Odds Ratios and 95% CIs for the Ratio of Total to Fecal Coliform, Restricted to Days When Total Coliform was > 1,000 cfu, and Using Cutpoints of 2, 4, 5, 6, and 8.

Outcome*	Cutpoint				
	2	4	5	6	8
# exposed:	710	1370	1503	1724	1941
Fever*	45.00 1.44 1.03-2.03	78.00 1.32 0.99-1.76	84.00 1.30 0.98-1.73	91.00 1.19 0.90-1.58	102.00 1.20 0.91-1.59
Chills*	13.00 0.88 0.49-1.59	37.00 1.58 1.03-2.42	39.00 1.51 0.99-2.31	42.00 1.39 0.91-2.12	44.00 1.23 0.81-1.88
Eye discharge	16.00 1.58 0.90-2.78	26.00 1.34 0.82-2.20	29.00 1.40 0.86-2.28	32.00 1.35 0.83-2.18	35.00 1.31 0.81-2.11
Earache	28.00 1.28 0.84-1.96	52.00 1.28 0.91-1.82	55.00 1.22 0.87-1.73	63.00 1.24 0.89-1.74	73.00 1.35 0.96-1.89
Ear discharge	3.00 0.73 0.22-2.44	9.00 1.30 0.57-2.97	9.00 1.13 0.49-2.58	11.00 1.28 0.57-2.86	13.00 1.45 0.65-3.25
Skin rash	6.00 0.80 0.34-1.90	13.00 0.90 0.47-1.73	14.00 0.87 0.46-1.65	18.00 1.04 0.57-1.91	22.00 1.23 0.68-2.23
Infected cut	5.00 1.34 0.50-3.61	9.00 1.30 0.57-2.97	9.00 1.13 0.49-2.58	10.00 1.08 0.48-2.43	13.00 1.45 0.65-3.25
Nausea*	30.00 1.18 0.79-1.77	67.00 1.58 1.15-2.18	70.00 1.48 1.08-2.04	79.00 1.49 1.09-2.05	86.00 1.45 1.05-1.99
Vomiting*	21.00 1.90 1.15-3.16	33.00 1.60 1.01-2.51	34.00 1.46 0.93-2.30	38.00 1.44 0.92-2.26	39.00 1.23 0.79-1.93
Diarrhea*	49.00 1.47 1.06-2.05	87.00 1.42 1.07-1.87	94.00 1.40 1.07-1.85	105.00 1.38 1.05-1.80	119.00 1.45 1.10-1.90
Diarrhea with blood	1.00 1.27 0.14-11.41	2.00 1.44 0.24-8.62	2.00 1.25 0.21-7.50	2.00 1.01 0.17-6.02	2.00 0.82 0.14-4.90
Stomach pain	45.00 1.11 0.80-1.55	83.00 1.06 0.81-1.39	90.00 1.05 0.80-1.36	100.00 0.99 0.76-1.29	115.00 1.03 0.80-1.33
Cough*	62.00 1.37 1.02-1.83	106.00 1.21 0.94-1.54	115.00 1.19 0.94-1.52	128.00 1.15 0.90-1.45	147.00 1.21 0.96-1.53
Cough & phlegm*	32.00 1.58 1.05-2.36	47.00 1.13 0.79-1.62	51.00 1.12 0.79-1.59	58.00 1.11 0.79-1.57	64.00 1.08 0.77-1.52

Table 59b (continued)

Runny nose*	93.00 1.60 1.25-2.05	140.00 1.16 0.93-1.44	155.00 1.19 0.96-1.47	171.00 1.12 0.91-1.38	198.00 1.20 0.98-1.47
Sore throat*	57.00 1.44 1.06-1.96	94.00 1.21 0.94-1.58	100.00 1.16 0.90-1.50	115.00 1.18 0.92-1.52	131.00 1.23 0.96-1.58
HCGI 1*	30.00 1.65 1.09-2.51	48.00 1.37 0.95-1.98	51.00 1.32 0.92-1.90	55.00 1.21 0.84-1.73	60.00 1.16 0.81-1.65
HCGI 2*	13.00 2.79 1.41-5.51	22.00 3.20 1.65-6.18	23.00 3.12 1.60-6.07	25.00 3.17 1.59-6.33	25.00 2.58 1.29-5.14
Signif. resp. disease	50.00 1.45 1.05-2.01	80.00 1.17 0.88-1.54	86.00 1.14 0.86-1.50	98.00 1.14 0.87-1.49	110.00 1.14 0.88-1.49

* Statistically significant ($P<0.05$ for at least one of the cutpoints).

Table 59c. Odds Ratios and 95% Confidence Intervals for Ratio of Total to Fecal Coliform, Dichotomizing by Cutpoints at 2, 4, 6, and 8, and Restricting Subjects to Those Swimming on Days When the Total Coliform Level at the Drain > 5,000 CFU. The Number of Diseased Subjects are Given on the First Line for Each Outcome.

	Cutpoint			
# exposed:	2 189	4 318	6 457	8 543
Fever*	18.00 2.21 1.30-3.73*	23.00 1.62 1.01-2.60*	28.00 1.33 0.86-2.06	34.00 1.40 0.93-2.11
Chills	6.00 1.95 0.81-4.68	8.00 1.53 0.70-3.33	10.00 1.31 0.64-2.69	10.00 1.05 0.51-2.15
Eye discharge	5.00 1.76 0.68-4.57	8.00 1.73 0.79-3.82	9.00 1.30 0.61-2.77	12.00 1.56 0.78-3.11
Earache*	9.00 1.68 0.82-3.43	17.00 2.04 1.17-3.57*	20.00 1.63 0.96-2.76	22.00 1.50 0.90-2.49
Ear discharge	2.00 1.78 0.40-7.94	3.00 1.61 0.45-5.75	4.00 1.52 0.48-4.80	6.00 2.25 0.80-6.35
Skinrash	3.00 1.28 0.39-4.27	5.00 1.29 0.49-3.40	5.00 0.83 0.32-2.19	8.00 1.22 0.54-2.76
Infected cut	1.00 1.28 0.16-10.16	1.00 0.71 0.09-5.65	1.00 0.46 0.06-3.66	1.00 0.37 0.05-2.90
Nausea*	12.00 2.35 1.24-4.45*	19.00 2.34 1.37-4.01*	23.00 1.97 1.19-3.26*	25.00 1.78 1.09-2.92*
Vomiting*	10.00 3.23 1.58-6.60*	14.00 2.81 1.49-5.31*	16.00 2.20 1,19-4.05*	16.00 1.75 0.95-3.23
Diarrhea*	22.00 3.20 1.95-5.24*	28.00 2.37 1.52-3.71*	33.00 1.90 1.25-2.90*	40.00 2.05 1.37-3.07*
Diarrhea with blood	1.00 3.85 0.40-37.20	2.00 6.47 0.91-46.08	2.00 4.19 0.59-29.80	2.00 3.36 0.47-23.90
Stomach pain	10.00 0.97 0.50-1.89	19.00 1.13 0.68-1.87	26.00 1.07 0.69-1.66	33.00 1.18 0.78-1.77
Cough*	28.00 2.31 1.50-3.57*	41.00 2.03 1.40-2.94*	48.00 1.58 1.11-2.23*	57.00 1.62 1.16-2.25*

Table 59c (continued)

Cough & phlegm	13.00 2.36 1.28-4.36*	17.00 1.81 1.04-3.13*	19.00 1.34 0.79-2.26	21.00 1.22 0.74-2.03
Runny nose	27.00 1.67 1.09-2.58*	43,00 1.61 1.13-2.30*	49.00 1.19 0.85-1.66	63.00 1.35 0.99-1,84
Sorethroat*	21.00 2.02 1.24-3.28*	28.00 1.55 1.01-2.38*	35.00 1.32 0.89-1.95	41.00 1.31 0.90-1.90
HCGI-1*	14.00 2.97 1.62-5,44*	18.00 2.26 1.30-3.90*	20.00 1.67 0.98-2.82	23.00 1.63 0.98-2.71
HCGI-2*	7.00 6.93 2.70-17.82*	9.00 5.93 2.39-14.71*	9.00 3.81 1.54-9.43*	9.00 3.05 1.23-7.55*
Signif. resp disease	18.00 1.92* 1.14-3.24*	28.00 1.82* 1.18-2.82*	33.00 1.44 0.95-2.16	37.00 1.34 0.91-1.99

* Statistically significant at p<.05.

Table 60. Crude odds ratios and 95% confidence intervals for the ratio of total to fecal coliform by quintiles and from a linear model. Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects in the quintiles are given on the first line for each exposure.

		Quintile				linear model*	
	1	2	3	4	5		
midpoints:	57.07	12.19	3.64	1.83	1.20		
# exposed:	2085	2082	2081	2080	2081		
Fever	101.00	85.00	119.00	84.00	111.00		
	1.00	0.84	1.19	0.83	1.11	0.98	
		0.62-1.12	0.91-1.56	0.61-1.11	0.84-1.46	0.90-1.07	
Chills	51.00	41.00	68.00	44.00	51.00		
	1.00	0.80	1.35	0.86	1.00	1.02	
		0.53-1.21	0.93-1.95	0.57-1.30	0.68-1.48	0.90-1.16	
Eye discharge	45.00	38.00	30.00	38.00	39.00		
	1.00	0.84	0.66	0.84	0.87	1.09	
		0.54-1.30	0.42-1.06	0.55-1.30	0.56-1.34	0.92-1.30	
Earache	80.00	51.00	76.00	79.00	72.00		
	1.00	0.63	0.95	0.99	0.90	1.01	
		0.44-0.90	0.69-1.31	0.72-1.36	0.65-1.24	0.91-1.12	
Ear discharge	17.00	10.00	9.00	14.00	18.00		
	1.00	0.59	0.53	0.82	1.06	0.91	
		0.27-1.29	0.23-1.19	0.41-1.68	0.55-2.07	0.75-1.11	
Skin rash	26.00	14.00	25.00	16.00	19.00		
	1.00	0.54	0.96	0.61	0.73	0.88	
		0.28-1.03	0.55-1.67	0.33-1.15	0.40-1.32	0.76-1.01	
Infected cut	10.00	11.00	13.00	16.00	14.00		
	1.00	1.10	1.30	1.61	1.41	1.39	
		0.47-2.60	0.57-2.98	0.73-3.55	0.62-3.17	0.88-2.21	
Nausea	77.00	65.00	87.00	71.00	84.00		
	1.00	0.84	1.14	0.92	1.10	1.08	
		0.60-1.18	0.83-1.56	0.66-1.28	0.80-1.50	0.96-1.22	
Vomiting	39.00	25.00	44.00	31.00	43.00		
	1.00	0.64	1.13	0.79	1.11	1.12	
		0.38-1.06	0.73-1.75	0.49-1.28	0.71-1.71	0.93-1.35	
Diarrhea	91.00	98.00	122.00	111.00	134.00		
	1.00	1.08	1.36	1.24	1.51	1.19	*
		0.81-1.45	1.03-1.80	0.93-1.64	1.15-1.98	1.05-1.34	
Diarrhea with blood	1.00	2.00	1.00	1.00	6.00		
	1.00	2.00	1.00	1.00	6.03	3.15	
		0.18-22.12	0.06-16.03	0.06-16.04	0.72-50.09	0.29-33.74	
Stomach pain	137.00	118.00	123.00	138.00	133.00		
	1.00	0.85	0.89	1.01	0.97	1.10	*
		0.66-1.10	0.69-1.15	0.79-1.29	0.76-1.24	1.00-1.21	
Cough	127.00	151.00	145.00	150.00	165.00		
	1.00	1.21	1.15	1.20	1.33	1.15	*
		0.94-1.54	0.90-1.48	0.94-1.53	1.04-1.69	1.04-1.27	

Table 60 (continued)

Cough & phlegm	58.00 1.00	77.00 1.34 0.95-1.90	71.00 1.23 0.87-1.76	59.00 1.02 0.71-1.47	91.00 1.60 1.14-2.23	1.22 1.04-1.43	*
Runny nose	190.00 1.00	190.00 1.00 0.81-1.24	182.00 0.96 0.77-1.18	201.00 1.07 0.87-1.31	191.00 1.01 0.82-1.24	1.04 0.97-1.12	
Sore throat	127.00 1.00	136.00 1.08 0.84-1.38	141.00 1.12 0.87-1.44	141.00 1.12 0.87-1.44	158.00 1.27 0.99-1.61	1.09 1.00-1.20	
HCGI 1	63.00 1.00	54.00 0.85 0.59-1.24	72.00 1.15 0.82-1.62	54.00 0.86 0.59-1.24	74.00 1.18 0.84-1.67	1.06 0.93-1.20	
HCGI 2	17.00 1.00	7.00 0.41 0.17-0.99	28.00 1.66 0.91-3.04	16.00 0.94 0.48-1.87	25.00 1.48 0.80-2.75	1.13 0.87-1.46	
Signif. resp disease	103.00 1.00	124.00 1.22 0.93-1.59	123.00 1.21 0.92-1.58	115.00 1.13 0.86-1.48	129.00 1.27 0.97-1.66	1.09 0.99-1.20	

* Noteworthy results.

Table 61. Adjusted odds ratios and 95% confidence intervals for the ratio of total to fecal coliform by quintiles and from a linear model. Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. Number of diseased subjects are given on the first line for each exposure.

	Quintile					linear model*
	1	2	3	4	5	
midpoints:	57.07	12.19	3.64	1.83	1.20	
# exposed:	2085	2082	2081	2080	2081	
Fever	101.00	85.00	119.00	84.00	111.00	
	1.00	0.82	1.17	0.80	1.05	0.96
		0.61-1.10	0.85-1.59	0.57-1.12	0.75-1.46	0.88-1.05
Chills	51.00	41.00	68.00	44.00	51.00	
	1.00	0.80	1.34	0.67	0.71	0.98
		0.53-1.22	0.88-2.03	0.42-1.07	0.44-1.14	0.86-1.11
Eye discharge	45.00	38.00	30.00	38.00	39.00	
	1.00	0.83	0.69	0.97	1.01	1.16
		0.54-1.30	0.41-1.16	0.59-1.59	0.61-1.68	0.95-1.40
Earache	80.00	51.00	76.00	79.00	72.00	
	1.00	0.60	0.84	0.90	0.80	0.97
		0.42-0.86	0.58-1.21	0.62-1.30	0.54-1.17	0.87-1.09
Ear discharge	17.00	10.00	9.00	14.00	18.00	
	1.00	0.51	0.34	0.48	0.59	0.83
		0.23-1.15	0.13-0.85	0.20-1.15	0.25-1.38	0.69-1.01
Skin rash	26.00	14.00	25.00	16.00	19.00	
	1.00	0.52	0.98	0.76	0.94	0.89
		0.27-1.00	0.52-1.86	0.38-1.54	0.46-1.89	0.76-1.04
Infected cut	10.00	11.00	13.00	16.00	14.00	
	1.00	1.02	1.01	1.26	1.06	1.25
		0.42-2.44	0.40-2.55	0.50-3.15	0.41-2.74	0.79-1.96
Nausea	77.00	65.00	87.00	71.00	84.00	
	1.00	0.81	1.00	0.72	0.81	1.03
		0.58-1.14	0.70-1.43	0.49-1.06	0.56-1.19	0.91-1.16
Vomiting	39.00	25.00	44.00	31.00	43.00	
	1.00	0.66	1.36	0.80	1.06	1.13
		0.40-1.10	0.84-2.21	0.47-1.38	0.63-1.78	0.93-1.38
Diarrhea	91.00	98.00	122.00	111.00	134.00	
	1.00	1.01	1.13	0.99	1.16	1.09
		0.75-1.36	0.82-1.55	0.72-1.38	0.84-1.60	0.97-1.23
Diarrhea with blood	1.00	2.00	1.00	1.00	6.00	
	1.00	1.96	0.98	0.86	4.79	2.45
		0.18-21.98	0.05-19.17	0.04-17.14	0.41-55.59	0.23-25.92
Stomach pain	137.00	118.00	123.00	138.00	133.00	
	1.00	0.81	0.74	0.76	0.70	1.05
		0.62-1.05	0.55-0.98	0.57-1.02	0.52-0.94	0.95-1.16
Cough	127.00	151.00	145.00	150.00	165.00	
	1.00	1.23	1.27	1.36	1.51	1.19 *
		0.96-1.57	0.97-1.67	1.04-1.79	1.14-1.99	1.06-1.32

Table 61 (continued)

Cough & phlegm	58.00 1.00	77.00 1.37 0.97-1.94	71.00 1.33 0.90-1.96	59.00 1.07 0.71-1.61	91.00 1.65 1.12-2.44	1.25 1.05-1.408	*
Runny nose	190.00 1.00	190.00 0.99 0.80-1.22	182.00 0.90 0.71-1.15	201.00 1.01 0.80-1.29	191.00 0.93 0.72-1.19	1.03 0.96-1.11	
Sore throat	127.00 1.00	136.00 1.07 0.83-1.38	141.00 1.10 0.84-1.45	141.00 1.11 0.84-1.47	158.00 1.23 0.92-1.63	1.08 0.98-1.19	
HCGI 1	63.00 1.00	54.00 0.85 0.59-1.24	72.00 1.19 0.80-1.75	54.00 0.80 0.52-1.22	74.00 1.06 0.71-1.59	1.04 0.91-1.18	
HCGI 2	17.00 1.00	7.00 0.42 0.17-1.01	28.00 1.77 0.89-3.50	16.00 0.82 0.38-1.80	25.00 1.21 0.58-2.54	1.05 0.81-1.36	
Signif. resp. disease	103.00 1.00	124.00 1.24 0.94-1.62	123.00 1.27 0.94-1.71	115.00 1.14 0.83-1.55	129.00 1.25 0.92-1.71	1.09 0.98-1.21	

* Noteworthy results.

Table 62. Odds Ratios and 95% Confidence intervals for Ratio of Total Coliform to Enterococcus, Dichotomizing by Cutpoints at 4, 7, 10, and 13. The Number of Diseased Subjects are Given on the First Line for Each Outcome.

	Cutpoint			
# exposed:	4 1952	7 3326	10 4412	13 5304
Fever*	103.00 1.13 0.91-1.41	165.00 1.05 0.87-1.27	225.00 1.12 0.93-1.34	277.00 1.21 1.01-1.45*
Chills	44.00 0.90 0.65-1.25	78.00 0.94 0.72-1.23	112.00 1.07 0.83-1.37	144.00 1.26 0.98-1.61
Eye discharge	28.00 0.75 0.50-1.12	59.00 0.96 0.70-1.31	78.00 0.95 0.71-1.27	91.00 0.88 0.66-1.18
Earache	76.00 1.17 0.91-1.52	127.00 1.18 0.94-1.47	163.00 1.14 0.92-1.41	198.00 1.20 0.97-1.48
Ear discharge	16.00 1.34 0.76-2.34	29.00 1.59 0.98-2.57	31.00 1.14 0.71-1.84	38.00 1.22 0.76-1.97
Skinrash	16.00 0.82 0.48-1.41	26.00 0.75 0.48-1.17	35.00 0.73 0.48-1.10	53.00 1.09 0.73-1.61
Infected cut	16.00 1.45 0.82-2.55	22.00 1.12 0.67-1.87	33.00 1.45 0.89-2.37	40.00 1.61 0.97-2.67
Nausea*	79.00 1.13 0.88-1.45	136.00 1.17 0.95-1.45	181.00 1.22 1.00-1.50*	221.00 1.32 1.07-1.62*
Vomiting	38.00 1.15 0.80-1.64	52.00 0.85 0.61-1.17	75.00 0.95 0.71-1.28	96.00 1.08 0.80-1.44
Diarrhea	135.00 1.42 1.16-1.73*	223.00 1.46 1.22-1.74*	280.00 1.40 1.18-1.67*	339.00 1.54 1.29-1.83*
Diarrhea with blood	4.00 2.48 0.72-8.48	4.00 1.22 0.36-4.16	4.00 0.78 0.23-2.65	4.00 0.55 0.16-1.88
Stomach pain*	131.00 1.10 0.90-1.34	224.00 1.13 0.96-1.34	310.00 1.26 1.08-1.48*	366.00 1.26 1.08-1.48*
Cough	137.00 0.99 0.81-1.20	237.00 1.01 0.86-1.18	311.00 0.99 0.85-1.15	385.00 1.05 0.91-1.22
Cough & phlegm	63.00 0.93 0.70-1.23	119.00 1.07 0.86-1.34	154.00 1.04 0.84-1.28	193.00 1.14 0.93-1.42

Table 62 (continued)

Runny nose	166.00 0.90 0.76-1.08	313.00 1.04 0.91-1.20	429.00 1.12 0.98-1.28	504.00 1.09 0.95-1.24
Sorethroat	130.00 0.98 0.81-1.20	233.00 1.06 0.90-1.25	308.00 1.06 0.91-1.24	366.00 1.05 0.90-1.22
HCGI-1	67.00 1.17 0.89-1.53	103.00 1.03 0.81-1.30	148.00 1.20 0.96-1.50	185.00 1.36* 1.09-1.71*
HCGI-2	20.00 1.19 0.72-1.95	25.00 0.78 0.49-1.24	41.00 1.07 0.71-1.62	55.00 1.40 0.92-2.12
Signif. resp disease	97.00 0.84 0.67-1.05	191.00 1.01 0.85-1.21	256.00 1.03 0.87-1.22	311.00 1.06 0.90-1.25

* Statistically significant at $p<.05$.

Table 63. Crude odds ratios and 95% confidence intervals for the ratio of total coliform to enterococcus by quintiles and from a linear model. Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

	Quintile					linear model*	
	1	2	3	4	5		
midpoints:	289.47	39.00	12.77	6.55	2.59		
# exposed:	2087	2081	2081	2098	2062		
Fever	97.00	91.00	97.00	106.00	109.00		
	1.00	0.94	1.00	1.09	1.15	1.01	
		0.70-1.26	0.75-1.34	0.82-1.45	0.86-1.52	0.96-1.07	
Chills	39.00	49.00	59.00	61.00	47.00		
	1.00	1.27	1.53	1.57	1.22	1.04	
		0.83-1.94	1.02-2.31	1.05-2.36	0.80-1.88	0.95-1.13	
Eye discharge	29.00	35.00	50.00	45.00	31.00		
	1.00	1.21	1.75	1.56	1.08	0.97	
		0.74-1.99	1.10-2.77	0.97-2.49	0.65-1.80	0.91-1.04	
Earache	63.00	62.00	80.00	74.00	79.00		
	1.00	0.99	1.28	1.17	1.28	1.05	
		0.69-1.41	0.92-1.80	0.83-1.65	0.91-1.79	0.97-1.14	
Ear discharge	14.00	12.00	11.00	14.00	17.00		
	1.00	0.86	0.79	0.99	1.23	1.20	
		0.40-1.86	0.36-1.74	0.47-2.09	0.61-2.50	0.87-1.65	
Skin rash	21.00	23.00	21.00	18.00	17.00		
	1.00	1.10	1.00	0.85	0.82	0.94	
		0.61-1.99	0.55-1.84	0.45-1.60	0.43-1.55	0.87-1.00	
Infected cut	10.00	10.00	15.00	13.00	16.00		
	1.00	1.00	1.51	1.30	1.62	0.98	
		0.42-2.41	0.68-3.36	0.57-2.96	0.74-3.59	0.87-1.10	
Nausea	51.00	79.00	79.00	94.00	81.00		
	1.00	1.58	1.58	1.87	1.63	1.02	*
		1.10-2.25	1.10-2.25	1.32-2.65	1.14-2.33	0.95-1.08	
Vomiting	25.00	47.00	38.00	34.00	38.00		
	1.00	1.91	1.53	1.36	1.55	1.00	
		1.17-3.11	0.92-2.55	0.81-2.29	0.93-2.57	0.92-1.09	
Diarrhea	75.00	109.00	107.00	125.00	140.00		
	1.00	1.48	1.45	1.70	1.95	1.05	*
		1.10-2.00	1.08-1.97	1.27-2.28	1.47-2.60	0.99-1.13	
Diarrhea with blood	1.00	4.00	2.00	0.00	4.00		
	1.00	4.02	2.01	0.00	4.05	1.96	
		0.45-35.97	0.18-22.15	0.00-+INF	0.45-36.31	0.36-10.77	
Stomach pain	109.00	127.00	123.00	155.00	135.00		
	1.00	1.18	1.14	1.45	1.27	1.01	
		0.91-1.53	0.87-1.49	1.12-1.86	0.98-1.65	0.96-1.06	
Cough	137.00	149.00	157.00	143.00	152.00		
	1.00	1.10	1.16	1.04	1.13	0.99	
		0.86-1.40	0.92-1.47	0.82-1.33	0.89-1.44	0.96-1.03	

Table 63 (continued)

Cough & phlegm	67.00 1.00	70.00 1.05 0.75-1.48	73.00 1.10 0.78-1.54	74.00 1.10 0.79-1.54	72.00 1.09 0.78-1.53	0.99 0.94-1.05	
Runny nose	188.00 1.00	176.00 0.93 0.75-1.16	192.00 1.03 0.83-1.27	215.00 1.15 0.94-1.42	183.00 0.98 0.79-1.22	0.97 0.94-1.00	
Sore throat	128.00 1.00	146.00 1.15 0.90-1.48	143.00 1.13 0.88-1.45	147.00 1.15 0.90-1.47	139.00 1.11 0.86-1.42	1.01 0.97-1.05	
HCGI 1	45.00 1.00	64.00 1.44 0.98-2.12	69.00 1.56 1.06-2.28	71.00 1.59 1.09-2.32	68.00 1.55 1.06-2.27	1.00 0.94-1.07	*
HCGI 2	9.00 1.00	25.00 2.81 1.31-6.03	18.00 2.01 0.90-4.49	21.00 2.33 1.07-5.11	20.00 2.26 1.03-4.98	1.16 0.91-1.49	*
Signif. resp. disease	113.00 1.00	117.00 1.04 0.80-1.36	124.00 1.11 0.85-1.44	131.00 1.16 0.90-1.51	109.00 0.97 0.74-1.28	0.99 0.95-1.04	

* Noteworthy results.

Table 64. Adjusted odds ratios and 95% confidence intervals for the ratio of total coliform to enterococcus by quintiles and from a linear model. Linear results correspond to an increase in the exposure equal to the difference between the 90th and 10th percentiles. The number of subjects with each outcome are given on the first line.

	Quintile					linear model
	1	2	3	4	5	
midpoints:	289.47	39.00	12.77	6.55	2.59	
# exposed:	2087	2081	2081	2098	2062	
Fever	97.00	91.00	97.00	106.00	109.00	
	1.00	0.96	1.02	1.09	1.14	1.00
		0.71-1.29	0.75-1.39	0.79-1.51	0.81-1.60	0.95-1.06
Chills	39.00	49.00	59.00	61.00	47.00	
	1.00	1.27	1.49	1.48	1.10	1.02
		0.83-1.94	0.96-2.31	0.93-2.35	0.67-1.82	0.94-1.11
Eye discharge	29.00	35.00	50.00	45.00	31.00	
	1.00	1.30	2.19	2.11	1.57	0.98
		0.79-2.14	1.35-3.56	1.25-3.57	0.88-2.82	0.92-1.05
Earache	63.00	62.00	80.00	74.00	79.00	
	1.00	0.96	1.26	1.09	1.18	1.03
		0.67-1.38	0.87-1.81	0.74-1.61	0.79-1.77	0.96-1.12
Ear discharge	14.00	12.00	11.00	14.00	17.00	
	1.00	0.82	0.59	0.68	0.75	1.13
		0.38-1.79	0.24-1.41	0.28-1.63	0.31-1.83	0.84-1.53
Skin rash	21.00	23.00	21.00	18.00	17.00	
	1.00	1.21	1.10	0.93	0.90	0.94
		0.66-2.20	0.57-2.11	0.45-1.93	0.41-1.95	0.88-1.01
Infected cut	10.00	10.00	15.00	13.00	16.00	
	1.00	0.91	1.25	0.96	1.15	0.94
		0.38-2.20	0.52-3.01	0.37-2.47	0.44-2.96	0.84-1.05
Nausea	51.00	79.00	79.00	94.00	81.00	
	1.00	1.55	1.53	1.72	1.47	0.99
		1.08-2.22	1.04-2.24	1.16-2.55	0.97-2.22	0.93-1.05
Vomiting	25.00	47.00	38.00	34.00	38.00	
	1.00	1.98	1.63	1.48	1.65	1.00
		1.21-3.23	0.95-2.79	0.83-2.64	0.91-2.99	0.92-1.09
Diarrhea*	75.00	109.00	107.00	125.00	140.00	
	1.00	1.39	1.29	1.36	1.54	1.01
		1.03-1.89*	0.93-1.79	0.97-1.90	1.09-2.16*	0.95-1.08
Diarrhea with blood	1.00	4.00	2.00	0.00	4.00	
	1.00	3.93	1.31	0.00	2.00	1.76
		0.43-36.15	0.10-17.14	0.00-+INF	0.16-24.94	0.33-9.44
Stomach pain	109.00	127.00	123.00	155.00	135.00	
	1.00	1.13	1.03	1.23	1.05	0.99
		0.87-1.48	0.77-1.37	0.91-1.64	0.77-1.43	0.94-1.03
Cough	137.00	149.00	157.00	143.00	152.00	
	1.00	1.11	1.25	1.14	1.25	0.99
		0.87-1.42	0.97-1.62	0.86-1.50	0.94-1.66	0.95-1.04
Cough & phlegm	67.00	70.00	73.00	74.00	72.00	
	1.00	1.07	1.13	1.17	1.13	0.99
		0.76-1.51	0.79-1.63	0.80-1.72	0.76-1.70	0.94-1.05

Table 64 (continued)

Runny nose	188.00 1.00	176.00 0.91 0.73-1.13	192.00 1.02 0.81-1.28	215.00 1.10 0.87-1.40	183.00 0.93 0.72-1.20	0.96 0.93-0.99
Sore throat	128.00 1.00	146.00 1.14 0.89-1.46	143.00 1.09 0.84-1.43	147.00 1.08 0.82-1.43	139.00 1.01 0.75-1.36	1.00 0.95-1.05
HCGI 1*	45.00 1.00	64.00 1.47 1.00-2.17*	69.00 1.67 1.11-2.51*	71.00 1.71 1.12-2.62*	68.00 1.68 1.07-2.62*	0.99 0.93-1.06
HCGI 2	9.00 1.00	25.00 2.83 1.31-6.10	18.00 1.75 0.75-4.10	21.00 1.97 0.83-4.69	20.00 1.75 0.71-4.29	1.12 0.88-1.43
Signif. resp. disease	113.00 1.00	117.00 1.05 0.81-1.38	124.00 1.12 0.85-1.49	131.00 1.18 0.88-1.60	109.00 0.97 0.70-1.34	0.99 0.95-1.04

* Noteworthy results.

Table 65. Summary of Noteworthy Stratified Results Comparing Subjects who Swam at the Drain with those Swimming 400+ Yards from the Drain.†

Outcome	Relative Risk	Attributable Number*
Fever	1.57	259
Chills	1.58	138
Ear discharge	2.27	88
Vomiting	1.61	115
Coughing with phlegm	1.59	175
HCGI 2	2.11	95
SRD	1.66	303

* The attributable number estimates the number of new occurrences of the specified outcome attributable to swimming at the drain (for every 10,000 people swimming there) versus swimming 400 yards from the drain.

† Results presented in terms of relative risks and attributable numbers.

Table 66. Summary of Noteworthy Results (in the Entire Dataset) Comparing Subjects Who Swam When the Bacterial Indicator was Above the Highest Cutpoint (as Defined in the Text) with Those Who Swam When the Same Bacterial Indicator was Below the Cutpoint.‡

Indicator	Outcome	OR	Attributable Number*
E. coli	Earache	1.46	149
	Nasal Congestion	1.24	211
Enterococcus	Diarrhea w/ bld.	4.23	27
	HCGI 1	1.44	130
Total coliform	Skin rash	3.00	165
Fecal coliform	Skin rash	1.88	74
Total:fecal ratio**	Diarrhea	1.28	125
	HCGI 2	1.87	48
Total:entero ratio†	Nausea	1.63	147
	Diarrhea	1.95	262
	HCGI 1	1.55	111
	HCGI-2	2.26	53

* The attributable number estimates the number of new occurrences of the specified outcome attributable to swimming when the corresponding bacterial indicator was above the highest cutpoint (for every 10,000 swimmers) versus swimming when the bacterial indicator was below the cutpoint.

† From the crude categorical model, comparing the fifth to first quintile.

‡ Results are Presented in Terms of Relative Risks and Attributable Numbers.

** Using the cutpoint of 5.0.

Table 67. Summary of Noteworthy Results from the Crude Linear Models Corresponding to Unit Increases Equal to the Difference Between the 90th and 10th Percentiles.†

Indicator	Outcome	OR	Attributable Number*
E-coli	Skin rash	1.07	5
	Nausea	1.04	14
	Stomach pain	1.04	23
Enterococcus	Fever	1.04	21
	Skin rash	1.06	5
	Nausea	1.04	14
	Diarrhea	1.04	23
	Stomach pain	1.02	12
	Cough	1.03	25
	Runny nose	1.03	27
	HCGI 1	1.04	19
Fecal coliform	Fever	1.05	23
	Skin rash	1.10	8
	HCGI 1	1.06	17
Total:fecal ratio	Diarrhea	1.19	85
	Stomach pain	1.10	56
	Cough	1.15	93
	Cough & phlegm	1.22	61
	Sore throat	1.09	56

* The attributable number estimates the number of new occurrences of the specified outcome attributable to swimming when the corresponding bacterial indicator was equal to the 90th percentile (for every 10,000 swimmers) versus swimming when the bacterial indicator was equal to the 10th percentiles (where these percentiles are given in previous tables).

† Results are presented in terms of odds ratios (i.e., approximate relative risks) and attributable numbers.

Table 68. Attributable number of cases per every 10,000 swimmers who are exposed to ratios of total to fecal coliform of 2, 4, 5, 6, and 8.

Outcome*	Cutpoint				
	2	4	5	6	8
Diarrhea	72	126	125	167	135
Diarrhea with blood	15	9	8	4	6
Cough	113	76	76	68	72
Sore throat	111	81	81	81	76
HCGI-2	23	49	48	40	56

* We only include outcomes with statistically significant increases in risk for at least one of the cutpoints.

Table 69a. Attributable Number of Cases Per Every 10,000 Swimmers Who are Exposed to Ratios of Total to Fecal Coliform of 2, 4, 5, 6, and 8, and Who Swim on Days When the Total Coliform Level at the Drain > 5,000 cfu.

	Cutpoint				
Outcome*	2	4	5	6	8
Fever	521	276	206	152	179
Earache	193	273	224	169	135
Nausea	365	342	288	248	202
Vomiting	365	284	244	191	126
Diarrhea	800	509	463	342	377
Diarrhea with blood	39	53	48	33	26
Cough	840	654	563	386	402
Cough with phlegm	396	344	187	105	70
Runny nose	573	512	411	171	301
Sore throat	561	312	226	186	179
HCGI 1	491	316	263	176	164
HCGI 2	317	235	211	145	111

* We only include outcomes with statistically significant increases in risk for at least one of the cutpoints.

Table 69b. Attributable Number of Cases Per Every 10,000 swimmers Who are Exposed to Ratios of Total to Fecal Coliform of 2, 4, 5, 6, and 8, Restricted to Individuals Who Swam on Days When Total Coliform > 1,000 cfu.

Outcome*	Cutpoint				
	2	4	5	6	8
Fever	194	139	128	86	89
Chills	-25	99	87	68	43
Nausea	65	180	152	151	137
Vomiting	140	90	71	68	38
Diarrhea	222	187	180	167	189
Cough	236	132	125	95	132
Cough+phlegm	165	40	36	34	24
Runny nose	492	141	163	105	170
Sore throat	247	121	93	104	128
HCGI 1	167	96	83	55	42
HCGI 2	117	110	104	99	79
Sig Resp Dis	220	84	69	68	71

* Only including outcomes with statistically significant associations

Table 70. Attributable Number of Cases Per Every 10,000 Swimmers Who are Exposed to Ratios of Total Coliform to Enterococcus of 4, 7, 10, and 13.

Outcome	Cutpoint			
	4	7	10	13
Fever	61	24	54	89
Nausea	46	61	74	101
Diarrhea	204	210	183	224
Stomach pain	62	78	146	144
HSGI 1	69	8	55	93

* We only include outcomes with statistically significant increases in risk for at least one of the cutpoints.

TABLE 71

SANTA MONICA BAY RESTORATION PROJECT
POLIOVIRUS SEED EXPERIMENTS

Water Source	Date of Collection	Volume Used	% Recovery
Santa Monica Canyon	July 3, 1995	38	Toxic
	July 17, 1995	24	42.58
	Aug. 7, 1995	20	35.08
	Aug. 21, 1995	20	35.18
	Sept. 5, 1995	20	48.04
	Oct. 17, 1995	20	83.31
Malibu	July 3, 1995	24	Toxic
	July 17, 1995	24	50.04
	Aug. 7, 1995	20	50.00
	Aug. 21, 1995	18	51.43
	Sept 5, 1995	19	50.88
	Sept 18, 1995	21	32.55
	Sept 26, 1995	20	64.50
Ashland	July 24, 1995	32	Toxic
	Aug. 2, 1995	30	13.05
	Aug. 7, 1995	20	23.07
	Aug. 21, 1995	20	21.60
	Sept 5, 1995	21	<10.00
	Sept 18, 1995	20	Toxic
	Sept 26, 1995	20	54.60

Table 72

SANTA MONICA RESTORATION PROJECT

CSDOC/VIROLOGY

15-Nov-95

SAMPLE ID	WATER QUALITY ANALYSIS				SAMPLE VOLUME	
	pH	TEMPERATURE Deg. Celcius	CONDUCTIVITY mS/cm	TDS g/L	FILTERED Gal	FINAL mL
950623SMCyn	6.8	19.2	1.30	NT	73	16.0
950623Ashland	6.8	20.2	3.00	NT	32.5	23.0
950623Malibu	7.8	21.5	1.90	NT	119	24.0
950624Malibu	7.5	20.5	2.19	1.08	100	10.3
950624Ashland	6.8	21.5	12.18	5.99	18	12.8
950625Malibu	7.7	NT	2.3	NT	100	14.5
950625Ashland	7.9	NT	2	19.73	76	13.8
950630Ashland	3.4	NT	[illegible]	14.49	52	12.2
950630SMCyn	NT	NT	1.33	0.68	55	7.5
950630Malibu	7.9	[illegible]	20.3	NT	100	9.3
950701Malibu	7.7	[illegible]	164.5	NT	100	14.6
950701SMCyn	NT	NT	NT	NT	100	9.0
950702Malibu	8.1	22.3	14.2	NT	100	25.8
950702Ashland	8.2	NT	1	1	100	11.0
950702SMCyn	8.4	NT	1.32	0.66	100	12.6
950703SMCyn seeded	8.5	NT	1.59	0.794	38	10.7
950703Malibu seeded	7.8	NT	1.93	0.962	24	16.9
950706SMCyn blank	NT	NT	0.496	0.233	100	11.2
950706Malibu blank	NT	NT	0.496	0.233	100	12.9
950707Ashland	8.1	23.1	2.22	1.11	12	12.1
950707SMCyn	8.5	19.6	1.36	0.68	100	10.3
950707Malibu	8.4	20.5	20.4	NT	100	11.9
950708Malibu	8.0	20.5	1.92	NT	100	9.4
950708Ashland	7.9	20.6	1	1	100	11.6
950708SMCyn	8.4	19.1	1.37	0.68	100	20.0
950709SMCyn	8.5	18.5	1.19	0.66	100	11.1
950709Ashland	7.9	20.9	16.12	8.09	100	20.0
950709Malibu	7.8	22.3	18.4	NT	100	9.3
950714SMCyn	8.3	20.6	1.33	0.66	100	14.0
950714Ashland	7.9	22.0	1	1	85	14.0
950714Malibu	7.8	20.5	19.8	NT	100	14.5
950715SMCyn	8.7	19.3	1.54	0.77	101	17.0
950715Ashland	8.3	21.3	13.66	6.83	26	15.0
950715Malibu	8.8	20.3	1.9	NT	100	12.0
950716Malibu	7.8	20.5	7.12	NT	100	10.5
950716SMCyn	8.5	19.3	1.37	0.72	100	18.0
950717Malibu-Seeded	NT	NT	NT	NT	24	10.8
950717SMCyn-Seeded	NT	NT	NT	NT	24	9.5
950720Malibu-Blank	7.8	NT	NT	NT	100	10.0
950720SMCyn-Blank	7.8	NT	NT	NT	100	10.4
950721Malibu	7.5	25.0	13.96	6.97	100	12.2
950721SMCyn	8.3	20.4	1.35	0.67	86	12.4
950722Malibu	7.6	22.5	3.2	NT	100	11.4
950722SMCyn	7.7	20.1	1.38	0.69	100	11.6

Historical Document

SANTA MONICA RESTORATION PROJECT

CSDOC/VIROLOGY

15-Nov-95

SAMPLE ID	WATER QUALITY ANALYSIS				SAMPLE VOLUME	
	pH	TEMPERATURE Deg. Celcius	CONDUCTIVITY mS/cm	TDS g/L	FILTERED Gal	FINAL mL
950722Ashland	6.3	22.2	10.18	5.09	12	16.1
950723Malibu	7.8	22.4	8.8	NT	100	25.9
950723SMCyn	8.5	22.9	1.47	0.73	100	17.2
950723Ashland	7.8	22.1	1	10.90	100	19.4
950724Ashland-Seeded	NT	24.0	NT	NT	32	10.7
950727Ashland-Blank	NT	NT	NT	NT	100	5.7
950728Malibu	8.4	22.9	7.94	NT	100	10.7
950728SMCyn	7.5	22.5	1.51	0.75	100	11.7
950728Ashland	7.2	22.3	1	1.80	100	16.2
950729Malibu	7.7	22.6	3.5	NT	100	17.2
950729SMCyn	8.0	20.9	1.63	0.82	100	9.6
950729Ashland	7.9	22.1	11.30	5.63	60	27.2
950730SMCyn	8.5	21.1	1.431	0.716	72	14.0
950730Ashland	7.7	23.2	16.35	8.48	100	12.3
950730Malibu	7.6	25.3	NT	NT	85	15.4
950802Ashland-Seeded	NT	NT	NT	NT	30	15.6
950803Ashland-Blank	NT	NT	NT	NT	100	12.2
950804SMCyn	8.4	19.8	1.55	0.77	62	12.5
950804Ashland	7.4	21.6	1	1	89	12.0
950804Malibu	7.9	20.9	3.78	NT	100	10.7
950805Malibu	7.8	22.6	27.9	NT	100	7.1
950805SMCyn	8.4	18.7	1.49	0.74	100	9.4
950805Ashland	NT	20.2	1	1	80	9.9
950806SMCyn	8.4	NT	1.55	0.783	100	10.4
950806Ashland	7.8	21.4	1	1	100	13.4
950806Malibu	8.1	21.7	47.6	NT	100	10.0
950807SMCyn-Seeded	NT	NT	NT	NT	20	15.2
950807Ashland-Seeded	NT	NT	NT	NT	20	11.1
950807Malibu-Seeded	NT	NT	NT	NT	20	9.5
950810Malibu-Blank	7.8	NT	NT	NT	100	13.1
950810SMCyn-Blank	7.8	NT	NT	NT	100	7.2
950811Malibu	7.7	19.8	0.90	1	100	12.7
950811SMCyn	8.4	22.2	1.39	0.690	89	26.9
950811Ashland	7.9	22.5	1	1	100	10.3
950812Malibu	8.2	20.0	NT	NT	100	11.1
950812SMCyn	8.4	21.7	1.44	0.72	100	12.9
950812Ashland	7.9	21.5	1	1	100	18.8
950813Malibu	7.8	21.1	29.1	NT	100	15.0
950813SMCyn	8.7	20.0	2.06	0.80	110	12.9
950813Ashland	8.1	21.4	1	1	100	26.6
950818SMCyn	8.5	21.9	1.45	0.72	52	10.8
950818Ashland	7.9	24.2	1	1	100	10.9
950818Malibu	8.3	21.8	34.6	NT	100	9.4
950819SMCyn	8.4	19.9	0.432	0.71	52	15.1

Confidential Information

SANTA MONICA RESTORATION PROJECT

CSDOC/VIROLOGY

15-Nov-95

SAMPLE ID	WATER QUALITY ANALYSIS				SAMPLE VOLUME	
	pH	TEMPERATURE Deg. Celcius	CONDUCTIVITY mS/cm	TDS g/L	FILTERED Gal	FINAL mL
950819Ashland	8.0	22.3	1	1	100	11.0
950819Malibu	7.6	20.9	>20	18.30	90	9.6
950820SMCyn	8.6	20.4	1.50	0.754	100	11.3
950820Ashland	8.0	22.9	1.0	1.0	100	7.5
950820Malibu	7.5	22.6	> 20	NT	100	9.7
950821Malibu-Seeded	NT	NT	NT	NT	15.9	7.8
950821SMCyn-Seeded	NT	NT	NT	NT	20	12.7
950821Ashland-Seeded	NT	NT	NT	NT	20	10.9
950824SMCyn-Blank	7.5	NT	1.08	0.53	100	9.6
950824Ashland-Blank	7.5	NT	1.08	0.53	100	8.1
950824Malibu-Blank	7.5	NT	1.08	0.53	100	10.4
950825Malibu	8.0	23.6	1.0	19.37	58	10.7
950825Ashland	7.8	21.3	1	1	100	14.8
950825SMCyn	8.4	18.5	1.5	0.75	100	11.1
950826Ashland	8.0	22.9	1	1	100	15.4
950826Malibu	7.9	22.3	NT	NT	100	8.2
950827SMCyn	8.6	19.6	1.57	0.78	100	8.5
950827Ashland	7.8	23.6	1	1	100	11.5
950827Malibu	9.4	NT	NT	NT	51	7.8
950901Malibu	7.1	22.3	15.63	7.79	100	15.8
950901Ashland	8.3	22.7	1	1	100	11.8
950902Ashland	8.0	23.1	NT	NT	100	12.1
950902Malibu	7.7	NT	NT	NT	100	11.1
950902SMCyn	8.7	27.8	1.35	0.67	100	13.1
950903SMCyn	8.2	20.5	1.41	0.71	100	9.3
950903Ashland	7.9	27.3	1	1	100	7.0
950903Malibu	7.8	NT	NT	NT	100	7.8
950905SMCyn-Seeded	NT	NT	NT	NT	20	11.9
950905Ashland-Seeded	NT	NT	NT	NT	21	9.0
950905Malibu-Seeded	NT	NT	NT	NT	19	15.0
950907Malibu-Blank	7.9	23.8	0.123	0.612	100	8.7
950907SMCyn-Blank	7.9	23.8	0.123	0.612	100	7.1
950907Ashland-Blank	7.9	23.8	0.123	0.612	100	10.8
950909Malibu	7.3	NT	NT	NT	100	9.3
950909Ashland	7.7	21.8	NT	NT	100	14.0
950910Malibu	7.1	20.0	NT	NT	100	7.2
950910Ashland	7.8	21.1	NT	NT	100	12.8
950916Malibu	7.7	20.5	6.36	3.19	100	10.8
950916Ashland	7.9	22.3	19.74	9.88	100	13.5
950917Ashland	8.0	20.8	NT	NT	100	10.1
950917Malibu	7.4	22.0	NT	6.41	100	8.1
950918Malibu-Seeded	NT	NT	NT	NT	21	17.3
950918Ashland-Seeded	NT	NT	NT	NT	20	11.0
950921Malibu-Blank	7.4	23.1	1.56	0.78	100	9.2

SANTA MONICA RESTORATION PROJECT

CSDOC/VIROLOGY

15-Nov-95

SAMPLE ID	WATER QUALITY ANALYSIS				SAMPLE VOLUME	
	pH	TEMPERATURE Deg. Celcius	CONDUCTIVITY mS/cm	TDS g/L	FILTERED Gal	FINAL mL
950921Ashland-Blank	7.4	23.1	1.56	0.78	100	6.1
950923Malibu	8.2	22.0	NT	NT	100	11.8
950923Ashland	8.1	21.3	NT	NT	104	15.1
950924Malibu	8.6	22.0	NT	NT	100	11.1
950924Ashland	7.8	21.8	NT	NT	100	9.4
950926Malibu-Seeded	NT	NT	NT	NT	20	7.7
950926Ashland-Seeded	NT	NT	NT	NT	20	9.3
951017 SMCyn-Seeded	8.3	22.1	NT	NT	23	10.1

Confidential
Not Circulate

Table 73. Crude odds ratios and 95% confidence intervals for outcomes of interest by whether virus was isolated. The number of diseased subjects are given on the first line for each outcome.

	Virus		
	No	Yes	P
# exposed:	3168	386	value
Fever	126.00	23.00	
	1.00	1.53	0.07
		0.97-2.42	
Chills	65.00	10.00	
	1.00	1.27	0.49
		0.65-2.49	
Eye discharge	36.00	8.00	
	1.00	1.84	0.12
		0.85-3.99	
Earache	93.00	10.00	
	1.00	0.88	0.70
		0.45-1.70	
Ear discharge	15.00	0.00	
	1.00	0.00	1.00
		0.00-+INF	
Skinrash	32.00	4.00	
	1.00	1.03	0.96
		0.36-2.92	
Infected cut	31.00	2.00	
	1.00	0.53	0.38
		0.13-2.21	
Nausea	101.00	12.00	
	1.00	0.97	0.93
		0.53-1.79	
Vomiting	44.00	10.00	
	1.00	1.89	0.07
		0.94-3.78	
Diarrhea	130.00	21.00	
	1.00	1.34	0.22
		0.84-2.16	
Diarrhea with blood	2.00	1.00	
	1.00	4.11	0.25
		0.37-45.45	
Stomach pain	191.00	23.00	
	1.00	0.99	0.96
		0.63-1.54	
Cough	181.00	28.00	
	1.00	1.29	0.23
		0.85-1.95	
Cough & phlegm	92.00	13.00	
	1.00	1.17	0.61
		0.65-2.10	

Table 73 (continued)

Runny nose	246.00 1.00	32.00 1.07 0.73-1.58	0.72
Sorethroat	198.00 1.00	32.00 1.36 0.92-2.00	0.13
HCGI-1	72.00 1.00	15.00 1.74 0.99-3.06	0.06
HCGI-2	22.00 1.00	6.00 2.26 0.91-5.60	0.08
Signif. resp. disease	160.00 1.00	26.00 1.36 0.88-2.08	0.16

Table 74. Adjusted odds ratios and 95% confidence intervals for outcomes of interest by whether virus was isolated. The number of diseased subjects are given on the first line for each outcome.

	Virus		
# exposed:	No 3168	Yes 386	P value
Fever	126.00 1.00	23.00 1.56 0.98-2.50	0.06
Chills	65.00 1.00	10.00 1.24 0.62-2.47	0.54
Eye discharge	36.00 1.00	8.00 1.80 0.82-3.95	0.14
Earache	93.00 1.00	10.00 0.93 0.47-1.81	0.82
Ear discharge	15.00 1.00	0.00 0.00 0.00-+INF	1.00
Skin rash	32.00 1.00	4.00 0.95 0.33-2.75	0.93
Infected cut	31.00 1.00	2.00 0.55 0.13-2.34	0.42
Nausea	101.00 1.00	12.00 0.96 0.52-1.78	0.90
Vomiting	44.00 1.00	10.00 1.84 0.91-3.74	0.09
Diarrhea	130.00 1.00	21.00 1.33 0.82-2.15	0.25
Diarrhea with blood	2.00 1.00	1.00 5.43 0.42-69.49	0.19
Stomach pain	191.00 1.00	23.00 0.94 0.60-1.48	0.79
Cough	181.00 1.00	28.00 1.22 0.80-1.85	0.35
Cough & phlegm	92.00 1.00	13.00 1.14 0.63-2.08	0.66

Table 74 (continued)

Runny nose	246.00 1.00	32.00 1.05 0.71-1.54	0.82
Sore throat	198.00 1.00	32.00 1.40 0.94-2.08	0.10
HCGI 1	72.00 1.00	15.00 1.71 0.96-3.04	0.07
HCGI 2	22.00 1.00	6.00 2.27 0.89-5.77	0.09
Signif. resp disease	160.00 1.00	26.00 1.32 0.85-2.04	0.21

APPENDIX A

QUESTIONNAIRES

3-477

Last Date for Phone Appt. _____ ID# _____
Date (MM/DD/YY) | A | B | C | D | E | F | G |

CONFIDENTIAL (ASHLAND BEACH ONLY)

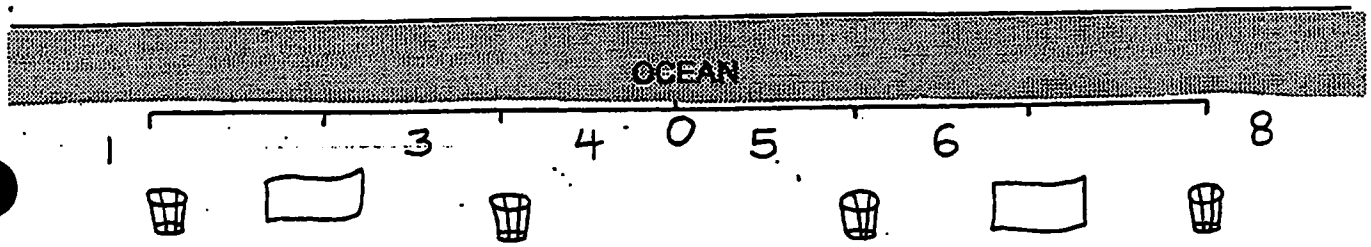
Interviewer (include #) _____ Date (MM/DD/YY)_____ (Day of week)_____

Phone Appt._____ _____ _____ Ethnicity: W | B | L | A | O English / Spanish
Day of week Date (MM/DD/YY) Time

Name -- in water today	Relation (S/M/F/C)	Age	Age Cat	Gender (M/F)	Face Wet? (Y/N) B*	Face Wet? (Y/N) T*	Map Code	Study Eligible (Y/N) T*
A.) *Returned to the Beach? Yes / No*								
B.) *Returned to the Beach? Yes / No*								
C.) *Returned to the Beach? Yes / No*								
D.) *Returned to the Beach? Yes / No*								
E.) *Returned to the Beach? Yes / No*								
F.) *Returned to the Beach? Yes / No*								
G.) *Returned to the Beach? Yes / No*								

B* -- Determined during Beach Interview

T* -- Determined during Telephone Interview



name of contact person (relation)

Where would you like to be called?

work / home (____)_____ _____
number time

work / home (____)_____ _____
number time

name of contact person (relation)

Where would you like to be called?

work / home (____)_____ _____
number time

work / home (____)_____ _____
number time

Beach Interviewer's Comments

Phone Interviewer's Comments

ID Number

Beach Interview Date

Month	Day
June	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July	
Aug	
Sept	
Oct	

Phone Interview Date

Month	Day
June	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
July	
Aug	
Sept	
Oct	
Nov	

Water clean?
- Yes
- No

Gender
- Female
- Male

Age - Code from beach questionnaire:
- 0 to 12
- 13 to 18
- 19 to 25
- 26 to 35
- 36 to 45
- 46 to 55
- 56 to 65
- 66 to 75
- > 75

Map Code: 0 1 2 3 4 5 6 7 8 9

Beach Interviewer's Number

Phone Interviewer's Number

1. (Refer to the Beach Questionnaire) **Did respondent get her/his face wet?**

○ No, face did not get wet ○ Yes, face got wet

2. Did you (child's name) get your (her/his) face wet while you (she/he) were (was) in the water on (DAY)?
- ○ No
- ○ Yes
- ○ Don't know/don't remember

3. I'm going to go through a list of symptoms to find out about your (child's) health since you (she/he) were (was) at the beach on (DAY). Since your (her/his) visit to the beach on (DAY), have (has) you (child's name) had any of the following problems or symptoms?

Problem or Symptom For each "Yes" in a, ask b, and c.	a) How about (EACH)? Did you (child's name) have that at any time since your (her/his) visit to the beach on (DAY)? No Yes DK	b) Was this a problem that you (child's name) had during the week before you went to the beach on (DAY)? No Yes DK	c) IF YES to b, Please describe how often you experienced this symptom when you had it before.
1. Fever	○ ○ ○		○
2. Chills	○ ○ ○		○
3. Redness and discharge from the eyes	○ ○ ○	○ ○ ○	○
4. Earache	○ ○ ○	○ ○ ○	○
5. Discharge/draining from the ear	○ ○ ○	○ ○ ○	○
6. Skin rash	○ ○ ○	○ ○ ○	(If yes to a, describe site.)

PLEASE DO NOT WRITE IN THIS AREA

12501

DesignExpert™ by NCS Printed in U.S.A. Mark Reflex® MM105190:32

Problem or Symptom For each "Yes" in a, ask b, and c.	a) How about (EACH)? Did you (child's name) have that at any time since your (her/his) visit to the beach on (DAY)? No Yes DK	b) Was this a problem that you (child's name) had during the week before you went to the beach on (DAY)? No Yes DK	c) IF YES to b, Please describe how often you experienced this symptom when you had it before.
7. Cuts or scrapes that became infected	○○○	○○○	
8. Nausea (ask a woman who says "yes" if she's pregnant)	○○○	○○○	(Exclude nausea caused by pregnancy in a.)
9. Vomiting	○○○	○○○	
10. Diarrhea (If 11a is no, 12a is no. Skip to 13.)	○○○	○○○	
11. Diarrhea with blood	○○○	○○○	
12. Stomach pain or cramps	○○○	○○○	(Exclude menstrual periods in a.)
13. Coughing (If 14a is no, 15a is no. Skip to 16.)	○○○	○○○	
14. Coughing accompanied by phlegm	○○○	○○○	
15. Nasal congestion or runny nose	○○○	○○○	
16. Sore throat	○○○	○○○	

4. How worried or concerned are you about environmental hazards at the beach? Would you say you are...

- ○ Not at all worried or concerned
- ○ Somewhat worried or concerned
- ○ A little worried or concerned
- ○ Very worried or concerned

5. What is your ethnic background? (Read choices if necessary.)

- ○ White
- ○ Black
- ○ Latino
- ○ Asian
- ○ Multi-ethnic
- ○ Other, _____

6. What is your 5-digit postal zip code? (Code "99999" for foreign respondents.)

Zip Code:

0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

(If there are other household members to interview, use another phone questionnaire, otherwise...)

THANK YOU VERY MUCH. I REALLY APPRECIATE THAT YOU HAVE TAKEN THE TIME TO ANSWER THESE QUESTIONS.

APPENDIX B

FORMS USED ON THE BEACH AND IN THE OFFICE

Information Pamphlet
Log of Non-participants
Age Categories
Beach Interview: Daily Tally Sheet
Phone Interviewer Daily Tally Sheet
Update: Phone Calls to Make
Repondent Callbacks
Log of Weekly Loss-to-Follow-up
Timesheet

IS IT SAFE FOR YOU TO SWIM IN SANTA MONICA BAY?

A few minutes of your time will help us find out.

HERE'S WHAT YOU DO

Answer a few questions such as:
"Did you go in the water?" "Did you get your face wet?" Then, when we call you in about ten days, answer a few questions about your health since you were at the beach.

HERE'S WHAT WE DO

We sample the water you swim in. We compare our analyses of the water with your answers...along with those of 9,999 other participating swimmers. Then, we will use the results to determine what action, if any, is needed to protect your health while swimming in the bay.

WHO WE ARE

We are a group of Southern California scientists requested to study the health effects of swimming in the bay by the Santa Monica Bay Restoration Project... a coalition of Federal, State and Local agencies, environmental and industry groups and the general public, dedicated to enhancing the quality of Santa Monica Bay.

THANK YOU FOR YOUR PARTICIPATION

We will be calling you on _____ at _____

Santa Monica Bay Beach Study
3107 Santa Monica Boulevard, Santa Monica, CA 1-800-992-8395

This project is funded by: California State Water Resources Control Board,
Cities of Los Angeles and Santa Monica, Los Angeles County Department of Public Works,
Beach Cities Health District, Los Angeles Regional Water Quality Control Board,
Topanga Las Virgines Municipal Water District, Heal The Bay and Chevron.

Printed on recycled paper. Please recycle.

¿ES SANO NADAR EN LA BAHÍA DE SANTA MONICA?

Unos minutos de su tiempo nos ayudará.

ESTO ES LO QUE SE PUEDE HACER

Conteste algunas preguntas:
"¿Estuvo Ud. en el agua?" "¿Se mojó Ud. la cara?" Entonces, cuando lo llamemos en diez días, conteste algunas preguntas acerca de su salud.

ESTO SERÁ LO QUE NOSOTROS HAREMOS POR UD.

Nosotros vamos a analizar el agua en la que Ud. está nadando. Entonces, vamos a comparar nuestro analysis del agua con sus repuestos...y con las otros participantes. Después vamos a usar los resultados para determinar que acción tomaremos, si es necesario, para su protección.

¿QUIENES SOMOS NOSOTROS?

Nosotros somos un grupo de investigadores del proyecto de la Restoración de La Bahía de Santa Monica. Nosotros nos dedicamos a mejorar la calidad del agua de la Bahía de Santa Monica.

GRACIAS POR SU PARTICIPACIÓN

Nosotros vamos a llamarle en _____ al _____

Santa Monica Bay Beach Study
3107 Santa Monica Boulevard, Santa Monica, CA 1-800-992-8395

Este proyecto es patrocinado por: California State Water Resources Control Board, Cities of Los Angeles and Santa Monica, Los Angeles County Department of Public Works, Beach Cities Health District, Los Angeles Regional Water Quality Control Board, Topanga Las Virgines Municipal Water District, Heal The Bay and Cheevo.

Printed on recycled paper. Please recycle.

Beach (Circle one): A | M | W

Interviewer # _____

Date _____

LOG OF NON-PARTICIPANTS

*Instruction: Tally each non-participant (i.e., HH) in each of the following categories: **A)** Reason for non-participation; **B)** Gender; and **C)** Ethnicity. **Note: Ineligibles** in this case are only **1)** those persons who have gotten their faces wet during the past week at any of the study beaches or at Mother's Beach (Marina Del Rey) or Santa Monica Pier, or **2)** those persons who tell you they are planning to return to any of these beaches (and get their faces wet) during the upcoming week.*

A)Reason for non-participation	B)Gender		C)Ethnicity				
Reason	Female	Male	White	Black	Latino	Asian	Other
Refusal							
Language Difficulty							
No telephone							
Ineligible							

AGE CATEGORIES

A.) 0 to 12

B.) 13 to 18

C.) 19 to 25

D.) 26 to 35

E.) 36 to 45

F.) 46 to 55

G.) 56 to 65

H.) 66 to 75

I.) over 75

BEACH INTERVIEW : DAILY TALLY SHEET

DATE: _____ **BEACH:** MALIBU **SUPERVISOR:** _____

PART I

STAFF NAME	ZONE Assignment		HOURS Interviewed		INELIGIBLE Sheet (completed)	# of Completed Interviews
			from	to		
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
					TOTAL	

PART II : INDIVIDUALS

STUDY AREA I				
# of Interviews	ADULTS	CHILDREN	FAMILIES	SINGLES
TOTAL	TOTAL	TOTAL		

STUDY AREA II				
# of Interviews	ADULTS	CHILDREN	FAMILIES	SINGLES
TOTAL	TOTAL	TOTAL		

TOTALS PART I: _____ PART II: _____ (part I and part II (column I) totals should match)

prepared : 7/10/95

PHONE INTERVIEWER DAILY TALLY SHEET

INT. NAME :_____ DATE: _____

INT. # :_____

TIME IN: _____ TIME OUT: _____

OF INTERVIEWS

HOUSEHOLD : _____

INDIVIDUALS : _____

BUSY	NO ANSWER	ANSWER MACHINE	CALL BACKS

# OF ATTEMPTS TO COMPLETE INTERVIEW (household)				
1	2	3	4	> 4

COMMENTS :

prepared : 7/10/95

UPDATE: PHONE CALLS TO MAKE

MORNING ENGLISH		AFTERNOON ENGLISH		EVENING ENGLISH		O.S.C. (out of state calls)	
DATE	#	DATE	#	DATE	#	DATE	#
TOTAL		TOTAL		TOTAL		TOTAL	

MORNING SPANISH		AFTERNOON SPANISH		EVENING SPANISH		O.S.C. (out of state calls)	
DATE	#	DATE	#	DATE	#	DATE	#
TOTAL		TOTAL		TOTAL		TOTAL	

INDIVIDUAL CALLS

NAME	DATE	LANG	#	NAME	DATE	LANG	#
TOTAL				TOTAL			

PROBLEM CALLS

DATE	LANG	TIME	#	DATE	LANG	TIME	#
TOTAL				TOTAL			

RESPONDENTS CALL BACKS

DATE:_____ DAY OF WEEK : _____

NAME (INTERVIEWER)	TIME CALLED	NAME (RESPONDENT)	BEACH	ENG. OR SPAN.

PREPARED : 7/6/95

Last date for follow-up _____

Beach (Circle one): A | M | W

Beach interview dates _____ – _____

LOG OF WEEKLY LOSS - TO - FOLLOW - UP

A)Reason for loss-to-follow-up	B)Ethnicity	C)Age	D)Gender	E) Map code

Reason	White	Black	Latin	Asian	Other	DK	<12	≥12	F	M	I	II
Refusal												
Other reason (specify) 1) 2)												
No answer												
Answering machine												
Wrong number/ disconnect												
Ineligible (back to the beach)												

SANTA MONICA BAY BEACH STUDY

TIMESHEET

EMPLOYEE NAME _____ PERIOD COVERED FROM _____ TO _____

DAY	DATE	IN FOR DAY	OUT	IN	OUT FOR DAY	TOTAL OF HOURS WORKED
SAT	/	:	:	:	:	.
SUN	/	:	:	:	:	.
MON	/	:	:	:	:	.
TUES	/	:	:	:	:	.
WED	/	:	:	:	:	.
THUR	/	:	:	:	:	.
FRI	/	:	:	:	:	.
SAT	/	:	:	:	:	.
SUN	/	:	:	:	:	.
MON	/	:	:	:	:	.
TUES	/	:	:	:	:	.
WED	/	:	:	:	:	.
THUR	/	:	:	:	:	.
FRI	/	:	:	:	:	.
					TOTAL HOURS	

EMPLOYEE SIGNATURE _____

I hearby certify that this time is a true statement of hours worked by this employee and that the assigned work has performed in a satisfactory manner.

FOR OFFICE USE ONLY			
HOURLY RATE	$.	$.	$.
TOTALS	$.	$.	$.

Supervisor _____ Date _____

3-494

APPENDIX C

TYPICAL BEACH INTERVIEW
TYPICAL PHONE INTERVIEW

Example of a Typical Beach Interview

Interviewer: "Hello, my name is (*Name*) and I am here with the Santa Monica Bay Restoration Project. We are down here this summer doing a research study on the quality of the water in the Santa Monica Bay. Do you have a minute to answer a few quick questions?"

Beachgoer: "Sure." (If the response had been "no", the response would be politely acknowledged.)

I: "Have you been or do you plan on swimming in the water today?"

B: "Yes, I went in swimming earlier today."

I: "Have you been to the beach in the past week?"

B: "No, this is my first time this summer." (If the respondent had been to any of the 3 study beaches or any other "ineligible" beach in the last week (7 days) and gone swimming, the interview would have been politely terminated.)

I: "All right. If it is OK with you I am going to take down the names and ages of anyone in your family who has been in the water today. (Last names were required from adults who only gave work telephone numbers.) Then what we do is, in nine days, give you a brief phone call. It is completely confidential and we will ask you some general health questions. Would that be OK?

B: "I guess so."

I: "OK, your name and age?" (Respondents were allowed to point to an age category on a laminated chart. Names and ages of every eligible participant were recorded on the field sheet.)

I: "Where did you (and other household members) go swimming today?" (The location was recorded.)

"OK, a phone number, either work or home, and a time that it is convenient to reach you?" (The information was recorded along with comments which might be helpful to the telephone interviewer during the follow-up interview.)

"Here is a flier which tells you a little more about the study and there is a phone number on there that you can call if you have any further questions. I want to thank you very much for your time and, for your participation. We have a frisbee or pail for you (and/or for the children)."

B: "OK, thank you."

I: "Have a nice day."

Example of a Typical Telephone Interview

Interviewer: "Hello, my name is (*Name*) and I am calling from the Santa Monica Bay Beach Study."

Participant: "Hello."

I: "I understand that you attended Ashland beach on (*Date*) and you spoke with (*Name*), one of our interviewers."

P: "Yes, I remember (*Name*)."

I: "Have you been back to the beach since that day?"

P: "No, I have not had the chance to return to the beach. I was on vacation that week and that was the only chance I've had all summer to go."

I: "Were you swimming that day?"

P: "Yes I was."

I: "Did you get your face wet?"

P: "Yes I did."

I: "Was anyone else swimming with you that day?"

P: "No."

I: "Since that day at the beach, have you had either a fever or chills?"

P: "No."

I: "Have you experienced any redness or discharge from the eyes?"

P: "No."

I: "What about an earache or any substance draining from the ear?"

P: "No."

I: "Have you noticed a skin rash or any infected cuts or scrapes?"

P: "No, but should I expect to contract any of these illnesses in the future?"

I: "No. We're not saying that you will be experiencing any of these symptoms."

P: "All right."

I: "Have you been nauseous or vomiting?"

P: "No."

I: "Have you had diarrhea since your visit to Ashland beach?"

P: "I had a little diarrhea for two days following the beach but I don't think that had anything to do with the beach or the water."

I: "Why do think so?"

P: "It just seems highly unlikely that this could have been the cause."

I: "Did you experience diarrhea in the week prior to your beach visit?"

P: "No. It wasn't a problem the week before."

I: "For the two days you did have diarrhea, did you see blood in the diarrhea?"

P: "No."

I: "Have you had stomach pain or cramps?"

P: "Yes, a little stomach cramping when I had the diarrhea."

I: "Was the cramping a problem before your visit to the beach?"

P: "No."

I: "All right, have you been coughing since that day?"

P: "No."

I: "Have experienced nasal congestion or a runny nose?"

P: "No."

I: "Have you had a sore throat?"

P: "No."

I: "How concerned are you about the environmental hazards at the beach? Would you say you are not at all concerned, somewhat concerned, a little concerned or very concerned?"

P: "Well I'm very concerned, of course."

I: "And your ethnic background?"

P: "I am white."

I: "And your zip code?"

P: "90405."

I: "Well, I think that is all the information I need. Do you have any questions for me?"

P: "No, but I just want to say that you and your organization are doing a wonderful job. Keep up the good work."

I: "I thank you for your interest and support in our study. Your cooperation is much appreciated."

P: "You're welcome. Good-bye."

I: "Good-bye."

APPENDIX D

TRAINING MANUAL

SANTA MONICA BAY BEACH STUDY

TRAINING MANUAL

1995 Santa Monica Bay Beach Study

TRAINING MANUAL

TABLE OF CONTENTS

	page
ABOUT THE STUDY	1
INTERVIEWING TECHNIQUES	2
BEACH INTERVIEW GUIDELINES	9
EXPECTED QUESTIONS AND RECOMMENDED ANSWERS	10
DAILY SCHEDULE FOR BEACH INTERVIEWERS	11
INSTRUCTIONS FOR TELEPHONE INTERVIEWERS	12
MEDICAL APPENDIX	14
HOW TO PROTECT YOURSELF FROM SUNBURN	16

QUESTIONNAIRES

ADDENDA

- Timesheets
- Mileage and Expenses
- Employee Confidentiality Pledge

ABOUT THE STUDY

The Santa Monica Bay Beach Study is being conducted by scientists commissioned by the Santa Monica Bay Restoration Project (SMBRP) -- a coalition of Federal, State and Local agencies, environmental and industry groups, and the general public, all dedicated to enhancing the quality of the Santa Monica Bay.

SMBRP was formed in 1988 to address such concerns as preserving the Bay's ecosystem and living resources, Bay water quality, and public health issues associated with swimming in the Bay and consuming Bay seafood. The Santa Monica Bay extends from the Ventura County line to Point Fermin on the Palos Verdes Peninsula.

The major purpose of the study is to characterize the health effects of swimming at beaches in the Santa Monica Bay, which have never before been studied. The health outcomes of interest include skin rashes and infections, eye infections, ear infections, upper respiratory infections (cold- and flu-like symptoms), and gastroenteritis (including diarrhea and vomiting).

Approximately 12,000 subjects, adults and children, will be recruited from 3 beaches [Santa Monica Beach (Ashland), Will Rogers' State Beach, and Malibu Lagoon State Beach] once it is determined that they have met certain eligibility criteria (*see BEACH QUESTIONNAIRE SUPPLEMENT*). Approximately 10 days later, we will re-contact these same subjects to ascertain the health outcomes of interest. On the same days that beach interviews are being conducted, water samples will be collected at various points nearby and tested for selected measures of water quality.

We want to determine whether the frequency of each health outcome is correlated with measures of water quality.

It is our hope that 12,000 completed beach interviews will result in 10,000 completed telephone interviews.

In spite of the large number of beach visitors, as well as the time, money and effort spent by the County of Los Angeles, we still do not know the health effects of swimming at these beaches. We do not know under what conditions parts of beaches or entire beaches should be closed or posted with warning signs. For the first time, we have a study designed to answer these questions.

The results will be relevant, not only for the Santa Monica Bay, but for beaches throughout the county (and other countries) that are located within or near large urban areas.

INTERVIEWING TECHNIQUES

Data Collection

The data collection stage is a key element of any research study. During the interviewing phase, the success of the study rests in the hands of the interviewers. THE BEST QUESTIONNAIRE IS ONLY AS GOOD AS THE INTERVIEWER'S SKILL AT USING IT. Throughout the data collection period, the beach or office supervisor keeps in close touch with each interviewer. The supervisor prepares the interviewing materials and works to maintain the quality of the interviewing. Interviews completed at the beach will be counted there before they are transported to the study office where they will be counted again.

Editing the Interviews

Completed interviews should be edited first by the interviewer and then reviewed by the supervisor to be sure they are complete and clear. Missing information is provided by the interviewer, if possible, or later by the Respondent during the telephone interview.

Reporting the Results

Using statistical analysis, conclusions about the questions being studied are derived. Reports are written which contain the conclusions and a description of the findings.

Your Role as an Interviewer

As a survey research interviewer, you are involved in the very important act of data collection. The information given and recorded during the interview must be accurate and complete, so as not to bias or distort the study results.

Ethics of Survey Interviewing

People who work in professions which deal with the experiences, thoughts, and health of others have an ethical responsibility to these people. Just as doctors and lawyers must respect the information about their patients and clients as privileged, so must study interviewers.

The research team promises Respondents that the information they provide will never be reported or revealed in any way which would allow the information to be connected with their names. A Respondent's answers are combined with those of other Respondents in the study, and the results are reported in percentages and totals in such a way that no individual Respondent's answers can be identified. Information collected or seen during an interview can be shared only with other members of the research team.

PREPARING FOR THE INTERVIEW

Review Your Study Manual and Materials

Review this manual and any other study materials until you are sure you understand all aspects of your job. Go over the general principles of interviewing, learn the field procedures, and understand the intent of each question included in the interview.

Review the Questionnaire

Before you begin interviewing, practice using the questionnaire until you feel confident.

A successful interview requires you to fully understand and easily and correctly use the questionnaire. Maintaining an even interview flow (knowing the skip patterns, having flash cards handy) will greatly facilitate the interview process.

Organize Your Materials

Be sure you know what materials you need and have them organized before you begin the interview. Be accustomed to handling them so that you don't find yourself fumbling for what you need.

MECHANICS OF RECORDING AND EDITING BEACH INTERVIEWS

It will be easier for the phone interviewers as well as the supervisors and the analyst when these procedures are followed:

1) **Writing must be legible.** Regardless of how good the interview may have been it is worthless if the record of it cannot be read. In editing your interview check to be sure that all writing can be read easily.

2) **Use a pencil to record.** Carry several pencils with you when you start your interviewing day so you will always have a sharp one.

3) **Account for each question in the questionnaire.** Each question must be answered or it must have some explanation from the interviewer as to why it wasn't answered.

4) **Identify each interview.** Proper identification of the interviewer must appear on each interview.

With practice (try recording radio newscasts, practice on friends, etc.) you will be able to record the interview with little difficulty. You can become adept at speedy recording by beginning to write immediately when the respondent starts to talk. Any comment that may help us in the phone interview (i.e., is concerned about confidentiality, is unsure about going back to the beach, very concerned about the environment, etc.) may be

written in the margins or on the back of the interview.

We know how difficult it is to record information at the beach. Do not be concerned about the overall neatness of the interview but rather be concerned about the understandability and legibility. Feel free to cross out information, and make notes in free spaces. The field interview is a tool and should be thought of as such.

When you edit your questionnaire, remember that they will be seen and used by someone who was not present when you conducted the interview. The best time to edit an interview is right after you complete it, when recollections are clearest. Also, if you find you are missing information you can return to your Respondents if necessary.

BEGINNING THE INTERVIEW

Gaining Cooperation

1) The Respondent and interviewer need to establish good rapport. Rapport provides the foundation of good interviewing. The Respondent's impression of you during your introduction and early remarks will determine the nature of the rapport that develops. Be sure that your tone is pleasing and friendly, that you speak clearly, and that you know what you are going to say.

2) The Respondent needs to perceive the study as being important and worthwhile. Some Respondents may be doubtful about the study's value. You must be prepared to interest the Respondent in the study. The Respondent should see the interview as an opportunity to contribute important information and to have that information used meaningfully.

3) Any barriers the Respondent feels about the interview need to be overcome. You must use your initial time with the Respondent to your advantage and be alert to any doubts they may have, even if they are not expressed verbally. Your professional and friendly manner, your introductory statements, and the success with which you answer the Respondent's questions are the things that will sell both you and the study to the Respondent.

   Your own state of mind has a large impact on the Respondent's willingness to participate in the interview. Your conviction that the interview is important strongly influences the Respondent's cooperation. Your belief that the information you obtain is significant and useful motivates the Respondent to answer accurately. Although people are sometimes reluctant to give specific information, they

will often give that information if they are convinced that good use will be made of it and that their privacy will be maintained.

Conducting the Interview

1) Tell the Respondent who you are and who you represent.

2) Have information about the study clearly in mind so you can explain it readily.

3) Mention that the Respondent's answers are confidential. The questionnaire provides an introduction,but additional introductory remarks may be required to answer the Respondent's questions.

4) Keep the introduction brief. Listen to the Respondent carefully and answer only what is asked. You must be able to provide answers to most common questions that will be asked about the study. If there is a question about which you simply have too little information to answer, you can show them the number of the study office which is printed on the brochure.

5) **Always remain neutral** while asking the questions. You must maintain a neutral attitude with Respondents. You must be careful that nothing in your words or manner implies criticism, surprise, approval or disapproval of either the questions asked or the Respondent's answers. The answers should not be influenced by your behavior or attitudes.

6) **Ask all questions in the order presented in the questionnaire** and do not skip over any of the questions, even though you think there may be some repetition. Never change the order of the questions even though you may feel that the Respondent has already answered some of the questions before you get to them.

PROBING

What is Probing and Why is it Necessary?

Probing is a technique used to stimulate discussion and to obtain more information. Probing is necessary if a Respondent's answer is unclear, irrelevant or incomplete. Probing motivates the Respondent to enlarge or clarify their answers.

Know the Objective or Intent of the Question

You will be best able to determine the adequacy of an answer if you fully understand the purpose and meaning of each question. Once you know the purpose of a question, you will find it much

easier to decide if you have a satisfactory answer or whether you should try to probe to obtain a clearer and fuller one.

The Importance of Keeping Probes Neutral

It is very important to use neutral probes. You should not imply that you expect a specific answer or that you are dissatisfied with an answer.

Remember that the reason for probing is to motivate the Respondent to respond more fully or to focus the answer, without introducing bias.

Kinds of Probes

There are several different kinds of neutral probes which appear to be part of a normal conversation and can be used to stimulate a fuller, clearer response:

1) **An expression of interest and understanding.** By saying such things as "uh-huh" or "I see" or "yes," you indicate that the response has been heard, that it is interesting, and that more is expected.

2) **An expectant pause.** The easiest way to convey to a Respondent that you know he or she has begun to answer the question but has more to say, is to be silent. A pause, often accompanied by an expectant look or nod of the head, allows the Respondent time to gather his or her thoughts and then continue.

3) **Repetition of the question.** When the Respondent does not seem to understand the question, misinterprets it, or strays from the subject, repeat the question.

4) **Repetition of the Respondent's reply.** Your repetition of what the Respondent has said is often an excellent probe.

5) **A neutral question or comment.** Neutral questions or comments are often used to obtain clearer and fuller responses. Following are some suggested probes:

PROBES TO CLARIFY

"What do you mean exactly?"

"What do you mean by...?"

"I don't understand. Could you please explain that a little more?"

PROBES FOR SPECIFICITY

"What in particular do you have in mind?"

"Could you be more specific about that?"

"Tell me about that. What/who/how/why...?"

"Would that have been closer to ____ or to ____?"

PROBES FOR RELEVANCE

"I see. Well, let me ask you again, (REPEAT QUESTION EXACTLY)."

"Would you tell me how you mean that?"

PROBES FOR COMPLETENESS

"What else?"

"What other (reasons/things/examples) can you think of?"

Probing a Don't Know (DK) Response

The "I don't know" answer can mean a number of things. The Respondent may not understand the question and answers with "don't know" to avoid saying that he or she doesn't understand. The Respondent may be thinking the question over and says, "I don't know" to fill the silence but also to have time to think. The Respondent may be trying to evade the question, or may really not know or have any opinion on the question.

Don't be in too big a rush to settle for a "don't know" reply. An expectant pause will usually give the Respondent time to think of something further to say. Always try at least once to obtain a reply to a "don't know" response, before accepting it as the final answer. But be careful not to antagonize the Respondent or force an answer.

Examples of Probing

Q: When you used a thermometer to take your child's temperature, what did it read?

A: Oh, about 98°-102°.

Improper probe: So, you'd say 100°?

Proper probe: Can you be more specific?

Proper probe: Would it be closer to 98° or to 102°?

Q: What has been your usual occupation?

A: I assisted the manager in the office.

Improper probe: Oh, you did supervisory work?

Proper probe: Assisted the manager? Could you be a little bit more specific?

When to Stop Probing

When you have obtained as much information from the Respondent as possible and when you have encouraged the Respondent to clarify when necessary, you should stop probing. However, if at any time the Respondent becomes irritated or annoyed, stop probing. It is important to gain the information, but not at the expense of discontinuing the interview.

TELEPHONE INTERVIEWING

The basic procedures and techniques employed in face-to-face interviewing are applicable to telephone interviewing as well. There are obvious differences and unique problems in a telephone survey. Communication in any interviewing situation is not simple, and in telephone interviewing communication is complicated by the elimination of normal face-to-face contact.

In the telephone interview the Respondent reacts to the interviewer's voice rather than to a beheld personality. This emphasizes a need for the interviewer to be courteous, to sound pleasant and to speak slowly and clearly. It is important that the interviewer identifies himself immediately and addresses the Respondent (or whomever answers the phone) by name whenever possible. The interviewer must establish friendly relations with the person on the other end of the line by concisely stating the purpose of the call and expressing enthusiasm for the project with sincerity. Introductions should be brief, however, so that the interest of the Respondent is not lost.

If there seems to be suspicion or wariness on the part of the Respondent, stress the confidentiality of the information that is sought. It is important to remind the Respondent that their name is in no way connected to the data being analyzed.

The instructions for recording responses in a telephone interview are the same as in a face-to-face interview: all responses are recorded. However, in a telephone interview it is more imperative

to be completely familiar with the questionnaire to avoid embarrassing pauses. A constant flow is essential; otherwise, the Respondent will lose interest, resulting in premature termination of the interview.

All probes must be verbal and nondirective. The telephone interviewer cannot rely on a facial expression or a raised eyebrow to gauge whether or not the Respondent understands the questions, and may fall into the pitfall of prodding, suggesting, or rushing the respondent. A pleasant, nicely modulated and interested voice is the most effective technique, coupled with the know-how of probing effectively.

ENDING THE INTERVIEW

Respondents must be treated courteously and tactfully. Try to leave them with the impression that they have taken part in an interesting and worthwhile experience -- one they would be willing to repeat.

After all the questions have been asked, thank the Respondent. Also mention that their contribution has been very helpful in providing important information to the study. You may spend a few minutes answering any additional questions the Respondent may have.

BEACH INTERVIEW GUIDELINES

Though people at the beach will be engaged in a variety of activities, the most convenient way to approach them about the study is while they are lounging or sunbaking. This approach is usually less disruptive and allows the interviewer a chance to collect information away from the activity at the shoreline or at the water. Nevertheless, people who are simply wading or just getting their feet wet should be approached as well.

Single adults or any adult member of a family can be the source of information on themselves or any family member. That same adult can be the source for children who are not part of the family but have come to the beach under their supervision.

We will contact the adult who we spoke to on the beach by telephone at the time of the followup and get permission to telephone the parent of the non-family member who was at the beach that day.

Children 12 years or older may be questioned directly by the beach surveyor. It is important that the surveyor take the time to make any accompanying adult aware of the purpose of the study. Teenagers at the beach who are not accompanied by an adult can be recruited, but should be told to inform their parents that a followup telephone interview will occur.

Most people we will encounter on the beach will not be surprised

to know that this type of survey is being done. For years, discussion in the news media has focused on the condition of the water in the Santa Monica Bay.

Most people will be helpful and willing to participate. To establish good rapport, surveyors should be friendly and encourage questions and comments but try to limit the amount of information they give about the study.

Beachgoers should be reminded that the results of the study will provide answers to the some of the most important questions regarding the safety of swimming in the Bay.

Many people will express strong opinions about the pollution in the water, who causes it, what should be done about it, and other aspects of the study. Please do not attempt to persuade those with strong preconceptions that their opinions are wrong. Avoiding arguments and long discussions will insure that the work is accomplished in a timely and friendly manner.

EXPECTED QUESTIONS AND RECOMMENDED ANSWERS

QUESTIONS:

1) Why do you want to know where I swim? Is there a problem?

2) Should I swim near a storm drain? Is it safe?

3) Why are you asking health questions? Do a lot of people get sick swimming in the Bay?

4) What are the chances of getting sick if I swim in the Bay? Are my children at greater risk?

5) Why do you want to know if my face got wet? Does that matter?

6) Why do you want to know what beaches I have gone to in order to swim? Are some beaches safer than others?

7) Just how polluted is the Santa Monica Bay?

8) I went swimming at the beach last week and got a skin rash. Does that mean the water is polluted?

9) Why do you want to know if my kids swam in the lagoon? Isn't it safe?

10) I surf here every day. Why is someone suddenly asking questions? Have other surfers been having problems?

11) What kinds of health questions will you be asking?

ANSWERS:

Answers to all questions except 7) and 11) would essentially be the same:

"We don't know. That's why we are doing this study. No one has ever done a scientific study of the question you're asking about."

7) "I don't know. That's the kind of important information we need to have. Watch the newspapers for results of this study in the Fall."

11) "The questions will be a general health review."

It's okay to say, in general, "I'm working for a scientific study and it's important for me to remain impartial and objective so that the results of the study won't be biased."

DAILY SCHEDULE FOR BEACH INTERVIEWERS

9-10:	Meet at study office/gather materials/discuss problems/change strategy(ies)/ transportation to beach
10-12:	Interviewing (with break)
12-12:30	Lunch
12:30-3:30	Interviewing (with break)
3:30-4:00	Count questionnaires/transportation to study office
4:00-5:00	Edit questionnaires/participate in daily count/place questionnaires in bins

INSTRUCTIONS FOR TELEPHONE INTERVIEWERS

HEALTH QUESTIONNAIRE

BACKGROUND: The health questionnaire is a simple two-page scannable form that lists the most frequent symptoms of common, acute infectious diseases that could be contracted from swimming in the Santa Monica Bay. The diseases targeted are:
1) PINK EYE (Conjunctivitis)-an inflammation of the delicate transparent membrane (covering) that lines the eyes.
2) INFECTIONS OF THE MIDDLE AND OUTER EAR (Otitis media and otitis externa)-middle ear infections are mainly characterized by pain while outer ear infections feature painless discharge.
3) SKIN PROBLEMS-Rashes or infections pertaining to the skin
4) "STOMACH FLU"(Gastroenteritis)-illness identified by sudden onset of crampy abdominal pain, vomiting and/or diarrhea
5) COLD SYMPTOMS (Upper respiratory infections)-this category includes congestion, sore throat and cough
6)FEVER AND CHILLS-is defined as a temperature equal to or greater than 100° Fahrenheit or 38° centigrade. Could accompany almost any of the above symptoms included on the questionnaire.

THE QUESTIONNAIRE: The goal of the questionnaire is to reliably identify symptoms that meet the criteria for the above diseases.

Since our diagnosis will be based only on "word of mouth" it is crucial that all phone interviewers carefully comply with the following directions so our answers are reliable and reproducible.

QUESTIONNAIRE INSTRUCTIONS FOR INTERVIEWERS:

Each symptom is divided into three columns a,b, and c. Column a asks if the person (or child) has developed that particular symptom SINCE his visit to the beach. Column b asks if the person had the symptom during the week PRIOR to the beach visit. Column c is for comments. This is how the questions flow for each symptom EXCEPT fever and chills:
-Ask "a". Did you or your child have (symptom) at any time since your visit to the beach? If the answer is no go on to the next symptom.
-If "a" is yes, ask b. Did you or your child have (symptom) during the week before you went to the beach? If this is no, go on to the next symptom.
-If the answer is yes, the interviewer will write the person's

comments in column c (you may need to use a probe) and go on to the next symptom.
-Use probes (SEE BELOW) on most symptoms before marking any "don't knows". If the probe does not elicit any more information mark "don't know" and go on to the next symptom.
-For fever and chills only ask "a" since this can only be an acute problem. Note that the scantron does not have a "b" or "c" for these symptoms.

IMPORTANT NOTE: THE SUPERVISOR, NOT THE INTERVIEWER, WILL DECIDE FROM THE COMMENTS IF WE CAN COUNT THIS AS A SYMPTOM RELATED TO SWIMMING IN THE OCEAN. THEREFORE ANY TIME YOU MARK YES TO A AND YES TO B YOU MUST WRITE COMMENTS IN C SO A PHONE SUPERVISOR CAN DECIDE THE APPROPRIATE ANSWER.

QUESTIONNAIRE GUIDELINES Many of you have never done health questionnaires before, so the following is a list of the symptoms with appropriate probes if the FIRST answer is "don't know". Remember, the probe is used to help the person being interviewed make a decision, not the interviewer!!! If after the probe the SECOND answer is still "don't know" go on to the next symptom after marking "don't know". If something still isn't clear write it out and have the supervisor check it.

NOTE: Most of these guidelines pertain to COLUMN A ONLY, to help identify the symptom if you get a "don't know." Anytime the answer is NO, go on to the next symptom. If the answer is yes to "a" after probing be sure to ask b and write in c.

1. FEVER: If "don't know" ask the probe: "Were you very hot, did you have a fast pulse, aches or chills that caused you discomfort?"
2. CHILLS: If "don't know" ask: "Did you have shaking that was hard to control? Did your teeth chatter?"

3. REDNESS and DISCHARGE FROM EYES: If "don't know" ask, "Did you have pink eye?" "Did you have thick yellow discharge from either eye?"

4. EARACHE: If "don't know", do not probe.

5. DISCHARGE/DRAINING FROM EARS: Again no probe necessary.

6. SKIN RASH: If yes, ask where? (A rash from ocean swimming should cover all or most of the body, not just an isolated spot on an arm for example). If "don't know" don't probe.

7. CUTS OR SCRAPES THAT BECOME INFECTED: Any cut or scrape can become slightly pinker if exposed to salt water, therefore, if "don't know" ask, "Was there a marked increase in pain, redness, swelling and/or red streaks in the skin around the cut?"

8. **NAUSEA:** If don't know ask,"Did you feel sick to your stomach so you couldn't eat?" Did you feel like throwing up?" If yes, ask if pregnant.

9. **VOMITING.** No probe necessary.

10. **DIARRHEA:** No probe.

11. **DIARRHEA WITH BLOOD:** No probe.

12. **STOMACH PAIN OR CRAMPS:** If "don't know" ask, "Did you have any stomach pain that lasted a few minutes, then went away, then returned?"

13. **COUGHING:** If yes, ask if the person has allergies or is a smoker?" If yes to either of those ask, "Was this cough stronger, and more frequent?" If you get a yes to these answers write this down for a supervisor to check.

14. **COUGHING WITH PHLEGM:** Same probes apply here as to plain coughing.

15. **NASAL CONGESTION/RUNNY NOSE:** "Ask the person if they have allergies that give them these symptoms often. If yes ask, "Was this cold more severe?" Write down answers for a supervisor.

16. **SORE THROAT:** "Ask, did your throat hurt especially when swallowing?"

Final Note: We cannot anticipate all responses that will be elicited. The key to the interviewer becoming comfortable with this questionnaire will be communication with a supervisor. Please feel free to ask ANY question at ANY time. If an interview becomes too complicated or difficult feel free to inform the interviewee that a supervisor will need to call them back. Good Luck!

MEDICAL APPENDIX

There are many ways that storm drains can become contaminated with bacteria and viruses that cause disease in humans. Direct dumping of human or animal feces into a catch basin or storm drain is one way while at times an overloaded raw sewage can leach into the storm drain system. Once in the drain some bacteria and viruses can live easily flowing along with the liquids and debris directly into the ocean. When human beings swim near these germs they can be ingested and cause a variety of diseases that affect the skin, eye, respiratory tract and gastrointestinal symptoms. For those of you interested I have listed the common bacteria and viruses that exist in this system and the problems they might cause.

BACTERIA:

Vibrio family: This is a group of bacteria most famous for causing cholera which can be deadly if untreated but is rare in this country. The most common vibrio species found in our waters only causes a short-lived gastroenteritis.

E. Coli family: This group of bacteria is found in abundance in our storm drains as this is the most common bacteria found in our stool. Many types of E.Coli do not cause any disease but some can cause gastroenteritis. Them most well-known of this group is E. coli 0157 which had a lot of media attention because it has been found in fast food chains when hamburger meat was not cooked well enough. This strain can cause bloody diarrhea.

Salmonella/Shigella family: These groups of bacteria are not common anymore but can cause serious illness of the intestinal tract.

Campylobacter: This bacteria accounts for up to 11% of all diarrhea cases. It has a wide spectrum of disease with not only diarrhea but bloody diarrhea, fatigue, fever and severe chills. It can last up to two weeks and there is no good drug to cure it.

Strep and Staph families: can cause conjunctivitis and wound infections if someone swims with a cut. Certain strains of staph cause diarrhea but salt water is not an important way this is transmitted.

VIRUSES: Account for up to 40% of all diarrhea cases.

Rotavirus family: This virus attacks kids more than adults causing a lot of vomiting and some diarrhea. It is a very common virus and a vaccine is in the works.

Norwalk: 40% of non-bacterial epidemics of diarrhea are caused by this virus. It is usually a mild illness lasting one to two days.

Enterovirus family: Enterovirus are known to to occur in summer and express themselves in a variety of diseases, the most famous being polio which is now eradicated in the Americas. They can cause sore throats, colds, heart and respiratory problems, skin eruptions and possibly diarrhea.

Adenovirus: This is a virus renown for causing epidemic conjunctivitis but is more commonly spread through direct contact or freshwater contact.

HOW TO PROTECT YOURSELF FROM SUNBURN

All one has to do to figure out that sun protection is a big issue is go to any drugstore and note virtually dozens of preparations available for sun protection. But how do you know which one is best for your skin? Understanding the science of sunburn is a good place to start before answering that question.

Everyone knows that sunlight can damage skin and increase the risk of getting skin cancer. What everyone doesn't know is that it ONLY takes three or more sunburns before the age of 20 to significantly increase your risk of getting skin cancer. This is not a lot of sun exposure!

The sun damages the skin by emitting two types of light, Ultraviolet A (UVA) and Ultraviolet B (UVB). UVA penetrates the skin more deeply more than UVB and is more responsible for deeper skin damage that leads to cancer. UVB is captured at the surface and is responsible for what we call sunburn. Now, most sunscreens which say UVA protection ONLY block about 10-20% of UVA light! Thus even though they are preventing sunburn by blocking UVB light they are NOT working effectively to decrease your risk of getting skin cancer since UVA light is still penetrating your skin! Therefore it is important to use a product that blocks UVB and at least 90% of UVA light!

There are two products on the market now that work well for total UVA and UVB block. The first one uses an ingredient called Parsol 17 and is called UVAGUARD by Shade. There is also a second ingredient called titanium dioxide that completely blocks both kinds of light. I am not sure which products are yet using this so you need to read labels. One other note, SPF factor of 15 blocks 95% of UVB light and is all that is necessary.

Other measures should be taken as well. Wearing your hat and shirt at all times is not only good protection but looks professional as well. Lip balm with SPF 15 is also helpful. Or you can coat your lips with sunscreen. Remember to re-apply sunscreen after four hours if sun exposure is to continue. If you forget to sunscreen or need more all beach supervisors will have sunscreen with them at the beach.

Finally, if you should get sunburned there is no product that can heal you faster. Any drug store will have medicated creams or sprays to help alleviate the discomfort. However sunburn is avoidable and we expect our workers to follow our guidelines and keep protected from the sun! Remember, we are thinking of your best interest!

THE BIG QUESTION: Won't tanning protect me from the sun, i.e., is a tan healthy?
THE EVEN BIGGER ANSWER: Dermatologists believe that even though tanning is a way to increase a natural pigment called melanin in the skin this is only partially protective against UVB and UVA light. Therefore allowing your skin to tan, especially heavily, cannot be called healthy.

ADDENDA

QUESTIONNAIRES

Last Date for Phone Appt. _____ ID# _____
Date (MM/DD/YY) | A | B | C | D | E | F | G |

CONFIDENTIAL (ASHLAND BEACH ONLY)

Interviewer (include #) _____ Date (MM/DD/YY)_____ (Day of week)_____

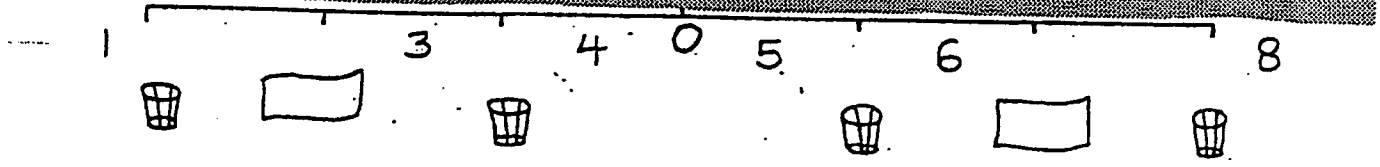
Phone Appt._____ _____ _____ Ethnicity: W | B | L | A | O English / Spanish
Day of week Date (MM/DD/YY) Time

Name – In water today	Relation (S/M/F/C)	Age	Age Cat	Gender (M/F)	Face Wet? (Y/N) B*	Face Wet? (Y/N) T*	Map Code	Study Eligible (Y/N) T*
A.) *Returned to the Beach? Yes / No*								
B.) *Returned to the Beach? Yes / No*								
C.) *Returned to the Beach? Yes / No*								
D.) *Returned to the Beach? Yes / No*								
E.) *Returned to the Beach? Yes / No*								
F.) *Returned to the Beach? Yes / No*								
G.) *Returned to the Beach? Yes / No*								

B* – Determined during Beach Interview

T* – Determined during Telephone Interview

OCEAN



name of contact person (relation)

Where would you like to be called?

work / home (____) _____ _____
number time

work / home (____) _____ _____
number time

name of contact person (relation)

Where would you like to be called?

work / home (____) _____ _____
number time

work / home (____) _____ _____
number time

Beach Interviewer's Comments

Phone Interviewer's Comments

BEACH QUESTIONNAIRE SUPPLEMENT

1995 SANTA MONICA BAY BEACH STUDY
MALIBU BEACH ONLY

Participant Eligibility

First Eligibility Requirement -- Eligible people are those who have not been in the water within the exposure area at this beach (Malibu beach) before today over the past week, or anywhere in the water at either Will Rogers, Ashland Beach, Mothers' Beach (Marina Del Rey), or Santa Monica Pier before today over the past week. The exposure area at this beach is within the area between the two supervisor blankets.

Once the first eligibility requirement has been met, the eligibility of adults and children is determined differently.

Eligible Adults

Adults *With* Children -- Adults who are at the beach today with children are automatically eligible for this study if they have submerged their heads (or gotten their faces/hair wet). They are also eligible if they have been in the water without submerging their heads and at least one of their accompanying children has been in the water.

Adults *Without* Children -- Adults who are at the beach today without children are eligible for this study only if they submerged their heads while in the water.

Eligible Children -- Children are eligible if they have been in the water today, whether they submerged their heads or not.

1995 SANTA MONICA BAY BEACH STUDY

INSTRUCTIONS FOR BEACH QUESTIONNAIRE

INTRODUCTION:

Hi! I'm from the Santa Monica Bay Beach Study. Have you or any of your family been in the water today?

My name is _____. We're doing a survey to determine whether the measures of water quality for this beach are useful. We're interested in the health of adults and children who swim here. Can I have a few minutes of your time to ask you some questions? Your answers will be confidential.

EXPLANATION OF STUDY:

This interview has 2 parts. During the first part, here, I am going to ask you where you (*your children*) were when you (*your children*) were in the water today. During the second part of the interview, someone will be telephoning you in about 9 days to ask you some health questions. That call should take about 5 minutes. Will that be all right?

USE OF TABLE AND MAP ON BEACH QUESTIONNAIRE:

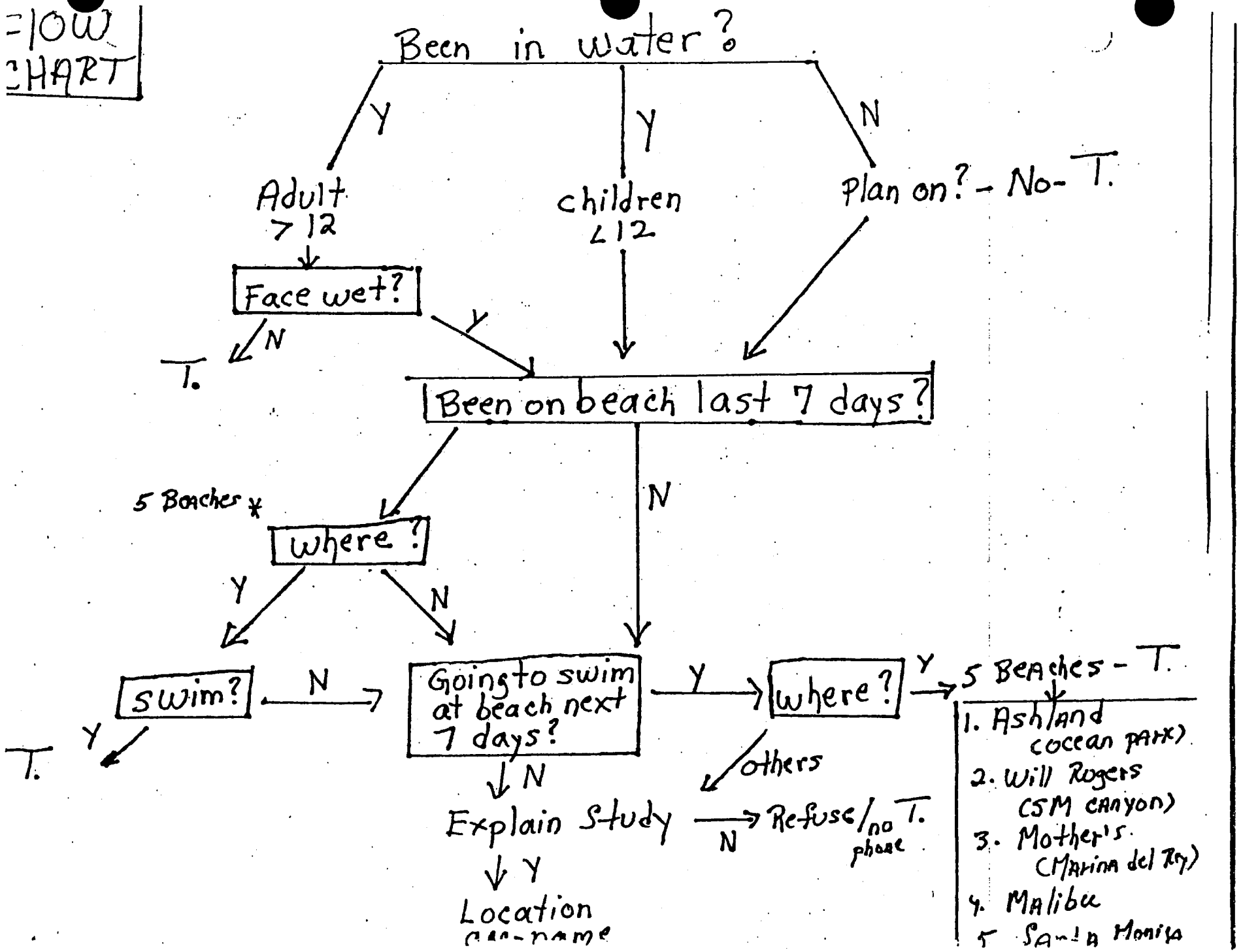
Record all **ELIGIBLE** household participants in the table (refer to the FLOW CHART to determine eligibility.) Include the ages of minors, and include only the age category (Age Cat) of adults (use **"Age Categories"** flashcard).Code relations as follows: **S = Self; M = Mother; F = Father; C = Child.** Describe other relations to the respondent fully, i.e.,aunt,cousin, friend,etc.

Use the letter corresponding to each eligible household participant to indicate their location on the map. Then mark the appropriate number from the map in the "Map Code" section of the table.

ETHNICITY CODES:

W: White **B: Black** **L: Latino** **A: Asian** **O: Other**

FLOW CHART


Been in water?
Y
Y
N
Adult > 12
children < 12
Plan on? - No - T.
Face wet?
N
Y
T.
Been on beach last 7 days?
5 Beaches *
N
where?
Y
N
swim?
N
Y
T.
Going to swim at beach next 7 days?
Y
where?
Y
5 Beaches - T.
1. Ashland (ocean park)
2. Will Rogers (CSM canyon)
3. Mother's (Marina del Rey)
4. Malibu
5. Santa Monica
others
N
Explain Study
N
Refuse/no phone T.
Y
Location
can-name

ID Number

Beach Interview Date

Month	Day
○ June	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
○ July	
○ Aug	
○ Sept	
○ Oct	

Phone Interview Date

Month	Day
○ June	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
○ July	
○ Aug	
○ Sept	
○ Oct	
○ Nov	

Water clean?
○ Yes
○ No

Gender
○ Female
○ Male

Age - Code from beach questionnaire
○ 0 to 12
○ 13 to 18
○ 19 to 25
○ 26 to 35
○ 36 to 45
○ 46 to 55
○ 56 to 65
○ 66 to 75
○ > 75

Map Code
0 1 2 3 4 5 6 7 8 9

Beach Interviewer's Number

Phone Interviewer's Number

1. (Refer to the Beach Questionnaire) **Did respondent get her/his face wet?**

○ No, face did not get wet ○ Yes, face got wet

2. **Did you (child's name) get your (her/his) face wet while you (she/he) were (was) in the water on (DAY)?**
   ○ No
   ○ Yes
   ○ Don't know/don't remember

3. **I'm going to go through a list of symptoms to find out about your (child's) health since you (she/he) were (was) at the beach on (DAY). Since your (her/his) visit to the beach on (DAY), have (has) you (child's name) had any of the following problems or symptoms?**

Problem or Symptom For each "Yes" in a, ask b, and c.	a) How about (EACH)? Did you (child's name) have that at any time since your (her/his) visit to the beach on (DAY)? No Yes DK	b) Was this a problem that you (child's name) had during the week before you went to the beach on (DAY)? No Yes DK	c) IF YES to b, Please describe how often you experienced this symptom when you had it before.
1. Fever	○ ○ ○		○
2. Chills	○ ○ ○		○
3. Redness and discharge from the eyes	○ ○ ○	○ ○ ○	○
4. Earache	○ ○ ○	○ ○ ○	○
5. Discharge/draining from the ear	○ ○ ○	○ ○ ○	○
6. Skin rash	○ ○ ○	○ ○ ○	(If yes to a, describe site.)

PLEASE DO NOT WRITE IN THIS AREA

12501

DesignExpert™ by NCS Printed in U.S.A. Mark Reflex® MM105160:32

Problem or Symptom For each "Yes" in a, ask b, and c.	a) How about (EACH)? Did you (child's name) have that at any time since your (her/his) visit to the beach on (DAY)? No Yes DK	b) Was this a problem that you (child's name) had during the week before you went to the beach on (DAY)? No Yes DK	c) IF YES to b, Please describe how often you experienced this symptom when you had it before.
7. Cuts or scrapes that became infected	○○○	○○○	○
8. Nausea (ask a woman who says "yes" if she's pregnant)	○○○	○○○	○ (Exclude nausea caused by pregnancy in a.)
9. Vomiting	○○○	○○○	○
10. Diarrhea (If 11a is no, 12a is no. Skip to 13.)	○○○	○○○	○
11. Diarrhea with blood	○○○	○○○	○
12. Stomach pain or cramps	○○○	○○○	○ (Exclude menstrual periods in a.)
13. Coughing (If 14a is no, 15a is no. Skip to 16.)	○○○	○○○	○
14. Coughing accompanied by phlegm	○○○	○○○	○
15. Nasal congestion or runny nose	○○○	○○○	○
16. Sore throat	○○○	○○○	○

4. How worried or concerned are you about environmental hazards at the beach? Would you say you are...

- ○ Not at all worried or concerned
- ○ Somewhat worried or concerned
- ○ A little worried or concerned
- ○ Very worried or concerned

5. What is your ethnic background?
(Read choices if necessary.)

- ○ White
- ○ Black
- ○ Latino
- ○ Asian
- ○ Multi-ethnic
- ○ Other, _____

6. What is your 5-digit postal zip code? (Code "99999" for foreign respondents.)

Zip Code				
⓪	⓪	⓪	⓪	⓪
①	①	①	①	①
②	②	②	②	②
③	③	③	③	③
④	④	④	④	④
⑤	⑤	⑤	⑤	⑤
⑥	⑥	⑥	⑥	⑥
⑦	⑦	⑦	⑦	⑦
⑧	⑧	⑧	⑧	⑧
⑨	⑨	⑨	⑨	⑨

(If there are other household members to interview, use another phone questionnaire, otherwise...)

THANK YOU VERY MUCH. I REALLY APPRECIATE THAT YOU HAVE TAKEN THE TIME TO ANSWER THESE QUESTIONS.

TELEPHONE INTERVIEW CHECKLIST

1 Ask respondant if there were other individuals that may have accompanied them to the beach.

2. Make sure "ID" control number on the Scan-tron corresponds with the "Interview sheet" at the top of the page.

3. If eligible for the study, don't forget to write "Y" in the proper box on the interview sheet.

4. If beach patron did not get wet at the beach, ask again. If yes, place a "Y" in the "Face Wet" column.

5. If the respondant is ineligible, write "INELIGIBLE" in the ID section of the interview sheet.

6. When interview is eligible and completed, write your initials, date, time, and "CI" for completed interview in the phone interviewer comments section of the interview sheet.

7. Appropriate map code must be transferred from interview sheet to the scan-tron.

8. The letter in the ID number section of the Scan-tron should correspond with the appropriate person on the interview sheet.

9. If "A" is yes, remember to bubble in "B"!

10. Bubble in zip code.

11. Write our probe - don't just list P_1 and P_2. Don't know answer? Probe for more information.

12. Water clean field refers to whether or not people returned to the SAME BEACH WITHIN 24 hours of the interview. If yes, bubble "yes," of no, bubble "no".



PHONE INTERVIEW

1 Adults ? 12 children L 12 yr.

Introduction

↓

CHECK ELIGIBILITY

- ? Adults → ↓ Face wet? N → T. / Y →
- Eligible Adults/Kids → ↓ Been Back to the Beach in the last 7 days? + Beaches
  - Y ↓ T.
  - N ↓ Proceed with phone questionnaire.
- ? Children → ↓ Hands + Body wet? Y → / N → T.

Beaches

Ashland (SM)
Will Rogers
Malibu
S.M. Pier
Mother's (Marina del Rey)

SANTA MONICA BAY BEACH STUDY

TIMESHEET

EMPLOYEE NAME Sandy Beach PERIOD COVERED FROM 6/2/95 TO 6/15/95

DAY	DATE	IN FOR DAY	OUT	IN	OUT FOR DAY	TOTAL OF HOURS WORKED
SAT	/	:	:	:	:	.
SUN	6 / 3	9 :30	12 :30	1 :00	4 :30	6.5
MON	/	:	↑ lunch	:	:	.
TUES	/	:	dinner ↓	:	:	.
WED	6 / 6	2 :30	6 :00	6 :30	9 :00	6.0
THUR	6 / 7	9 :00	12 :00	12 :30	3 :15	5.75
FRI	/	:	:	:	:	.
SAT	/	:	:	:	:	.
SUN	/	:	:	:	:	.
MON	/	:	:	:	:	.
TUES	6 / 12	9 :45	1 :00	5 :00	8 :00	6.25
WED	/	:	:	:	:	.
THUR	/	:	:	:	:	.
FRI	/	:	:	:	:	.
					TOTAL HOURS	24.5

EMPLOYEE SIGNATURE Mr. Sandy Beach

I hearby certify that this time is a true statement of hours worked by this employee and that the assigned work has performed in a satisfactory manner.

FOR OFFICE USE ONLY			
HOURLY RATE	$.	office completes	$.
TOTALS	$.	$.	$.

Supervisor _____ Date _____

3-534

MILEAGE AND EXPENSES

Mileage, at 25¢ a mile, will be reimbursed for the following:

1. Using your car to transport field workers from the office to the beach and back.

2. Any mileage incurred in obtaining information or equipment requested by supervisors.

3. Hopefully, we will have some free spaces at each beach. Any parking fees that are not covered, but requested by the supervisor will be reimbursed.

SANTA MONICA BAY BEACH STUDY
Employee Confidentiality Pledge

I recognize the importance of maintaining the confidentiality of all data collected by the Santa Monica Bay Beach Study and of assuring the right to privacy of persons we interview in the field and on the phone. I also understand that my employer has agreed to uphold its obligation to protect the privacy of these persons. I therefore agree to protect the confidentiality of the data in accordance with the following requirements:

I will avoid any action that will provide confidential information to any unauthorized individual or agency.

I will not make copies of any data except as specifically authorized.

I will not remove confidential identifying information from the office except as authorized in the performance of my duties.

I will not discuss in any manner, with any unauthorized person, information that would lead to identification of individuals interviewed in the Santa Monica Bay Beach Study.

I will use confidential files and data only for purposes for which I have been specifically authorized.

I understand that confidential information or data is defined as any information where the individual is identifiable. As an employee, breech of confidentiality may be cause for immediate termination of my employment.

I therefore pledge that I will not divulge to any unauthorized person any confidential information or data.

EMPLOYEE: _____
(print)

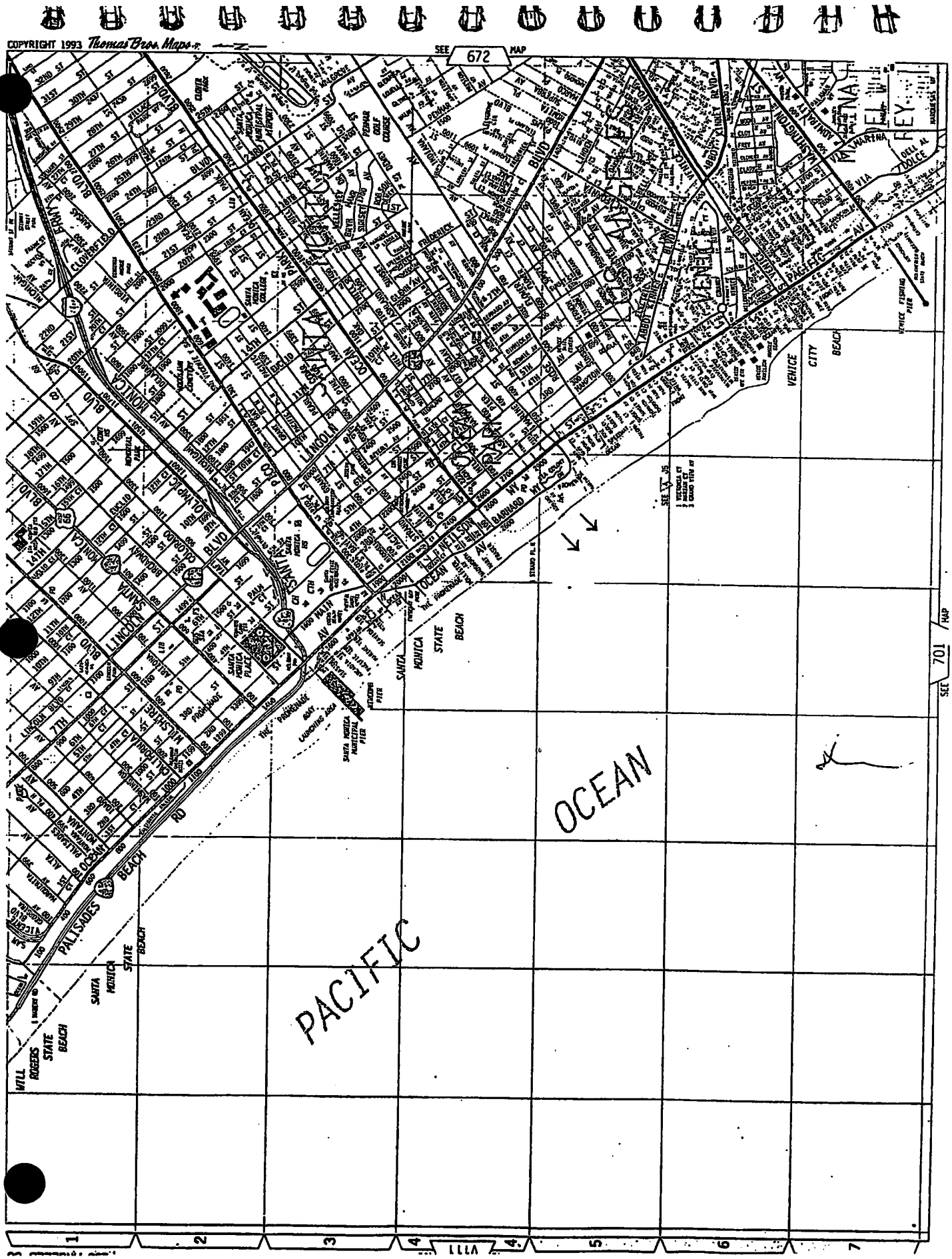
(signature)_____

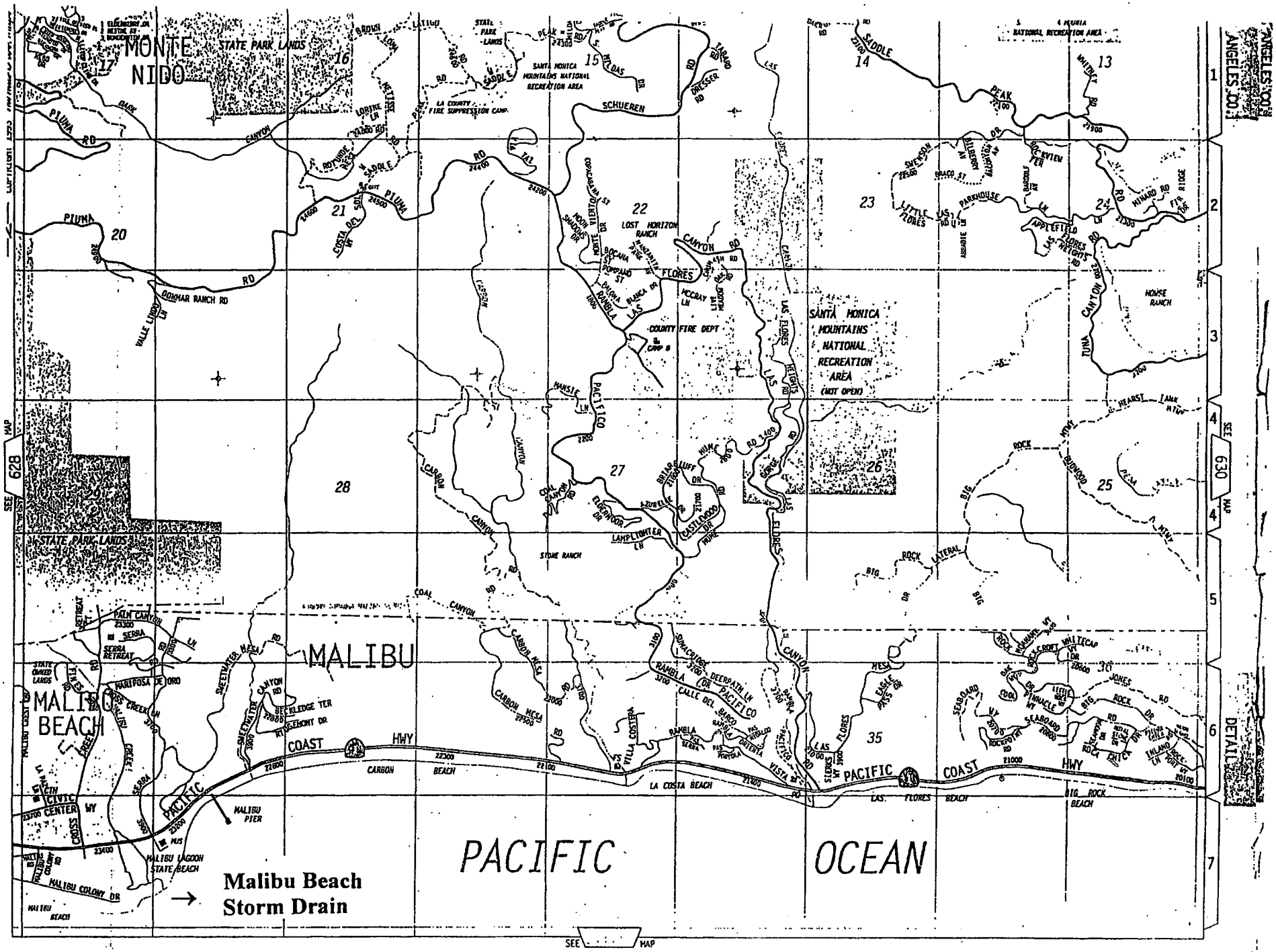
Address:_____

Date: _____

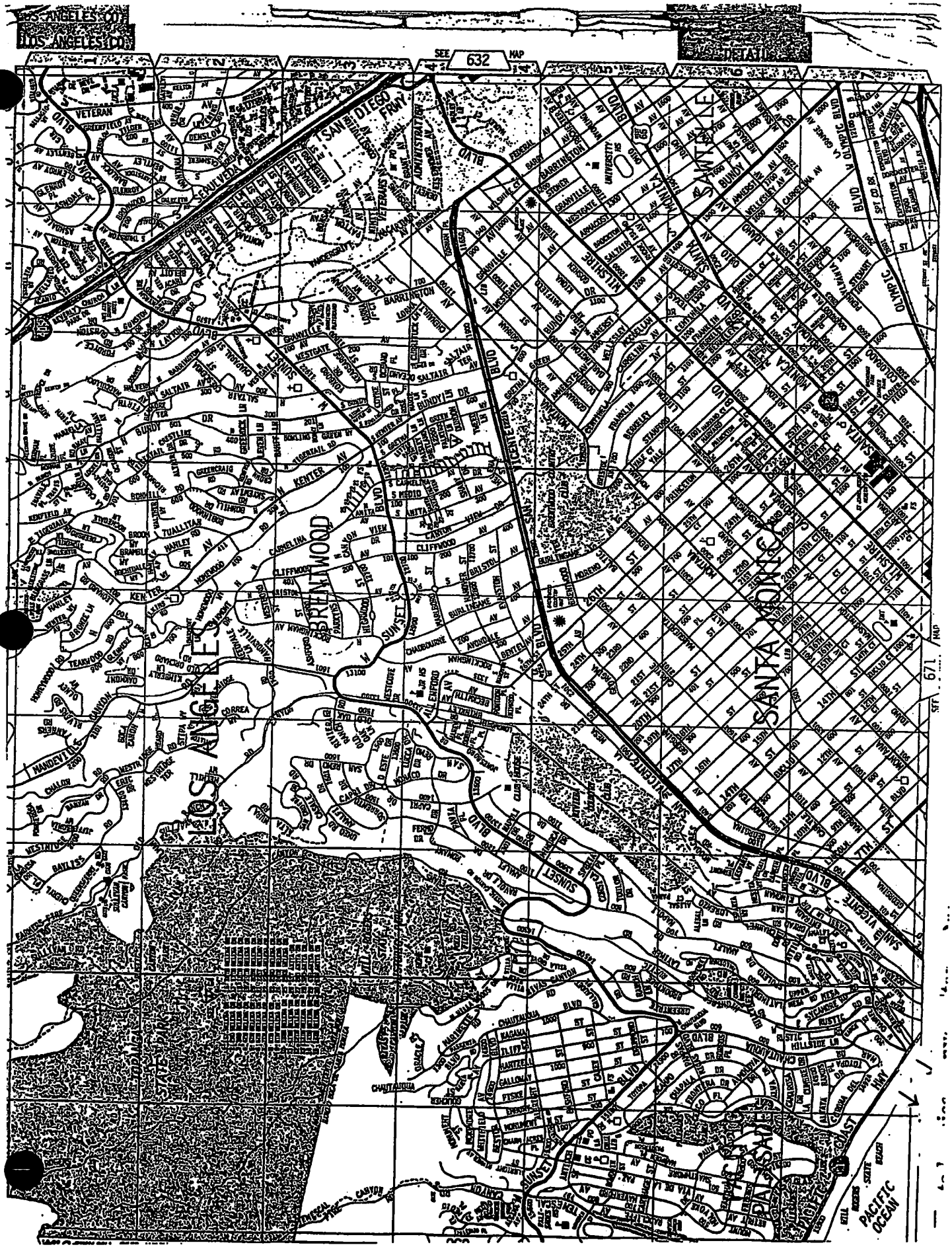
APPENDIX E

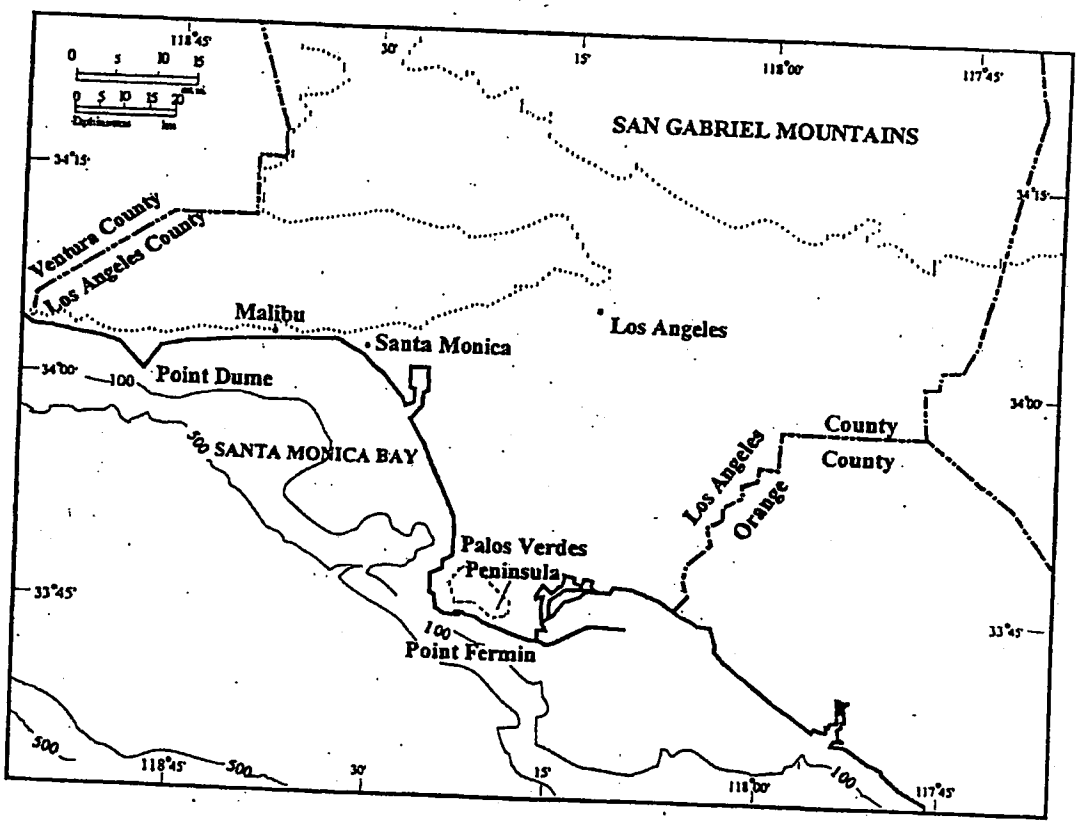
MAPS


COPYRIGHT 1993 Thomas Bros. Maps
SEE 672 MAP
SEE 701 MAP
PACIFIC
OCEAN
VENICE
CITY
BEACH
SANTA MONICA STATE BEACH
PALISADES BEACH RD
WILL ROGERS STATE BEACH
MARINA DEL REY
OCEAN AV
PACIFIC AV
LINCOLN BLVD
WASHINGTON BLVD
VENICE BLVD
SANTA MONICA BLVD
WILSHIRE BLVD
OLYMPIC BLVD
SUNSET BLVD
BARRINGTON AV
SAN VICENTE BLVD
1 2 3 4 5 6 7

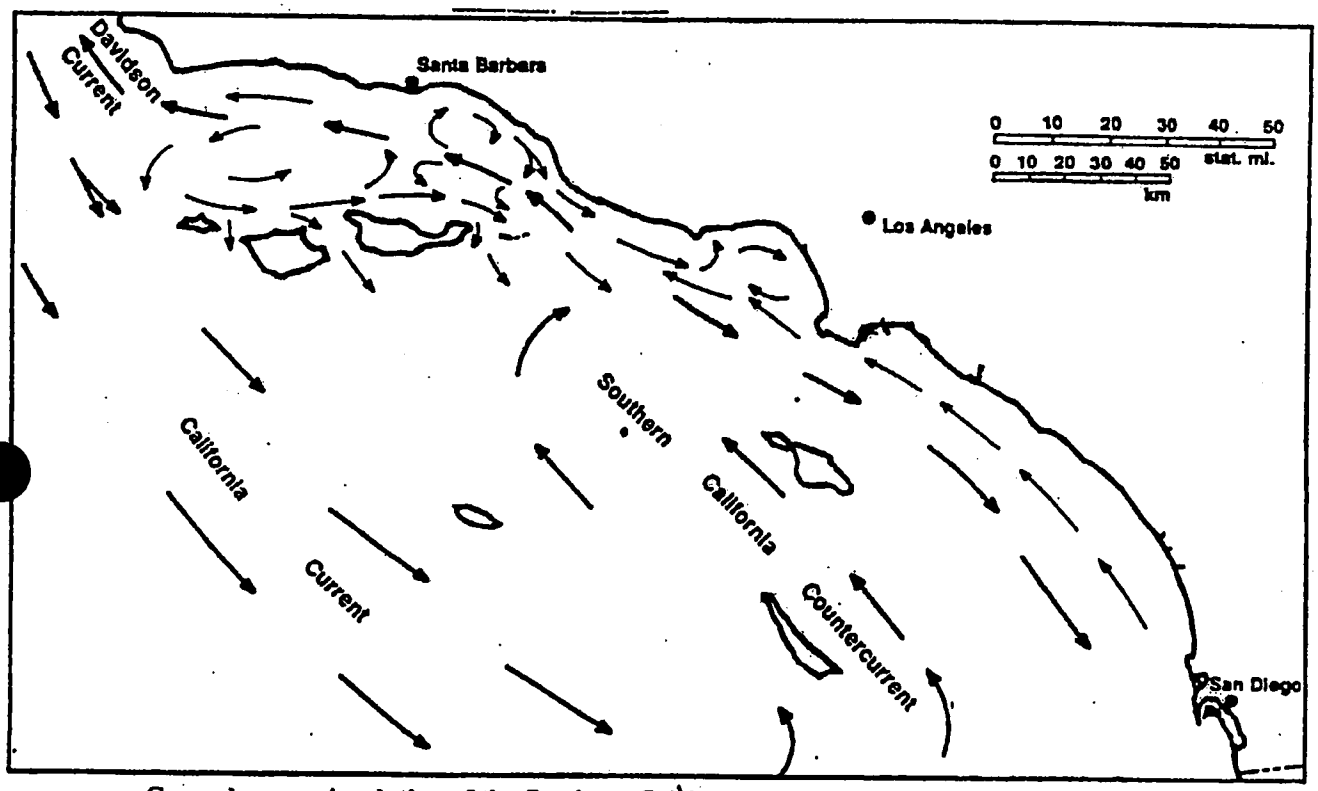

MONTE NIDO
STATE PARK LANDS
MALIBU
MALIBU BEACH
PACIFIC OCEAN
Malibu Beach
Storm Drain
SANTA MONICA MOUNTAINS NATIONAL RECREATION AREA (NOT OPEN)
COUNTY FIRE DEPT
LOST HORIZON RANCH
STONE RANCH
HOUSE RANCH
PACIFIC COAST HWY
MALIBU PIER
MALIBU LAGOON STATE BEACH
CARBON BEACH
LA COSTA BEACH
LAS FLORES BEACH
BIG ROCK BEACH
SEE MAP 829
SEE 630 MAP
SEE MAP
DETAIL 3

3-539


LOS ANGELES CO
SEE 632 MAP
SAN DIEGO FWY
SANTA MONICA
BRENTWOOD
PACIFIC OCEAN
671



Los Angeles Basin.



General ocean circulation of the Southern California Bight (modified from CLA,DWP and USEPA 1977).

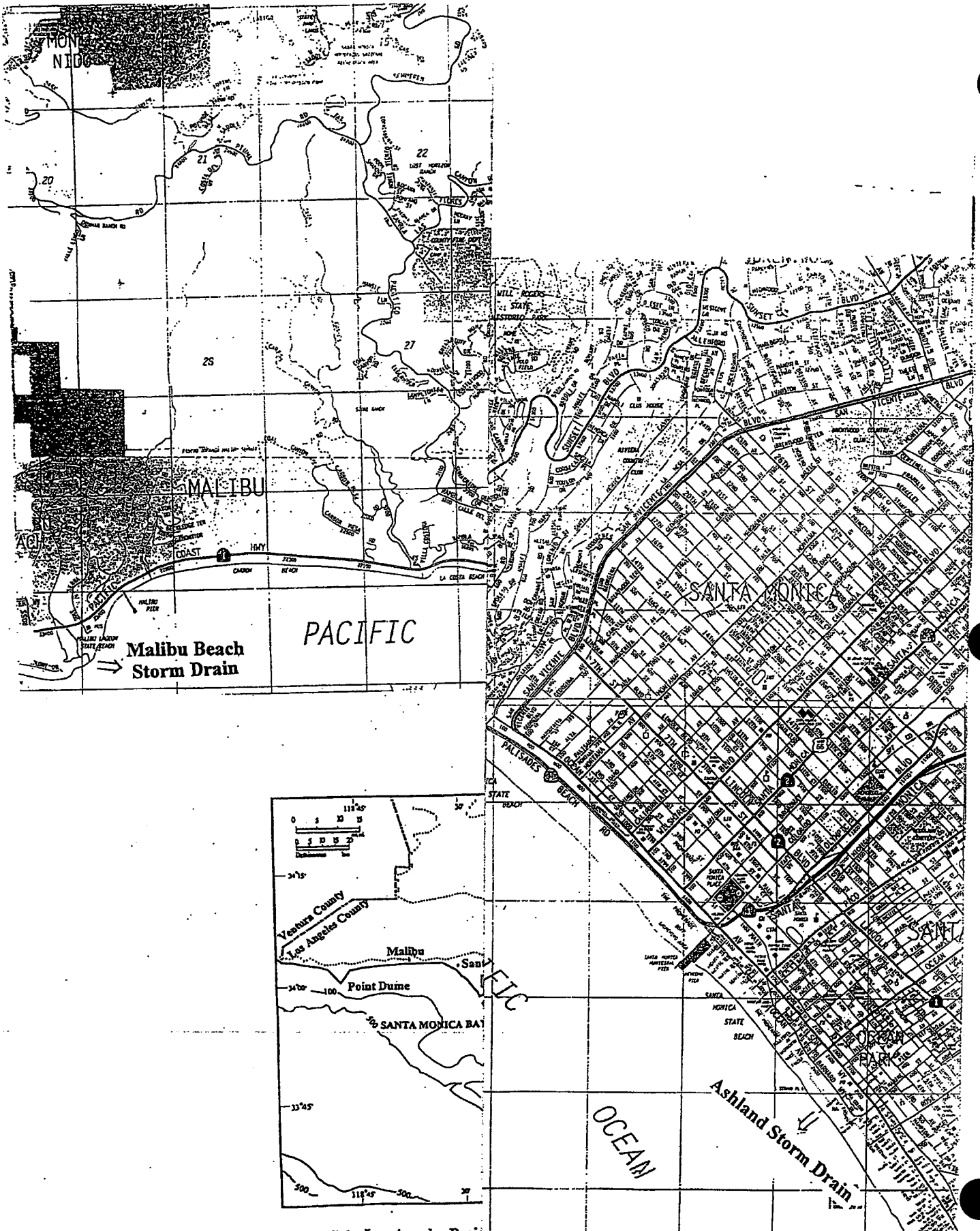


Figure I-1. Los Angeles Basi

The Health Effects of Swimming in Ocean Water Contaminated by Storm Drain Runoff

Robert W. Haile,[1] John S. Witte,[2] Mark Gold,[3] Ron Cressey,[4] Charles McGee,[5] Robert C. Millikan,[6] Alice Glasser,[7] Nina Harawa,[8] Carolyn Ervin,[1] Patricia Harmon,[1] Janice Harper,[1] John Dermand,[1] James Alamillo,[3] Kevin Barrett,[1] Mitchell Nides,[9] and Guang-yu Wang[10]

Waters adjacent to the County of Los Angeles (CA) receive untreated runoff from a series of storm drains year round. Many other coastal areas face a similar situation. To our knowledge, there has not been a large-scale epidemiologic study of persons who swim in marine waters subject to such runoff. We report here results of a cohort study conducted to investigate this issue. Measures of exposure included distance from the storm drain, selected bacterial indicators (total and fecal coliforms, enterococci, and *Escherichia coli*), and a direct measure of enteric viruses. We found higher risks of a broad range of symptoms, including both upper respiratory and gastrointestinal, for subjects swimming (a) closer to storm drains, (b) in water with high levels of single bacterial indicators and a low ratio of total to fecal coliforms, and (c) in water where enteric viruses were detected. The strength and consistency of the associations we observed across various measures of exposure imply that there may be an increased risk of adverse health outcomes associated with swimming in ocean water that is contaminated with untreated urban runoff. (Epidemiology 1999;10:355–363)

Keywords: environmental epidemiology, gastrointestinal illness, ocean, recreational exposures, sewage, storm drains, waterborne illnesses, waterborne pathogens.

Runoff from a system of storm drains enters the Santa Monica Bay adjacent to Los Angeles County (CA). Even in the dry months of summer 10–25 million gallons of runoff (or non-storm water discharge) per day enter the bay from the storm drain system. Storm drain water is not subject to treatment and is discharged directly into the ocean. Total and fecal coliforms, as well as enterococci, are sometimes elevated in the surf zone adjacent to storm drain outlets; pathogenic human enteric viruses have also been isolated from storm drain effluents, even when levels of all commonly used indicators, including F2 male-specific bacteriophage, were low.[1]

Approximately 50–60 million persons visit Santa Monica Bay beaches annually. Concern about possible adverse health effects due to swimming in the bay has been raised by numerous interested parties.[2] Previous reports indicate that swimming in polluted water (for example, due to sewage) increases risks of numerous adverse health outcomes (Pruss[3] provides a recent review of this literature). To our knowledge, however, there has never been a large epidemiologic study of persons who swim in marine waters contaminated by heavy urban runoff.

These circumstances provided the motivation to study the possible health effects of swimming in the bay. We present here the main results from a large cohort study of people that addressed the issue of adverse health effects of swimming in ocean water subject to untreated urban runoff.

Methods

Design and Subjects

The exposures of interest were distance swimming from storm drains, levels of bacterial indicators (total coli-

From [1]University of Southern California, Department of Preventive Medicine, Los Angeles, California; [2]Case Western Reserve University, Department of Epidemiology and Biostatistics, Cleveland, Ohio; [3]Heal the Bay, Santa Monica, California; [4]City of Los Angeles, Department of Public Works, Bureau of Sanitation, Environmental Monitoring Division, Los Angeles, California; [5]County Sanitation Districts of Orange County, California; [6]University of North Carolina, Department of Epidemiology, Chapel Hill, North Carolina; [7]University of California Los Angeles, Department of Prevention & Control, Los Angeles, California; [8]University of California Los Angles, Department of Epidemiology, Los Angeles, California; [9]University of California Los Angeles, Department of Pulmonary and Critical Care Medicine, Los Angeles, California; [10]Santa Monica Bay Restoration Project, Monterey Park, California.

Address reprint requests to: Robert W. Haile, USC/Norris Comprehensive Cancer Center, Department of Preventive Medicine, 1441 Eastlake Avenue, Room 4455, P.O. Box 33800, Los Angeles, CA 90033-0800.

This work was supported by the Santa Monica Bay Restoration Project, City of Los Angeles, California State Water Resources Control Board, Beach Cities Health District, City of Santa Monica, Los Angeles County Department of Public Works, Heal the Bay, Los Angeles Regional Water Quality Control Board, Cheyron USA, Las Virgenes Municipal Water District, U. S. Environmental Protection Agency, and Milken Families Foundation.

Submitted March 4, 1998; final version accepted January 22, 1999.

Editors' note: See related editorial on page 351 of this issue.

© 1999 by Epidemiology Resources Inc.

forms, fecal coliforms, enterococcus, *Escherichia coli*) for pathogens that potentially produce acute illness, and human enteric viruses. We studied three beaches located in Santa Monica Bay (CA) that exhibited a wide range of pathogen indicator counts and a high density of swimmers (Santa Monica, Will Rogers, and Surfrider).

Persons who immersed their heads in the ocean water were potential subjects for this study. There was no restriction based on age, sex, or race. We excluded anyone who swam at the study beaches, or in heavily polluted areas (that is, Mothers' Beach in Marina del Rey or near the Santa Monica Pier) within 7 days before the study date, or between the date of the beach interview and the telephone follow-up interview. We excluded subjects who swam on multiple days, as one of our primary questions was whether risk of health outcomes was associated with levels of indicator organisms on the specific day a subject entered the water. We targeted persons bathing within 100 yards upcoast or downcoast of the storm drain and persons bathing greater than 400 yards beyond a storm drain.

For this study, 22,085 subjects were interviewed on the beach from June 25 to September 14, 1995, to ascertain eligibility and willingness to participate. We found that 17,253 of these subjects were eligible and able to participate (that is, had a telephone and were able to speak English or Spanish). Of these, 15,492 (90% of the eligible subjects) agreed to participate. They were interviewed about their age, residence, and swimming, particularly immersion of the head into ocean water. The interviewer noted distance from the storm drain (within the categories 0, 1–50, 51–100, or 400 yards), gender, and race of the subject. (Distances from each drain were marked with inconspicuous objects such as beach towels and umbrellas.)

Nine to 14 days after the beach interview, subjects were interviewed by telephone to ascertain the occurrence(s) of: fever, chills, eye discharge, earache, ear discharge, skin rash, infected cuts, nausea, vomiting, diarrhea, diarrhea with blood, stomach pain, coughing, coughing with phlegm, nasal congestion, and sore throat. For this study we defined *a priori* three groupings of symptoms indicative of gastrointestinal illness or respiratory disease. In particular, following Cabelli *et al*,[4] subjects were classified as having highly credible gastrointestinal illness 1 (HCGI 1) if they experienced at least one of the following: (1) vomiting, (2) diarrhea and fever, or (3) stomach pain and fever. We also classified subjects as having highly credible gastrointestinal illness 2 (HCGI 2) if they had vomiting and fever. Finally, we classified subjects as having significant respiratory disease (SRD) if they had one of the following: (1) fever and nasal congestion, (2) fever and sore throat, or (3) coughing with phlegm.

We were able to contact and interview 13,278 subjects (86% follow-up). Of those interviewed, 1,485 were found to be ineligible because they swam (and immersed their heads) at a study beach or in heavily polluted waters between the day of the beach interview and the telephone follow-up. We excluded 107 subjects because they did not confirm immersing their faces in ocean water, leaving 11,686 subjects. One subject had a missing value for age, which we imputed (as the median value among all subjects) for inclusion in the adjusted analyses (discussed below). For the bacteriological analyses, we excluded an additional 1,227 subjects who had missing values, leaving 10,459 subjects. In the virus analyses we included only the 3,554 subjects who swam within 50 yards of the drain on days when viruses were measured (as the samples were collected only at the storm drain).

Collection and Analysis of Samples for Bacterial Indicators

Samples were collected on days that subjects were interviewed on the beaches. Each day, ankle depth samples were collected from each location (0 yards, 100 yards upcoast and downcoast of the drain, and one sample at 400 yards). One duplicate sample per site was collected daily. Samples were collected in sterile 1 liter polypropylene bottles and transferred on ice to the microbiology laboratory. All samples were analyzed for total coliforms, fecal coliforms, enterococcus, and *E. coli*. Densities of total and fecal coliforms and enterococci were determined using the appropriate membrane filtration techniques in Ref 5. *E. coli* densities were determined by membrane filtration using Hach Method 10029 for m-ColiBlue24 Broth.

Collection and Analysis of Samples for Enteric Viruses

For looking at enteric viruses, we collected samples from the three storm drain sites on Fridays, Saturdays, and Sundays, using Method 9510 C g of Ref 5. Ambient pH, temperature, conductivity, and total dissolved solids were measured. Samples as large as 100 gallons chosen to minimize the impacts of seawater dilution were filtered through electropositive filters at ambient pH. Adsorption filters were eluted in the field with 1 liter of sterile 3% beef extract adjusted to pH 9.0 with sodium hydroxide. Field eluates were reconcentrated in the laboratory using an organic reflocculation procedure.[6] All final concentrates were detoxified before analysis.[7]

All samples were analyzed for infectious human enteric viruses in Buffalo green monkey kidney cells (BGMK) by the plaque assay technique. Ten percent of the final concentrate was tested in this manner to determine whether there were a quantifiable number of viruses present. The remaining concentrate volume was divided in half and analyzed using the liquid overlay technique known as the cytopathic effect (CPE) assay.[8] The CPE assay generally detects a greater number of viruses than the plaque assay, but it is not quantitative. Flasks that did not exhibit CPE were considered to be negative for detectable infectious virus. We further examined any flask exhibiting CPE by the plaque-forming unit method to confirm the presence of infectious viruses.

Statistical Analysis

Our analysis addressed two main questions. First, are there different risks of specific outcomes among subjects swimming 0, 1–50, 51–100, and 400 or more yards from a storm drain? If pathogens in the storm drain result in increased acute illnesses, one would expect higher risks among swimmers closer to the drain. Second, are risks of specific outcomes associated with levels of specific bacterial indicators or enteric viruses?

To address the second question, we estimated risks arising from exposure to levels within categories defined *a priori* by existing standards or expert consensus. Specifically, for total coliforms we defined categories using 1,000 and 10,000 colony-forming units (cfu) per 100 ml as cutpoints, which are based on the California Code of Regulations (S.7958 in Title 17).[9] For fecal coliforms we created categories using cutpoints of 200 and 400 cfu per 100 ml, which reflect criteria set by the State Water Resources Control Board.[10] For enterococcus we used cutpoints of 35 and 104 cfu per 100 ml of water, which were established by the U.S. Environmental Protection Agency.[11] Finally, categories for *E. coli* were selected in meetings with staff from the Santa Monica Bay Restoration Project (SMBRP), Heal the Bay, and the Los Angeles County Department of Health Services. These meetings resulted in initially selecting categories based on cutpoints of 35 and 70 cfu per 100 ml, and then subsequently adding categories using cutpoints of 160 and 320 cfu per 100 ml; the latter were added because it is believed that *E. coli* comprises about 80% of the fecal coliforms. Using these knowledge-based categories, however, assumes a homogeneous risk between cutpoints. This might not be a reasonable assumption because the adequacy of these cutpoints is unclear, and because a large percentage of the subjects were in a single (that is, the lowest) category. Therefore, we further explored the bacteriological relations using categories defined by deciles.

In addition to considering total and fecal coliforms separately, we investigated the potential effect of the ratio of total to fecal coliforms. Motivation for this arose from our expectation that the risk of adverse health outcomes might be higher when the ratio is smaller, indicating a relatively greater proportion of fecal contamination. We used categories of this ratio defined by a cutpoint of 5 (where 5 corresponds to there being 5 times as much total as fecal coliform in the water). The human enteric virus exposure was reported as a dichotomous (that is, virus detected *vs* not detected) measure.

We first calculated simple descriptive statistics giving the number of subjects with each adverse health outcome who swam (1) at the prespecified distances from the drain or (2) in water with the prespecified levels of pathogens. From these counts we estimated the crude risk associated with each exposure. We then used logistic regression to estimate the adjusted relative risks of each outcome. For each exposure/outcome combination, we fit a separate model. All models adjusted for the potential confounding of: age (three categories: 0–12 years, 13–25 years, >25 years); sex; beach; race (four categories: white, black, Latino/a, and Asian/multiethnic/other); California *vs* out-of-state resident; and concern about potential health hazards at the beach (four categories: not at all, somewhat, a little, and very).

Results

Table 1 presents results for each of the adverse health outcomes by distance swimming from the storm drain. Across all distances, risks ranged from about 0.001 (that is, 1 per 1,000) for diarrhea with blood to about 0.1 for runny nose. The risk of numerous outcomes was higher for people who swam at the drain (0 yards away), in comparison with those who swam 1–50, 51–100, or >400 yards from the drain. In particular, we observed increases in risk for fever, chills, ear discharge, coughing with phlegm, HCGI 2, and SRD. In addition, the risks for eye discharge, earache, sore throat, infected cut, and HCGI 1 were also slightly elevated. A handful of outcomes exhibited small increased risks among swimmers at 1–50 yards (skin rash) or at 51–100 yards (cough, cough with phlegm, runny nose, and sore throat). Adjusted estimates of relative risk (RR) comparing swimmers at 0, 1–50, or 51–100 yards from the drain with swimmers at least 400 yards away from the drain showed similar relations as the aforementioned patterns of risks (Table 1). Among the positive associations for swimmers at the drain, RRs ranged in magnitude from about 1.2 (eye discharge, sore throat, HCGI 1) to 2.3 (earache), with varying degrees of precision; most of these RRs ranged from 1.4 to 1.6.

In Table 2 we see that the risk of skin rash increased for the highest prespecified category of total coliforms (that is, >10,000 cfu). Furthermore, the adjusted RR comparing swimmers exposed at this level *vs* those exposed to levels ≤1,000 cfu was 2.6. Whereas the RR for diarrhea with blood also suggested a positive association, this result was based on a single adverse health event (as evinced by the wide 95% CIs). When looking at deciles, in relation to the lowest exposure level (that is, the lowest 10%), we observed increased risks of skin rash at all other levels (Figure 1). The adjusted RRs ranged from 1.6 to 6.2, with five of the nine RRs in the 2–3 range. In addition, there were increased risks of HCGI 2 for all deciles except one (the eighth); the corresponding adjusted RRs ranged from 1.4 to 4.7, with varying levels of precision (Figure 1).

When looking at fecal coliforms, we again observed among those in the highest category (that is, >400 cfu) an increased risk for skin rash (Table 3). There were also *slight* increased risks for infected cut, runny nose, and diarrhea with blood in the highest category, as well as for nausea, vomiting, coughing, sore throat, and HCGI 2 in the middle category (200–400 cfu). The adjusted RRs also indicated positive associations for these outcomes (Table 3). When we used deciles to categorize subjects, however, in comparison with the lowest decile, we only observed marginal increased risks for infection and skin rash (not shown). In our investigation of the ratio of

TABLE 1. Adverse Health Outcomes by Distance Swimming from Drain: Number Ill, Acute Risks, Adjusted Relative Risk (RR) Estimates and 95% Confidence Intervals (CI)

	Distance from Drain (in Yards)										
	>400 (N = 3030)*		51–100 (N = 3311)			1–50 (N = 4518)			0 (N = 827)		
Outcome	No. Ill	Risk	No. Ill	Risk	RR (95% CI)†	No. Ill	Risk	RR (95% CI)†	No. Ill	Risk	RR (95% CI)†
Fever	138	0.046	158	0.048	1.06 (0.84–1.34)	208	0.046	1.07 (0.85–1.33)	59	0.071	1.61 (1.16–2.24)
Chills	72	0.024	85	0.026	1.07 (0.77–1.47)	108	0.024	1.05 (0.77–1.42)	31	0.037	1.60 (1.03–2.50)
Eye discharge	61	0.020	59	0.018	0.88 (0.61–1.27)	73	0.016	0.77 (0.55–1.09)	19	0.023	1.15 (0.67–1.98)
Earache	116	0.038	116	0.035	0.89 (0.68–1.16)	136	0.030	0.81 (0.63–1.04)	38	0.046	1.34 (0.91–1.98)
Ear discharge	21	0.007	19	0.006	0.78 (0.42–1.46)	25	0.006	0.80 (0.45–1.44)	13	0.016	2.09 (1.01–4.33)
Skin rash	23	0.008	30	0.009	1.16 (0.67–2.01)	53	0.012	1.50 (0.91–2.46)	4	0.005	0.62 (0.21–1.83)
Infected cut	17	0.006	16	0.005	0.79 (0.40–1.58)	37	0.008	1.51 (0.84–2.69)	6	0.007	1.48 (0.57–3.87)
Nausea	133	0.044	115	0.035	0.77 (0.60–1.00)	143	0.032	0.75 (0.59–0.95)	40	0.048	1.13 (0.78–1.65)
Vomiting	57	0.019	58	0.018	0.97 (0.67–1.40)	63	0.014	0.76 (0.53–1.09)	25	0.030	1.40 (0.85–2.31)
Diarrhea	204	0.067	163	0.049	0.70 (0.56–0.86)	202	0.045	0.69 (0.56–0.84)	53	0.064	1.04 (0.75–1.44)
Diarrhea with blood	7	0.002	2	0.001	0.26 (0.05–1.26)	3	0.001	0.27 (0.07–1.06)	2	0.002	0.87 (0.15–4.57)
Stomach pain	206	0.068	194	0.059	0.85 (0.70–1.05)	271	0.060	0.93 (0.77–1.12)	61	0.074	1.11 (0.82–1.51)
Cough	209	0.069	263	0.079	1.18 (0.97–1.42)	296	0.066	0.98 (0.82–1.18)	55	0.067	1.01 (0.73–1.38)
Cough and phlegm	90	0.030	114	0.034	1.16 (0.88–1.54)	143	0.032	1.09 (0.83–1.43)	39	0.047	1.65 (1.11–2.46)
Runny nose	273	0.090	351	0.106	1.18 (1.00–1.40)	371	0.082	0.95 (0.80–1.12)	74	0.089	1.10 (0.84–1.46)
Sore throat	190	0.063	244	0.074	1.17 (0.96–1.43)	304	0.067	1.12 (0.93–1.35)	59	0.071	1.25 (0.92–1.71)
HCGI 1	102	0.034	96	0.029	0.88 (0.66–1.17)	121	0.027	0.84 (0.64–1.10)	35	0.042	1.21 (0.81–1.82)
HCGI 2	26	0.009	28	0.008	1.04 (0.61–1.79)	32	0.007	0.90 (0.53–1.53)	15	0.018	1.64 (0.84–3.21)
Significant respiratory disease	139	0.046	177	0.053	1.18 (0.94–1.49)	205	0.045	1.03 (0.82–1.23)	63	0.076	1.78 (1.29–2.45)

The total number of swimmers in each category is given in parentheses (N). HCGI1, highly credible gastrointestinal illness with vomiting, diarrhea and fever or stomach pain and fever. HCGT2, highly credible gastrointestinal illness with vomiting and fever only. Significant respiratory disease, fever and nasal congestion, fever and sore throat or coughing with phlegm.

* Referent category (RR = 1.0).

† Adjusted for age, sex, beach, race, California vs out-of-state resident, and concern about potential health hazards at the beach.

total to fecal coliforms, we observed a consistent pattern of higher risks for diarrhea and HCGI 2 as the ratio category became lower (not shown, but available in Ref 12). Because any effect of this lower ratio should be stronger when there was a higher degree of contamination, indicated by total coliform counts in excess of 1,000 or 5,000 cfu, we then restricted our analysis to subjects swimming in water above these levels. In the first case, increased risks with decreasing cutpoints were observed for nausea, diarrhea, and HCGI 2.[12] When we restricted our investigation to subjects in water in which the total coliforms exceeded 5,000 cfu, we observed

TABLE 2. Adverse Health Outcomes by Total Coliform Levels: Number Ill, Acute Risks, Adjusted Relative Risk (RR) Estimates and 95% Confidence Intervals (CI)

	Total Coliforms (cfu/100ml)							
	≤1,000 (N = 7,574)*		>1,000–10,000 (N = 1,988)			>10,000 (N = 757)		
Outcome	No. Ill	Risk	No. Ill	Risk	RR†	No. Ill	Risk	RR†
Fever	368	0.049	88	0.044	0.92 (0.72–1.17)	42	0.055	1.23 (0.87–1.73)
Chills	193	0.025	51	0.026	1.03 (0.75–1.42)	9	0.012	0.51 (0.26–1.01)
Eye discharge	151	0.020	21	0.011	0.46 (0.29–0.74)	15	0.020	0.81 (0.47–1.41)
Earache	270	0.036	66	0.033	0.96 (0.72–1.27)	21	0.028	0.86 (0.54–1.38)
Ear discharge	51	0.007	15	0.008	1.22 (0.67–2.23)	2	0.003	0.46 (0.11–1.93)
Skin rash	65	0.009	14	0.007	0.75 (0.41–1.36)	19	0.025	2.59 (1.49–4.53)
Infected cut	49	0.006	11	0.006	0.97 (0.49–1.91)	3	0.004	0.82 (0.25–2.72)
Nausea	292	0.039	69	0.035	0.94 (0.72–1.24)	18	0.024	0.71 (0.43–1.16)
Vomiting	137	0.018	34	0.017	0.90 (0.61–1.33)	9	0.012	0.64 (0.32–1.29)
Diarrhea	434	0.057	85	0.043	0.80 (0.63–1.03)	33	0.044	0.95 (0.65–1.39)
Diarrhea with blood	8	0.001	2	0.001	1.08 (0.22–5.35)	1	0.001	1.73 (0.19–15.88)
Stomach pain	487	0.064	125	0.063	1.05 (0.85–1.29)	29	0.038	0.69 (0.47–1.02)
Cough	546	0.072	133	0.067	0.90 (0.73–1.10)	51	0.067	0.94 (0.69–1.28)
Cough and phlegm	267	0.035	58	0.029	0.81 (0.60–1.09)	27	0.036	1.03 (0.68–1.57)
Runny nose	703	0.093	170	0.086	0.93 (0.78–1.12)	67	0.089	1.06 (0.81–1.40)
Sore throat	534	0.071	116	0.058	0.83 (0.67–1.03)	47	0.062	0.95 (0.69–1.30)
HCGI 1	242	0.032	54	0.027	0.84 (0.62–1.14)	17	0.022	0.74 (0.44–1.23)
HCGI 2	72	0.010	16	0.008	0.89 (0.51–1.55)	5	0.007	0.83 (0.32–2.12)
Significant respiratory disease	396	0.052	84	0.042	0.80 (0.62–1.02)	42	0.055	1.11 (0.79–1.55)

The total number of swimmers in each category is given in parentheses (N).

* Referent category (RR = 1.0).

† Adjusted for age, sex, beach, race, California vs out-of-state resident, and concern about potential health hazards at the beach.

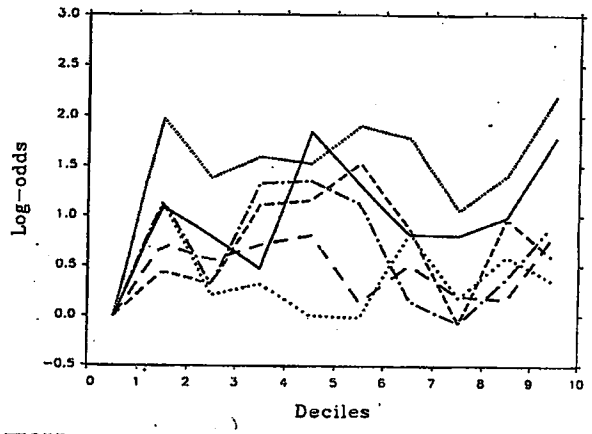


FIGURE 1. Log odds of adverse health outcomes by deciles of exposure for selected bacterial exposures. —, Total coliform and skin rash; – – –, total coliform and HCGI 2; · · ·, Enterococci and infected cut; — — —, *E coli* and eye discharge; ···, *E coli* and skin rash; · — ·, *E coli* and infected cut. HCGI 2 = highly credible gastrointestinal illness with vomiting and fever only.

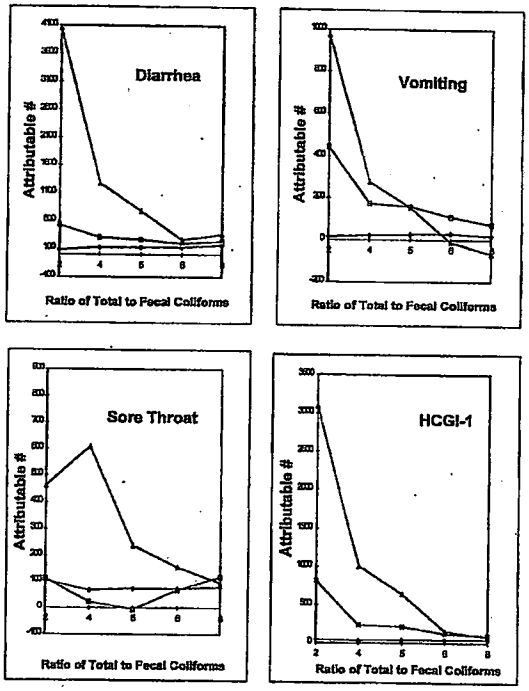


FIGURE 2. Selected attributable numbers/10,000 exposed subjects for total to fecal coliforms. ♦, All days; ■, >1000; ▲, > 5000. HCGI 1 = highly credible gastrointestinal illness with vomiting, diarrhea and fever or stomach pain and fever.

increased risks with eye discharge, ear discharge, skin rash, nausea, diarrhea, stomach pain, nasal congestion, HCGI 1, and HCGI 2.[12] There was a consistent pattern of stronger risk ratios as the cutpoint became lower (when the analyses were restricted to times when total coliforms exceeded 1,000 or 5,000 cfu), with the strongest effects generally observed with the cutpoint of 2, as illustrated in Figure 2 for diarrhea, vomiting, sore throat, and HCGI1.

Table 4 gives results for the relation among enterococci and the adverse health outcomes. Again, we observed an increased risk of skin rash among those in the highest category (that is, >104 cfu). In addition, comparing the highest to other categories of exposure, there

TABLE 3. Adverse Health Outcomes by Fecal Coliform Levels: Number Ill, Acute Risks, Adjusted Relative Risk (RR) Estimates and 95% Confidence Intervals (CI)

Outcome	Fecal Coliforms (cfu/100ml)							
	≤200 (N = 8,005)*		>200–400 (N = 768)			>400 (N = 1,636)		
	No. Ill	Risk	No. Ill	Risk	RR†	No. Ill	Risk	RR†
Fever	381	0.048	39	0.051	1.04 (0.74–1.46)	80	0.049	1.02 (0.80–1.32)
Chills	197	0.025	24	0.031	1.14 (0.74–1.76)	34	0.021	0.78 (0.54–1.14)
Eye discharge	149	0.019	11	0.014	0.70 (0.38–1.31)	30	0.018	0.97 (0.65–1.46)
Earache	275	0.034	26	0.04	0.93 (0.62–1.41)	57	0.035	1.00 (0.75–1.35)
Ear discharge	53	0.007	8	0.010	1.29 (0.60–2.73)	7	0.004	0.56 (0.25–1.24)
Skin rash	69	0.009	5	0.007	0.64 (0.26–1.60)	26	0.016	1.86 (1.17–2.95)
Infected cut	47	0.006	2	0.003	0.40 (0.10–1.65)	15	0.009	1.50 (0.83–2.74)
Nausea	289	0.036	38	0.049	1.29 (0.91–1.84)	57	0.035	0.93 (0.69–1.24)
Vomiting	133	0.017	18	0.023	1.33 (0.81–2.21)	31	0.019	1.07 (0.71–1.60)
Diarrhea	425	0.053	50	0.065	1.17 (0.86–1.60)	81	0.050	0.90 (0.70–1.15)
Diarrhea with blood	7	0.001	1	0.001	1.22 (0.15–10.01)	3	0.002	1.69 (0.42–6.75)
Stomach pain	495	0.062	51	0.066	1.04 (0.77–1.41)	103	0.063	0.98 (0.78–1.23)
Cough	551	0.069	70	0.091	1.34 (1.03–1.74)	117	0.072	1.06 (0.86–1.31)
Cough and phlegm	265	0.033	31	0.040	1.16 (0.79–1.70)	60	0.037	1.10 (0.82–1.47)
Runny nose	722	0.090	72	0.94	1.03 (0.79–1.33)	160	0.098	1.11 (0.93–1.34)
Sore throat	527	0.066	70	0.091	1.40 (1.07–1.82)	106	0.065	0.99 (0.80–1.24)
HCGI 1	239	0.030	28	0.036	1.18 (0.79–1.77)	50	0.031	0.99 (0.72–1.36)
HCGI 2	65	0.008	11	0.014	1.63 (0.85–3.12)	17	0.010	1.13 (0.65–1.95)
Significant respiratory disease	399	0.050	42	0.055	1.08 (0.77–1.50)	85	0.052	1.04 (0.81–1.33)

The total number of swimmers in each category is given in parentheses (N).
* Referent category (RR = 1.0).
† Adjusted for age, sex, beach, race, California vs out-of-state resident, and concern about potential health hazards at the beach.

TABLE 4. Adverse Health Outcomes by Enterococci Levels: Number Ill, Acute Risks, Adjusted Relative Risk (RR) Estimates and 95% Confidence Intervals (CI)

	Enterococci (cfu/100ml)							
	≤35 (N = 7,689)*		>35–104 (N = 1,863)			>104 (N = 857)		
Outcome	No. Ill	Risk	No. Ill	Risk	RR†	No. Ill	Risk	RR†
Fever	371	0.048	84	0.045	0.91 (0.71–1.16)	45	0.053	1.00 (0.72–1.40)
Chills	198	0.026	33	0.018	0.67 (0.46–0.97)	24	0.028	0.94 (0.60–1.48)
Eye discharge	149	0.019	25	0.013	0.69 (0.45–1.07)	16	0.019	1.01 (0.58–1.75)
Earache	270	0.035	57	0.031	0.82 (0.61–1.11)	31	0.036	0.88 (0.59–1.31)
Ear discharge	52	0.007	12	0.006	0.85 (0.45–1.62)	4	0.005	0.53 (0.19–1.51)
Skin rash	74	0.010	13	0.007	0.71 (0.39–1.30)	13	0.015	1.72 (0.89–3.31)
Infected cut	46	0.006	12	0.006	0.95 (0.49–1.82)	6	0.007	0.90 (0.37–2.18)
Nausea	271	0.035	72	0.039	1.07 (0.82–1.41)	41	0.048	1.19 (0.84–1.70)
Vomiting	130	0.017	34	0.018	1.13 (0.77–1.67)	18	0.021	1.20 (0.71–2.04)
Diarrhea	398	0.052	101	0.054	0.99 (0.78–1.25)	57	0.067	1.01 (0.75–1.36)
Diarrhea with blood	8	0.001	0	—	—	3	0.004	2.90 (0.66–12.68)
Stomach pain	464	0.060	126	0.068	1.09 (0.89–1.35)	59	0.069	0.97 (0.72–1.30)
Cough	554	0.072	121	0.065	0.91 (0.73–1.12)	63	0.074	1.00 (0.75–1.34)
Cough and phlegm	266	0.035	59	0.032	0.91 (0.68–1.22)	31	0.036	1.03 (0.69–1.54)
Runny nose	704	0.092	165	0.089	0.96 (0.80–1.15)	85	0.099	1.01 (0.79–1.30)
Sore throat	533	0.069	118	0.063	0.89 (0.72–1.10)	52	0.061	0.80 (0.59–1.09)
HCGI 1	230	0.030	51	0.027	0.92 (0.67–1.26)	36	0.042	1.31 (0.89–1.92)
HCGI 2	67	0.009	14	0.008	0.82 (0.46–1.48)	12	0.014	1.30 (0.67–2.51)
Significant respiratory disease	397	0.052	84	0.045	0.86 (0.67–1.11)	45	0.053	0.98 (0.70–1.37)

The total number of swimmers in each category is given in parentheses (N).
* Referent category (RR = 1.0).
† Adjusted for age, sex, beach, race, California *vs* out-of-state resident, and concern about potential health hazards at the beach.

were increased risks of nausea, vomiting, diarrhea with blood, HCGI 1, and HCGI 2. Our adjusted RRs suggested similar positive associations, except for diarrhea; although the risk increased from 0.05 to 0.07, the adjusted RR comparing the highest to lowest category was 1.0 (Table 4). When comparing the lowest to higher deciles, we observed increased risks in most categories for infected cut and skin rash (Figure 1). Other adverse health outcomes—infected cut, nausea, diarrhea, diarrhea with blood, HCGI 1, and HCGI 2—exhibited increased risks only in particular quantiles. In comparison with the lowest decile, the risk of each of these outcomes was higher in the 10th decile. For example, the risk for HCGI 2 was 0.007 in the first decile, but 0.015 in the 10th.

Table 5 presents results for *E. coli*. We once again found an increased risk of skin rash in the highest prespecified category (that is, >320 cfu). Furthermore, we observed slight increased risks in this highest category for eye discharge, earache, stomach pain, coughing with phlegm, runny nose, and HCGI 1 (Table 5). In our decile-based analysis, however, we only observed materially increased risks for eye discharge, skin rash, and infection (Figure 1).

Numerous adverse health outcomes exhibited higher risks among subjects swimming on days when samples were positive for viruses (Table 6). In particular, the risk of fever, eye discharge, vomiting, sore throat, HCGI 1, and HCGI 2, and to a lesser extent, chills, diarrhea, diarrhea with blood, cough, coughing with phlegm, and SRD were higher on days when viruses were detected. Our adjusted RR estimates showed similar relations, most ranging from 1.3 to 1.9 (Table 6). Additionally, adjusting for each bacterial indicator (one-at-a-time) also left these results essentially unchanged.[12] As expected, there was an association between presence of virus and fecal coliforms within 50 yards of the drain. The mean density of fecal coliforms when no virus was detected was 234.8 cfu (SD 542.5 cfu); whereas it was 2,233.8 (SD 2,634.1) when viruses were detected (N = 386). The median values were 47.8 and 452.6 cfu, respectively.

Discussion

We observed differences in risk for a number of outcomes when we compared subjects swimming at 0 yards *vs* 400+ yards. Most of the relative risks suggested an approximately 50% increase in risk. Furthermore, as evinced by both the risks and RRs, there is an apparent threshold of increased risk occurring primarily at the drain: no dose response is evinced with increasing closeness to the drain, but there is a jump in risk for many adverse health outcomes among those swimming at the drain. We also found that distance is a reasonably good surrogate for bacterial indicators, with higher levels observed closer to the drain.[12]

For bacterial indicators, we observed a relation among numerous higher exposures and adverse health outcomes. These increases were mostly restricted to the highest knowledge-based categories (no effect was observed below any existing standards). When looking at quantiles, we found higher risks of skin rash and infection at fairly low levels. In contrast with what one might expect, however, there was no clear dose-response pattern across increasing levels of bacteriological exposures.

TABLE 5. Adverse Health Outcomes by E. coli Levels: Number Ill, Acute Risks, Adjusted Relative Risk (RR) Estimates and 95% Confidence Intervals (CI)

	E. coli (cfu/100ml)												
	≤35 (N = 6,104)*		>35–75 (N = 1,620)			>75–160 (N = 1,145)			>160–320 (N = 518)			>320 (N = 991)	
Outcome	No. Ill	Risk	No. Ill	Risk	RR†	No. Ill	Risk	RR†	No. Ill	Risk	RR†	No. Ill	Risk	RR†
Fever	274	0.045	89	0.055	1.22 (0.95–1.56)	61	0.053	1.20 (0.90–1.60)	29	0.056	1.22 (0.81–1.84)	45	0.045	0.98 (0.70–1.37)
Chills	145	0.024	41	0.025	1.00 (0.70–1.44)	28	0.024	1.00 (0.66–1.52)	18	0.035	1.38 (0.82–2.33)	22	0.022	0.79 (0.49–1.26)
Eye discharge	116	0.019	30	0.019	0.99 (0.65–1.49)	14	0.012	0.65 (0.37–1.15)	6	0.012	0.61 (0.26–1.43)	23	0.023	1.36 (0.84–2.19)
Earache	214	0.035	45	0.028	0.75 (0.54–1.04)	33	0.029	0.78 (0.53–1.14)	18	0.035	0.91 (0.55–1.50)	47	0.047	1.25 (0.89–1.77)
Ear discharge	42	0.007	8	0.005	0.60 (0.28–1.28)	5	0.004	0.57 (0.22–1.46)	6	0.012	1.28 (0.52–3.15)	6	0.0066	0.67 (0.27–1.62)
Skin rash	57	0.009	15	0.009	1.01 (0.56–1.80)	7	0.006	0.66 (0.30–1.46)	6	0.012	1.21 (0.49–2.98)	15	0.015	2.04 (1.11–3.76)
Infected cut	42	0.007	7	0.004	0.53 (0.24–1.20)	3	0.003	0.33 (0.10–1.06)	3	0.006	0.66 (0.20–2.19)	9	0.009	1.02 (0.48–2.19)
Nausea	216	0.035	74	0.046	1.22 (0.93–1.61)	34	0.030	0.80 (0.55–1.16)	18	0.035	0.88 (0.53–1.46)	42	0.042	1.03 (0.73–1.47)
Vomiting	107	0.018	31	0.019	1.09 (0.72–1.64)	16	0.014	0.82 (0.48–1.40)	8	0.015	0.87 (0.41–1.85)	20	0.020	1.05 (0.63–1.74)
Diarrhea	310	0.051	101	0.062	1.14 (0.90–1.44)	63	0.055	1.00 (0.75–1.33)	25	0.048	0.80 (0.52–1.23)	56	0.057	0.91 (0.67–1.23)
Diarrhea with blood	5	0.001	3	0.002	2.06 (0.48–8.89)	1	0.001	1.03 (0.12–9.01)	2	0.004	3.98 (0.68–23.21)	0	—	—
Stomach pain	353	0.058	124	0.077	1.28 (1.03–1.59)	70	0.061	1.02 (0.78–1.33)	31	0.060	0.95 (0.64–1.40)	70	0.071	1.06 (0.80–1.40)
Cough	444	0.073	96	0.059	0.81 (0.64–1.02)	86	0.075	1.04 (0.82–1.33)	29	0.056	0.77 (0.51–1.14)	82	0.083	1.14 (0.88–1.48)
Cough and phlegm	226	0.037	41	0.025	0.66 (0.47–0.92)	34	0.030	0.78 (0.54–1.12)	11	0.021	0.53 (0.28–1.00)	43	0.043	1.12 (0.79–1.59)
Runny nose	566	0.093	136	0.084	0.87 (0.71–1.06)	105	0.092	0.96 (0.77–1.20)	38	0.073	0.76 (0.53–1.08)	108	0.109	1.12 (0.89–1.41)
Sore throat	417	0.068	99	0.061	0.86 (0.68–1.08)	82	0.072	1.02 (0.80–1.31)	29	0.056	0.78 (0.52–1.17)	75	0.076	1.04 (0.80–1.37)
HCGI 1	183	0.030	51	0.031	1.03 (0.75–1.42)	30	0.026	0.88 (0.59–1.30)	17	0.033	1.06 (0.63–1.80)	36	0.036	1.12 (0.76–1.64)
HCGI 2	48	0.008	21	0.013	1.55 (0.92–2.64)	8	0.007	0.85 (0.40–1.81)	6	0.012	1.25 (0.51–3.03)	10	0.010	1.04 (0.51–2.13)
Significant respiratory disease	319	0.052	71	0.044	0.82 (0.62–107)	58	0.051	0.96 (0.72–1.28)	21	0.041	0.74 (0.47–1.18)	56	0.057	1.03 (0.76–1.40)

The total number of swimmers in each category is given in parentheses (N).
* Referent category (RR = 1.0).
† Adjusted for age, sex, beach, race, California vs out-of-state resident, and concern about potential health hazards at the beach.

TABLE 6. Number Ill, Risks, and Adjusted Relative Risk (RR) Estimates of Adverse Health Outcomes by Virus

Outcome	Viruses				
	No (N = 3,168)*		Yes (N = 386)		
	No. Ill	Risk	No. Ill	Risk	RR (95% CI)†
Fever	126	0.040	23	0.060	1.56 (0.98–2.50)
Chills	65	0.021	10	0.026	1.25 (0.63–2.50)
Eye discharge	36	0.011	8	0.021	1.86 (0.85–4.09)
Earache	93	0.029	10	0.026	0.92 (0.47–1.80)
Ear discharge	15	0.005	0		
Skin rash	32	0.010	4	0.010	0.97 (0.34–2.82)
Infected cut	31	0.010	2	0.005	0.57 (0.13–2.40)
Nausea	101	0.032	12	0.031	0.93 (0.50–1.73)
Vomiting	44	0.014	10	0.026	1.86 (0.92–3.80)
Diarrhea	130	0.041	21	0.054	1.27 (0.78–2.07)
Diarrhea with blood	2	0.001	1	0.003	5.82 (0.45–75.72)
Stomach pain	191	0.060	23	0.060	0.92 (0.58–1.45)
Cough	181	0.057	28	0.073	1.22 (0.80–1.86)
Cough and phlegm	92	0.029	13	0.034	1.20 (0.66–2.18)
Runny nose	246	0.078	32	0.083	1.01 (0.68–1.49)
Sore throat	198	0.063	32	0.083	1.38 (0.93–2.06)
HCGI 1	72	0.023	15	0.039	1.69 (0.95–3.01)
HCGI 2	22	0.007	6	0.016	2.32 (0.91–5.88)
Significant respiratory disease	133	0.042	21	0.054	1.34 (0.83–2.18)

The total number of swimmers in each category is given in parentheses (N).
* Referent category (RR = 1.0).
† Adjusted for age, sex, beach, race, California *vs* out-of-state resident, and concern about potential health hazards at the beach.

When looking at the ratio of total to fecal coliforms using the entire dataset, no consistent pattern emerged.[12] This is not entirely surprising inasmuch as an analysis of all data points treats all ratios of similar numerical value equally. Thus, for example, even though a ratio of 5 when the total coliforms are very low may not increase risk, the same ratio may be associated with increased risks when the density of total coliforms is above 1,000 or 5,000 cfu. When the analysis was restricted to swimmers exposed to total coliform densities above 1,000 or 5,000 cfu, a consistent pattern emerged, with higher risks associated with low ratios.[12]

This is the first large-scale epidemiologic study that included measurements of viruses. A number of adverse health effects were reported more often on days when the samples were positive, suggesting assays for viruses may be informative for predicting risk. Norwalk-like viruses are a plausible cause of gastroenteritis.[4,13] Enteroviruses, the most common viruses in sewage effluent, can cause respiratory symptoms. Not only are viruses responsible for many of the symptoms associated with swimming in ocean water but also they die off at slower rates in sea water than do bacteria, and they can cause infection at a much lower dose.[14]

Our design substantially reduced the potential for confounding by restricting the study entirely to swimmers and making comparisons between groups of swimmers (for example, defined by distance from the drain) to estimate relative risks. Previous studies looking at the effects of exposure to polluted recreational water (for example, due to sewage outflows) have been criticized for comparing risks in swimmers with risks in nonswimmers.[4,14,15] In these earlier studies, background risks among subjects who swim *vs* those choosing not to swim may differ because there are many other (potentially noncontrollable) exposures/pathways that can produce the symptoms under investigation. By restricting the present study to swimmers, we have reduced potential differences between the background risks of exposed *vs* unexposed subjects (for example, swimmers choosing to swim at the drain *vs* those swimming at the same beach but farther away from the drain). Furthermore, we were able to adjust our relative risk estimates for a number of additional factors (listed above) that could confound the observed relations. Of course, this does not exclude the possibility that residual confounding in these factors, or other unknown factors, might have confounded the observed relations.

Nevertheless, any actual (that is, causal) effects may be higher than we observed in this study because both distance and pathogenic indicators are proxy measures of the true pathogenic agents. Also, recall that we excluded subjects who frequently entered the water at these beaches. If there is a dose-response relation such that higher cumulative exposures are associated with increased risk, then one may infer that persons who frequently enter the water and immerse their heads (for example, surfers) may have a higher risk of adverse health outcomes than the relatively infrequent swimmers included in this study.

In summary, we observed positive associations between adverse health effects and (1) distance from the drain, (2) bacterial indicators, and (3) presence of enteric viruses. Taken together, these results imply that there may be an increased risk of a broad range of adverse health effects associated with swimming in ocean water subject to urban runoff. Moreover, attributable numbers—that is, estimates of the number of new cases of an adverse health outcome that is attributable to the exposure of interest—reached well into the 100s per

10,000 exposed subjects for many of the positive associations observed here.[12] This finding implies that these risks might not be trivial when we consider the millions of persons who visit these beaches each year. Furthermore, the factors apparently contributing to the increased risk of adverse health outcomes observed here are not unique to Santa Monica Bay (similar levels of bacterial indicators are observed at many other beaches). Consequently, the prospect that untreated storm drain runoff poses a health risk to swimmers is probably relevant to many beaches subject to such runoff, including areas on the East, West, and Gulf coasts of North America, as well as numerous beaches on other continents.

Acknowledgments

We thank the reviewers for their helpful comments.

References

1. Gold M, Bartlett M, Dorsey J, McGee C. Storm drains as a source of surf zone bacterial indicators and human enteric viruses to Santa Monica Bay: Document prepared for the Santa Monica Bay Restoration Project, August 1991.
2. Santa Monica Bay Restoration Project 1995 - State of the Bay.
3. Pruss A. Review of epidemiological studies on health effects from exposure to recreational water. Int J Epidemiol 1998;27:1–9.
4. Cabelli V, Dufour AP, McCabe, LJ, Levin MA. Swimming-associated gastroenteritis and water quality. Am J Epidemiol 1982;115:606–616.
5. APHA. Standard Methods for the Analysis of Wastewater. 16th ed. Sections 909, 909a, and 913-A. Sections 9222B, 9222D, and 9230C, 1985.
6. Katzenelson E, Fattal B, Hostovesky T. Organic flocculation: an efficient second step concentration method for the detection of viruses in tap water. Appl Environ Microbiol 1976;32:638–639.
7. Glass JS, van Sluis RJ, Yanko WA. Practical method for detecting poliovirus in anaerobic digester sludge. Appl Environ Microbiol 1978;35:983–985.
8. Lennette EH, Schmidt NJ. Diagnostic procedures for viral and rickettsial infections. New York: APHA Publishers, 1969.
9. State Water Resources Control Board. Water Quality Control Plan for Ocean Waters of California (California Ocean Plan). State Board Resolution No. 90–27. 1990;23.
10. State Water Resources Control Board. Functional Equivalent Document: Amendment of the Water Quality Control Plan for Ocean Waters of California (California Ocean Plan). State Board Resolution No. 90–27. 1990;179.
11. Cabelli V. Health effects criteria for marine recreational waters. EPA 600: 1–80-31, Washington DC: U.S. Environmental Protection Agency, 1983.
12. Haile RW, Witte JS, Gold M, Cressey R, McGee C, Millikan RC, Glasser A, Harawa N, Ervin C, Harmon P, Harper J, Dermand J, Alamillo J, Barrett K, Nides M, Wang G-y. An epidemiologic study of possible adverse health effects of swimming in Santa Monica Bay. Final (technical) report, 1996.
13. Kay D, Fleisher JM, Salmon RL, Jones F, Wyer MD, Godfree AF, Zelenauch-Jacquotte Z, Shore R. Predicting likelihood of gastroenteritis from sea bathing: results from randomized exposure. Lancet 1994;344:905–909.
14. Walker, A. Swimming: the hazards of taking a dip. BMJ 1992;304:242–245.
15. Saliba L, Helmer R. WHO Stats Q 1990;43:177–187.
16. Fleisher JM, Jones F, Kay D, Stanwell-Smith R, Wyer M, Morano R. Water and non-water-related risk factors for gastroenteritis among bathers exposed to sewage-contaminated marine waters. Int J Epidemiol 1993;22:698–708.

Item 14
Sept. 11, 2006
Bd Mtg

Order Number 9431179

What are the health risks of swimming in Santa Monica Bay?: An examination of the issues surrounding the public health debate

Gold, Mark Andrew, Ph.D.

University of California, Los Angeles, 1994

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

3-554

12-253

This is an authorized facsimile, made from the microfilm master copy of the original dissertation or masters thesis published by UMI.

The bibliographic information for this thesis is contained in UMI's Dissertation Abstracts database, the only central source for accessing almost every doctoral dissertation accepted in North America since 1861.

U·M·I Dissertation Services

A Bell & Howell Company

300 N. Zeeb Road, Ann Arbor, Michigan 48106

1-800-521-0600 313-761-4700

Printed in 1994 by xerographic process on acid-free paper

3058

0-556

12-201

3-556

INFORMATION TO USERS

This manuscript has been reproduced from the microfilm master. UMI films the text directly from the original or copy submitted. Thus, some thesis and dissertation copies are in typewriter face, while others may be from any type of computer printer.

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleedthrough, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send UMI a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.

Oversize materials (e.g., maps, drawings, charts) are reproduced by sectioning the original, beginning at the upper left-hand corner and continuing from left to right in equal sections with small overlaps. Each original is also photographed in one exposure and is included in reduced form at the back of the book.

Photographs included in the original manuscript have been reproduced xerographically in this copy. Higher quality 6" x 9" black and white photographic prints are available for any photographs or illustrations appearing in this copy for an additional charge. Contact UMI directly to order.

UMI

University Microfilms International
A Bell & Howell Information Company
300 North Zeeb Road, Ann Arbor, MI 48106-1346 USA
313-761-4700 800-521-0600

12-295

3-557

12-266

UNIVERSITY OF CALIFORNIA

Los Angeles

What Are the Health Risks of Swimming in Santa Monica Bay?: An Examination of the Issues Surrounding the Public Health Debate

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of

Environmental Science and Engineering

by

Mark Andrew Gold

1994

Table of Contents

vledgements	vii
	ix
	x
	1
ction	3
1 - The Evolution of Santa Monica Bay Beach Closure and Health ting Policy	6
Summary	6
Introduction	7
The Lifeguard Cancer Scare	7
Increasing public awareness of Bay pollution issues	11
The Pico-Kenter Storm Drain	13
The Santa Monica Bay Restoration Project	20
History of Ocean Bathing Water Standards in California	21
The large-scale epidemiology studies completed by the EPA	24
The enterococcus water quality objective in California	25
Problems with the bacterial indicators	27
Storm Drain Health Warning Signs	29
The Evolution of the Los Angeles County Beach Closure and Health Warning Protocol	33
The 1989 beach closure protocol	37
The recommended beach closure protocol from Heal the Bay	39
The current beach closure protocol	41
The Ballona Creek clean-up task force	45
State Beach Closure and Health Warning Protocol	46
California Senate Bill 1865	48
California Senate Bill 1084	51
Local Monitoring and Research	52
Acute Illnesses in Los Angeles County Lifeguards	52
LACDHS shoreline monitoring program	53
The City of Los Angeles shoreline monitoring program	55
The Heal the Bay beach pollution reports	57
The SMBRP virus and microbial indicator studies	59
The second SMBRP virus and microbial indicator study	61
The third SMBRP virus and microbial indicator study	64
Current Public Opinion on Santa Monica Bay Pollution	70
Chapter 2 - Recommendations to Better Determine and Reduce the Health Risks of Swimming in Santa Monica Bay	74
Summary	74
Introduction	75
Risk Assessment	76
Epidemiology Studies	81
The proposed Santa Monica Bay epidemiology study	82

3-558

12-207

Recommendations 86
Research needs 86
Policy needs 90
Source reduction measures 97
Conclusions 102
Glossary of Agency and Organization Acronyms 104
References 105
Appendix 1 114
Appendix 2 153
Appendix 3 185

ACKNOWLEDGEMENTS

The research for the dissertation was completed under the auspices of the Santa Monica Bay Restoration Project (SMBRP). Funding for the research was supplied by the SMBRP and the City of Santa Monica. The co-authors of the studies were Charles McGee, Melinda Bartlett, John Dorsey, and Greg Deets. Voluntary contributions to the studies were provided as follows: The microbiology staff at the Orange County Sanitation District's virology laboratory completed sample analysis for enteric viruses and coliphage; the microbiology staff at the City of Los Angeles' Environmental Monitoring Division (EMD) analyzed samples for indicator bacteria and collected urban runoff samples for enteric virus analysis: Cindy Mayer, Greg Deets, Ron Dergrigorian, Maria Aparicio and Jerry Shea of the EMD and Roger Gorke of Heal the Bay completed most of the virus sampling. Surf-zone samples for indicator bacteria analysis were primarily collected by John Austin of the EMD and volunteers Carlos Urrunaga, Roger Kintz, Jennifer Wellman, Roger Gorke, and Patty Warner of Heal the Bay. Assistance in data analysis was provided by Scott Johnson of the EMD. The graphics were produced by Greg Deets and Mike Mullin of the EMD. Rainer Hoenicke and Guang-Yu Wang of the SMBRP managed the contracts with the SMBRP and provided additional technical guidance.

The staff and Board of Heal the Bay, especially Dorothy Green, strongly supported my efforts to finish the dissertation while healing the Bay.

Professor Malcolm Gordon and Professor Robert Haile, as Co-chairs of my doctoral committee, provided needed guidance and editorial assistance on numerous drafts of the dissertation. Professor Arthur Winer and Professor Richard Ambrose provided the support that was needed for my continued perseverance during difficult times.

C-559

12-208

Judith Gold, my mother, and Jonathan Gold, my brother, provided essential editorial assistance. My mother's courage during the most difficult of times was an inspiration that will remain with me the rest of my life.

Eternal thanks go to my wife, Lisette Bauersachs, for encouraging me to finish the dissertation, providing editorial assistance, and taking care of our son Zachary over countless weekends and evenings. Without her, I would have never found the will to continue working on my dissertation after the loss of my loving parents.

VITA

October 10, 1963	Born, Los Angeles, California
1984	B.S., Biology University of California, Los Angeles Los Angeles, California
1985-1986	Teaching Assistant University of California, Los Angeles Los Angeles, California
1986	M.A., Biology University of California, Los Angeles Los Angeles, California
1986-1988	Environmental Consultant Engineering Science Inc. Pasadena, California
1987-1988	Research Assistant University of California, Los Angeles Los Angeles, California
1988-1994	Staff Scientist Heal the Bay Santa Monica, California

PUBLICATIONS AND PRESENTATIONS

Gold, M., Bartlett, M., Dorsey, J. and C. McGee (1990) An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses from Two Santa Monica Bay Storm Drains. Prepared for the Santa Monica Bay Restoration Project (SMBRP).

Gold, M., Bartlett, M., Dorsey, J. and C. McGee (1991) Storm Drains as a Source of Surf-Zone Bacterial Indicators and Human Enteric Viruses to Santa Monica Bay. Prepared for the SMBRP.

Gold, M., Bartlett, M., Deets, G., and C. McGee (1992) Pathogens and Indicators in Storm Drains Within the Santa Monica Bay Watershed. Prepared for the SMBRP.

3-560

12-295

ABSTRACT OF THE DISSERTATION

What Are the Health Risks of Swimming in Santa Monica Bay?:
An Examination of the Issues Surrounding the Public Health Debate

by

Mark Andrew Gold
Doctor of Environmental Science and Engineering
University of California, Los Angeles, 1994
Professor Malcolm Gordon, Co-chair
Professor Robert Haile, Co-chair

In 1989, the state and federally sponsored Santa Monica Bay Restoration Project (SMBRP) was created. One of its three highest priorities was to assess the health risk to Bay swimmers because beach visitor populations were reduced from previous years, anecdotal evidence of illnesses caused by exposure to Bay waters was commonplace, and there were many unregulated sources of urban runoff to local beaches. The SMBRP lacked adequate information to accurately assess the risk to Bay swimmers, and it would not secure funding for an epidemiology study of recreational bathers in urban runoff contaminated waters until new information on pathogens and pathogen indicators in the storm drains and surf-zone was attained.

From 1990 to 1992, three studies completed by the author et al., demonstrated that high indicator bacteria densities were frequently present at ankle-depth shoreline locations up to 100 yards from flowing storm drains, and human enteric viruses were present in runoff from three local storm drains.

The results of the storm drain virus studies brought greater state and local government focus on the problem of sewage contaminated urban runoff. The Los Angeles County Department of Health Services amended its beach closure and health warning protocol to make it more protective of human health. The State Legislature passed a bill, Senate Bill 1084, which required the completion of the SMBRP epidemiology study, and local cities implemented measures ranging from dry-weather runoff diversions to sewage treatment plants, to sanitary surveys designed to detect illegal discharges of sewage to storm drains.

Despite the lack of an accurate estimate of health risks to local swimmers and of health-based microbial water quality standards in California, the development of a strong beach closure and health warning protocol for Los Angeles County demonstrates that health risk management has become a priority to the public and local government. There are other policy and pathogen source reduction measures that, if executed, would further reduce health risks to swimmers. Until research on more effective human sewage indicators, the health risks of swimming in runoff contaminated waters, and a sanitary survey to detect sources of sewage to the shoreline is completed, implementation of risk management measures should prevent significant outbreaks of swimming associated illnesses.

3-591

12-219

Preface

The research included within this dissertation was completed during an internship at the local environmental group Heal the Bay, a non-profit environmental organization with more than 12,000 members working through research, advocacy and public education to make Santa Monica Bay and Southern California's beaches safe and healthy again for people and marine life. The dissertation includes three studies on pathogens and pathogen indicators in storm drain runoff and the surf-zone that were completed by Heal the Bay, the City of Los Angeles-Bureau of Sanitation-Environmental Monitoring Division, and the Orange County Sanitation Districts under the auspices of the Santa Monica Bay Restoration Project (SMBRP). The SMBRP, part of the National Estuary Program, is a federal, state and locally funded entity whose primary goal is the creation of a Comprehensive Conservation and Management Plan (CCMP) for the Bay.

As the staff scientist at Heal the Bay and the principal investigator (P.I.) of the three storm drain studies, my responsibilities on the studies included acquiring funding, study design, project management and oversight, sample collection for indicator bacteria analysis, assistance in statistical analysis, primary authorship and final editor of the reports. Also, the P.I. presented the study findings to the Technical Advisory Committee (TAC) and Management Committee of the SMBRP.

The report review and approval process of the SMBRP TAC was a seven-step process. All submitted reports met the SMBRP technical report formatting and presentation guidelines before they were reviewed by TAC members and outside reviewers. The Draft Final Reports were reviewed by two outside reviewers chosen by SMBRP staff and the Surf-Zone Pathogen subcommittee of the TAC. In addition, all members of the TAC had the opportunity to review the three reports. All comments by the outside reviewers and TAC members were collected and compiled by a review coordinator for the reports. The review coordinator sent the comments to the P.I. for document revisions. After the Draft Final Reports were revised by the P.I., the documents were submitted to the review coordinator and the full TAC for their sequential final approvals. Following TAC approval, the reports were sent to the Management Committee for their final approval and subsequent public release of the reports.

Introduction

The beaches along Santa Monica Bay attract nearly 60 million visitors each year (Los Angeles County Deparument of Beaches and Harbors, 1992), yet over half of the visitors do not go in the water, and nearly one third of the population of Los Angeles County does not go to the beach because of the potential health impacts of water pollution in the Bay (Fairbank, Maullin and Assoc., 1992). This first chapter of the dissertation is an examination of how public opinion on water quality in Santa Monica Bay has changed over the last fifteen years, what local events were responsible for the change in the public's concern about the health risks of swimming in the Bay, and what environmental groups, elected officials and state and local government agencies have done to characterize and minimize the health risks to swimmers in the Bay.

The health risk management strategies that are discussed in Chapter One are microbial water quality standards and local and state comprehensive beach closure and health warning protocols. The microbial water quality standards in California, based on the densities of indicator bacteria (total and fecal coliforms and enterococcus), are not associated with the incidence of illness in ocean swimmers (State Water Resources Control Board, 1990b). The lack of health based bathing water standards has led to greater local public reliance on the implementation of a comprehensive beach closure and health warning protocol. The beach closure protocol for Los Angeles County has changed extensively over the last decade because of public pressure from environmental groups and elected officials, numerous large sewage spills to Santa Monica Bay, chemical spills and high indicator bacteria densities in and adjacent to the Pico-Kenter storm drain, and new research on pathogens in the storm drains and indicator bacteria densities in the surf-zone. The current protocol is far more protective of human health than previous protocols

because the beaches are automatically closed after all sewage spills, all flowing storm drains are posted with health warning signs, and source investigations are required when there are chronically high indicator bacteria densities in the surf-zone (Los Angeles County Department of Health Services, 1992).

The second chapter contains an analysis of the efficacy of risk assessment and epidemiological techniques at providing an accurate estimate of the health risks of recreational water contact in Santa Monica Bay. Numerous risk assessments have been performed on people exposed to pathogens in drinking water (Haas, 1983, Regli et al., 1991), but the lack of reliable environmental exposure and infectivity estimates has led to substantial difficulties in accurately assessing the health risks to the public in ocean waters. Epidemiology studies of swimmers exposed to sewage contaminated waters generally demonstrated increased health risks to swimmers as compared to non-swimmers for gastroenteritis, respiratory symptoms, and infections of the skin, ears and eyes (Stevenson, 1953; Bryan, et al., 1974; Cabelli, et al., 1979, 1982; Fattal, et al., 1983; Seyfried, et al., 1984, 1985; Philipp, et al., 1985; Dewailly, et al., 1986; Brown, et al., 1987; Ferly, et al., 1989; New Jersey Department of Health, 1990; Deitner, et al., 1990; Robson, et al., 1990; Cheung, et al., 1990; Balarajan, et al., 1991; von Schirndig, et al., 1992 and Corbett, et al., 1992). However, correlations with the incidence of illness and the densities of indicator organisms were inconsistent, thereby providing little support to existing microbial water quality standards (Elliot et al., 1985; Salas, 1987; Jones et al., 1989; Saliba et al., 1990; and Walker, 1992).

In order to provide an accurate assessment of the health risks to Santa Monica Bay swimmers, a large-scale epidemiology study on swimmers in urban runoff contaminated

3-563

12-212

waters was designed (Haile et al., 1992) and approved by the Santa Monica Bay Restoration Project, the California Legislature, and the Governor of California. The study, when initiated in 1995, will be the first study ever completed on swimmers off the western coast of North America, and it will be the first epidemiology study of bathers in urban runoff contaminated waters. If the results of the epidemiology study demonstrate an association between the incidence of illness and the densities of indicator organisms along the shoreline, then the California Department of Health Services and the State Water Resources Control Board will modify the microbial bathing water standards for the State.

The large uncertainty inherent in the outcome of the proposed epidemiology study makes the implementation of a number of research, policy and source reduction recommendations a high priority. Promising research on sewage indicators could provide needed information on the extent of sewage contamination in the surf-zone and storm drain system. Changes in current stormwater management and health risk notification policies could reduce the health risks to swimmers in the Bay. Implementation of source reduction measures could greatly reduce the pollutant and pathogen loads to Santa Monica Bay. No single practicable measure will result in the elimination of health risks to local swimmers, but increased public awareness of the causes of beach and storm drain pollution, and increased awareness of risk management measures to reduce surf-zone exposures to pathogens would probably prove more effective at reducing the health risk to swimmers than the implementation of technological and regulatory measures.

Chapter 1 - The Evolution of Santa Monica Bay Beach Closure and Health Warning Policy

Summary

Since a cluster of cancer cases among lifeguards was first discussed in 1980, the public has become more aware of pollution problems in Santa Monica Bay. Beach visitor populations remain below levels in the early 1980s, and approximately half of the general public is concerned about the health risks of swimming in the Bay (LACDHS, 1992). With this increasing public awareness and the work of environmental groups, government agencies, and elected officials, the Los Angeles County Department of Health Services (LACDHS) policy on beach closures and health warnings has evolved to be more protective of public health.

The results of completed studies on pathogens and pathogen indicators in urban runoff and the surf-zone were used by the public and by government agencies to convince the LACDHS that the Los Angeles County policy on beach closures and health warnings needed to be more protective of human health. Despite the results of these studies and the efforts of environmental groups and elected officials, the California Department of Health Services (CDHS) has not been convinced that a stronger statewide beach closure and health warning protocol is needed. Because of a lack of strong epidemiological evidence, the CDHS believes that none of the three commonly regulated bacterial indicators is adequate to develop and implement a new protocol. However, with the passage of Senate Bill 1465 in 1992, health agencies are required to post health warning or beach closure signs whenever a sewage spill causes high total coliform densities in the surf-zone. One recommendation generally agreed on by health service agencies, the State

6) Reporting on the feasibility of a comprehensive storm drain monitoring program for carcinogens; and

7) Preparing a measure subject to Board approval to provide a monetary reward to anyone providing information that lead to the arrest and conviction of people who illegally dump toxic material in the storm drain system (CAO, 1981).

All seven measures were completed or had begun implementation by March, 1981. The County determined that the water quality of the Pico-Kenter effluent did not pose a significant health risk to the public after four runoff samples came back with very low to non-detectable concentrations of carcinogenic chemicals. Because of these results and the high cost of chemical analysis of runoff samples, the County decided that a comprehensive toxics monitoring program would not be undertaken. In addition, the County determined that illegal toxics dumping was not a significant problem because their quarterly urban runoff monitoring program had failed to detect illegal dumpers. The County recommended better street sweeping, public education, and anti-littering and pollution ordinances to control the toxic pollutant load in the storm drain system rather than recommending improvements to their illegal dumping and illicit connection inspection and enforcement program. Currently, comprehensive monitoring programs and illegal dumping and illicit connection abatement programs are required under the Federal Municipal Stormwater Discharge Permit for Los Angeles County.

The public's concern about the cancer risk from swimming in Santa Monica Bay led to the initiation of a cancer registry cohort study by the Los Angeles County Department of Health Services and Dr. Thomas Mack at the University of Southern California (USC)

Cancer and Epidemiology Program. By March, 1981, before the onset of the cohort study, Dr. Mack had rendered an opinion that the incidence of cancer among lifeguards was no greater than that among the rest of the Los Angeles County workforce (CAO, 1981). The cohort study was designed to test this hypothesis.

Evaluating the relationship between occupational exposure and the incidence of cancer in lifeguards was difficult for a number of reasons. There were relatively few lifeguards, and most of them were significantly younger than the age group in which most cancers occur. For both of these reasons, the frequency of cases was small and the incidence of cancer was susceptible to chance variation. Another problem was that most lifeguards work for short periods of time before going on to other jobs, while others work only during the summer. These variable work patterns produce wide ranges of occupational exposure, and they make recognition of an association between cancer and the occupation of lifeguard far more unlikely.

The researchers compared the incidence of cancer in 20 to 44 year old lifeguards from 1972 to 1980 to the incidence of cancer in a control population of white males in the same age group that lived in Los Angeles County. The relative risk of cancer for the 830 lifeguards that worked in Santa Monica Bay during that time period was 2.4 times that of the control population (Mack, 1982). The researcher concluded that the increased relative risk was not significantly different from the risk expected by the chance grouping of populations in Los Angeles County. Exposures to the ocean waters of the Bay were discounted as the probable cause of the cancers because of the quick onset of many of the cancers after exposure, the lack of a consistent relationship between the degree of expo

6-55
12-215

sure and the incidence of cancer in lifeguards, and the absence of any predominant type of cancer.

The researchers recommended against funding a long term epidemiology study on lifeguards because of the prohibitive study cost, the small number of lifeguards, and the long-time-period requirements to track the exposed population (Mack et al., 1982). In addition, residents of Los Angeles County were exposed to many different types of carcinogens that could have further confounded the results of such a study. To date, there has been no further research on cancer risk to lifeguards or swimmers and surfers in Santa Monica Bay.

Increasing public awareness of Bay pollution issues - Over the next three years, the pollution of Santa Monica Bay became more of a public issue. DDT and PCB contamination of certain fish species, the refusal of the city of Los Angeles to require the Hyperion Sewage Treatment Plant to comply with the full secondary treatment requirements of the Federal Clean Water Act, sewage sludge dumping in the ocean on the Palos Verdes shelf and at the mouth of the Santa Monica submarine canyon, and a high incidence of fin erosion and tumors in juvenile bottomfish were just some of the issues that brought greater public awareness of the Bay's pollution problems (Southern California Association of Governments (SCAG), 1988). In addition, then Assemblyman Tom Hayden (Santa Monica) brought greater public attention to pollution in Santa Monica Bay by holding public hearings and introducing a number of bills on pollution in the Bay. In 1985, an environmental group, Heal the Bay, was formed for the sole purpose of enhancing and restoring the water quality and natural resources of Santa Monica Bay. The first goal of the organization was to force Los Angeles to stop its pursuit of a waiver from the full secondary treatment requirements of the Clean Water Act.

During the first year of operation of Heal the Bay, a large number of people contacted the organization to express their concern about the health risks of swimming in the Bay. Most of the ocean-going public were aware of the lifeguard cancer cluster, and they were concerned about their own health and safety. In addition, many people called to report illnesses as a possible result of swimming at certain Santa Monica Bay beaches. As it turned out, the callers were representative of a large beach-going public that had the same concerns in 1985 and 1986 as the number of yearly beach visitors dropped by over 25 million from 1984 (LACDBH, 1992).

The large amount of anecdotal evidence led Heal the Bay to issue an informal questionnaire to their 700 members and approximately 1,000 beachgoers in 1986. The one page questionnaire asked members a number of basic questions: 1) Do you swim in Santa Monica Bay?; 2) Where do you usually swim in the Bay?; 3) Have you ever become sick when you swam in the Bay?; and 4) If so, what were your symptoms? Approximately 300 people responded to the questionnaire, over 150 of whom thought they had sustained illnesses from swimming in the Bay. The results of the questionnaire were probably not representative of the general population because the questions were answered by members of an environmental group that was concerned about the health risks of swimming in the Bay. Other questionnaires were filled out by beachgoers that were interested enough in Santa Monica Bay water quality to stop at a Heal the Bay table to ask questions and collect the literature from the environmental group.

The Pico-Kenter Storm Drain

In 1985, the Pico-Kenter storm drain, which discharged untreated urban runoff to Santa Monica Beach, again was the focus of public attention on beach pollution. At that time, the Los Angeles County Department of Public Works (LACDPW) estimated that the drain discharged 500,000 gallons per day across the most visited beach along Santa Monica Bay (SMBRP, 1994a). The urban runoff from the Pico-Kenter drain formed a permanent, warm temperature pool on the beach that was frequented by small children. Indicator bacteria densities in the Pico-Kenter pool were often orders of magnitude above the bacterial health standards in Title 17 of the California Code of Regulations and the bacterial objectives in the California Ocean Plan. In addition, the bacterial densities in the surf zone adjacent to the storm drain flow exceeded these standards more frequently than of any other beach along Santa Monica Bay.

To ease the runoff problem, the City of Santa Monica suggested the Pico-Kenter runoff be diverted to the Hyperion Treatment Plant. This suggestion was immediately dismissed by the City of Los Angeles because, from the early 1980's to 1988, the Hyperion Treatment Plant was having serious hydraulic and treatment capacity problems (Horil, 1986). Any additional flows to the plant could have caused problems in the quantity and/or quality of sewage treatment at Hyperion. Shortly thereafter, the city of Santa Monica Department of General Services suggested diverting the Pico-Kenter drain flow to the nearby Ashland Avenue drain, which flows to a less popular stretch of beach, or to Ballona Creek, the largest storm drain flowing to the Bay. The LACDHS was supportive of the Ashland Avenue diversion, but it never took place.

In the summer of 1986, a dry weather flow storm drain pipe was connected to the Pico-Kenter storm drain. The pipe discharged runoff at the mean tide line, which eliminated the ponding problem on the beach. However, the pipe was labelled with a small sign, "Contents of Pipe Unfit for Human Contact," which further increased public concern about swimming at Santa Monica Beach. Immediately after installation of the pipe, the LACDHS weekly indicator bacteria monitoring data were not above total coliform standards. However, the LACDHS was taking samples 100 yards from the flowing drain. At the request of Los Angeles City Councilman Marvin Braude, additional samples were taken by LAEMD staff only 20 yards from the flowing drain. Total coliform counts exceeded California Ocean Plan objectives and the State Department of Health Services standard. Shortly thereafter, a new, similar pipe was constructed at the Santa Monica Pier storm drain nearby. In June and July, the Santa Monica City Council discussed the problems at the Pico-Kenter drain and some council members agreed that the high bacteria problems should be treated as a sewage contamination problem.

In late August and early September of 1986, five spills of diesel fuel in the drain over a two week period caused additional beach closures. Lifeguards, complaining of foul odors causing headaches and nausea, notified the LACDHS of the spills. At this point, pollution problems at Santa Monica Beach were being reported by the press on a near-weekly basis. The Director of General Services for Santa Monica stated: "Illegal dumping in the drain is simply what has happened nearly every two months for the past several years."(Scholl, 1986) At this point, as with the public reaction to the lifeguard cancer scare, the public began to pressure government agencies to solve the problem of Pico-Kenter storm drain pollution. The City of Santa Monica immediately offered a $3,000 reward for information leading to the arrest and conviction of the parties responsible for

3-59J

12-216

dumping diesel fuel into the storm drain. Though no suspect was ever found, Santa Monica and the LACDHS started an industrial waste inspection program of 400 businesses in the city. Also, Santa Monica approved a pilot project to disinfect Pico-Kenter runoff with chlorine.

Lifeguard, Heal the Bay, and beachgoer complaints about the runoff from the storm drain led to the creation of the multi-jurisdictional Pico-Kenter Task Force in the spring of 1986. The task force was made up of representatives from the LACDPW, the City of Los Angeles Board of Public Works, the City of Santa Monica, and the concerned public. In addition, representatives from the offices of Assemblyman Tom Hayden, County Supervisor Deane Dana, Los Angeles Councilman Marvin Braude, Representative Mel Levine (Santa Monica), and the Environmental Protection Agency (EPA) often participated in these meetings. After meeting for three months the task force arrived at a series of recommendations to reduce the potential health risks of swimming near the flowing drain (Pico-Kenter Task Force, 1986):

1) Extend the drain from its discharge point on Santa Monica Beach to a point 600 feet offshore from the mean tide line. Once this project was endorsed by the task force, the chlorination pilot project was stopped;

2) Install a hydrocarbon sensor/alarm system to the storm drain to provide an early warning system for petroleum spills;

3) Enhance the existing pollution control enforcement program including the industrial waste program and the animal waste control ordinance;

4) Develop and implement an education program designed to reduce non-point source pollution;

5) Increase the existing effluent monitoring program for the drain; and

6) Improve the existing street sweeping and catch basin cleaning programs.

The city of Santa Monica approved the program in January of 1987. By the end of 1988, Santa Monica had implemented every recommendation except construction of the 600-foot pipe extension and installation of the hydrocarbon sensor system. Santa Monica passed a new industrial waste ordinance, hired new industrial waste inspectors, implemented the first catch basin stenciling education program in Southern California, and produced a storm drain education Public Service Announcement. The County of Los Angeles did not approve the Pico-Kenter program until the end of 1987, while the City of Los Angeles did not approve funding for the project until 1989.

There was widespread support for the Pico-Kenter Task Force recommendations. In 1986, only Assemblyman Tom Hayden on the task force adamantly opposed the recommendations, stating that the 600-foot pipe extension just moved the pollution problem further out to sea and did not guarantee that the urban runoff plume would not be transported back to the surf zone. In 1990, a group of people who surf at the Bay Street beach, just a few yards south of the storm drain, formed a non-profit group, the Free Pacific Association. The group formed shortly after the SMBRP released its findings that human enteric viruses were found in Pico-Kenter runoff on 11 out of 13 sampling days.

during the summer of 1989 (Gold et al., 1990). The Free Pacific Association was formed for the express purpose of preventing the pipe extension project.

The pipe extension took nearly three years to construct because of the difficulty of implementing inter-jurisdictional agreements with three government bureaucracies, because of contract overruns, and because of construction difficulties caused by the ocean surf. The original cost of the project, including the hydrocarbon sensors, was estimated at $300,000 to $400,000, but the pipe extension alone cost more than $600,000. The pipe, which can convey only dry-weather flows of up to 500,000 gallons per day, was finally completed in August, 1991, three years after the expected date of completion. Frequent (daily or every other day) removal of trash from the inlet grate to the pipe extension is required to prevent urban runoff overflows to the beach. Also, heavy surf uncovered the extension pipe on three occasions in 1992 and 1993, leading to expensive additional maintenance costs.

In 1991, Heal the Bay, the Free Pacific Association, the LACDPW, and the cities of Santa Monica and Los Angeles reached an agreement to temporarily divert the dry weather flow from the Pico-Kenter storm drain to the Hyperion Treatment Plant. Because of a successful water conservation program and upstream capacity expansion at their Tillman Treatment Plant, Los Angeles had nearly 100 million gallons per day of available capacity at the Hyperion Treatment Plant. The City of Los Angeles agreed to allow dry-weather flow diversion to Hyperion until the City of Santa Monica completed construction of an urban runoff treatment facility in 1996. On May 29, 1992 the Pico-Kenter low flow diversion project was complete, which relegated the 600-foot pipe extension to function only as a system backup in case of pump failure. On July 4th, after

more than a month of system testing, the four entities led by Los Angeles Mayor Tom Bradley held a press conference announcing the Pico-Kenter storm drain diversion.

In addition to the diversion and pipe extension, from 1989 to 1992 the City of Santa Monica installed and began to test the hydrocarbon detection system in the Pico-Kenter drain. The computerized sensor system was designed to detect volatile hydrocarbons in the air above the storm drain flow. If a large gasoline, oil, or diesel spill occurred in the drain, the sensors were designed to detect the hydrocarbon vapors and trigger an alarm to the industrial waste inspectors of Santa Monica. After the system is fully tested and implemented, the alarm will cause an automatic closure of the storm drain opening, so the spill can be contained, pumped out and appropriately treated. The system is quite expensive, fragile, and the technology is somewhat unreliable. Santa Monica, with additional funding from the LACDPW and the Los Angeles Board of Public Works, plans to expand the hydrocarbon sensor system in the Pico-Kenter drain from the current two sensors to ten sensors by 1994.

Another major project at the Pico-Kenter drain was the design, construction and implementation of a pilot ozonation facility at the Santa Monica bus yard on Sixth Street and Colorado Avenue. The project operated from 1989 to 1991 and was funded by the EPA and Santa Monica as an Early Action Project under the Santa Monica Bay Restoration Project. The principal objective of the pilot facility was to determine the efficacy of ozone as a stormwater disinfectant. As late as January, 1988, Santa Monica had planned to install a chlorination-dechlorination facility to disinfect Pico-Kenter urban runoff. Santa Monica dropped their plans for a chlorination facility because of the high

3-569

12-218

cost of dechlorination. Dechlorination was deemed necessary in order to reduce the toxicity of the disinfected runoff to people and marine life.

Ozone was a successful disinfectant of urban runoff indicator bacteria at the Pico-Kenter drain (Greene, 1993), but the efficacy of ozone in reducing concentrations of organic contaminants in runoff was marginal. The City of Santa Monica has plans to build a permanent, dry-weather flow, urban runoff treatment facility for Pico-Kenter and Santa Monica Pier runoff by the end of 1996. The role of ozone at the facility has yet to be determined, but Santa Monica may ozonate the runoff if the facility becomes a water reclamation plant.

Media coverage of both chemical spill and pathogen pollution problems at the Pico-Kenter storm drain led to increased public awareness of urban runoff pollution and potential health risks to swimmers in Santa Monica Bay. The efforts of government agencies, elected officials, and environmental groups to abate the pollution problems led to the implementation of a model comprehensive stormwater management plan for the Pico-Kenter storm drain watershed. Many of the management practices implemented in the watershed have achieved reductions in the number of spills to the drain, greater public and business awareness of the sources of storm drain pollution, and reductions in the potential health risks to people who swim and surf near the drain. Some of the management practices including catch basin stenciling, comprehensive business and public education programs, diversion of dry weather runoff to sewage treatment plants, and enhanced street-sweeping and catch basin cleaning programs have been implemented in a number of cities throughout the Santa Monica Bay watershed. Other management practices, including storm drain outfall extensions and hydroacoustic sensor/alarm systems, have not been implemented by cities within the watershed because of high capital, operation, and maintenance costs and/or lack of demonstrated efficacy in solving urban runoff pollution problems.

The Santa Monica Bay Restoration Project

In 1988, then-Governor George Deukmejian nominated Santa Monica Bay to the EPA's National Estuary Program because of the historic and continuing pollution problems in the Bay. The U.S. Congress and the EPA accepted the governor's nomination, and the Santa Monica Bay Restoration Project (SMBRP) was created. The SMBRP is a federal, state, and locally funded entity whose primary goal is the creation of a Comprehensive Conservation and Management Plan (CCMP) for the Bay. The SMBRP is part of the federal National Estuary Program which has funded the development of CCMPs at over twenty bays and estuaries throughout the country. There are three different committees of the SMBRP, the Public Advisory Committee, the Technical Advisory Committee, and the Management Committee, which is the decision making body of the Bay Project. The Management Committee is made up of the primary stakeholders in the Santa Monica Bay watershed: local, state and federal elected officials and agencies, dischargers, user groups, and environmental groups. In January of 1989, the SMBRP Management Committee determined that the health risks of swimming in the Bay was one of three priority areas of concern, along with the cancer risk of eating seafood from the Bay, and marine and coastal habitat protection and restoration. To date, over six million dollars has been spent by various entities on research, public education, numerous meetings, and the creation of the CCMP (SMBRP, pers. comm. 1994).

3-570

12-219

The SMBRP has funded research on pathogens and pathogen indicators in urban runoff, the development of a design for a large-scale epidemiology study on swimmers in the Bay, research on the mass pollutant loads of various contaminants to the Bay from the Santa Monica Bay watershed and subdrainages within the watersheds, research on sanitary survey techniques for storm drains, a compilation of recommended Best Management Practices for reducing urban runoff pollutant loadings to the Bay, and research on the toxicity of both dry- and wet-weather urban runoff to marine life. These SMBRP funded projects and others have influenced stormwater management regulations and programs, as well as influencing the Los Angeles County beach closure and health warning protocol.

History of Ocean Bathing Water Standards in California

Most of the controversy surrounding the issue of the health risks of swimming in polluted ocean waters stems from the fact that other than for enterococcus bacteria, bathing water standards are not health based. California's current bacteriological standards are the following:

The CDHS standard - S. 7958 of the California Code of Regulations (CCR) states that, "samples of water from each sampling station at a public beach or public water contact sports area shall have a most probable number (MPN) of coliform organisms less than 1,000 per 100 ml; provided that not more than 20% of the samples at any given sampling station, in any 30 day period, may exceed 1,000 per 100 ml, and provided that no single sample when verified by a repeat sample taken within 48 hours shall exceed 10,000 per 100 ml.

The State Water Resources Control Board (SWRCB) water contact standards -

Total coliforms - the same as above.

Fecal coliforms - "The fecal coliform density based on a minimum of not less than five samples for any 30 day period, shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10% of the total samples during any 60 day period exceed 400 bacteria per 100 ml."

Enterococcus Bacterial Assessment and Remedial Action Requirements - "If a shore station exceeds a coliform standard or exceeds a mean enterococcus density of 24 organisms per 100 ml for a 30 day period or 12 organisms per 100 ml for a six month period, the Regional Water Board shall require the appropriate agency to conduct a sanitary survey to determine if the agency's discharge is the source of contamination."

The first California Ocean Plan was approved by the SWRCB in 1972, and it contained the total coliform standard that is presently in the plan. The water quality limits in Chapter II were developed to "ensure the reasonable protection of beneficial uses and the prevention of nuisance." The Ocean Plan defines beneficial uses as industrial water supply, water contact and non-contact recreation, including aesthetic enjoyment, navigation, commercial and sport fishing, mariculture, preservation and enhancement of Areas of Special Biological Significance, rare and endangered species, marine habitat, fish migration, fish spawning and shellfish harvesting (SWRCB, 1990). Although the bathing water quality objectives apply to the ocean waters of the state, the objectives are only enforced in cases where point source dischargers are the source of high indicator bacteria

9-57
12-220

counts. Currently, the SWRCB is determining how to implement the bacterial standards for non-point sources, including urban runoff (SWRCB, 1992).

The total coliform standard of 1,000 organisms per 100 ml in both Title 17 of the CCR and the Ocean Plan was developed during the 1940s based entirely on aesthetic considerations (Salas, 1987). When total coliform counts were consistently below the 1,000 coliform/100 ml standards, the beaches had no visible evidence of sewage pollution. During the forties, most sewage was discharged within a mile of shore, which often caused visible beach contamination (Metcalf and Eddy, 1944).

Large-scale epidemiological studies designed to assess the health risks of swimming at polluted beaches were conducted during a period from 1948-1950 by the U.S. Public Health Service. The studies were conducted at beaches on Lake Michigan, the Ohio River and Long Island Sound. At all three locations, eye, ear, nose and throat ailments were more common in bathers than non-bathers, particularly among children under ten years old (Stevenson, 1953). However, there was not an association between the incidence of illness in swimmers and bacterial densities at the ocean water sites. At the fresh water sites, detectable illness rates were associated with densities of total coliforms over 2,300 per 100 ml for Lake Michigan and 2,700 per 100 mls for the Ohio River. Although these studies were later found to be flawed by selection bias, disease misclassification, and residual confounding (Moore, 1974), they formed the basis for bathing water standards throughout the world for the next three decades.

In 1968, the Federal Water Pollution Control Administration developed a national fecal coliform guideline of 200 organisms per 100 ml (Geldreich, 1970). The guideline was

based on earlier work in the Ohio River demonstrating that fecal coliforms made up 18% of the total coliform densities, which would indicate that detectable health effects would occur at fecal coliform densities of 400 per 100 ml. or more. The 200 fecal coliform per 100 ml guideline was developed by the application of a safety factor of two to the 200 fecal coliform per 100 ml value. In 1976, after years of debate on the merits of the fecal coliform guideline, the EPA proposed the guideline that is in the current Ocean Plan. The primary rationale for the EPA guideline was the relationship of fecal coliform densities to the frequency of Salmonella isolations in surface water (Geldreich, 1970) rather than the Stevenson (1953) studies (Salas, 1987).

The large-scale epidemiology studies completed by the EPA - In order to determine the health risk associated with the densities of different indicator organisms in ocean waters, the EPA conducted extensive epidemiology studies between 1972 and 1978 (Cabelli et al. 1979, 1982). The purpose of these studies was to determine which indicator organism best correlated with the incidence of illness in bathers. The indicators used in the study were enterococci, E. coli, fecal and total coliforms, Enterobacter-Citrobacter, Clostridium perfringens, Klebsiella, Aeromonas hydrophyla, Pseudomonas aeruginosa, staphylococci, and Vibrio parahemolyticus. The studies were completed at beach sites in Boston Harbor, Rockaway and Coney Island in New York, and Lake Pontchartrain in Louisiana that had a high probability of sewage contamination.

The results of the studies were as follows:

(1) Swimmers at beaches with high indicator densities had a higher incidence of gastroenteritis than non-swimmers.

2) Low enterococcus and E. coli densities (10/100ml) significantly correlated with the incidence of illness (10/1000 swimmers). The illnesses were highly credible gastroenteritis (one or more symptoms including vomiting, diarrhea accompanied by fever or that required bedrest, and cases of nausea and abdominal pain accompanied by fever) and to a lesser extent, gastroenteritis;

3) Enterococcus densities were the best indicator of the incidence of illness in the bathing population; and

4) Highly credible gastrointestinal symptoms occurred at beaches which met coliform standards.

In 1986, the EPA recommended an enterococcus standard of no greater than 35 organisms per 100 ml for marine waters, which corresponded to an estimated illness rate of 19 per 1000 swimmers (EPA, 1986). EPA also recommended that the level of use at a beach should help dictate the bathing water standard for the area.

The enterococcus water quality objective in California - In 1988, the SWRCB assembled the Bacteriological Standards Subcommittee of the Southern California Bight Review committee. Representatives from the public, the SWRCB, the Southern California Regional Water Quality Control Boards, and sewage and health agencies devised a study to measure enterococcus and coliforms in parallel. The one-year study demonstrated that for stations unaffected by runoff, all stations attained the existing Ocean Plan coliform standards 100% of the time. For enterococcus, stations unaffected

by runoff attained average monthly densities of less than 12 organisms per 100 ml 100% of the time. In stations impacted by runoff, the results were far more variable.

After three years of discussions, the SWRCB added the enterococci bacterial objective to Chapter II of the Ocean Plan in 1990. Based on the results of the parallel monitoring study, the SWRCB chose an enterococcus "assessment and remedial action requirement" of 24 organisms per 100 ml for a 30 day period and 12 organisms per 100 ml for a six month period. Although 24 organisms per 100 ml corresponds to an estimated illness rate of approximately 14 per 1,000 swimmers, the objective that the SWRCB chose was not a risk management decision based on the acceptable risk of illness to swimmers in California recreational waters. Instead, the objectives were based on the bacterial density that was met 100% of the time by dischargers over the course of the parallel study.

The SWRCB decided against developing an enterococcus standard for a number of reasons. Although enterococcus was the only indicator that correlated with the incidence of illness in ocean waters, the SWRCB believed that they did not have a technically defensible basis for selecting a specific bacterial density for a standard. The SWRCB was uncertain about the applicability of the EPA studies to state waters because the colder waters off the California coast could cause longer pathogen survival rates (Yates and Gerba, 1984). The SWRCB did not want to spend an estimated $2-3 million (SWRCB, 1990b)(based on a sample size of approximately 70,0000) to complete an epidemiology study in order to determine the appropriate enterococci standard for California. Instead, the SWRCB decided that a sanitary survey for the source of high bacteria counts should be completed by the discharger whenever enterococci densities were exceeded. However, the State Water Board did not provide a definition of a sanitary survey or a standardized

22-222

25-6

protocol on how to complete such a survey. To date, four years after the SWRCB approval of the 1990 California Ocean Plan, a sanitary survey has not been completed as a result of high enterococci densities in recreational waters.

Problems with the bacterial indicators - In the context of bathing water standards, an indicator organism is a microorganism whose density in the water can be correlated to the potential health risks of swimming in the water or to sewage contamination of the water. The ideal indicator organism has the following characteristics:

1) An indicator organism should be consistently and exclusively associated with the source of pathogens likely to cause human illness. For example, most swimming associated gastroenteritis is caused by rotavirus or Norwalk-type viruses (Rao and Melnick, 1986 and CDC, 1987; 1990). The source of these enteric viruses is human fecal wastes. For gastroenteritis, an effective indicator should be associated with human sewage and the presence of enteroviruses. Indicator bacteria are poorly associated with the presence of enteroviruses in marine waters (Gerba et al., 1979);

2) The indicator should be present in large enough numbers to be accurately quantified when levels of pathogens pose unacceptable risks of illness; and

3) The indicator should persist and survive under ocean and sewage treatment plant environmental conditions as well as the most persistent pathogens of concern. Enterococcus better mimics the survival of viral pathogens than do total and fecal coliforms (Gantzer et al., 1983), while F-male specific coliphage, a virus

associated with coliforms, may survive even longer in marine waters than does enterococcus (Havelaar et al., 1985, Cabelli in SCAG, 1988); and

4) The indicator must be quantified inexpensively, accurately, consistently, and quickly in order for the indicator density data to be useful to risk managers (Cabelli, 1982).

The three indicator bacteria used for California bathing water standards and objectives are poor indicators for a number of reasons. Although total and fecal coliforms and enterococci are quickly and easily detectable and abundant in sewage and runoff, they are rarely pathogenic and are not specific to human fecal waste. Total coliforms can exist on soil particles and vegetation surfaces as well as in the feces of all warm blooded animals (Saiki, 1987). Fecal coliforms and enterococci are specific to warm blooded animals. As stated earlier, enterococci survive better in the marine environment than do the coliforms, and enterococcus is the only bacterial indicator that has correlated with the incidence of illness in ocean swimmers that use sewage contaminated waters.

F-male specific coliphage survive better in sewage treatment plants and the marine environment than do the bacterial indicators (SCAG, 1988, Debartolomeis et al., 1991). Also, coliphage are cheaply, quickly, and easily detectable in the ocean environment. However, in three years of studies, coliphage has not correlated with the presence of absence of human enteric viruses in sewage contaminated runoff (Gold et al., 1990, 1991, 1992).

3-574

12-223

Ideally, the best bathing water quality indicator would be a human pathogen. Human enteric virus studies of urban runoff have demonstrated that human viruses are discharged to Santa Monica Bay and Orange County (Charles McGee pers. comm.) coastal waters through creeks and the storm drain system. However, the plaque-forming unit and cytopathic effect methods of virus detection are expensive (approximately $350 per sample) and time consuming (weeks to months). Ongoing research on suitable bathing water quality indicators is focusing on human specific viral and bacterial gene probes, but to date, researchers have been unable to find a method and organism that fits the criteria for an ideal indicator.

Storm Drain Health Warning Signs

In 1986, Heal the Bay began focusing on urban runoff pollution because of the concern of the public about the health risks of swimming in the Bay and the amount of trash, debris, and chemical contaminants discharged from the sixty-four, unregulated storm drains that discharge to the Bay. One of the first urban runoff objectives of Heal the Bay was to persuade Los Angeles County to post all flowing storm drains with health warning signs. After nearly two years of discussion, the LACDHS and the LACDBH agreed to post "problem" storm drains with health warning signs displaying the universal No Swimming symbol (Green, 1986-88). A problem storm drain was defined as a drain that frequently discharged to the Bay, causing high indicator bacteria densities in recreational bathing waters.

Initially, Los Angeles County agencies did not agree to post warning signs near the storm drains because there had never been an outbreak of illness associated with exposure to runoff in Santa Monica Bay. Years of surf-zone monitoring data supported the contention that urban runoff was the source of high indicator bacteria densities at Santa Monica Bay beaches (LACDHS, 1986-92, the City of Los Angeles Bureau of Sanitation - Environmental Monitoring Division (LAEMD), 1986-92). However, the predominant sources of the bacteria are assumed to be warm blooded animals other than humans, because the Los Angeles County storm drain system is completely separate from the local sewer system. Therefore, because of the lack of illness outbreaks and the supposition that no human sewage was in urban runoff, the LACDHS took the position that exposure to urban runoff posed an insignificant health risk to the public. Heal the Bay took the position that since urban runoff did not receive water quality treatment, it could possibly contain substances ranging from motor oil to animal waste within any period of time, and the premise that animal-waste contaminated runoff posed an insignificant health risk could not be substantiated by the scientific literature. The position of the environmental group was that until the health risks of swimming in urban runoff contaminated waters are quantified, at a minimum, all flowing storm drains should be posted with health warning signs (Green, 1986-88).

The discussions between the County and Heal the Bay brought little progress until the involvement of Senior Deputy Mary Gray of Supervisor Deane Dana's office in July, 1987. A number of events in 1987 furthered negotiations on the posting issue. The LACDHS informed the office of Supervisor Dana that ocean bacterial monitoring was suspended for at least 48 hours after a rainstorm because shoreline indicator densities were high. The office of Supervisor Dana ordered the LACDHS to cease the 48 hour delayed monitoring practice. In addition, months of indicator bacteria monitoring data from the Pico-Kenter and Ashland Avenue area beaches, and Mothers' Beach in Marina Del Rey demonstrated chronic bacterial pollution problems. Regular monitoring of

3-575

12-221

Mother's Beach began shortly after a 2.4 million gallon sewage spill to Ballona Lagoon in June, 1987.

In October, the County agreed to post the problem drains. Also, the LACDHS agreed to post beaches with health warning signs after all sewage spills. Previously, beaches were often closed only after shoreline bacterial monitoring demonstrated that the sewage spill had caused high bacterial densities in the surf zone. Since analysis of ocean water for indicator bacteria takes 24 to 48 hours, beaches were usually posted one to two days after a sewage spill. After the decision to post signs was made, the discussions focused on the sign language. County agency and Heal the Bay representatives agreed that a large, brightly colored sign displaying the universal No Swimming symbol, was needed to attract the attention of the public. The new sign was permanently posted at nine problem storm drains in the spring of 1988. Also, the County agreed to temporarily post warning signs at beaches when bacterial densities were high for a number of consecutive weeks.

Unresolved was the disagreement over the warning language on the sign. Heal the Bay recommended that the public should stay at least 100 yards from a flowing storm drain or problem area while the County recommended a 25 yard distance. The County based their recommendation on a five-day sampling study in 1986 at three problem storm drains: Pico-Kenter, Pulgo Canyon, and Santa Monica Canyon (Kenablan, 1988). Because of the small sample size, the data could not be statistically analyzed, but the County interpreted the data as demonstrating that bacterial densities in the surf zone dropped off markedly at distances greater than 25 yards from the drain. Heal the Bay disagreed with this interpretation, citing the small sample size, the fact that the LACDHS weekly monitoring water samples were collected 50 to 100 yards from storm drains, and the frequent failure of the collected samples to meet the bacterial objectives of Title 17 of the California Health Code and the Ocean Plan. Although Heal the Bay disagreed with the County, the signs posted in problem areas instructed swimmers to stay at least 25 yards from flowing storm drains.

In the summer of 1990, Los Angeles County changed their policy to include all flowing storm drains to the Bay. If a storm drain flowed across the beach into the ocean, then Los Angeles County lifeguards posted a warning sign proximate to the location where the flow reached the surf zone. On any given day, 12 to 15 storm drains may flow into Santa Monica Bay. In addition, these warning signs were permanently posted near Malibu lagoon. The warning sign was developed over eight months of discussions by the Public Advisory Committee and Management Committee of the SMBRP. The final sign stated: In English and Spanish, "Caution! Storm Drain Water and Surf May Be Contaminated. No Swimming." The sign also displayed the universal No-Swimming symbol. The sign is currently used at beach locations all along the Bay. However, because of a lack of consensus by the SMBRP, the warning on the sign did not include a recommendation on the required number of yards needed to protect swimmers from exposure to storm drain flow.

Los Angeles County did not agree to post all flowing storm drains until a number of events occurred in 1990. In July, the Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) federal permit for Los Angeles County was approved by the RWQCB. For the first time, the LACDPW and the 19 co-permittee cities in the Santa Monica Bay watershed were required to develop stormwater management plans to reduce the pollutant load to Santa Monica Bay (RWQCB, 1990). Also, the creation of the

SMBRP brought far greater focus on the issue of the health risks of swimming in the Bay. The Technical Advisory Committee had Surf-Zone Pathogen and Storm Drain subcommittees and the Management Committee had a Non-Point Source subcommittee. In June of 1990, the SMBRP released their first study on storm drain inputs of fecal indicator organisms and human enteric viruses to Santa Monica Bay (Gold, et al., 1990). The researchers found that human enteric viruses, an indication of sewage contamination, were found in runoff from the Pico-Kenter storm drain. All of these events made communication to the public on the health risks of swimming near storm drains a priority for a larger and more influential group of decision makers.

The Evolution of the Los Angeles County Beach Closure and Health Warning Protocol

The issue of developing a County-wide policy for closing the beach and warning the public about potential health risks was first raised during the summer of 1986. Heal the Bay met with Robert Gates, Director of the LACDHS, to discuss the issue in September. In November, Gates summarized the LACDHS position on beach closures and health warnings to the County Board of Supervisors as follows (LACDHS, 1986):

1) No evidence exists which would justify closing or further restricting the use of bathing waters adjacent to the storm drains;

2) It is believed that the majority of coliform bacteria in storm drain runoff are from non-fecal sources;

3) Other studies indicate that contact with waters from storm drains containing elevated levels of non-human coliforms is not generally associated with measurable increases in human disease;

4) No increase in the incidence of disease has been associated with ocean water contact;

5) No significant health hazard exists for persons failing to observe the posted warning signs at the storm drains; and

6) Bacteria discharged into ocean waters are rapidly diluted at distances of 10 yards or more.

The LACDHS position on beach closures and health warnings was flawed for a number of reasons. By 1986, an epidemiology study on people who swim in storm drain runoff contaminated waters had not been undertaken. None of the contentions of the LACDHS on health risks could be justified without epidemiological or health risk assessment studies to support their conclusions. Also, the conclusions of the LACDHS were based on total coliform densities. Total coliform bacteria can come from vegetation and soil as well as warm blooded animals. The LACDHS had just added enterococcus, which is found only in the feces of warm blooded animals, to their monitoring program in the summer, yet these data and their fecal coliform data were ignored in the development of the LACDHS policy. Finally, as stated earlier, the interpretation of the indicator bacteria dilution data was flawed because the sample size was too small to analyze statistically.

3-577

12-226

Until the public or the research community could provide new technical information to prove otherwise, the LACDHS intended to remain firm in their belief that urban runoff posed an insignificant health risk to swimmers in Santa Monica Bay. However, because of public concern over the numerous sewage spills to the Bay, the LACDHS soon demonstrated flexibility on their beach closure and health warning policies during sewage spills.

The position of the LACDHS on the beach closure and health warning protocol remained unchanged until October, 1987. A number of well publicized dry-weather sewage spills to the Bay may have been the catalyst of change in the LACDHS policy. Three major sewage spills ranging from 1.5 million to approximately nine million gallons occurred between May 25 and June 5 because of electrical failures at the Hyperion Treatment Plant. The sewage was released from the Hyperion Treatment Plant's ocean outfall. Santa Monica Bay beaches remained open because the sewage spills had been reported neither to the LACDHS nor to officials at City Hall. Two shift superintendents were suspended for their failure to report the spills.

On Friday night, June 5, a power outage at the Venice pumping plant led to 2.4 million gallons of raw sewage spilling into Ballona Lagoon. The LACDHS was immediately notified that there had been a 300,000 gallon spill, but the LACDHS did not notify the lifeguards, the press, or the public because the size of the spill was considered small. Despite indicator bacteria densities orders of magnitude above Title 7 and Ocean Plan standards, only the Venice canals were posted with health warning signs. An estimated 180,000 people were reported to have visited the beach that weekend. The magnitude of

the spill was not reported to the public until the city of Los Angeles held a press conference on Friday, June 12.

The sewage spills led to a July meeting that was the first in a series of meetings referred to earlier in the health risk communication section. The meetings were chaired by Senior Deputy Mary Gray of Supervisor Deane Dana's office and attended by representatives of the LACDHS, LACDBH, the County lifeguards and Heal the Bay. By October, the LACDHS agreed to close all affected beaches after a sewage spill. Signs with the language "Contaminated Water Until for Human Contact" would be posted. The LACDHS would reopen the beaches only after bacteria counts were below State health standards. In addition, announcements of beach closures would be forwarded to the media.

In January, 1988, the County agreed to implement a number of other beach closure and health warning policies (LACDHS, 1988). The LACDHS and County Lifeguards began to inform the public that swimming in the Bay within 48 hours of a storm may pose a health risk. Press releases were sent to the media before predicted storms to warn the public of the potential health risks of swimming in the Bay. In addition, problem beaches would remain closed until the source of high bacteria counts was found and abated. This policy was immediately applied to Mothers' Beach, which had remained closed since the raw sewage spills of June, 1987. Finally, the LACDHS trained eight lifeguards to take samples of urban runoff suspected to be contaminated with illegally dumped toxic waste, and gave lifeguards the authority to close affected beaches in the event of a suspected toxic or sewage spill.

12-227

3-578

The 1989 beach closure protocol - In 1989, the LACDHS formalized their beach closure protocol (LACDHS, 1989). Their policy was, "The beaches in the affected areas will be closed when:

A suspected or real sewage discharge to the ocean exists. The affected area will be sampled and the beaches will remain closed until sampling data show that bacteriological levels have returned to a safe level.

Elevated bacteriological levels can be linked with a known sewage discharge. If no sewage discharge can be associated with high bacterial counts, the beaches will remain open, and monitoring and field evaluations will continue until the source(s) of the high bacteria counts are identified.

The Department of Beaches and Harbors will close the beaches when any suspected hazardous material discharge occurs until the affected waters are judged to be safe by the appropriate authority.

Areas affected by unusual discharges from storm drains caused by "breakthrough" of impounded waters or other activities, which are not sewage related but can cause elevated bacteria counts, will be posted by the Department of Beaches and Harbors with "caution" signs.

The issue of amending the beach closure and health warning protocol for the County to reduce the potential health risks of swimming in the Bay became a regular topic of discussion at the Management Committee and the Non-Point Source Subcommittee of the

SMBRP. After the SMBRP Pico-Kenter virus study was released in June of 1990, human enteric viruses were added to the list of pollutants that could be in urban runoff at any given time. The immediate result was a SMBRP consensus agreement on the language and design of the new beach health warning signs. Also, the SMBRP agreed that the signs would be posted near all flowing storm drains.

In 1990, the Los Angeles County Board of Supervisors was ordered by the California Courts to change the boundaries of supervisorial districts in order to create districts with equitable Latino representation. A byproduct of redistricting was a split of the Los Angeles County coastal district between Supervisors Deane Dana, who had previously represented the entire Santa Monica Bay coast, and Ed Edelman. Supervisor Edelman had previous environmental experience on the Board that included a long history of Santa Monica Mountains habitat protection and land acquisition while Supervisor Dana had a much weaker environmental record. Since 1990, Supervisor Edelman began to represent the activist coastal cities of Santa Monica and Malibu. The combination of a supervisor with a strong environmental record and constituents that demanded a clean Santa Monica Bay led to new progress on a number of coastal resource protection issues, including the County beach closure and health warning protocol.

On March 16, 1991 a drifting oil tanker dragged its anchor across an oil pipeline leading to the Chevron Refinery in El Segundo. The result was a light crude oil spill of an estimated 21,000 gallons. On March 17, all Santa Monica Bay beaches remained open despite numerous complaints of headaches, nausea, and dizziness from Malibu residents between Topanga State Beach and Malibu Surfrider State Beach. On March 18, the County lifeguards closed a one mile stretch of Malibu beach when the oil slick moved

6-15-3
4-2-2-2-0

onto the shoreline. Residents as far away as Las Tunas Creek, five miles south of Surfrider State Beach, reported that the oil slick came ashore. The beach was opened again on March 19th.

The environmental groups, Heal the Bay and the American Oceans Campaign, and many Malibu residents were upset that more Santa Monica Bay beaches were not closed as a precautionary measure after the oil spill. The oil spill was the largest ever in Santa Monica Bay and the oil was light crude, a more acutely toxic type of oil than heavy crude, yet the LACDHS did not act to close the beaches. In March, the two environmental groups began to lobby Supervisors Ed Edelman and Gloria Molina on the issue of beach closures.

On Memorial Day, Heal the Bay issued its first Beach Pollution Report and Report Card. The report summarized the bacterial monitoring data from the LACDHS and the LAEMD from 1989 to April of 1991. The data was then "transformed" into a public friendly form to inform the public how often Santa Monica Bay beaches failed to meet EPA recommended bathing water criteria. The Beach Report Card press conference was widely covered by print, radio and television media.

The recommended beach closure protocol from Heal the Bay. In addition, a recommended beach closure and health warning protocol was part of the report. The recommended Beach Closure Protocol from Heal the Bay was the following:

1) The beach 100 yards on either side of a flowing storm drain must be closed immediately if the surf zone indicator bacteria densities exceed State Ocean Plan

Objectives for recreational water contact. The beach must remain closed until the source of contamination is found and abated.

2) All Santa Monica Bay beaches must be closed for at least 48 hours after a storm of greater than 1/4 inch of rainfall in the Los Angeles area.

3) All Santa Monica Bay beaches must be closed for at least 48 hours in the event of a sewage spill or release in excess of 100,000 gallons. Any beach in the immediate vicinity of a small sewage spill must be closed for at least 48 hours.

4) All Santa Monica Bay beaches must be closed immediately in the event of any major toxic substance spill of greater than 10,000 gallons.

5) The Los Angeles County lifeguards must immediately close an impacted stretch of beach when a potential hazardous waste (for example: petroleum odor or appearance) is discharged from the storm drain system onto the beach. The Los Angeles County Department of Health Services' Hazardous Materials Response Team must then visit the site of the spill to assess the risk to public health and determine whether the risk is significant.

The main difference between the LACDHS beach closure protocol and the protocol recommended by Heal the Bay was that the LACDHS protocol was primarily discretionary unless there was a known sewage spill, while the Heal the Bay protocol would require automatic closures during sewage spills, hazardous material spills, and when bacteria densities exceeded the State Ocean Plan bathing water objectives.

12-229

3-580

Many of the LACDHS public health risk management decisions were made only after the completion of a field investigation for sources of high indicator bacteria densities in the surf-zone. With continual budget problems, the LACDHS rarely had the resources to implement investigations in a timely manner. One example from September, 1988 at the Santa Monica Pier storm drain: Though LACDHS shoreline samples collected south of the pier had exceeded EPA bathing water criteria for eight out of ten weeks, the beach near the pier was not closed until the end of summer, at the conclusion of the ten week period. The LACDHS investigation discovered that the source of the high bacteria counts was a blocked sump pump under the pier.

In June of 1991, the second SMBRP surf-zone pathogen study was released (Gold et al., 1991). As in the previous study, human enteric viruses were found in limited sampling of the Pico-Kenter storm drain. In addition, researchers found that indicator densities frequently exceeded Ocean Plan objectives at distances of up to 100 yards from the Pico-Kenter drain. This new
information was contrary to the LACDHS assertion that indicator densities dropped below Title 17 standards at distances greater than 25 yards from flowing storm drains.

The current beach closure protocol - On Labor Day, the Natural Resources Defense Council (NRDC) released their first annual "Testing the Waters: A National Perspective on Beach Closures" report, which revealed that California beaches had been closed 745 times in 1990 (NRDC, 1991). The vast majority of the beach closures (588) occurred at Southern California beaches. The report received national news coverage, and on October 1, Supervisor Edelman introduced a successful motion to have staff "report back within 90 days with proposed policy changes governing beach closures in the County for

maximum protection of swimmers in the Santa Monica Bay. The report should assess the impact of storm drain and sewage discharge including toxics on surf zone contamination." In addition, County staff from the LACDHS, Los Angeles County Department of Beaches and Harbors (LACDBH), LACDPW and the County Lifeguards were ordered to consult with Heal the Bay and the American Oceans Campaign regarding their concerns about the existing protocol.

The eight months of discussions on the beach warning sign issue convinced Heal the Bay and the American Oceans Campaign that the SMBRP Management Committee was not the most effective forum to pursue amendments to the Los Angeles County beach closure and health warning protocol. Instead, the environmental groups recommended that Supervisor Edelman directly mediate the beach closure debate. Over the next three months, a staff member from the office of Supervisor Edelman and representatives from the above entities met on five different occasions to negotiate a new protocol that was both acceptable to the County and the environmental community. With the backing of the entire Board of Supervisors, negotiations on the beach closure protocol were more productive than those of the previous four years. The new protocol was unanimously approved by the Board of Supervisors on February 11, 1992 (LACDHS, 1992).

The new beach closure and health warning protocol offered the following improvements over the previous policy:

1) For the first time, the length of beach closed was dependent on the size of the sewage spill. For example, any sewage spill less than 1,000 gallons triggered a beach closure of 1/4 mile on each side of the discharge while a spill of over 2

12-28

million gallons triggered a closure of 10 miles of beach on each side of the discharge (Topanga Creek to Palos Verdes).

2) The County formalized comparisons of bacterial densities with criteria other than Title 17 standards. Beaches were not reopened after a sewage spill until ocean samples were below EPA recommended criteria for fecal coliforms (200/100 ml) and enterococcus bacteria (35/100 ml).

3) All beaches impacted (visible material, strong odor, etc.) by the discharge of a verified hazardous material will be closed. The previous policy only closed the beaches when hazardous material was physically on the beach.

4) Many of the verbal policies of the LACDHS were formalized. For example, all beaches consistently exceeding state standards or federal bathing water criteria will be permanently posted with the SMBRP caution signs. Also, Malibu Surfrider beach will be posted for at least 48 hours after Malibu Lagoon is naturally or artificially breached.

5) All beaches with intermittent flow from storm drains will be posted with caution signs at a distance of 100 yards on each side when the drain is flowing. This is the first time that the County agreed to the 100 yard posting policy.

6) For the first time, the County agreed to post the SMBRP closure signs at beaches when monitoring activities reveal that surf zone waters exceed single sample bacterial criteria for the three types of indicator bacteria for

two consecutive monitoring periods. The criteria are 10,000 bacteria per 100 ml for total coliforms, 400 per 100 ml for fecal coliforms and 108 enterococcus per 100 ml. The beaches will be posted 100 yards on each side of the affected beach.

7) High bacteria counts will initiate an investigation by the LACDHS into the cause of the high densities.

8) The LACDHS will issue a media release advising the public to refrain from swimming in the ocean for at least 72 hours after a significant rain storm. Prior to the new protocol, the recommendation was for the public to avoid ocean contact for 48 hours after a significant rain.

In addition to the new beach closure and health warning protocol, the Board of Supervisors passed an additional motion to improve public notification of potential health risks from swimming in the Bay. The motion formalized notification procedures after sewage spills, hazardous material spills and oil spills. Also, the motion called for the LACDBH to post the entrances of parking lots when beaches are closed.

The new Los Angeles County beach closure and health warning protocol was sent to the coastal cities and the agencies on the spill notification lists. The City of Los Angeles immediately supported the new protocol and notification procedures. As of June 1, 1994, there have been 23 sewage spills that resulted in a total of more than 100 million gallons spilled in Santa Monica Bay (LACDHS, pers. comm., 1994), and the beach closure protocol has performed well on every occasion.

12-231

2-582

The Ballona Creek clean-up task force - Although the beach closure protocol better informed the public and government agencies of the potential health risks of recreational exposure to Santa Monica Bay waters, the protocol did not address the following issues:

1) The need for a standardized approach for conducting a sanitary survey to investigate the sources of high indicator bacteria densities and/or sewage spills in the storm drains;

2) The need for an inter-agency agreement that would allow timely access to storm drain channels and pipelines in the event of a sewage spill, high indicator bacteria counts, or a hazardous material spill;

3) The need for the implementation of Best Management Practices (BMPs) to reduce the sewage and toxic spills into the storm drains; and

4) The need for a standardized response by responsible and/or concerned government agencies in the event of a hazardous material or sewage spill.

The Ballona Creek Clean-up Task Force, upon a successful motion by Supervisor Deane Dana, was created by the Los Angeles County Board of Supervisors on September 22, 1992 following a series of dry-weather spills to Ballona Creek. The task force was charged with developing recommendations for addressing the four issues stated above. Members of the task force included the LACDPW, LACDBH, LACDHS, Los Angeles County Lifeguards, Los Angeles County Chief Administrator's Office, the RWQCB, the

SMBRP, Heal the Bay, City of Los Angeles Board of Public Works, LAEMD, Santa Monica, Culver City, West Hollywood, Inglewood, and Beverly Hills.

The task force was divided into two working groups: the emergency response working group charged with reviewing, amending and standardizing response programs for sewage and toxic spills; and the Best Management Practice (BMP) working group, which developed a prioritized list of BMPs to reduce the amount of sewage, trash, and chemical contaminants discharged from Ballona Creek into the Bay. The task force was required to report back to the Board of Supervisors by mid-February, 1993, but the report was delayed until August because the Los Angeles County Counsel was concerned about the potential liability involved in allowing other government agencies into County storm drains. The final report addressed each of the four major concerns except for the need for an inter-jurisdictional agreement that would allow timely access to storm drains in the event of a sewage spill, high indicator bacteria counts, or a hazardous material spill (CAO, 1993).

State Beach Closure and Health Warning Protocol

The issue of the need for uniform beach closure and health warning protocol throughout the state has been discussed by the Natural Resources Defense Council (NRDC), American Oceans Campaign, and Heal the Bay since 1990. The discrepancy between protocols of different counties was first highlighted publicly in a report entitled "Testing the Waters: A National Perspective on Beach Closures" (NRDC, 1991) which was released on Labor Day of 1991. None of the groups actively pursued a statewide protocol until the California Department of Health Services (CDHS) sent a memo to the SMBRP in November stating, "We are not aware of any findings which warrant beach closures, or

22-232
53-3

a warning that public health has been shown to be at significant risk, as a result of flow from storm drains that does not contain excreta from humans (CDHS, 1991)." The CDHS went on to say that, "participation on the Management Committee of the SMBRP should not be construed as a representation that the CDHS believes that beach closures and warning signs are warranted to protect public health from urban runoff without human sewage."

Upon reading the memo, Heal the Bay and AOC immediately responded by sending a letter to Dr. Molly Coye, Director of the CDHS to express disagreement with the CDHS policy for a number of reasons (Gold et al., 1991):

1) There have never been any health effects studies completed on people who swim in urban runoff contaminated waters, which makes it very difficult to accurately determine the health risks of recreational water contact;

2) Urban runoff flows across Southern California beaches untreated, and the flows can contain such toxic substances as heavy metals, motor oil and pesticides; and

3) There are a number of microbial pathogens from animals that cause disease in humans including Giardia, reoviruses, Salmonella and Vibrio species and toxigenic E. coli (Gerba et al., 1985, CDC, 1990).

The request by the environmentalists for the CDHS to strengthen Title 17 and change their beach closure and health warning protocol policy was rejected because of the lack of health data to substantiate the change. However, the CDHS did support the development and implementation of the SMBRP epidemiology study to provide the necessary health information.

The letter was also sent to the office of Governor Pete Wilson, the State Water Resources Control Board, and to Jim Strock, Secretary of the California Environmental Protection Agency (Cal-EPA). Although only the County and State Health Departments can order beach closures, Cal-EPA expressed interest in the issue because of the role of indicator bacteria in the regulation of point source and municipal stormwater discharges. In January, 1993, Cal-EPA held a meeting on the health risk issues attended by the Executive Officers of all nine Regional Water Boards, state and county health officers, environmental groups, and sewage agencies. The agenda for the meeting included the health risks of swimming in runoff contaminated waters, the problems with existing bacterial standards in Title 17 and the California Ocean Plan, the prevalence of human enteric viruses in runoff, the need for a large-scale epidemiology study of swimmers in runoff contaminated waters, and the issue of statewide beach closure and health warning protocol. To date, Cal-EPA has not issued any recommendations for actions based on that meeting.

California Senate Bill 1865 - After the Point Loma sewage outfall collapse and the 68 million gallon sewage spill from the Los Angeles sewage system in January and February of 1992 respectively, state legislators became interested in beach closure and health warning issues. State Senator Gary Hart (Santa Barbara) introduced SB 1865, the "Clean Beaches" bill, on February 21, 1992. The bill required the appropriate environmental health officers throughout the state to submit a summary of beach postings and closures to the State Water Resources Control Board (SWRCB) (Hart, 1992). In addition, the bill required the SWRCB to conduct and publish a statewide annual survey on beach postings and closures due to threats to public health starting June 1, 1994. Also, the bill asked for a discharge permit fee increase to fund the annual survey.

12-233

3-584

On March 11, representatives from Senator Hart's office, Heal the Bay, the Natural Resources Defense Council, American Oceans Campaign, and the Surfriders Foundation met for the first time to discuss modifications to language in the proposed bill. The consensus of the participants was to add a section to the bill modelled on EPA recreational water contact criteria and the Los Angeles County beach closure and health warning protocol.

In April and May, SB 1865 was approved by the Senate Agriculture and Water Committee by consent, the Senate Appropriations Committee by a 10-1 vote, and on the Senate floor by a 27-3 margin. The progress of the bill in the Senate was rapid and the bill emerged from the Senate with very few substantive changes after the March 26 amendments. However, in early June, the State Department of Health Services (CDHS) formally opposed SB 1865 on the grounds that the EPA bathing water bacteriological criteria were not adequate for a statewide beach closure and health warning protocol because of a lack of scientific justification for the criteria (CDHS, 1992a). In addition, the California Association of Environmental Health Administrators (CAEHA) and the California State Association of Counties (CSAC) opposed SB 1865 on the same grounds as the CDHS as well as its concerns about the potential economic impacts of closed beaches on coastal tourism (CAEHA and CSAC, 1992).

The CDHS, CAEHA, and the CSAC would withdraw opposition if large scale epidemiology and water quality studies, at a cost of $6.75 million, were completed to determine health based bacterial standards for recreational waters. The CDHS specified that the cost of the studies would come from the CDHS portion of the California General Fund

over a two to three year period. The CDHS made no other recommendations for possible funding sources for the studies. In 1992, any bill with an economic cost to the state of more than $100,000 had very little chance of approval because of California's unprecedented $13 billion deficit for the year.

As a result of the CDHS opposition to the bill and the high cost of CDHS recommended studies, Senator Hart removed the beach closure and health warning section of the bill. Without CDHS opposition, SB 1865 passed both the state Senate and Assembly in late August and the bill was signed into law by Governor Wilson on September 26.

The bill contains the following language on health warnings: "Whenever any beach fails to meet the bacteriological standards of Section 7958 of the California Code of Regulations, the health officer, after determining that the cause of the elevated bacteriological levels constitutes a public health hazard, shall, at a minimum, post the beach with conspicuous warning signs to inform the public of the nature of the problem and the possibility of risk to public health." This language is nearly identical to Section 7960 in Title 17 on corrective action which states, when the total coliform standard is not met, "the local health officer, after taking into consideration the causes therefore, may at his discretion, post with warning signs, or otherwise restrict use of said public beach until such time as corrective action has been taken." The only impact of the bill was the requirement that all beaches be posted with health warnings after a nearby sewage spill causes high total coliform densities in the surf zone. Before the bill, posting was solely at the discretion of the health officer.

42-231
585-3

The final bill was nearly identical to the one proposed by Senator Hart in February. The appropriate environmental health officers throughout the state were required to submit a summary of beach postings and closures to the State Water Resources Control Board (SWRCB) on or before March 30, 1994, and annually thereafter. The SWRCB must publish a statewide annual report documenting the beach postings and closures due to public health threats starting September 30, 1994. The reports must include the location and duration of each beach closure and the suspected sources of the contamination that caused the closure.

California Senate Bill 1084 - On September 16, 1992, Senator Charles Calderon (Los Angeles), chair of the Senate Toxics Committee, held a public hearing in Santa Monica on the issue of dry- weather sewage spills to Santa Monica Bay. The hearing was held shortly after a series of dry- weather sewage spills in Ballona Creek between the beginning of August and Labor Day weekend caused a number of closures of a five mile stretch of beach. At the hearing, representatives from the State and County Departments of Health Services, Los Angeles Board of Public Works, Los Angeles County Department of Public Works, the Regional Water Quality Control Board, numerous environmental groups, and the scientific community testified on a number of different beach pollution issues including: the recent history of sewage spills to Santa Monica Bay, sanitary survey programs, the effectiveness of sewer and storm drain inspection programs for illegal discharges, regulatory enforcement programs, urban runoff pollution, the health risks of swimming in sewage and or runoff contaminated waters, and a large scale epidemiology study of people who swim in Santa Monica Bay.

In 1993, Senator Calderon introduced SB 1084 to the State Senate. The passage of SB 1084 in the legislature resulted in the approval of the study without approval of an appropriation of the $630,000 needed for the implementation of the SMBRP approved epidemiology study of swimmers in Santa Monica Bay. On October 10, 1993, SB 1084 was signed by Governor Wilson.

Although the Governor approved the health effects study, the State Budget Bill that contained the appropriation language for implementing the epidemiology study was amended to eliminate the funding. The SMBRP, SWRCB and Heal the Bay are currently investigating potential funding sources for the epidemiology study which is scheduled to be completed during the summer of 1995.

Local Monitoring and Research

Acute Illnesses in Los Angeles County Lifeguards - Since the 1982 lifeguard-cancer study, only one additional study has been completed on the health risks of swimming in Santa Monica Bay. A case-control study of acute illnesses among Los Angeles County Lifeguards was conducted based on workers' compensation claims over a seven-year period (1980-1986). In the study, cases were defined as lifeguards who made a compensable claim for a work-related illness while the controls were healthy lifeguards working in the same job class (temporary assignment, permanent assignment, etc.). The study demonstrated a strong association between working at South Bay beaches (south of Ballona Creek) and the incidence of acute illnesses (Sullivan et al., 1989). The association between working at Central section beaches (Venice Beach to Topanga Creek) and

Northern section beaches (Malibu) and acute illness was less pronounced than for South Bay beaches.

Only 112 acute compensable illnesses occurred among lifeguards during the study period. Sixty-six percent of the illnesses were ear infections, and none of the compensable illnesses were gastroenteritis, the most likely outcome of swimming in polluted ocean waters. The researchers surmised that the workers' compensation reports probably underestimated the total number of work-related illnesses. Lifeguards who experienced mild symptoms, such as gastroenteritis, probably did not seek medical attention or they may not have associated stomach-flu symptoms with their jobs. Another flaw in the study was the lack of data controlling for types of aquatic exposure, including swimming habits, location of recreational swimming, and length of time in the water at work and during recreation.

Despite the lack of health effects studies, shoreline bacteriological monitoring programs and a series of studies completed under the auspices of the SMBRP have provided new information for the debate on the health risks of swimming in the Bay.

LACDHS shoreline monitoring program - A large data-base on indicator bacteria densities at Santa Monica Bay beaches has been developed as a result of large-scale monitoring programs. Since the summer of 1986, the LACDHS has monitored approximately 30 shoreline sites on a weekly basis in Los Angeles County for the indicator bacteria total and fecal coliforms, and enterococcus. Samples are collected every Monday at points usually 50 to 100 yards from storm drains. The collection sites range from

Cabrillo Beach in San Pedro to Leo Carrillo Beach in northern Malibu (LACDHS, 1988-1992).

The LACDHS has never summarized or analyzed their database although they do produce monthly summaries of their data. The bacterial data are used to determine if there are potential sanitary waste problems along the shoreline of Los Angeles County. The information is used by the LACDHS to make decisions on initiating site investigations and closing the beaches. The information was used in the late eighties to target the Pico-Kenter storm drain as the source of fecal material that produced some of the highest surf-zone bacterial densities in the County at Santa Monica Beach. The data were used by the LACDHS to discover sewer leaks under the Redondo Beach pier and adjacent to the Bel Air Bay Club near the Pulga Canyon drain. Also, the data have been used to detect septic system and sewer leaks in Malibu, and illegal horse manure disposal practices in the Santa Monica Canyon storm drain watershed.

Increased monitoring of Marina Del Rey waters after a major sewage spill in June, 1987, led to the discovery of chronically high bacteria counts at Mothers' Beach. In 1988, the LACDBH spent more than $70,000 on a study to determine the source of high bacteria counts at the popular enclosed beach. The study determined that the largest source of fecal contamination was the local sea gull population instead of the nearby Oxford flood control system, numerous small storm drains that discharged to the beach, and the thousands of boats docked at Marina Del Rey (James M. Montgomery Eng., 1988). In 1989, the LACDBH installed a monofilament line system over Mothers' Beach that deterred sea birds from flying and roosting in the area, thereby reducing shoreline indicator bacteria counts. Mothers' Beach was reopened within three months after the monofilament line

7-55-3

4-2-2-3

Other sources of fecal contamination to the storm drain system include campers, transient populations, and daytime visitors to State and County parks and beaches. Adequate toilet facilities and trash cans for disposable diapers should be provided in areas with large user populations. In addition, an educational effort that informs the public that all waste in the Santa Monica Bay watershed ends up at local beaches should reduce the fecal contamination of shoreline waters. Better maintenance of heavily visited parks also would assist in reducing sources of human fecal contamination to the watershed. Although these recommendations have a relatively low cost and they can be implemented relatively easily, the recommendations are included as a low priority in the SMBRP Action Plan (SMBRP, 1994a).

Another potential source of pathogens and pathogen indicators to the storm drains and beaches is the waste from hundreds of restaurants in the watershed. Currently, restaurants are not regulated under the municipal stormwater NPDES permit or the Statewide General industrial permit. Many restaurants hose off their kitchen wastes and their garbage receptacles into the alleys and gutters that lead to the storm drain system. Food-borne pathogens could potentially cause illnesses in swimmers that come in contact with the waste. Municipalities should implement a targeted restaurant worker education program to eliminate these illegal disposal practices. Shortly after the onset of the public education program, municipalities, the LACDPW, the LACDHS and the RWQCB should start enforcing illegal food waste disposal laws. Cities should be required to develop restaurant public education and illegal disposal enforcement programs under the municipal stormwater NPDES permit. The low cost of implementing the recommendations and the potential reduction in sewage indicator loadings that would result because of implementation, make these recommendations a high priority. Currently, only the city of Santa

Monica is implementing these recommendations and, unless the RWQCB requires the implementation of the BMPs under the municipal stormwater NPDES permit, other cities within the watershed are unlikely to follow these recommendations.

Pathogen and pathogen indicator sources in the watershed are not limited to humans. Domestic animals including dogs and cats are prevalent throughout the watershed while cattle and horses are common in the Malibu Creek watershed and Malibu subdrainages. Public education programs that focus on the human health and pollution consequences of failing to responsibly dispose of animal wastes should be developed and implemented as part of the large scale public education programs that are required under the municipal stormwater NPDES permit. In the Malibu Creek watershed, some residents have horses paddocked within a few yards of the Creek and its tributaries. Also, ranch owners still occasionally use ranch animal waste to stabilize stream banks on their property. These practices are contributing to the high concentrations of nutrients and indicator bacteria in the Malibu Creek watershed. These disposal methods demonstrate that enforcement of "pooper scooper" laws and ranch animal waste disposal laws are important source reduction management practices that should be implemented. However, like many of the source reduction measures previously described, these recommendations are unlikely to be implemented soon because environmental enforcement actions are uncommon under the current political and economic climate.

One measure that has proven effective at reducing the indicator bacteria concentrations in the surf zone is diversion of runoff to sewage treatment plants during dry weather. The projects at the Pico-Kenter and Manhattan Beach Pier storm drains have demonstrated that diversion of small flows during the months of peak beach use is a cost effective way

3-588

12-259

installation. In 1990, bacterial densities at Mothers' Beach returned to elevated levels. The cause of the high bacterial densities has not been investigated, and the beach remains open to the public.

The LACDHS has completed a number of small studies on shoreline indicator bacteria densities. As stated earlier, in 1986, the LACSD completed a five day sampling study at three problem storm drains to determine the distance from flowing storm drains where shoreline bacteria densities rapidly decrease (Kebabjian, 1988). These data were used to formulate the LACDHS health warning policy for bathers to swim at least 25 yards from flowing storm drains.

The City of Los Angeles shoreline monitoring program - The indicator bacteria monitoring program for the Hyperion Treatment Plant was substantially expanded after the plant received their first National Pollutant Discharge Elimination System permit in 1974. Since 1987, the Environmental Monitoring Division of the City of Los Angeles Bureau of Sanitation has monitored 17 shoreline stations for the three bacterial indicators on a daily basis. The stations range from Torrance Beach near the Palos Verdes peninsula in the south to Surfrider State Beach in Malibu to the north. Total coliform data have been regularly collected at Santa Monica Bay shoreline stations by staff of the Hyperion Treatment Plant since the mid-1940's. In 1991, the LAEMD decreased their sample collection for fecal coliform analysis to five times a month because the data were not providing additional information to the other two indicators.

In 1960, the LAEMD began monitoring at the mouths of five different storm drains on a three times a week to daily basis. Until July 1993, the LAEMD monitored five different

stations in Ballona Creek on a daily basis for the three bacterial indicators. In the event of a sewage overflow from the North Outfall Treatment Facility into Ballona Creek, the LAEMD increases the number of sampling locations and the frequency of sampling until bacterial densities return to dry-weather flow levels.

The additional storm drain monitoring by the LAEMD has led to the detection of a number of sewage spills in Ballona Creek. Whenever there are unusually high indicator bacteria densities in a storm drain (over one million bacteria per 100 ml), the LAEMD immediately reports the information to the LACDHS. In 1992, the daily Ballona Creek monitoring program led to the detection of sewage spills in August, September and shortly after the civil unrest in late April. On all three occasions, the LACDHS closed the beaches immediately upon receiving the monitoring data from the LAEMD.

The LAEMD detection of dry weather sewage spill problems in Ballona Creek led to the State Senate Toxics Committee hearing in 1992, and a motion by Los Angeles Councilwoman Ruth Galanter that requested, "no more dry weather sewage spills to Santa Monica Bay from the city of Los Angeles sewer system." Despite the fact that Los Angeles has yet to implement their storm drain illegal discharge and illicit connection program, and that the City has more than one thousand miles of sewer lines and over one hundred miles of storm drains (Richardson, 1992), the motion was passed by the City Council.

The LAEMD summarized their shoreline monitoring program in their annual reports. Every year since the five-mile outfall from the Hyperion Treatment Plant was completed in 1959, the City has demonstrated that the wastewater plume does not cause elevated

3-589
3-237

bacterial densities at shoreline stations. The first annual report that included an analysis of wet weather bacterial densities versus dry weather densities was 1988 (LAEMD, 1988). This report and every report since then have demonstrated that wet weather elevates shoreline bacteria counts for an average time-period of three days after the conclusion of a rainfall of greater than one tenth of an inch (LAEMD, 1989, 1990, 1991, and 1992). In 1990, information from the annual reports was utilized by the LACDHS in their decision to change their wet weather health warning from, "Do not swim in Santa Monica Bay within 48 hours of a significant rain." to "Do not swim within 72 hours of a significant rain (LACDHS, 1990)."

The Heal the Bay beach pollution reports - On Memorial Day of 1991, Heal the Bay released their first Beach Pollution Report to the public (Gorke, 1991). The report was a compilation of 1989 and 1990 indicator bacteria data from the LACDHS and LAEMD shoreline monitoring programs. The data were summarized and interpreted in the report in two different ways. The report included a table with all 48 of the shoreline monitoring stations and the frequency of days that the stations had bacterial densities that exceeded a modification of State Ocean Plan standards: 1,000 total coliforms per 100 ml, 200 fecal coliforms per 100 ml, and 35 enterococci per 100 ml. In addition, because the report was meant to be read by the general public, Heal the Bay created a grading system for the beaches based on the frequency of days in a year that exceeded indicator bacteria standards. The beaches that rarely exceeded bacterial standards received an "A" grade, while the beaches that frequently exceeded bacterial standards received a "D" or "F" mark. The grades from the beaches with the highest number of visitors and the highest densities of indicator bacteria were plotted on a map of Santa Monica Bay.

As stated earlier, the 1991 Beach Pollution Report received extensive media and public attention. Also, the report was used as a tool to focus the attention of the Los Angeles County Board of Supervisors on the issue of modifying the LACDHS beach closure and health warning protocol.

The formats of the 1992, 1993 and 1994 Beach Pollution Reports were identical to the 1991 report except that they contained comparisons of the frequency of high shoreline bacterial densities in dry weather versus wet weather (Gorke, 1991-1994). The comparisons further demonstrated the impact of precipitation on indicator bacteria densities in the surf-zone. Many beaches that rarely exceeded bacterial objectives in dry weather, frequently exceeded those same objectives in wet weather. The reports were used by Heal the Bay and the media to communicate the potential health risks of swimming in the Bay within three days of a rainstorm.

The 1992 report generated the first public demand for a daily or weekly beach pollution report similar to the daily air quality reports of the Air Quality Management District. Discussions on the value of a regular beach report of bacteria counts have focused on three major problems: 1) Except in wet weather, the data do not accurately predict the shoreline bacterial densities for the next day; and 2) Analysis of ocean samples for indicator bacteria takes 24 to 48 hours; and 3) Bacterial densities do not correlate well with health risks. The two arguments in favor of a regular reporting program are: 1) Bacteria densities are the only regularly available shoreline water quality data collected; and 2) The public has the right to know the information regardless of its lack of utility for estimating the health risks to the public. Although interest in a regular beach pollution

3-590

12-238

report continues to remain high, especially among surfers and lifeguards, a monthly program did not begin implementation until the summer of 1994.

The SMBRP virus and microbial indicator studies - In June of 1990, the SMBRP released a technical report on fecal indicator organisms and human enteric viruses in and adjacent to the Pico-Kenter and Ashland storm drains in Santa Monica (Gold et al., 1990. See Appendix 1). The study was designed and implemented in order to determine the validity of the assumption that storm drains are free from human sewage inputs. Before the study was released, many agencies including the CDHS and the LACDHS believed that because the storm drain system was separate from the sewer system, the storm drains were free of microbes that were pathogenic to humans. Heal the Bay was also under the assumption that urban runoff was free from sewage inputs, but the organization was concerned that runoff still posed a significant health risk to swimmers in the Bay because of the presence of microbes pathogenic to humans in animal waste (e.g. toxigenic E. coli, reovirus, Giardia, etc.). The LACDHS had never designed or implemented the water quality and epidemiological studies necessary to determine if there were any human pathogens in urban runoff because of the high cost of the needed research. Instead, Heal the Bay, the LAEMD, the LACDHS, and the Los Angeles County Sanitation Districts (LACSD) designed a study on pathogens in urban runoff for funding by the SMBRP. The SMBRP provided a portion of the funding for the urban runoff study, but most of the funding was provided as in-kind services from the LAEMD, LACSD, and Heal the Bay. The LACDHS chose not to participate in the implementation of the study.

Samples were collected from ankle and chest depth surf-zone locations adjacent to the Pico-Kenter and Ashland Avenue storm drains during August and September, 1989. The study sites were chosen because the LACDHS shoreline monitoring program demonstrated that the beaches near the storm drains exceeded bacterial standards more frequently than other Santa Monica Bay beaches. Surf-zone samples were taken on eight days while storm drain samples were collected fifteen times over a two month period. All samples were analyzed for total and fecal coliforms and enterococcus bacteria.

The results of the bacteria analysis were similar to previous findings by the LACDHS. Bacteria levels above State Ocean Plan objectives were found in the surf-zone on all eight sampling dates. Ocean Plan water quality objectives were exceeded in 100% of the storm drain samples, and they were exceeded more frequently in samples collected at ankle depth than in chest depth samples. Bacterial densities in storm drain samples were at least an order of magnitude greater than densities in ankle depth samples. In addition, ankle depth samples had approximately an order of magnitude higher densities than chest depth samples.

Storm drain samples were analyzed for human enteric viruses and the indicator, F-male specific coliphage on fifteen different days. The enteric virus data from runoff samples were qualitative instead of quantitative. Enteric viruses were not found in Ashland Avenue runoff, but they were found on 11 out of 15 days at the Pico-Kenter storm drain. The finding was significant because the enteric viruses were specific to humans, thereby demonstrating that human fecal waste was often present in Pico-Kenter runoff. Virus identification was attempted on only three Pico-Kenter samples and coxsackie B virus and echovirus were isolated and identified in those samples. The Ashland Avenue results

3-591

12-239

may have been impacted by seawater dilution in the drain and a high level of Buffalo Green Monkey Kidney cell toxicity in the runoff. F-male specific coliphage densities were over ten times greater in the Pico-Kenter storm drain than the Ashland drain, but coliphage densities did not correlate with the presence or absence of enteric viruses in the Pico-Kenter drain.

After the study was released by the SMBRP, the City of Santa Monica immediately closed a stretch of Santa Monica Beach 100 yards on each side of the storm drain. Within two weeks, Santa Monica found two different sources of human fecal waste to the drain: a broken sewer line at 20th Street and Colorado Blvd. and a recreational vehicle that dumped its holding tank into the storm drain. The beach remained closed for two years until Santa Monica and Los Angeles agreed to divert the dry-weather flow from the Pico-Kenter drain to the Hyperion Treatment Plant.

The second SMBRP virus and microbial indicator study - In August of 1991, the SMBRP released the second study on storm drains as a source of surf-zone bacterial indicators and human enteric viruses to Santa Monica Bay (Gold et al., 1991. See Appendix 2). The 1991 study was designed to provide new information on the prevalence of human enteric viruses in storm drains, the number of people who swam within 100 yards of flowing storm drains, and the distribution of indicator bacteria at various distances and depths from the Pico-Kenter drain.

Only five runoff samples each were collected from the Ballona Creek and Santa Monica Canyon storm drains and four samples were collected from the Pico-Kenter storm drain. For the second consecutive year, human enteric viruses were found in Pico-Kenter runoff.

Attenuated poliovirus (vaccine strain) were found in three of four samples collected from the Pico-Kenter drain. Viruses were not found in runoff samples from the Santa Monica Canyon and Ballona Creek drains.

Samples for the bacterial distribution study were collected from the surf-zone adjacent to the Pico-Kenter drain. Samples were collected on 20 days over a thirteen week period from late July to mid-October; months with large numbers of beach visitors. Samples were collected at ankle depth at seven different stations: in front of the drain, and 25 yards, 50 yards and 100 yards north and south of the drain. Chest depth samples were collected in front of the drain and 25 yards north and south of the drain. Surf-zone samples were analyzed for the same three bacterial indicators as in the 1990 study.

Indicator bacteria densities exceeding California Ocean Plan objectives were prevalent in ankle depth samples collected as far as 100 yards from the storm drain. In samples collected 100 yards from the storm drain, California Ocean Plan objectives were exceeded from 20% to 58% of the time for all three indicators. In samples collected at chest depth, Ocean Plan objectives were exceeded less frequently. As in the 1990 study, bacterial densities were approximately an order of magnitude higher in ankle depth samples than in chest depth samples.

As stated earlier, the results of the bacterial distribution section of the 1991 SMBRP study provided new information that was utilized during the LACDHS beach closure and health warning protocol negotiations. The new protocol instructed lifeguards to inform the public to swim at least 100 yards from all flowing storm drains. Both the environmental community and Los Angeles County agreed that there were problems with the

3-592

new 100 yard recommendation. An area greater than 100 yards from a drain may be impacted by runoff because of large flows, strong currents and high bacterial densities. Also, an area of shoreline less than 100 yards could be impacted because of currents, small flows, and low bacteria densities in the runoff. Both the Los Angeles County and the environmental organizations agreed to use the 100 yard figure for risk communication because the value was supported by the SMBRP study results at the Pico-Kenter drain.

A beach visitor characterization survey was completed on 22 different days from July to September, 1990 at Will Rogers Beach in front of the Santa Monica Canyon drain. Will Rogers Beach is one of the most frequently visited beaches along Santa Monica Bay (LACDBH, 1992). Surveys took place on Fridays, Saturdays, and Sundays from 11 AM to 3 PM because these were the times of peak bather use. An average of 81.0 people per day swam within 100 yards of the Santa Monica Canyon storm drain. On four days at the closed Santa Monica Beach in front of the Pico-Kenter drain, an average of 19.5 people swam within 100 yards of the drain. Although a few people ignored the beach closure signs, the signs and publicity were effective in reducing the number of swimmers in front of the Pico-Kenter drain.

Following the completion of the second SMBRP surf-zone pathogen study, discussions increased on the need for a large scale epidemiology study of people who swim in the urban runoff contaminated waters of the Bay. A workshop on the findings of the New Jersey epidemiology study (New Jersey Department of Health, 1990) and the fundamentals of epidemiology sponsored by the SMBRP was held in early 1992. Shortly thereafter, the surf-zone pathogen sub-committee of the SMBRP recommended funding for the

design of an epidemiology study. The study design was completed (Haile et al., 1992) and approved by the SMBRP Management Committee in October, 1992.

The third SMBRP virus and microbial indicator study - In June of 1992, the SMBRP released the third surf-zone pathogen study on pathogens and indicators in storm drains within the Santa Monica Bay watershed (Ohld et al., 1992. See appendix 3). The study had two objectives: 1) To determine the impact on shoreline bacterial densities of extending the Pico-Kenter drain 600 feet from the mean tideline; and 2) Determine the prevalence of human enteric virus contamination of runoff flowing to the Bay.

The sampling station design of the bacterial density study was identical to the previous study on runoff from the Pico-Kenter drain. However, due to continual problems with the storm drain extension and the impacts of an unexpected sewer replacement project nearby, surf-zone sampling occurred on only seventeen summer days over a five week period in 1991. Low densities of shoreline indicator bacteria were found in samples collected from all ankle depth and chest depth stations. California Ocean Plan bacterial objectives were not exceeded in samples collected more than nine percent of the time at any station. Bacterial densities in samples collected at the 10 shoreline stations were significantly less than the shoreline densities before the outfall was extended.

Although storm drain extensions do not reduce pollutant loads to nearshore waters, a properly designed and maintained extension can prove effective in reducing indicator densities in heavily used recreational waters. However, as stated previously, the Pico-Kenter pipe extension had been poorly maintained and frequently was damaged by strong wave action during storms. Because of these problems, the cities of Los Angeles and

2-152
12-241

Santa Monica agreed to divert the dry weather urban runoff from the Pico-Kenter drain to the Hyperion Treatment Plant in 1992.

During the third year enteric virus research, samples were collected from five different locations along Santa Monica Bay from June to October, 1991. Samples were collected on five different days from the Herondo storm drain located on the Hermosa Beach-Redondo Beach border. Thirteen samples were collected from the Pico-Kenter storm drain and 26 samples were collected from Malibu Lagoon. At Malibu Lagoon, nine virus samples each were collected near the C-channel bridge and the station 100 yards upstream from the Pacific Coast Highway. Eight samples were collected near the area where the lagoon is artificially breached by the California Department of Parks and Recreation. As in the previous studies, all of the samples were analyzed for enteric viruses, the three bacterial indicators, and F-male specific coliphage.

As in the 1989 and 1990 studies, indicator bacterial densities in samples collected from the storm drains were high. The geometric mean densities of the indicators in samples collected at the Pico-Kenter and Herondo drains were two to three orders of magnitude above Ocean Plan objectives. The mean bacterial densities in samples collected at the Malibu Lagoon sites ranged from one to twenty times state objectives. Indicator densities were higher in samples collected at the lagoon sampling locations further from the ocean and the dilution effect of incoming tides.

Human enteric viruses were found in samples collected at all five sampling locations along Santa Monica Bay demonstrating that human fecal contamination of storm drains was more prevalent than originally assumed. Viruses were found in collected samples on

three days at the Pico-Kenter drain, two days at the Herondo drain, one day at the Malibu Lagoon Breach location, two days at the C-channel bridge location and two days at the upstream location. All virus isolates identified were coxsackie B viruses. Coxsackie B viruses can cause illnesses ranging from gastroenteritis to, on rare occasions, pericarditis and meningitis. Attempts at quantifying the concentration of viruses resulted in estimates ranging from one plaque forming unit (pfu) per 2.3 gallons to one pfu per 79.5 gallons. The uncertainty of the virus concentrations was high for reasons that will be explained in more detail in Chapter 2.

Higher densities of F-male specific coliphage are expected in sewage contaminated waters than in waters without human fecal inputs (Cabelli, pers. comm., 1989). The trend predicted by Cabelli was not supported by the results of the third year study. Enteric viruses were found at all five sampling locations, although mean coliphage densities were approximately an order of magnitude higher in samples collected at the Pico-Kenter and Herondo drains than samples collected at the Malibu Lagoon sites. Enteric viruses were found in samples from the three Malibu Lagoon sites, yet coliphage densities were always low in samples from the Lagoon. For the third consecutive year, the researchers demonstrated that coliphage was not a reliable indicator of human pathogen contamination in runoff.

The third year pathogen work of the SMBRP had a number of immediate impacts on the issue of the public health risks of swimming in Santa Monica Bay. The Surfriders Foundation, an international environmental group with over 25,000 surfing members, immediately held a press conference on the viral contamination of Malibu Lagoon which flows into Malibu Surfrider State Beach; one of the most heavily visited surfing beaches

3-594

in the world. To many Malibu residents and members of the surfing community, the results from the third year pathogen study confirmed suspicions that contaminated flow from the Lagoon had caused illnesses in people who swam and surfed in the area.

Shortly thereafter, the Las Virgenes Metropolitan Water District (LVMWD), Heal the Bay, the NRDC, and the Environment Now Foundation arrived at a negotiated agreement on short term monitoring in the Malibu Creek watershed. The comprehensive water quality and natural resources monitoring program included extensive analysis of the tertiary treated wastewater from the Tapia Water Reclamation Facility for human enteric viruses using Standard Methods and gene probes for hepatitis, rotavirus, and other enteric viruses. In 1987, Tapia effluent was analyzed for enteric viruses on 25 different days and one virus was found during the sampling period, and that virus was detected on a day when the chlorination unit was not functioning (James M. Montgomery Engineers, 1989). However, the LVMWD had not completed any additional effluent analyses for viruses since 1987. After the 1992 SMBRP study and the increase in public pressure to find and abate the source of pathogens to Malibu Lagoon, the LVMWD agreed to implement a new study on viral pathogen contamination of the Tapia Water Reclamation Facility effluent. The monitoring program began in June of 1993 and will be completed by the summer of 1994. The monitoring program did not address other possible sources of human enteric viruses to the watershed including faulty septic systems, leaky sewer lines, illegal sewer connections to storm drains, recreational vehicles, and diffuse sources such as campers and picnickers.

On October 30, 1992, the SMBRP Management Committee passed a resolution approving the third year pathogen work and supporting the following strategies to guide immediate action on the pathogen contamination of runoff in the Santa Monica Bay watershed (SMBRP, 1992):

1) Continue to develop and implement a sanitary survey that can trace low-to-moderate sewage contamination in storm drains.

2) Develop indicators which will allow for easy detection and quantification of specific human pathogens.

3) Facilitate investigations of the health risks associated with various water quality indicator levels or with swimming at various distances from storm drains.

4) Continue to discourage swimmers from entering the water within 100 yards from all flowing storm drains.

5) Improve communication to the public regarding the water quality data from monitoring. Develop a protocol to ensure timely reporting and sharing of study results of indicators, pathogens and other potential health hazards.

6) Develop criteria for evaluating actions regarding the presence of pathogens in dry weather runoff. Discharges of pathogens should be eliminated from the surf-zone. Evaluate alternatives for eliminating surf-zone discharges that exceed established criteria.

3-595

12-243

Recommended actions specific to the Malibu Creek watershed area were:

1) Conduct a source survey in the watershed to identify major sources of pathogens from human wastes in Malibu Lagoon.

2) Improve the berm breaching protocol for the Malibu Lagoon and the closure protocol for beaches adjacent to Malibu Lagoon.

3) Improve the water quality monitoring protocol and health risk notification procedures for the Lagoon and nearby beaches.

4) Encourage scientific investigation of whether or not regrowth of pathogens occurs in Malibu Lagoon. Enhance water circulation in the lagoon to prevent pathogen regrowth, if necessary.

5) Minimize dry weather discharge into Malibu Lagoon from urban runoff and the Tapia Water Reclamation Facility.

The resolution was developed by SMBRP staff and numerous members of the Management Committee including the LACDPW, LACDHS, CDHS, the cities of Malibu, Santa Monica, and Redondo Beach, Heal the Bay, County Lifeguards, LACDBH, and the LVMWD. The resolution did not cause immediate implementation of the recommendations. The actions have been added to the draft Comprehensive Conservation and Management Plan (CCMP) as recommendations for immediate

implementation. However, the CCMP is not enforceable and it will not be completed and signed by the Governor until the fall of 1994.

Current Public Opinion on Santa Monica Bay Pollution

In June, 1992, the SMBRP released a public opinion survey of 500 Los Angeles County residents entitled "Attitudes Towards Santa Monica Bay" (Fairbank, Maullin, and Associates, 1992). The survey was a random digit dial sample that was supplemented with a random sample of Latino surname individuals residing in Los Angeles County. The phone survey covered topics ranging from the various uses of Santa Monica Bay to the public perceptions on Bay pollution and its possible sources. Residents interviewed for the survey were randomly selected from five different areas in Los Angeles County: Coastal, North to East Inland, Long Beach, West San Fernando Valley, and Mid-County

The geographic distribution of the interviews was as follows; Coastal = 9%, North to East inland = 21%, Long Beach = 14%, West Valley = 14%, and Mid-County = 42% of the interviews. Twenty five percent of the interviews were conducted with individuals of latino ethnic origin. Interviews were given in both English and Spanish.

Individuals were interviewed only if they were able to answer whether or not they visited Santa Monica Bay. Each interview lasted approximately 20 to 25 minutes. Although a large fraction of the beach-going public are young people, everyone interviewed was over 18 years old. One of the reasons for the emphasis of the survey on the adult population was a series of questions on the willingness of the public to vote for a measure to raise funds for enhancing, restoring and protecting Santa Monica Bay.

3-596

12-22-93

The report did not include information on the overall response rate of the Los Angeles County residents interviewed for the survey. The maximum margin of error for the sample as a whole was ± 4.4% at the 95% confidence level. The margin of error for subgroups was larger since the margin of error increases as the sample size decreases.

The results of the survey can be summarized as follows:

1) Eighty percent of the respondents said they visit the beach either frequently or sometimes. Fifty nine percent of the respondents visited Santa Monica Bay beaches.

2) Pollution of oceans and beaches tied for seventh with traffic congestion among fifteen social and environmental issues facing Southern California. Such issues as gang violence, drugs, air pollution and the high cost of health care ranked above ocean pollution while growth issues, housing costs, and ground water pollution were ranked lower. However, 80% of all respondents thought Ocean and Beach pollution was either an extremely serious (45%) or serious (35%) problem.

3) Forty eight percent of the respondents believed that the water in the Bay was very polluted while another 29% believed the Bay was somewhat polluted. Over two-thirds of the respondents in all geographic areas and demographic groups believed the Bay was polluted. Of the respondents that believed the Bay was polluted, over 50% cited industrial discharges (71%), coastal urban runoff (70%), untreated and treated sewage discharges (68% and 65%), hazardous waste (65%), offshore ocean dumping (64%), beach users trash (59%), and street trash (58%) as major sources of pollution to the Bay.

4) Of the 41% of the respondents that did not go in Santa Monica Bay, 66% of the non-Bay users cited, they "prefer to go to other places," while 62% and 39% respectively cited that "the water is polluted" or "the water is dirty." Forty two percent of the non-Bay users stated, "I might get sick if I swim in the water" as a reason for not swimming in the Bay.

5) Of the people who use Santa Monica Bay beaches, 55% do not ever go in the water and another 35% go in the water sometimes. Of the people who never go in the water, 59% cite water pollution as the reason. Only 10% of the Bay users always go in the water.

6) Fifty percent of the people who swim in the Bay think the water can make them sick. Overall, 52% of the respondents thought that the Bay water could make them sick. The most common types of illnesses people thought they could contract from swimming in the Bay were stomach flu (25%), cancer (23%), and skin rashes (11%). Concerns about the adverse health risks of swimming in Santa Monica Bay were prevalent in all demographic groups and geographic areas.

The survey results point to the lack of effective public education on Santa Monica Bay pollution problems. Forty eight percent of the public did not know that the storm drain system was completely separate from the sewer system and 34% did not know that urban runoff flows untreated to the ocean. More people thought industries were a major source of Bay pollution than thought urban runoff or sewage treatment plants were major sources. In addition, 23% of the people who think they risk illness from swimming in the

3-597
12-245

Bay are worried about cancer risks. Considering that the only cancer risk study on Bay users was the 1982 study that concluded that the cancer risks to lifeguards were negligible, it is surprising that the public places cancer risk as a major health concern.

Based on the results of the public opinion survey, the public may have an exaggerated view of the pollution problems in Santa Monica Bay. However, the majority of the public perceives that pollution in Santa Monica Bay poses a significant health risk to recreation users. Based on these findings, it is not surprising that as ocean pollution has become a larger media focus over the last decade, there has been a corresponding drop in the number of visitors to Santa Monica Bay beaches. Despite numerous media stories on various pollution problems in different parts of Santa Monica Bay, most of the public believes that the entire Bay is polluted.

The majority of the public (72%) believes that the government is not doing enough to control pollution in the Bay and 73% of the respondents believe that government should spend more money to control Bay pollution. A larger percentage (82%) of the public thinks that people are not doing enough to eliminate pollution in the Bay that is caused by their own actions. Seventy three percent of the respondents would vote for a bond measure to control pollution to the Bay despite the fact that 84% of the public thinks that industrial dischargers should have the major responsibility for solving the pollution problems in the Bay. Only 35% of the public thought that Los Angeles County residents should have the major responsibility for Santa Monica Bay clean-up.

Chapter 2 - Recommendations to Better Determine and Reduce the Health Risks of Swimming in Santa Monica Bay

Summary

Despite years of public concerns about the health risks of swimming in Santa Monica Bay, there is little information on the actual risks to swimmers in the urban runoff contaminated coastal waters that predominate along the southern California coast. Reasons for the lack of information include the expense of completing a large scale epidemiology study on Santa Monica Bay swimmers and the high uncertainty surrounding risk assessment derived estimates of the health risks of swimming in ocean waters. After years of discussions and three studies on pathogens in the storm drains and surf-zone, the SMBRP has made completion of a large scale health effects study on swimmers in urban runoff contaminated waters and other Santa Monica Bay beaches one of the highest priorities in their final Action Plan (SMBRP, 1994b).

Once the epidemiology study is completed and the health risks to swimmers have been estimated, state and local government agencies will be able to develop and implement effective risk management programs. The risk management measures that would significantly reduce health risks to swimmers and/or reduce the pathogen concentrations in urban runoff can be divided into policy and source reduction strategies. The policy measures include: improvements in the existing surf-zone and storm drain monitoring programs; regular public notification of stormwater and shoreline monitoring results; improved public education on the potential health risks of swimming at various locations along the Bay; elimination of storm drain management jurisdictional conflicts between local government agencies; and improvements in state and local beach closure and health

3-598

12-243

warning protocols. The source reduction BMPs include: the development and implementation of watershed management plans; public education on the sources of stormwater pollution; improvements in the compliance, implementation and enforcement of municipal stormwater permit requirements and more frequent sewer and storm drain inspection and maintenance programs.

Completion of the epidemiology study will provide information on the health risks to Bay swimmers, but the study may not demonstrate an association between the densities of indicator microbes and the incidence of illness in swimmers. New human sewage and pathogen indicator techniques need to be developed that are more closely associated with the presence of sewage and the health risks to swimmers in ocean waters than currently used indicator microbes. In addition, a sanitary survey protocol needs to be developed in order to quickly and effectively investigate the sources of indicator bacteria and human enteric viruses in storm drains and creeks.

Introduction

The potential health risks of recreational exposure to polluted water have been investigated and debated since the 1940's. To date, health risk studies have focused on recreational exposures in waters known to be contaminated by human sewage. None of the health effects studies were completed on recreational populations exposed to urban runoff contaminated waters.

The health risks to populations in recreational waters contaminated with pathogenic microbes can be determined by two primary research methods: risk assessment and epidemiology studies. Both research methods offer different advantages and disadvantages.

A risk assessment approach is quicker and less expensive than an epidemiological approach, while epidemiology studies, if designed and completed properly, give a more accurate estimate of the health risks of environmental exposures to pathogens. Until an accurate estimate of the health risks of swimming in the Bay can be determined, local government agencies will continue managing the risks solely by implementing the Los Angeles County Beach Closure and Health Warning Protocol and the CDHS will continue to take a conservative risk management approach to the issue of human exposure to storm drain runoff contaminated waters.

Risk Assessment

An example of the problems associated with a risk assessment approach to determining the health risks from environmental exposures to pathogens was the CDHS response to the approval of the third SMBRP storm drain and surf zone pathogen study. The CDHS submitted a technical memo on the health risks of swimming in waters receiving human enteric virus contaminated runoff (CDHS, 1992). Based on the results of the third year pathogen study (Gold et al., 1992), the Environmental Management Branch of the CDHS estimated the probability that a swimmer or surfer would contract an infection from exposure to human enteric viruses in urban runoff. The CDHS completed three risk assessments: for the beaches adjacent to the Hermosa Drain, Pico-Kenter Drain, and Malibu Creek.

The CDHS estimates of the probability of infection were based on the assumption that a swimmer or surfer swallowed 100 ml of runoff contaminated ocean water during a typical day at the beach. To compensate for limitations of the sampling, recovery, and analytical

3-599

12-217

methods, the CDHS assigned to the detected viruses the highest infectivity of virus known from dose-response experiments: the infectivity of rotavirus (Regli et al., 1991).

Enteric viruses were found in Herondo Drain runoff on July 31 and September 4. If human waste was present in Herondo runoff at the same concentrations as on those dates, then the probability of contracting a viral intestinal infection from swallowing runoff contaminated ocean water was estimated at:

> "more than six in 100,000 for a swimmer in water comprised of 90% ocean water and 10% drain water for conditions represented by the September 4 sample, and more than two in 100,000 for the July 31, sample. If someone was to swim in undiluted runoff from the drain, then the probability of infection would be greater than six in 10,000 for conditions represented by the September 4, sample and more than two in 10,000 for the July 31 sample."

In the Pico-Kenter drain, human enteric viruses were found in samples collected on August 13, September 25, and October 2, 1991. If human waste was present in Pico-Kenter runoff at the same concentrations as on those dates, then the probability of contracting a viral intestinal infection from swallowing runoff contaminated ocean water was estimated at:

> "more than five in 10,000 for a swimmer in water comprised of 90% ocean water and 10% drain water for conditions represented by the September 25 sample, more than six in 100,000 for the October 2 sample, and greater than three in 100,000 for the August 13, sample. If someone was to swim in undiluted runoff

> from the drain, then the probability of infection would be greater than five in 1,000 for conditions represented by the September 25 sample, more than six in 10,000 for the October 2, sample, and greater than three in 10,000 for the August 13, sample."

Human enteric viruses were found at various locations in Malibu Lagoon in samples collected on June 5 and 17, September 3 and 30, and October 9, 1991. For reasons not specified in the memo, the CDHS performed a risk assessment based on the virus concentrations in only two runoff samples; those collected on June 17 and October 9, 1991. If human waste was present in Malibu Creek runoff at the same concentrations as on those dates, and surfing and swimming occurred during and immediately after the State Department of Parks and Recreation released water from the Lagoon to the downstream ocean waters at Malibu Surfrider State Beach, then the probability of contracting a viral intestinal infection from swallowing runoff contaminated ocean water was estimated at:

> "more than one in 10,000 for a swimmer in water comprised of 90% ocean water and 10% drain water for conditions represented by the October 9 sample from the C-Channel, and greater than two in 100,000 for the June 17 sample from the Breach area. If someone was to swim in undiluted runoff from the drain, then the probability of infection would be greater than one in 1,000 for conditions represented by the October 9 sample from the C-Channel, and greater than two in 10,000 for the June 17 sample from the Breach area."

In the risk assessment memo, CDHS staff emphasized that infections do not usually result in illness. An infection may result in detectable pathogenic effects, an antibody response,

3-600

12-248

or other subclinical effects. The observed frequencies of symptomatic infection for various enteroviruses may range from 1% for poliovirus (Haas, 1983) to more than 75% for some of the coxsackie B viruses and hepatitis A virus (Regli et al, 1991).

The CDHS memo went on to characterize the symptoms of disease that may occur with one, four, and 95% of virus infections of the intestine in Californians with normal acquired immunities. The estimates were solely based upon the CDHS observation that among people who have not been inoculated, those infected with poliovirus contract infections that result in severe symptoms one percent of the time, mild symptoms four percent of the time, and subclinical effects 95% of the time. The CDHS characterization of illness rates from exposure to enteric viruses is seriously flawed because it is based solely on CDHS experience with one type of enteric virus. As stated earlier, many viruses, including the coxsackie B viruses that were detected in runoff from all three storm drains in 1991, are far more virulent than poliovirus.

A number of major problems with the CDHS risk assessment led to a probable underestimate of the actual risk of infection in the urban runoff contaminated waters adjacent to the Pico-Kenter drain, Herondo drain and Malibu Creek. The concentration of viruses in samples analyzed for the 1991 SMBRP study were considered rough estimates for the following reasons (Gold et al., 1992):

1. At low densities, viruses are not normally distributed throughout the sample. It is not appropriate to extrapolate viral densities based on an aliquot taken from a sample having low virus concentrations. Only 10% of the sample was assayed for plaque forming units. When that 10% was negative for virus, the remaining

sample was assayed by the more sensitive, but more qualitative cytopathic effect technique.

2) One of the basic limitations of virus testing is that no cell line can detect all of the enteric viruses that are present in the sample. The Buffalo Green Monkey Kidney cell line used in the analysis does not detect hepatitis virus, rotavirus, Norwalk Type virus, and non-viral pathogens. Also, the tests did not detect microbes from animal sources that are pathogenic to humans.

3) The results of the poliovirus seeding studies demonstrated that the densities of viruses in the samples were underestimated. Virus recovery in seeded samples from the three drain locations ranged from 0% to 45%, demonstrating the large uncertainty in the accuracy of the sampling method.

4) Toxicity to cultured cells was noted in the first year pathogen study at Ashland Avenue drain, so sample concentrates had to be diluted prior to assay to minimize toxicity effects. The toxic effects of the runoff concentrate on the viability of enteric viruses could not be assessed. The viruses may have been inactivated or may have experienced a loss in infectivity, so fewer, or even no viruses would have formed plaques during the analysis.

5) A plaque forming unit may be either one single virion or an aggregate of the virus (Bitton, 1980). The number of plaque forming units in a sample is an underestimate of the total number of viruses in the sample.

3-601

12-215

Risk assessments for human exposure to toxicants has been common since Congress approved the Toxic Substances Control Act, Resource Conservation and Recovery Act, and the Comprehensive Environmental Response, Compensation, and Liability Act in the late 1970's and early 1980's. Risk assessments for exposure to toxicants and pathogens are similar in that the approach for both relies on numerous exposure and outcome assumptions. However, there are a number of major differences between risk assessments for toxicants versus pathogens: the concentration of toxicants in the environment is more accurately determined through analytical chemistry techniques than the concentration of pathogens; toxicants are more easily detected and are detected at lower concentrations in the environment than pathogens; and the identity of the toxicants of concern is easier, quicker, and less costly to determine than the identity of human pathogens. For these reasons, plus the fact that the expected outcome from environmental exposure to pathogens is an infectious illness with symptoms that manifest themselves in a relatively short period of time, epidemiology studies have been the research method of choice for determining the health risks of environmental exposures to pathogens.

Epidemiology Studies

There have been numerous studies completed on the health risks of swimming in sewage contaminated waters (Stevenson, 1953; Bryan, 1974; Cabelli, 1979, 1982, Fattal, 1983; Seyfried, 1984, 1985; Philipp, 1985; Dewailly, 1986; Brown, 1987, Ferly, 1989; New Jersey State Department of Health, 1990; Deitner, 1990; Robson, 1990; Cheung, 1990; Balarajan, 1991, von Schirnding, 1992 and Corbett, 1993). These studies often demonstrated increased health risks to swimmers (head immersed in water) as compared to non-swimmers for gastroenteritis, respiratory symptoms, and infections of the eyes and ears. However, correlations with the incidence of illness and the densities of indicator organisms were inconsistent. Reviews of the studies and their applicability to microbial water quality standards in both the marine and fresh water environment have failed to provide strong recommendations for new bathing water standards (Elliot et al., 1985; Salas, 1987; Jones, 1989; Saliba, 1990; and Walker, 1992), although some support for an enterococcus standard emerged in the middle to late 1980s (EPA, 1986; SWRCB, 1990b).

A number of large scale EPA-type epidemiology studies were completed at various locations around the world in the late 1980s and early 1990s. The flaws inherent to the approach including pooling the results from the estuarine and marine locations, and combining results from several beach locations (Fleisher, 1991), were repeated in several of the later EPA-type studies. The most recent study of swimmers in the marine waters off the United States coast, the 1990 New Jersey study, repeated the above flaws and was completed during a summer when indicator organism densities in the surf-zone were abnormally low. The study, completed at an estimated cost of $2 million, did not demonstrate an association between indicator densities and the incidence of adverse health effects in swimmers. The results of the New Jersey study have made many members of the SMBRP Management Committee hesitant to pursue funding for a study that may not provide definitive information on the health risks of swimming in Santa Monica Bay.

The proposed Santa Monica Bay epidemiology study - In 1991, after the release of the second surf-zone pathogen study (Gold et al., 1991), the SMBRP Technical Advisory Committee and Management Committee decided to fund the design of a large scale health effects study on people who swim in Santa Monica Bay. Similar to the EPA type studies, the SMBRP study was designed to determine the incidence of such adverse health outcomes as highly credible gastroenteritis (includes nausea, fever, diarrhea, etc.) eye, ear,

3-902

respiratory, wound and sinus infections, and skin rashes in ocean swimmers. Subjects will be interviewed on the beach and later contacted 3-4 days and 10-12 days after going to the beach in order to determine the incidence of adverse health effects in swimmers at various locations.

Unlike previous studies, this one will focus on people who swim in storm drain runoff contaminated waters. The cohort study would compare the incidence of adverse health effects in swimmers at beaches with variable indicator bacteria densities within 100 yards of a storm drain with swimmers at beaches with low indicator densities 400 yards or more from a storm drain. Also, in order to increase the power of the study, only two beach locations were proposed for use in the study. Those two locations, the heavily visited beaches near the Ashland Avenue storm drain in Santa Monica and the Santa Monica Canyon storm drain in Pacific Palisades, have a history of high, surf-zone indicator bacteria densities near the storm drains. The study should provide information on the health risks of swimming in Santa Monica Bay, swimming at various distances from flowing storm drains, and whether or not the surf-zone densities of microbial indicators correlate with the incidence of illness in swimmers. The final study design was approved by the SMBRP in the fall of 1992.

In July, 1993, a California Superior Court judge approved a settlement between Chevron USA and the Los Angeles County District Attorney and California Attorney General over a 21,000 gallon oil spill to Santa Monica Bay in March of 1991. One of the settlement provisions was for Chevron El Segundo Refinery to give $50,000 to UCLA in order to implement the pilot epidemiology study. The goals of the pilot study were the following (Haile, 1993):

1) Determine the background prevalence of highly credible gastroenteritis (HCGI) in beachgoers at the two proposed sampling locations: Ashland Avenue and the Santa Monica Canyon storm drains;

2) Field test and amend as needed the interviewer techniques and questionnaires that were designed to provide information on the prevalence of HCGI and the health risks of swimming in Santa Monica Bay ;

3) Determine the feasibility and cost of the large scale epidemiology study on swimmers at urban runoff contaminated beaches;

4) Determine the number of people that swim and wade within 100, 200 and 400 yards of the two storm drains; and

5) Evaluate whether or not there are significant differences between indicator bacteria densities in samples collected in the morning versus those collected in the afternoon.

The results of the pilot study were presented to the SMBRP in February, 1994 (Haile et al., 1993). Among the findings were the following: i) The large scale epidemiology study could be completed over the course of one summer at a cost of approximately $650,000. ii) The questionnaires used to determine the prevalence of HCGI and the health risks to swimmers functioned effectively and small modifications were made to the questionnaires and interviewing protocols during the course of the pilot study. iii) The prevalence of HCGI in the local beach-going population was above the assumed background risk of

3-903

12-251

10 per 1000 that was based on the results of studies on the east coast (Cabelli, et al., 1982). iv) Surf-zone samples collected from 200 yards and 400 yards had indicator bacteria densities below health objectives in the Los Angeles County Beach Closure and Health Warning Protocol while samples collected in front of the two drains had elevated indicator densities. v) Surf-zone indicator bacteria densities in morning samples did not differ appreciably from the densities in samples collected in the afternoon.

The results of the pilot study were encouraging enough that the Management Committee of the SMBRP formed a subcommittee charged with obtaining the funds for the study as soon as possible. Until the pilot study was completed, most Management Committee members believed that the full scale study would cost over $1.2 million and would take two summers to complete. However, the results of the pilot study led to the conclusion that the full scale study was feasible to complete for less money and in a shorter time period. The lack of temporal variability in bacterial densities means that fewer surf-zone samples need to be collected and analyzed for the study. In addition, there were large populations swimming within 100 yards and 400 yards of the storm drains which reduces the number of days needed to interview the 8,000 subjects needed for the study. Also, the high background prevalence of HCGI increases the power of the study which, in turn, reduces the population sample size needed for the full scale study. And finally, the response rate of the subjects to the health effects questionnaire was extremely high.

Currently, the full scale study is on hold until funding can be secured for implementation and further peer review is completed. The study will occur during the summer of 1995.

Recommendations

The large uncertainty inherent with both research methods and the potentially widespread conditions of pathogen contamination of Santa Monica Bay beaches from urban runoff have made implementation of other recommendations besides determining the health risks of swimming in the Bay a priority to the SMBRP. The SMBRP recommendations and other recommendations can be categorized into research, policy, and source reduction measures. The research needs include: the development of new sewage indicators (microbial and/or chemical); and the development and implementation of a sanitary survey program to investigate the sources of indicator bacteria and human viruses in storm drains and creeks. The policy needs include: improvements in local and state beach closure and health warning protocols; elimination of storm drain management jurisdictional conflicts between local government agencies; improvements in the existing surf-zone and storm drain monitoring programs; regular public notification of stormwater and shoreline monitoring results; and improved public education on the potential health risks of swimming in runoff contaminated waters. The source reduction measures include: the development and implementation of watershed management plans; public education on the sources of stormwater pollution; improvements in the compliance, implementation and enforcement of municipal stormwater permit requirements; and more stringent and frequent sewer and storm drain inspection and maintenance programs.

Research needs - The primary research need, other than the completion of the large scale epidemiology study, is to develop a surf-zone and stormdrain indicator system capable of detecting human pathogens. The current system, based on the coliform indicators and enterococcus bacteria, is inadequate for a number of reasons previously discussed. Indicators that merit further research include a wide array of human enteric viruses

093-604

detected by gene probe techniques. Aeromonas bacteria, the protists Cryptosporidium and Giardia, and the fecal sterol coprostanol. Of the microbes on the list, only Aeromonas is not highly pathogenic to humans. F-male specific coliphage was not included on the list because densities correlated poorly with the presence of human enteric viruses during the SMBRP studies. Although high Cryptosporidium and Giardia densities have long been associated with illness outbreaks caused by contaminated drinking water (Regli, 1991), very little is known about the swimming associated risks of exposure to the protists in recreational waters. Recently, Australian researchers have found that Aeromonas correlated more strongly with the incidence of swimming associated illnesses than any of the more commonly used bacterial indicators (Corbett et. al., 1993).

Fecal coprostanol, a chemical indicator, has been found in high concentrations in sewage and in marine sediments adjacent to the sludge and effluent outfalls in Santa Monica Canyon and off the Palos Verdes shelf, the southern boundary of Santa Monica Bay (Venkatesan et al., 1986, 1990). Also, the fecal coprostanol isomer ratio differed between species of cetaceans, pinnipeds and humans in research completed on Antarctic marine sediments (Venkatesan et al., 1989). The fact that sewage contains high coprostanol concentrations and coprostanol isomer ratios differ between species, makes coprostanol a promising indicator for epidemiology and sanitary survey studies. Currently, the SMBRP is researching coprostanol isomer ratios via gas chromatography/mass spectrometry techniques in humans, sea birds, rats, ducks, and domestic animals in order to determine if the isomer ratios are species specific. If the coprostanol ratios differ strongly between species, then coprostanol may become an important human sewage indicator for storm drain and surf-zone monitoring because of the prevalence of gas chromatographs and

mass spectrometers in local laboratories and the short time period needed for sample analysis.

Perhaps the most promising field in research on pathogens in storm drains and the marine environment is taking place in the field of genetics. Many gene probes for human enteric viruses, the primary pathogens causing swimming associated illnesses, have been developed over the last few years (Atlas et al., 1992). The Orange County Sanitation District has used these techniques to detect viruses in stormdrains and in sewage. Advantages of the technique include the short time period needed for sample analysis compared to standard viral culture techniques and greater specificity for identifying a wide variety of enteric viruses (Atlas et al., 1992). The disadvantage of the technique is high analytical cost, the lack of laboratories with gene probe capabilities, and the inability of the techniques to differentiate between viable viruses and inactive viruses or gene fragments. Also, the techniques do not yet accurately quantify the number of viruses in a given sample.

Although human sewage indicator development is a high priority need for assessing the health risks to swimmers in ocean waters, the high cost of research, the small number of scientists working on developing a more reliable indicator, the lack of consistent and significant government funding, and the lack of a government mandate to create a health based indicator system and abandon the current system have resulted in slow progress in the field over the last ten years. An amendment to the Clean Water Act, which should be reauthorized in 1994, requiring the development of health based water quality standards for recreational waters would provide the needed impetus to develop a better human sewage indicator in the near future. Providing funding for the research through the Clean

3-995

12-253

Water Act, foundations or other potential sources is equally as important as creating a mandate for changing the current indicator system.

Sanitary surveys are short-term field investigations for the source(s) of high indicator densities or sewage in storm drains or the surf-zone. Often, a sanitary survey entails analyzing samples collected from storm drain system locations distributed over a wide area. Locally, the LACDHS and city departments of public works or general services conduct most of the sanitary surveys. Despite the fact that the State Ocean Plan requires sanitary surveys when enterococcus densities are high in marine waters, a standardized protocol for a survey has never been developed and field tested. Historically, whenever monitoring programs demonstrate that high bacteria counts are present in the surf-zone or storm drain, government agencies rely on bacteriology techniques to find the source of contamination. The largest problem with reliance on indicator bacteria analysis is the long time period needed for sample analysis. Recently, the City of Los Angeles and the LACDPW have started using ammonia probes during their sanitary surveys because high ammonia concentrations are associated with the presence of fecal contamination and the probes give ammonia concentration results in a few minutes.

A standard sanitary survey that uses a number of techniques other than sample analysis for ammonia and indicator bacteria concentrations needs to be developed. Other possible components of a survey could include visual inspection of open storm drain channels, video camera inspection of enclosed stormdrains, dye testing of sewer lines and septic systems, and water quality analysis for detergents, coprostanol, or pathogenic microbes. Another essential element of an effective sanitary survey is collecting stormwater samples for water quality analysis from multiple locations during the same time period. The results from these parallel monitoring events often can provide information on the source of the contamination and the size of the spill based on downstream dilution. Currently, there are no organized federal, state, or local efforts to standardize sanitary survey protocols despite the California Ocean Plan requirement for sanitary survey implementation when enterococci densities are consistently high in nearshore waters.

Development of a standard sanitary survey is a priority because of the Ocean Plan requirements, the problem of unknown human sewage sources to the storm drain system, the requirement for a comprehensive illegal dumping and illicit connection program under the region's municipal stormwater NPDES permit, and the large inconsistency in sanitary survey techniques currently used by various local government agencies. A likely implementation strategy is for representatives from local municipalities, environmental groups and the RWQCB to develop a standard sanitary survey as part of the renewal process for the municipal stormwater permit for the region. With the participation of these groups, the technical feasibility of the sanitry survey will probably be secondary to economic considerations, the ease of completing a successful, quick survey, and developing criteria for when a survey should be implemented. The standard sanitary survey would be developed and implemented statewide more quickly if the State Legislature provided funding for the SWRCB to develop the survey.

Policy needs - Although the Los Angeles County Beach Closure and Health Warning Protocol has been improved over the last five years, there still are a number of shortcomings in the protocol. Implementation of beach closures and health warnings is primarily at the discretion of public health officials. Chronic surf-zone contamination problems often lead to little more than the posting of health warning signs. Beach closures due to

E-2-1-93
3-909

high bacteria counts seldom occur and high bacteria counts rarely lead to sanitary surveys. Chronic problems in the Malibu Lagoon and adjacent Surfrider State Beach, Mothers' Beach in Marina Del Rey, and the beaches adjacent to the Redondo and Santa Monica Piers have continued for years without majorafforts to abate the contamination problems. As a precaution to protect public health until better health risk estimates are derived, beach closures and sanitary surveys should be required under certain conditions such as continually high surf-zone bacterial densities over a one month period. In previous years, chronically high bacterial indicator densities have been caused by leaky sewer lines, illegal sewer connections, faulty septic systems, food waste contaminated runoff from restaurants, and the presence of large populations of seabirds. All of these sources of indicator bacteria, with the possible exception of seabirds, could pose a significant health risk to swimmers exposed to surf-zone waters with high indicator densities.

Another improvement needed in the beach closure protocol is improved communication of potential health risks and monitoring data. The LACDHS should provide the media with a report on the number and locations of beach closures and health warnings over the previous month. Also, the LACDHS should provide the media with a compliance status report based on the surf-zone monitoring programs of the County and City of Los Angeles. Although the information cannot be used to assess the risks to swimmers at local beaches, the reports would provide the public with the best available information on beach water quality in Santa Monica Bay.

Modifications to the Los Angeles County Beach Closure and Health Warning Protocol are not a high priority because the most significant changes in the protocol already have been effectively implemented. The LACDHS is unlikely to automatically close beaches

with chronically high indicator densities unless new information is developed on the association of indicator densities from storm drains and the incidence of adverse health effects in swimmers. In order to provide the public with more frequent information on the water quality of Santa Monica Bay beaches, Heal the Bay will start reporting the results of the shoreline indicator bacteria monitoring program on a monthly basis starting in the summer of 1994.

The public education effort should not be limited to improved notification of monitoring results and beach closures and health warnings. The media, environmental groups, the tourism industry, and government agencies should begin a public education campaign on the shoreline water quality of Santa Monica Bay. Approximately 50% of the public believes that the entire Bay is too polluted for recreational contact (Fairbank, Maullin and Assoc., 1992). Also, many others still swim or surf near flowing storm drains near Santa Monica and Redondo Beach Piers, and in the Bay after a rain storm. A multi-media public education campaign consisting of newspaper, radio, magazine, billboards, movie theater and television public service announcements would help communicate a more accurate portrayal of shoreline water quality. Also, environmental curricula in the schools should reflect the current information on shoreline water quality and the health risks of swimming in Santa Monica Bay. The Los Angeles County Lifeguards should be trained to provide the most current water quality and health risk management information to inquiring beach visitors. Brochures should be developed and made readily available at hotels, lifeguard stations, and surfboard shops. A comprehensive public education program should lead to an informed public that makes sensible health risk management decisions at local beaches.

3-607
12-255

The public education effort is a high priority because the depressed economy in Los Angeles County makes a more accurate portrayal of Santa Monica Bay surf-zone water quality essential to increasing tourism dollars spent in the region. Inexplicably, local Chambers of Commerce and Tourism Bureaus have not made an effort to clear up misconceptions about shoreline pollution along the Bay. Considering the current political client in the region and the State, if the business and environmental communities would lead the effort to develop a comprehensive public education program on the shoreline water quality of Santa Monica Bay and managing potential health risks to swimmers, then full program implementation would likely occur. Without that coalition of interests, the full development and implementation of a comprehensive public education program is unlikely.

The current Los Angeles County shoreline monitoring program with 17 daily and 32 weekly sampling locations is among the most comprehensive in the Country. However, the program could be improved without additional costs by adding a few new sampling locations at popular beaches adjacent to flowing storm drains while deleting a few current locations that are in areas of small bather use or are in areas with low indicator density variability. For example, the current shoreline monitoring program does not include frequently visited locations near the Herondo or Sunset Boulevard storm drains. Developing regional ocean monitoring programs is a high priority of all members and member agencies of the Management Committee of the SMBRP. Modification of the current shorline monitoring program is an easy first step in the development and implementation of a comprehensive Santa Monica Bay monitoring program. The shoreline monitoring program modification process, involving the LAEMD, the LACDHS, the SWRCB, the RWQCB,

the Los Angeles County Sanitation Districts, and Heal the Bay is currently underway and should be completed by the end of July, 1994.

The Santa Monica Bay watershed storm drain monitoring program will not be implemented by the LACDPW until the summer of 1994. The monitoring program is designed to determine the mass pollutant loads from various subdrainages into Santa Monica Bay. However, the program is not designed to assist in the early detection of sewage spills into the storm drain system. Until recently, the LAEMD monitored five sites in the Ballona Creek watershed for the three commonly used bacterial indicators. This program enabled the LAEMD to detect a number of sewage spills to the Creek that otherwise would not have been detected through their shoreline monitoring program. Regular upstream monitoring (daily to weekly) of stormwater runoff for indicator bacteria and ammonia concentrations would provide information on small sources of fecal contamination to the storm drain system that are currently undetected and better information on the approximate location of sewage spills in the system. The RWQCB is leading an effort to modify the Los Angeles County storm drain monitoring program so the LACDPW can better detect sources of fecal contamination to the storm drain system. One of the goals of the effort is to produce a Santa Monica Bay watershed pathogen indicator monitoring program. An important element of the program will be to pool the data from the LAEMD, LVMWD and LACDPW storm drain monitoring programs in order to provide a better overview of the stormwater fecal contamination problem in the watershed.

Until a storm drain monitoring program for indicators of human sewage is implemented, there will continue to be a lack of information on the sources of fecal indicators to the storm drain system. Also, storm drain monitoring is needed to demonstrate the effective-

3-608

ness of implemented BMPs at reducing the concentration of indicators in urban runoff. In watersheds and subdrainages with known human sewage contamination problems, such as Malibu Creek and Ballona Creek, frequent monitoring for fecal indicators in the storm drains is a high priority in order to detect potential sources of sewage before they cause environmental or public health problems. The RWQCB effort to facilitate the development of a storm drain monitoring program for human sewage indicators will not be effective unless they require the LACDPW to implement the recommendations. Otherwise, the LACDPW will continue to effectively use budget problems in the County as justification for their failure to implement and expand their storm drain monitoring program.

The current beach closure and health warning protocol in California is entirely based on total coliform densities and the implementation of the protocol is at the discretion of County health agencies. This situation has led to the potentially false public perception that some counties have more polluted beaches than others because their health departments are more likely to close beaches during conditions of high surf-zone indicator bacteria densities. Further confounding the prospects of a statewide protocol is the problem that few counties have similar surf-zone monitoring programs. Los Angeles County has a thorough shoreline monitoring program and a stringent beach closure and health warning protocol which has led many people to believe that Santa Monica Bay beaches are among the most polluted in the Country.

In order to provide the public with consistent information on surf-zone water quality, the CDHS needs to develop and implement a statewide beach closure and warning protocol based on the surf-zone densities of all three indicator bacteria. All counties with popular bathing beaches should be required to monitor those beaches on a weekly, if not daily

basis during the months of peak bather use. For many counties, the recommended increased monitoring requirements could cost an additional hundred thousand dollars or more. If the results of the epidemiology study demonstrate that any of the indicators are poorly associated with the incidence of adverse health effects, then the CDHS should eliminate the bacteria as criteria for beach closures or health warnings. Also, in light of the wide variety of contaminants associated with runoff, the CDHS should seriously consider requiring permanent health warnings at all beaches adjacent to flowing storm drains, creeks, and rivers. Implementation of these recommendations is a high priority for region, because the current beach closure and health warning inconsistencies between counties has led to an inaccurate public perception of shoreline water quality in the State. However, those counties that have less protective protocols and/or rudimentary shoreline monitoring programs probably would join the CDHS, which would have to implement and enforce the modifications, in opposition to the recommended changes. Until the epidemiology study of Santa Monica Bay swimmers is completed and an association between surf-zone indicator densities and the incidence of adverse health effects is demonstrated, there is a low likelihood that these recommendations will be implemented.

Storm drain jurisdictional issues have led to problems during sewage spill events and sanitary surveys. The 5,000 miles of storm drains in Los Angeles County are owned by numerous entities including the County, cities and the California Department of Transportation (SMBRP, 1994). Employees need permission to enter and work in storm drains that are not owned by the employing government agency because of liability concerns. The need for formal permission can lead to long delays during sanitary surveys and delays in remediation of sewage and/or toxic chemical spills. The Ballona Creek Task Force agreed that a Memorandum of Understanding (MOU) between government

3-609
12-257

agencies was a high priority. The MOU has not been entered into because the personnel liability concerns have not been resolved.

Source reduction measures - Stormwater pollution reduction measures at the source would effectively reduce the health risks of recreational water contact in Santa Monica Bay. In 1990, the RWQCB issued a National Pollution Discharge Elimination System (NPDES) permit for stormwater from 19 municipalities in Los Angeles County, Cal-Trans and Los Angeles and Ventura County. The permit regulated municipalities in a phased approach by watersheds. The first watershed regulated under the permit was the Santa Monica Bay watershed. Cities were required to develop and implement stormwater management programs that contained numerous Best Management Practices (BMPs) for reducing the pollutant loads in stormwater runoff (RWQCB, 1990). In 1993, the RWQCB amended the permit by requiring the implementation of thirteen BMPs as part of the NPDES permit requirements. Many of these BMPs and the BMPs recommended in the SMBRP Action Plan would effectively reduce the concentration of pathogens in stormwater.

One of the permit requirements is to develop and implement a storm drain and sewer inspection program for illegal connections and illicit discharges. Regular inspection programs can detect sources of fecal contamination including recreational vehicles, septic system pump-out trucks, leaking sewer lines, and illegal sewer connections to the storm drain system. They also can assist in the development and implementation of more effective sewer and storm drain maintenance programs. In areas that are not sewered, like much of Malibu and the lower reaches of the Malibu Creek watershed, regular septic system inspections are needed to ensure that sewage is not leaching into the ocean or

nearby creeks, streams and coastal lagoons. If sewage is leaching into surface waters, then the responsible government agency should immediately require repairs to the malfunctioning septic system. The current rate of compliance on the NPDES permit requirement for a regular inspection program is low. Many cities and both Los Angeles and Ventura County have not implemented widespread storm drain inspection programs because of the high cost of implementation and the lack of enforcement from the RWQCB. Most municipalities and the two local counties in the region will probably not develop and implement effective inspection programs until the RWQCB begins enforcement of the NPDES permit requirement.

One suggestion that could potentially reduce the cost of an inspection program for illegal connections and illicit discharges would be to combine the program with existing industrial waste inspection programs. The industrial waste inspection program was created to ensure that industries were complying with their sewer discharge permits as required by the federal Clean Water Act. The program, in existence for over a decade, has been especially successful at reducing priority pollutant loads to the sewer and detecting industrial waste permit violations in the city of Los Angeles and those cities that have contracted the services to the LACDPW and the LACSD programs. With established, successful programs and numerous trained inspectors, the industrial waste programs are better prepared to develop and implement stormwater inspection programs in an efficient manner than stormwater divisions that are starting inspection programs for the first time. Implementation of this recommendation is essential for a timely reduction of the number of illegal connections and illicit discharges in the watershed.

3-619

12-259

of reducing the potential health risk to people that swim near storm drains. The diversions are simple to build and cost under $50,000 for a small to average size storm drain. During the dry months of April to October, the local sewage treatment plants have the additional capacity to accept the flows from flowing storm drains (Crosse, pers. comm., 1993). Although runoff diversions are not practical for all storm drains, especially natural watercourses like Topanga and Malibu Creeks or Ballona Creek because of the large dry weather flow and the small number of beach users adjacent to the Creek, diversions are an effective solution at popular beaches that have storm drains that flow during the dry season. Some examples of storm drains that make good candidates for diversion are, from north to south, Sunset Boulevard, Pulga Canyon, Santa Monica Canyon, Ashland Avenue, Windward Avenue, Culver Boulevard, Imperial Highway, Herondo Avenue, and Avenue I. Pico-Kenter and Santa Monica Pier drains were not included on the list because a separate dry weather treatment facility will be built for those flows by 1996. Currently, only the Herondo storm drain is being seriously considered for a dry weather runoff diversion. Diversions at the other sites could occur if environmental groups, community groups, and local residents that swim at the affected beaches make a concerted effort to pressure local governments to build and maintain the diversions. Potential funding sources for the diversions include, in order of decreasing likelihood, environmental government grants, stormwater user fees, sewer fees, the LACDPW Flood Control Benefit Assessment District, and the State or local government General Funds.

Conclusions

Although the public concern about the health risks of swimming in Santa Monica Bay has been high for over a decade, there is still little information on the actual risks to swimmers in local urban runoff contaminated waters and at the majority of Bay beaches which are not impacted by runoff pollution in dry weather. The analytical methods available to assess the health risks are risk assessments and epidemiology studies. The lack of strong association between indicator bacteria densities and the incidence of bather illnesses combined with the analytical problem of accurately quantifying the concentrations of enteric viruses in stormwater samples, make the uncertainty surrounding a risk assessment too large to provide an accurate estimate of health risks to swimmers in the Bay. A large scale epidemiology study of swimmers in both urban runoff contaminated waters and at cleaner beaches is needed to provide an accurate assessment of the health risks to swimmers in the Bay.

Once the study is completed, the LACDHS and the CDHS can develop risk management strategies based on the actual health risks to swimmers rather than the densities of indicator bacteria that may not be associated with the incidence of health risks. Risk management strategies could include new bathing water contact standards and a statewide beach closure and health warning protocol. Other risk management strategies that could be implemented by other government agencies can be categorized as policy and source reduction measures. Wide scale public education programs, better public notification of water quality, health warnings and beach closures, watershed wide storm drain inspection programs for illegal connections and illicit disposal practices, and dry weather urban runoff diversions are just a few of the BMPs that would result in health risk reductions to swimmers in the Bay.

C-154
12-256

Other sources of fecal contamination to the storm drain system include campers, transient populations, and daytime visitors to State and County parks and beaches. Adequate toilet facilities and trash cans for disposable diapers should be provided in areas with large user populations. In addition, an educational effort that informs the public that all waste in the Santa Monica Bay watershed ends up at local beaches should reduce the fecal contamination of shoreline waters. Better maintenance of heavily visited parks also would assist in reducing sources of human fecal contamination to the watershed. Although these recommendations have a relatively low cost and they can be implemented relatively easily, the recommendations are included as a low priority in the SMBRP Action Plan (SMBRP, 1994a).

Another potential source of pathogens and pathogen indicators to the storm drains and beaches is the waste from hundreds of restaurants in the watershed. Currently, restaurants are not regulated under the municipal stormwater NPDES permit or the Statewide General Industrial permit. Many restaurants hose off their kitchen wastes and their garbage receptacles into the alleys and gutters that lead to the storm drain system. Food borne pathogens could potentially cause illnesses in swimmers that come in contact with the waste. Municipalities should implement a targeted restaurant worker education program to eliminate these illegal disposal practices. Shortly after the onset of the public education program, municipalities, the LACDPW, the LACDHS and the RWQCB should start enforcing illegal food waste disposal laws. Cities should be required to develop restaurant public education and illegal disposal enforcement programs under the municipal stormwater NPDES permit. The low cost of implementing the recommendations and the potential reduction in sewage indicator loadings that would result because of implementation, make these recommendations a high priority. Currently, only the city of Santa

Monica is implementing these recommendations and, unless the RWQCB requires the implementation of the BMPs under the municipal stormwater NPDES permit, other cities within the watershed are unlikely to follow these recommendations.

Pathogen and pathogen indicator sources in the watershed are not limited to human. Domestic animals including dogs and cats are prevalent throughout the watershed while equine and horses are common in the Malibu Creek watershed and Malibu surroundings. Public education programs that focus on the human health and pollution consequences of failing to responsibly dispose of animal wastes should be developed and implemented as part of the large scale public education programs that are required under the municipal stormwater NPDES permit. In the Malibu Creek watershed, some residents have horse paddocks within a few yards of the Creek and its tributaries. Also, small owners still occasionally use rural animal waste to stabilize stream banks on their property. These practices are contributing to the high concentrations of nutrients and indicator bacteria in the Malibu Creek watershed. Thus, disposal methods demonstrate that enforcement of "scoop and bag" laws and rural animal waste disposal laws are important source reduction management measures that should be implemented. However, like many of the source reduction measures previously described, these recommendations are unlikely to be implemented soon because full implementation enforcement actions are uncommon under the current political and economic climate.

One measure that has proven effective at reducing the indicator bacteria concentrations in the surf zone is diversion of runoff to sewage treatment plants during dry weather. The projects at the Pico-Kenter and Manhattan Beach Pier storm drains have demonstrated that diversion of small flows during the months of peak beach use is a cost effective way

3-612

12-259

Many of these policy and source reduction measure are included in the SMBRP Action Plan. However, all of the measures in the SMBRP Action Plan are voluntary. In addition, few of these BMP's are required in the municipal stormwater NPDES permit. To date, the RWQCB has initiated only one enforcement action in the four year history of the permit despite the fact that the majority of municipalities in the Santa Monica Bay watershed are not complying with the NPDES permit requirements. The challenge ahead is to persuade local municipalities that voluntary implementation of BMPs is in the best interest of the cities because of the economic and aesthetic value of Santa Monica Bay beaches. The likelihood of the RWQCB and local municipalities taking a stronger enforcement posture is small during a period of time when California has not recovered yet from an economic recession and the State and local governments are refusing to implement several unfunded federal mandates. The role of public pressure on cities to implement measures to reduce health risks to swimmers in the Bay has been magnified under the current political climate. Perhaps the results of the epidemiology study, as the results of the surf-zone and storm drain pathogen studies before it, will serve as a catalyst to reduce urban runoff pollution at Santa Monica Bay beaches.

Glossary of Agency and Organization Acronyms

AOC - American Oceans Campaign
CAEHA - California Association of Environmental Health Administrators
Cal-EPA - California Environmental Protection Agency
Cal-Trans - California Department of Transportation
CAO - Chief Administrative Officer
CDHS - California Department of Health Services
CSAC - California State Association of Counties
EPA - The United States Environmental Protection Agency
LACDBH - Los Angeles County Department of Beaches and Harbors
LACDHS - Los Angeles County Department of Health Services
LACDPW - Los Angeles County Department of Public Works
LACSD - Los Angeles County Sanitation Districts
LAEMD - City of Los Angeles - Bureau of Sanitation - Environmental Monitoring Division
LVMWD - Las Virgenes Municipal Water District
OCSD - Orange County Sanitation District
NRDC - The Natural Resources Defense Council
RWQCB - Regional Water Quality Control Board
SCAG - Southern California Association of Governments
SMBRP - Santa Monica Bay Restoration Project
SWRCB - State Water Resources Control Board

3-613
12-261

Bibliography

American Public Health Association. 1985. Standard Methods for the Analysis of Wastewater. 16th Edition: Sections 909, 909a, and 913-A.

Atlas, R., Sayler, G., Burlage, R. and A. Bej. 1992. Molecular Approaches for Environmental Monitoring of Microorganisms. BioTechniques V12(5):706-717

Balarajan R., Soni Raleigh, V., Yuen, P., Wheeler, D., Machin, D. and R. Cartwright. 1992. Health Risks Associated with Bathing in Sea Water. British Med. J. V.303:1444-1445

Bernstein, Sid. 1980. Lifeguards' Cancer Prompts Beach Probe. Los Angeles Times. Part II pg. 1

Bitton, G. 1980. Introduction to Environmental Virology. published by John Wiley and Sons. N.Y., N.Y.

Brown, J., Campbell, E., Rickards, A. and D. Wheeler. 1987. Sewage Pollution of Bathing Water. Lancet 11-21:1209-1210

Bryan, J. and J. Lehmann. 1974. An Outbreak of Hepatitis A Associated with recreational Lake water Exposures. Am. J. Epi. V.99:145-148

Chief Administrative Office of Los Angeles County. 1981. Progress Report on the implementation of the motion introduced by Supervisor Yvonne Brathwaite Burke and subsequently passed by the Los Angeles County Board of Supervisors.

Chief Administrative Office of Los Angeles County. 1992-1993. Correspondence and memos on the Purpose and Proceedings of the Ballona Creek Task Force.

Cabelli, V.J., Dufour, A.P., McCabe, L.J., Levin, M.A. and P.W. Haberman. 1979. Relationship of Microbial Indicators to Health Effects at Marine Bathing Beaches. AJPH. V.69(7):690-696

Cabelli, V.J., Dufour, A.P., McCabe, L.J., and M.A. Levin. 1982. Swimming Associated Gastroenteritis and Water Quality. Am. J. Epidemiology. V.115(4):606-616

Cabelli, V.J. 1982. Microbial Indicator Systems for Assessing Water Quality. Antonie van Leeuwenhoek V.48:613-618

Cabelli, V. 1989. Pers. comm. on the densities of F.-Male Specific Coliphage in sewage contaminated waters.

Calderon, C. 1993. California State Senate Bill 1084 and related correspondence.

California Association of Environmental Health Administrators and California State Association of Counties. 1992. Correspondence in opposition to SB 1865.

California Department of Health Services. 1990. California Code of Regulations. Section 7958 in Title 17.

California Department of Health Services. 1991. Comments on Proposed Los Angeles County Department of Health Services Beach Closure and Health warning Protocol

California Department of Health Services. 1992a. Correspondence in opposition to SB 1865.

California Department of Health Services. 1992b. Comments on 1992 SMBRP Storm Drain and Surf-zone Pathogen Study.

Center for Disease Control. 1987. Outbreak of Viral Gastroenteritis: Pennsylvania and Delaware. MMWR 36:710-711

Center for Disease Control. 1990. Viral agents of Gastroenteritis. Public Health Importance and Outbreak Management. MMWR V.39:1-21

Cheung, W., Chang, K., Hung, R. and J. Kleevens. 1990. Health Effects of Beach Water Pollution in Hong Kong. Epi. Infect. V.105:139-162

City of Los Angeles, Environmental Monitoring Division. 1989. Santa Monica Bay Annual Assessment Report. Bacteriology section. 1987-88. Report submitted to EPA and the RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 189pp

City of Los Angeles, Environmental Monitoring Division. 1990. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1988 through June 1989. Bacteriology section. Report submitted to EPA and the RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 215pp

City of Los Angeles, Environmental Monitoring Division. 1991. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1989 through June

3-614

12-293

1990. Bacteriology section. Report submitted to EPA and the RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 220pp

City of Los Angeles, Environmental Monitoring Division. 1992. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1990 through June 1991. Bacteriology section. Report submitted to EPA and the RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA.

Corbett, S., Rubin, G., Curry, G. and D. Kleinbaum. 1993. The Health Effects of Swimming at Sydney Beaches. V.83(12):1701-1706

Crosse, J. 1993. Pers. Comm. on the excess treatment capacity available for the treatment of urban runoff at the Hyperion Treatment Plant during dry weather.

Debartolomeis, J. and V. Cabelli. 1991. Evaluation of an E. coli Host Strain for Enumeration of F Male Specific Coliphage. App. and Env. Micro. V.57(5):1301-1305

Deltmer, T. and R. Scheffler. 1990. Possible Pathogenesis of Swimming Sinusitis. Laryngo- Rhino- Otologie. V.69:221-225

Dewailly, E., Poirier, C. and F. Meyer. 1986. Health Hazards Associated with Windsurfing on Polluted water. Am. J. Pub. Health V.76:690-691

Edelman, E. 1992. Motion to amend Los Angeles County Beach Closure and Health Warning Protocol.

Elliot, E.L., and R.R. Colwell. 1985. Indicator Organisms for Estuarine and Marine Waters. FEMS Microbiology Reviews. V.32:61-79

Fairbank, Maullin and Associates. 1992. Attitudes Towards the Santa Monica Bay: A Public Opinion Survey. Conducted for the Santa Monica Bay Restoration Project.

Fattal, B., Vasl, R.J., Katznelson, E. and H.I. Shuval. 1983. Survival of Bacterial Organisms and Enteric Viruses in the Mediterranean Coastal Waters of Tel Aviv. Wat. Res. V.17(4):397-402

Fattal, B., Peleg-Olevsky, E., Yoshe-Purer, Y. and H. shuval. 1986. The Association Between Morbidity among Bathers and Microbial Quality of Sea Water. Water Sci. Tech. V.18:59-69

Ferley, J., Zmirou, D., Balducci, F. Baleux, B. Fem. P., Larbaigt, G. Jacq, J., Moissonnier, B., Blineau, A., and J. Boudbt. 1984. Epidemiological Significance of Microbiological Criteria for River Recreational Waters. International Journal of Epidemiology. V.75:83-86

Fleisher, J. 1991. A Reanalysis of Data Supporting U.S. Federal Bacteriological Water Quality Criteria Governing Marine Recreational Waters. Res. J. Water Poll. Control Fed. V.63:259-263

Geldreich, E. 1970. Applying Bacteriological Parameters to Recreational Water Quality. J. AWWA. Feb.1:113-120

Gerba, C., Goyal, S., LaBelle, R. Cech, I., and G. Bodgan. 1979. Failure of Indicator Bacteria to Reflect the Occurrence of Enteroviruses in Marine Waters. Amer. J. of Pub. Health. V. 69(11):1116-1119

Gerba, C., Rose, J. and S. Singh. 1985. Waterborne Gastroenteritis and Viral Hepatitis CRC Critical Reviews in Environmental Control.V.15(3):213-236

Glass, J.S., van Sluis, R.J., and W.A. Yanko. 1978. Practical Method for Detecting Poliovirus in Anaerobic Digester Sludge. Appl. Env. Micro. V.35:983

Gold, M., Bartlett, M., Dorsey, J. and C. McGee. 1990. An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses from Two Santa Monica Bay Storm Drains. A technical report prepared for the Santa Monica Bay Restoration Project.

Gold, M., Bartlett, M., Dorsey, J. and C. McGee. 1991. Storm Drains as a Source of Surf-Zone Bacterial Indicators and Human Enteric Viruses to Santa Monica Bay. A technical report prepared for the Santa Monica Bay Restoration Project.

Gold, M. and L. Well. 1991. letter to the CDHS on the disagreement of Heal the Bay and the American Oceans Campaign with their policy on beach closures and health warnings.

Gold, M., Bartlett, M., McGee, C. and G. Deets. 1992. Pathogens and Indicators in Storm Drains Within the Santa Monica Bay Watershed. A technical report prepared for the Santa Monica Bay Restoration Project.

Gorke, R. 1991-1994. Annual Santa Monica Bay Beach Pollution Report. Prepared for Heal the Bay. First, second, third and fourth annual reports.

Green, D. 1986-1988. Heal the Bay Newsletter. Articles on Bacterial Pollution at Santa Monica Bay Beaches and the Los Angeles County Beach Closure and Health Warning

Protocol. V.1(1,2,3). 2(1,2,4,5,6). 3(3)

Greene, G. 1993. Ozone Disinfection and Treatment of Urban Storm Drain Dry-weather Flows: A Pilot Treatment Plant Demonstration Project on the Kenter Canyon Storm Drain System in Santa Monica. Prepared for the Santa Monica Bay Restoration Project.

Haas, C. 1983. Effect of Effluent Disinfection on Risks of Viral Disease Transmission Via Recreational Water Exposure. J. Water Poll. Cont. Fed. V.55(8):1111-1116.

Halle, R., Greenland, S., Millikan, R., and J. Witte. 1992. Study Design to Investigate the Potential Health Effects of Recreational Exposure to Storm Drain Runoff in the Santa Monica Bay. A design submitted and approved by the Santa Monica Bay Restoration Project.

Halle, R., Greenland, S., Millikan, R., and J. Witte. 1993. Unpublished Data from a Feasibility Study Designed to Investigate the Potential Health Effects of Recreational Exposure to Storm Drain Runoff in the Santa Monica Bay.

Hart, G. 1992. California State Senate Bill 1865 and related correspondence.

Havelaar, A., Hogeboom, W. and R. Pot. 1984. F Specific RNA Bacteriophages in Sewage: Methodology and Occurrence. Wat. Sci. Tech. V.17:645-655

Havelaar, A. and Th. Nieuwstad. 1985. Bacteriophages and Fecal Bacteria as Indicators of Chlorination Efficiency of Biologically Treated Wastewater. J. Water Poll. Control Fed. V.57(11)1084-1088

Horii, R. 1986. The Los Angeles City Engineer's response to the request from the City of Santa Monica to divert runoff from the Pico-Kenter storm drain to the Hyperion Treatment Plant.

Horowitz, Joy. 1980. Lifeguard Cancer Victims Urge Action. Los Angeles Times. 9-15-80 Part II. pg 1.

Hsiung, G.D. 1973. Diagnostic Virology. Yale University Press. New Haven, CT.

James M. Montgomery Engineers, Inc. 1988. Filtration-Disinfection Study. Part II: Virus Monitoring final Report. Prepared for the Las Virgenes Municipal Water District.

James M. Montgomery Engineers, Inc. 1988. Marina del Rey-Marina Beach Bacterial Remediation Study. Prepared for the LACDBH.

Jones, F. and D. Kay. 1989. Bathing Waters and Health Studies. Water Serv. V.93:87-95

Katznelson, E., Fattal, B., and T. Hostovesky. 1976. Organic Flocculation: an Efficient Second Step Concentration Method for the Detection of Viruses in Tap Water. Appl. Env. Micro. V.32:638

Kebabjian, R. 1988. Letter with data entitled, "Enterococcus Levels Adjacent to Storm Drains from 1987-1988." Los Angeles County Department of Health Services

Las Virgenes Municipal Water District. 1991-92. Monthly Monitoring Reports for the Tapia Water Reclamation Facility. Submitted to the Regional Water Quality Control Board.

Lennette, E.H. and N.J. Schmidt. 1969. Diagnostic Procedures for Viral and Rickettsial Infections. APHA publishers. N.Y., N.Y.

Lim, K.A. and Benyesh-Melnick, M. 1960. Typing of Viruses by Combination of Anti-serum Pools. Application to Typing of Enteroviruses (Coxsackie and Echo). J. Immunol. V.84:309-317

Los Angeles County Department of Beaches and Harbors. 1993. Beach attendance along Santa Monica Bay. unpublished data from 1972-1992.

Los Angeles County Department of Health Services. 1986. Presentation to the Los Angeles County Board of Supervisors on their beach closure and health warning protocol. Presented by Robert Gates, LACDHS Director.

Los Angeles County Department of Health Services. 1988-1992. Unpublished bacterial monitoring data from their surf-zone weekly monitoring program.

Los Angeles County Department of Health Services. 1988-92. Los Angeles County Beach Closure and Health Warning Protocol and Ocean Monitoring Procedure Manual.

Los Angeles County Department of Health Services. 1994. Unpublished data on beach closures and sewage spills.

Mack, T. 1982. Summary of Investigation into the Relationship Between Cancer and Work as a Lifeguard at Santa Monica Beach. USC/Los Angeles County Department of Health Services County Cancer Surveillance Program.

McGee, C. 1993. Personal communication on the presence of enteric viruses in three storm drains in Orange County. Orange County Sanitation Districts

Metcalf and Eddy Engineers. 1944. Technical Report to the Los Angeles Board of Public Works upon the Sewage Disposal Problem of Los Angeles and Associated Communities. V.1 20pp

Moore, B. 1974. The Case Against Microbial Standards for Bathing Beaches. In: The Discharge of Sewage from Sea Outfalls. A. Gameson (ed.). Oxford Press

Natural Resources Defense Council. 1991. Testing the Waters: A National Perspective on Beach Closures. 65pp. New York, New York.

New Jersey Department of Health. Division of Occupational and Environmental Health, Environmental Health Service, and Arthur D. Little, Inc. 1990. Ocean Health Study: A Study of the Relationship Between Illness and Ocean Beach Water Quality. Final Report

Pico-Kenter Storm Drain Task Force. 1986. Recommendations to reduce the health risks to swimmers adjacent to the Pico-Kenter Storm Drain. Report was submitted to the cities of Santa Monica and Los Angeles and the County of Los Angeles.

Philipp, R., Evans, E., Hughes, A., Grisdale, S., Enticott, R. and A. Jephcott. 1985. Health Risks of Snorkel Swimming in Untreated Water. International J. of Epi. V.14:624-627

Rao, V.C. and J.L. Melnick. 1986. Environmental Virology. ASM publishers. Washington D.C.

Regional Water Quality Control Board. 1990. Municipal Stormwater National Pollution Discharge Elimination System Permit for the Los Angeles Region.

Regli, S., Rose, J., Haas, C. and C. Gerba. 1991. Modeling the Risk from Giardia and Viruses in Drinking Water. J. AWWA November:76-84

Richardson, P. 1992. Pers. comm. on the storm drain and sewer systems in the city of Los Angeles. Los Angeles Department of Public Works, Bureau of Engineering, Stormwater Division.

Robson, W. and A. Leung. 1990. Swimming and Ear Infections. J. Royal Soc. Health. V.110:199-203

Salas, H.J. 1987. History and Application of Microbiological Water Quality Standards in the Marine Environment. Wat. Sci. Tech. V.18(11):47-57

Santa Monica Bay Restoration Project. 1992. Resolution on immediate action to reduce the risk of human exposure to pathogens in urban runoff.

Santa Monica Bay Restoration Project. 1994a. Characterization Study of the Santa Monica Bay Restoration Plan. Chapters 7-1 and 11-1

Santa Monica Bay Restoration Project. 1994b. The Santa Monica Bay Restoration Plan. Chapters 3, 8 and 13

Santa Monica Bay Restoration Project. 1994. Personal communication on the cost of preparing the Comprehensive Conservation and Management Plan.

SAS. 1990. SAS/STAT User's Guide, Volume 2, GLM-VARCOMP. Version 6, fourth Edition. SAS Institute Inc. Cary, NC

Scholl, S. 1986. Memo to Santa Monica City Council on pollution in the Pico-Kenter storm drain.

Secter, Bob. 1980. Lifeguard Involved in Cancer Furor Dies. Los Angeles Times. 10-17-80 Part II pg. 6

Seyfried, P. and R. Cook. 1984. Otitis Externa Infections Related to Pseudomonas aeroginosa levels in Five Ontario Lakes. Can. J. Pub. Health. V.75:83-87

Seyfried, P. and R. Tobin. 1985. A Prospective Study of Swimming-Related Illness. I. Swimming Associated Health Risk. II. Morbidity and the Microbiological Quality of the Water. Am. J. Pub. Health. V.75:1068-1074

Southern California Association of Governments. 1988. State of the Bay: Scientific Assessment. section by V.J. Cabelli on Microbial Risk Assessment. 5-30 to 5-53

State Water Resources Control Board. 1990a. Water Quality Control Plan for Ocean Waters of California. State Board Resolution No. 90-27. 23p

State Water Resources Control Board. 1990b. Functional Equivalent Document: Amendment of the Water Quality Control Plan for Ocean Waters of California. State Board Resolution No. 90-27. 179p

Stevenson, A. 1953. Studies of Bathing Water Quality and Health. Am. J. Pub. Health. V.43:529-537

Sullivan, S. and M. Barron. 1989. Acute Illnesses among Los Angeles County Lifeguards According to Workplace Exposures. Amer. J. Pub. Health. V.79(11):1561-1563

United States Environmental Protection Agency. 1984. The USEPA Manual of Methods for Virology. EPA-600/4-84-013

United States Environmental Protection Agency. 1985. Test Methods for E. coli and Enterococci. EPA 600/4-85/076

United States Environmental Protection Agency. 1986. Ambient Water Quality Criteria for Bacteria. Office of Water Regulations and Standards. Criteria and Standards Division. EPA 440/5-84-002. Washington D.C.

Venkatesan, M., Ruth, E. and I. Kaplan. 1986. Coprostanols in Antarctic Marine Sediments: A Biomarker for Marine Mammals and not Human Pollution. Marine Poll. Bull. V.17(12)554-557

Venkatesan, M. and C. Santiago. 1989. Sterols in Ocean Sediments: Novel Tracers to Examine Habitats of Cetaceans, Pinnipeds, Penguins and Humans. Marine Biology. V.102:431-437

Venkatesan, M. and I. Kaplan. 1990. Sedimentary Coprostanol as an Index of sewage Addition in Santa Monica Basin, Southern California. Environ. Sci. Tech. V.24(2)208-214

von Schirnding, Y., Strauss, N., Robertson, P., Fattal, B., Mathee, A., Blignaut, R. Kfir, R. and V. Cabelli. 1992. Morbidity Among Bathers Exposed to Polluted Seawater. A Prospective Epidemiology study. South African Med. J. V.81:534-540

Walker, A. 1992. Swimming: The Hazards of Taking a Dip. British Med. J. V.304:242-247

Warshall, P. and R. Coats. 1992. Malibu Wastewater Management Study. Prepared by Peter Warshall and Assoc. and Phil Williams and Assoc. for the City of Malibu.

Yates, M. and C. Gerba. 1985. Virus Persistence in Groundwater. Appl. Env. Micro. V.49:778-781

Prepared For:

The Santa Monica Bay Restoration Project
101 Civic Plaza Drive
Monterey Park, CA 91754-2156

(213) 266-7516

Prepared By:

Mark Gold
(Principal Investigator)
Staff Scientist,
Heal The Bay

John Dorsey
Biology Lab Manager, City of Los Angeles' Environmental Monitoring Division, Hyperion Sewage Treatment Plant

Mellada Bartlett
Microbiology Lab Director, City of Los Angeles' Environmental Monitoring Division, Hyperion Sewage Treatment Plant

Charles McGee
Senior Microbiologist in the Virus Lab of the Los Angeles County Sanitation Districts

An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses From Two Santa Monica Storm Drains

Technical Report

June, 1990

EXECUTIVE SUMMARY TO TECHNICAL REPORT

Concern has been raised that swimming near storm drains in Santa Monica Bay may increase health risks. In order to address this concern, a multi-phased approach was begun to determine if there is a health risk from swimming in storm drain contaminated waters without human fecal sources. As a first step, a pilot study was designed to address two questions:

1) Are there excessive levels of bacteria in the surfzone adjacent to storm drain outfalls?; and

2) Are there human fecal inputs to the storm drains?

The pilot study consisted of samples collected from the storm drains and surfzone in front of two Santa Monica storm drains (Pico-Kenter and Ashland) during August and September, 1989. Surfzone samples were analyzed for the bacterial indicators: enterococcus and total and fecal coliforms. Runoff from the storm drains was analyzed for the presence of human enteric viruses, and the densities of bacterial indicator organisms and male specific coliphage. Samples were taken on eight days in the surfzone and on fifteen days in the storm drains over a two month period.

Elevated bacterial indicator levels were found in the storm drains on all fifteen sampling days. In addition, excessive levels were exceeded in the surfzone adjacent to the storm drains on all eight sampling days. In the surfzone, excessive levels were frequently exceeded at ankle depth and less often at chest depth.

For the purpose of this study, indicator excessive levels were defined as levels that exceeded the surfzone numerical values contained in the California Ocean Plan (SWRCB, 1990a). Those levels were: 1000 total coliform, 200 fecal coliform, and 24 enterococcus per 100 mls of water. Although there are no standards for human enteric virus or male specific coliphage, their levels were measured because enteric viruses are pathogenic and male specific coliphage may simulate the behavior of pathogenic viruses in the ocean. Also, the level of concern for human enteric viruses was virus detection.

Human enteric viruses were found on 11 of 15 sampling days in the Pico-Kenter storm drain. The finding is significant because it demonstrated that there was human fecal waste in the runoff. Possible sources could have included illegal sewage connections, leaking sewer lines, blocked sewer overflows, or the local homeless population. Although no enteric viruses were found in the Ashland storm drain samples, further analysis of the samples suggested that the failure to detect viruses could have been due to sea water

dilution or to the presence of other constituents in the Ashland runoff which interfered with virus detection. Therefore, Ashland storm drain results cannot be considered conclusive.

The virus data collected for this study produced qualitative, not quantitative results. While the presence or absence of viruses in runoff was determined, the data were inadequate for the purposes of calculating the health risk from swimming near storm drains.

Based on the results of this study, the following are recommended for completion in 1990:

1) Investigate potential sources of human fecal input to the Pico-Kenter storm drain system.

2) Conduct enteric virus sampling at an expanded number of storm drains along Santa Monica Bay.

3) Assess the dispersion of runoff in the shoreline environment.

4) Assess the number of people bathing near storm drains in order to estimate the number of people exposed to storm drain runoff.

TABLES

1. Percentage of Days where Excessive Levels Exceeded at Ankle Depth for Pico-Kenter and Ashland at 25 and 150 Yards from the Drains

2. Seed Virus Recovery Experiments

3. Results of Enteric Virus and F-male Specific Coliphage Collection

4. Correlation Matrix for Indicators in the Storm Drains

5. Division Table: Possible Outcomes of Surfzone Pathogen Assessment

FIGURES

1. Location of Sampling Sites

2. The Locations in the Surfzone and Stormdrain where Monitoring Took Place.

3. Percentage of Sampling Days Where Excessive Levels of Bacterial Indicators Were Exceeded Near the Pico-Kenter Storm Drain

4. Geometric Means of Bacterial Indicator Densities at Pico-Kenter Storm Drain

5. Percentage of Sampling Days Where Excessive Levels of Bacterial Indicators Were Exceeded Near the Ashland Storm Drain.

6. Geometric Means of Bacterial Indicator Densities at Ashland Storm Drain

I. INTRODUCTION

Reports of ear, eye, wound and intestinal infections, skin rashes and other more serious illnesses, have heightened the public's perception that recreational activities in Santa Monica Bay may increase health risks. In Santa Monica Bay, high densities of bacteria that may indicate pathogens (organisms actually causing illness) are most often associated with inputs from storm drains and sewage spills (SCAG, 1988). However, large sewage spills usually do not occur during the warm, dry months when millions of people visit the beaches. Nearly all of the human exposure to high surfzone indicator densities occurs in close proximity to storm drains. However, no scientific assessment has yet been undertaken of health risks associated with high densities of indicator bacteria in the surfzone near storm drains.

High densities of indicator bacteria in the surfzone are associated with urban runoff, based on a survey of existing data (SCAG, 1988, CLA EMD, 1989) and an examination of L.A. County Department of Health Services weekly surfzone monitoring data from 1987 and 1988. In order to decide whether or not there is a health risk from swimming near storm drains, characterization of the microbial organisms in the storm drains and surfzone is a necessary first step.

The purpose of this pilot study was to address two questions:

1) Are densities of indicator bacteria above excessive levels in the surfzone adjacent to the storm drains?
Since the results of this study may be used by decision makers and regulators, excessive levels for bacterial densities were based on standards and recommended values found in the California Ocean Plan (SWRCB, 1990a). Levels were exceeded when:

a. total coliforms were greater than 1000 colony forming units per 100 ml of water (cfu/100 ml);

b. fecal coliforms were greater than 200 cfu/100 ml; and,

c. enterococci were greater than 24 cfu/100 ml.

2) Are there human fecal inputs to the storm drains?
Samples from the storm drains were analyzed for human enteric viruses, pathogens that cause adverse health effects and are specific to human waste (Lennette and Schmidt, 1969). Also, analyses of runoff for enteric virus differentiates between effluent with high levels of bacterial indicators from strictly urban runoff sources and runoff containing human sewage.

The state and federal water contact standards are not based on the densities of pathogens because they are usually few in numbers and they are difficult and expensive to detect. Rather, standards are based on densities of indicator bacteria owing to their ease of detection, abundance in mammalian guts, and long history of use to indicate sewage contamination (SWRCB, 1990a). Bacterial indicator standards are detailed in the California Ocean Plan (SWRCB, 1990a).

The indicator bacteria, total and fecal coliform, usually are not pathogenic, but they are easily detectable and abundant in sewage and runoff. However, total and fecal coliform bacteria are not specific to humans or other warm blooded animals. Total coliforms can exist on soil particles and vegetation surfaces. In addition, both total and fecal coliforms do not survive as long in the marine environment as the viral pathogens of concern. Therefore, they tend to be poor indicators of viral contamination in ocean waters.

Suitable indicator organisms should have similar persistence and survivability in the ocean to the viral pathogens of concern. Enterococcus better mimics the survival of viral pathogens than total and fecal coliforms (Fattal et al. 1983). Female specific coliphage, a possible viral simulant, may survive even longer in marine waters than enterococcus (SCAG, 1988). For this reason, the utility of coliphage as an indicator organism now is being examined closely by both public agencies and researchers.

Based on an epidemiology study between 1972 and 1978, Cabelli et al. (1979, 1982) found that swimmers in sewage polluted marine water on the East and Gulf coasts experienced a higher incidence of gastroenteritis (short-term illness characterized by nausea, fever, and diarrhea). Gastroenteritis probably is caused by exposure to the Norwalk-type viruses and rotaviruses (Rao and Melnick, 1986, and CDC, 1987). Because gastroenteritis was the only illness that occurred with a significantly increased incidence in swimmers, these viruses may be the major pathogens of concern for ocean swimmers.

Cabelli et al. (1979, 1982) also found that coliform densities did not correlate significantly with the incidence of adverse health effects in swimmers in sewage contaminated waters. However, the densities of enterococci correlated with the incidence of gastroenteritis.

There has never been a study similar to the EPA study on the Pacific coast, with colder water temperatures and possibly longer pathogen survival rates (Yates and Gerba, 1984), to corroborate EPA's findings on the east coast. The results of other studies have demonstrated that there are few data that support the use of coliforms as indicators of the human health safety in marine recreational waters (Elliot et al., 1985, Salas, 1987). The results of these health studies, in conjunction with the fact that no one has ever done an

epidemiology study on swimmers in runoff contaminated waters point to the fact that existing state and federal recreational standards are not health based.

II. METHODS

A. Site Selection

Sites were selected based on historical data collected by the Los Angeles County Department of Health Services (R. Kebabjian, unpublished data). The surfzone adjacent to the Ashland and Pico-Kenter storm drains had the highest densities of indicator bacteria. Only the summer data generated by the LACDHS was examined because this is the time of peak beach use and human exposure to runoff contaminated waters. Because these sites frequently exceeded the Ocean Plan shoreline standards for indicator bacteria, they were selected for the study.

B. Site Descriptions

1) Pico-Kenter Storm drain

This drain is located where Pico Boulevard intersects the beach (Figure 1). The storm drain system drains a large area that includes much of Santa Monica and part of West L.A. and Brentwood. There are two drains: one owned by L.A. County and the other by Cal-Trans. Dry weather flow is conveyed in a single pipe underneath the beach. Flow exits from the pipe under pressure at a zone close to the mean high tide line. The storm drain flows year round with a typical dry flow of approximately 0.5 cubic feet per second (Mitchell, pers. comm., 1990).

2) Ashland Storm drain

This drain is an extension of the point where Ashland Avenue intersects the beach, approximately one half mile south of the Pico-Kenter drain (Figure 2). The storm drain discharges from a large concrete outfall on the south side of a rock jetty near the mean tide line. Ashland storm drain, like most of the smaller storm drains, has intermittent flow during the dry season. The storm drain system drains a small commercial and residential area on the south side of Santa Monica.

C. Sampling Design and Procedures

1) Bacteriology

a) Sampling Design and Frequency

The study was carried out over a nine week period during August and September, 1989. Ideally, sampling would have occurred during weekends when the most people were using the beach. However, because of the logistical requirements of the microbiology laboratories, sampling was conducted during morning hours on Thursdays and Fridays. All bacterial samples were tested within six hours of sampling.

Surfzone sampling occurred on eight days over a five week period, and on 15 days over a nine week period in each of the two drains. Replicate samples (n=3) for bacterial analyses were collected at six sites offshore from each drain (Figure 2) and at one site from within the storm drain itself. Samples from the Pico-Kenter drain were pumped from pooled runoff flow redirected by a weir to the dry flow pipe. The sampling site was approximately one quarter mile upstream from the mouth of the drain. Samples from the Ashland drain were pumped up from the drain's manhole approximately 200 yards upstream from the drain's outlet.

The six surfzone sampling points represented a grid presumably covering the most elevated indicator counts in the surfzone. Northern sampling points for the Ashland drain were thirteen yards from the drain because the drain empties on the south side of a rock jetty. Also, single samples were taken at 25 and 150 yds north and south of the storm drains at ankle depth in order to provide information on bacterial densities further away from the drains. All samples were taken from the incoming breaking surf. The ankle depth samples were taken as the surf foam reached the sample bottle at the height of the sampler's ankle. The chest samples were taken where the breaking waves reached the chest height (approximately 3 to 4 ft) of a medium sized adult. Chest depth sampling usually occurred between 30 and 50 yards further away from the drain than ankle depth sampling.

b) Sampling and Analysis

Samples were collected in 125 ml and one liter, high-density, sterile polypropylene bottles, placed on ice, and transferred to the Environmental Monitoring Division's (EMD) microbiology laboratory at the Hyperion Treatment Plant.

Densities of total and fecal coliforms were determined according to Standard Methods (APHA, 1985) using the membrane filtration technique (Section 909). The nutrient enrichment procedure was used for total coliform analyses as recommended in Standard Methods Section 909a. Tests for enterococci followed recommended EPA

3-622

(1985) procedures using m-E and Esculin Iron Agar media. Results were reported in colony forming units (cfu/100 ml).

2) Virology

a) Sampling Design and Frequency

Virus sampling occurred concurrently with bacteria sampling at both drains during the entire fifteen days of sampling. The Ashland storm drain was sampled for viruses on 14 days. Storm drain sampling occurred concurrently with surfzone sampling during the eight days of surfzone sampling.

Fifteen days were determined necessary to ensure that there were no enteric viruses in the storm drains sampled. This number of days without detectable enteric virus in a sample were deemed sufficient to predict with 90% certainty that fewer than 20 out of 100 samples contain human enteric viruses (Paul Papanek, pers. comm., 1989).

b) Seed Study

Seed studies were performed using methods described by adsorption and elution techniques (Standard Methods 913-A modified, 1985). Prior to virus sampling, two 35 gal containers were filled with storm drain effluent. A known quantity of attenuated poliovirus (vaccine strain) was added to each container. Replicate (n=3) grab samples (1 ml) were taken from each container at the beginning and the end of the field concentration procedure. Concentrations of the poliovirus then were determined in these samples, establishing baseline virus levels and effluent toxicity to the virus.

The seeded runoff then was concentrated as described below. Virus levels in the final concentrate were compared with expected levels derived from baseline measurements to give the percent recovered. Two seed studies were completed at the Pico-Kenter storm drain and one at the Ashland drain.

c) Sampling and Analysis

i) Enteric Viruses

Enteric viruses were sampled at the storm drain sites using a modified version of Standard Method 913-A (1985). Approximately 100 gallons were filtered per sample. The field sampling was conducted by James M. Montgomery Engineers, Inc. A detailed description of the enteric virus sampling protocol is in "The USEPA Manual of Methods for Virology" (1984).

The long field processing time (approximately 1.5 hours) required that sampling began in the morning and continued until noon. Because of possible variation in storm drain effluent from morning to afternoon, morning sampling was alternated between the two drains.

Two-liter eluates from the field sample were delivered to the laboratory and reconcentrated using an organic flocculation procedure (Katzenelson et al. 1976). Final concentrates were detected prior to assay (Glass et al. 1978).

All of the samples were initially put on test (Buffalo green monkey kidney cells) for the detection of plaque forming units (PFU). If a sample was negative for PFU then another fraction of the sample was put on test for detection of cytopathic effect (CPE)(Lennette and Schmidt, 1969). If the sample was positive for CPE, then the result was confirmed by plaque assay. A detailed description for cell culture and virus assay is presented by EPA (1984).

ii) F-Male Specific Coliphage

Replicate grab samples (n=3) were obtained on 15 days at the storm drain sites (from splits of the bacterial samples) and analyzed for F male-specific coliphage by the Sanitation Districts' virology laboratory. The F-male specific coliphage assay methods used were obtained from Dr. V. Cabelli (personal communication). See Appendix I for the methods.

3. Quality Assurance and Quality Control (QA/QC)

The QA/QC protocols established by Standard Methods (APHA,1985) and USEPA (1984, 1985) were followed. In addition the QA/QC project plan for the study was approved by Rose Fong, a QA officer for EPA Region IX.

4. Other Measurements and Observations

a) Chemical/Physical

Concurrent with microbiological sampling, temperature of the storm drain runoff and surfzone waters was measured. Also, conductivity and pH of the storm drain runoff was determined on each sampling day.

b) Beach Observations

Among the parameters noted on the beach were number of birds on the shoreline, number of swimmers at the site, tidal conditions, surf conditions, and general conditions (litter, physical changes at the site, decaying organic matter on-site).

5. Data Analyses

Geometric means (+ or - 2 standard errors) were calculated for bacterial indicators and F-male specific coliphage. The storm drain runoff and ankle depth surfzone means may represent underestimations because the data included many values outside the countable range (greater than 3). The chest depth means may represent overestimations because the data often included values less than 1 (-) the countable range.

Correlation coefficients were calculated using Spearman's Rank Correlation test for F-male specific coliphage and bacterial indicators. The correlation coefficients for F-male specific coliphage and enteric viruses were determined using logistic regression.

The percentage of days which exceeded excessive levels was calculated with all raw data. If any replicate on any day exceeded the level of concern, the day was considered above the level of concern.

III. RESULTS

A. Indicator Bacteria

1) Pico-Kenter Storm Drain

All of the storm drain samples exceeded excessive levels for enterococcus and total and fecal coliforms. The frequency of measurements that exceeded the excessive levels was lower in the surfzone compared with storm drain effluent (Figure 3). At ankle depth, excessive levels were always exceeded in front of the drain for all indicators, and except for fecal coliforms, at the sampling point 10 yards south of the drain. At chest depth, excessive levels were exceeded less frequently compared with ankle depths (Figure 3).

Although very few samples were taken, indicator excessive levels were frequently exceeded at sampling points 25 and 150 yards from the Pico-Kenter drain (see Table 1).

The geometric means of the bacterial measurements (Figure 4) further demonstrate the differences in indicator densities between the storm drain, ankle depth and chest depth samples. For both storm drains, the geometric means, 95% confidence intervals and countable ranges for the bacterial indicators are presented in Appendix 2. Storm drain samples had mean levels easily one hundred times the excessive levels for the three indicators, while the geometric means of the ankle depth samples were very close to excessive levels. The geometric means of the chest depth samples were well below the excessive levels.

The mean densities of bacterial indicators in samples from the Pico-Kenter drain significantly correlated with each other (Table 4).

2) Ashland Storm Drain

As at Pico-Kenter, excessive levels at the Ashland drain site were exceeded most frequently in the storm drain and least at chest depth (Figure 5). In the surfzone, at both ankle and chest depths, enterococci and total coliform levels were exceeded from 38 to 86 percent of the time. Densities of fecal coliforms exceeded excessive levels less frequently. Like Pico-Kenter, excessive levels were frequently exceeded at sampling points 25 and 150 yards from the storm drain (Table 1).

The geometric means of the bacterial indicators (Figure 6) also were similar to the Pico-Kenter results. Indicator densities in drain samples were nearly 100 times above the surfzone excessive levels. Although indicator densities at ankle depth were not as high as Pico-Kenter, they still were above excessive levels for enterococci and total coliforms. The reduction in densities from ankle to chest depth was not as marked as at Pico-Kenter; geometric means of the densities at chest depth were below excessive levels.

Unlike Pico-Kenter, mean densities of bacterial indicators in Ashland drain runoff did not significantly correlate with each other (Table 4).

B. Viruses

1) The Seeding Study

Seeding studies were carried out at the Pico-Kenter drain on August 2 and 3, 1989. Recovery of the seeded poliovirus was 21% and 27% (Table 2). Only 2.5% of the seeded poliovirus was recovered from Ashland runoff.

2) Enteric Virus

Human enteric viruses were detected in Pico-Kenter runoff on 11 of the 15 sampling dates (Table 3). However, no enteric viruses were detected during the 14 days of sampling at the Ashland drain.

To ensure that the runoff was not contaminated with poliovirus from the seeding study, the isolates (viruses from the plaques) from the first Pico-Kenter drain sample were identified using the LBM (Lim Benyesh-Melnick) virus pool (Lim and Benyesh-Melnick, 1960). The isolates were identified as a coxsackievirus and an echovirus (two pathogenic enteric viruses), which ruled out the possibility that these isolates were residual poliovirus from the seeding study. These were the only isolates identified during the study.

C. F-Male Specific Coliphage

The Pico-Kenter indicator densities ranged from 100 to 15,000 coliphage per 100 ml with a geometric mean of 2,200 (Table 3). The Ashland indicator densities were much lower. They ranged from less than 10 to 4,000 coliphage per 100 ml with a geometric mean of only 140.

There was no correlation between male specific coliphage densities and the densities of bacterial indicators (Table 4). Coliphage densities varied independently from bacterial indicator densities. Also, there was no correlation between male specific coliphage densities and the presence or absence of enteric viruses in the storm drains.

D. Other Measurements and Observations

Conductivity of Ashland runoff over the 15 days of sampling, ranged from 3 to 34 mmhos with a mean of 25.2 mmhos. Conductivity of Pico-Kenter runoff ranged from 0.8 to 8.6 mmhos with a mean of 5.6 mmhos.

The ocean water temperature ranged from 18 to 20 C during the eight days of surfzone sampling.

The number of seabirds within 25 yards of the storm drains ranged from none to a high of 34. Generally, there were about ten times more seabirds recorded in the vicinity of the Pico-Kenter drain compared with the Ashland site.

IV. DISCUSSION

A. Indicator Bacteria

The first question of the study focused on whether or not elevated levels of indicator bacteria occurred in the surfzone around the mouths of storm drains. By the eighth day of surfzone monitoring, densities of indicator bacteria were found to frequently exceed excessive levels at ankle depth, and less often at chest depth at the two drains. Because the question was answered early in the study, surfzone monitoring was concluded after the eighth day. Further study is needed to assess the spatial extent of high indicator bacteria densities in the surfzone.

Although few samples were taken further than 10 yards from the storm drain at ankle depth, indicator densities exceeding excessive levels were measured as far as 150 yards from the drains. The City of Los Angeles' Environmental Monitoring Division conducts daily shoreline indicator bacteria monitoring at a site (Station S6) approximately 200 yards

south of the Pico-Kenter drain. The densities at Station S6 were far below state standards on all eight days of the sampling period.

Bacterial indicator densities in Pico-Kenter runoff significantly correlated with each other, while this was not the case in Ashland runoff. One possible explanation for the Pico-Kenter bacterial indicator correlations was the confirmed presence of human sewage in the drain affecting indicator ratios.

B. F-Male Specific Coliphage

Mean male specific coliphage densities in the Pico-Kenter drain were over ten times greater than those found in the Ashland drain (2,200 to 140). Higher densities of male specific coliphage are expected in sewage contaminated waters than in waters without human fecal inputs (Cabelli, pers. comm., 1989), but there was not enough information on inputs to explain the higher coliphage densities in the Pico-Kenter drain. Also, the variability in the coliphage data was extremely large. Conductivity data also suggest that the Ashland drain may have had a larger input of tidal ocean water (which would have diluted the flow and lowered the coliphage densities) than the Pico-Kenter drain.

Other than with fecal coliform densities at Ashland, the male specific coliphage measurements did not correlate with the densities of any of the indicator bacteria (Table 4). Also, male specific coliphage densities did not significantly correlate with the presence or absence of enteric viruses in the Pico-Kenter runoff. However, none of the other bacterial indicators correlated with the presence or absence of enteric viruses. For the purposes of this study, none of the indicators were good predictors for the presence or absence of human enteric viruses.

C. Enteric Virus

1) Seeding study

The results of the seeding study demonstrated the effectiveness of the sampling methodology in capturing enteric viruses in the field. The results from the Pico-Kenter seed study were fairly typical (virus recoveries of 20 to 30%, Rao and Melnick, 1986) of environmental virus sampling of water and wastewater. However, the recovery of only 2.5% of the Ashland poliovirus was extremely poor. One reason for the poor recovery was that materials in the runoff may have negatively impacted the efficiency of the filter. Runoff with a high oil and grease and/or humic acid content can cause the virus adsorbing filter to function poorly. The Ashland watershed is predominantly residential so vegetation (a potential source of humic acid) in the storm drain would be expected as a fairly common occurrence. Another possible reason for the poor recovery was runoff toxicity. Future storm drain sampling for virus should include at least three preliminary seeding studies, in order to obtain a more accurate recovery estimate.

2) Ashland

No enteric viruses were detected at the Ashland storm drain during the sampling period. However, the problems with the sampling method's low virus recovery decreased the probability of detecting virus in the runoff. Also, the average conductivity of the runoff sampled was 25.0 mmhos which is nearly the same as sea water (approximately 32 mmhos). It is clear that sea water diluted the runoff sampled. Other factors that may have affected the results were runoff toxicity, variation in runoff flow (the drain did not flow on at least three separate days), and temporal variation in contaminant sources and loadings to the storm drain.

3) Pico-Kenter

Human enteric viruses were detected on eleven of fifteen sampling days, indicating that human fecal waste was present in Pico-Kenter runoff during the majority of the sampling period. The detection of a single human enteric virus is indicative of human fecal contamination in the storm drain. Possible sources of human fecal inputs could be leaky sewer lines, blocked sewer overflows, illegal connections, or homeless populations within the storm drain watershed. Due to the aforementioned problems with virus recovery, runoff toxicity to the cultured cells, etc., negative results found on four days were considered inconclusive.

4) Quantification of enteric virus concentrations in the runoff

Detection of enteric viruses in the storm drains established that Pico-Kenter was receiving human fecal inputs during the two month sampling period. However, accurate measurements of virus concentrations in runoff can not be made because of the following limitations:

a) In the final virus concentrates low levels of viruses would not be normally distributed. Since the entire volume was not analyzed, some viruses may have been missed.

b) One of the basic limitations of virus testing is that no cell line can detect all of the enteric viruses present in the sample.

c) Quantification using the cytopathic effect (CPE) technique is possible using the Tissue Culture Infectious Dose or Most Probable Number techniques, but these were not attempted with these samples. Therefore, samples exhibiting CPE could have been positive by one infectious unit or by many infectious units.

d) The results of the seeding studies demonstrated that the density of viruses in the samples were estimated. Poliovirus recovery at Ashland drain was only 2.5%, demonstrating the large uncertainty in the accuracy of the sampling method.

e) Toxicity to cultured cells was noted in the beginning of the study and concentrates had to be diluted prior to assay. However, the toxicity effect of the runoff concentrate on enteric viruses could not be assessed. The viruses may have been inactivated and/or experienced a loss of infectivity which could have triggered a negative result on the assays.

f) It is not appropriate to extrapolate densities from a portion of a sample with low densities of viruses. Only 10% of the sample was used in plaque screening.

g) One plaque forming unit or one infectious unit may be one infectious virus or a large clump of viruses (Bitton, 1980).

5) Implications to recreational bathers

Finding evidence of human fecal inputs into the Pico-Kenter drain may affect the public's perception of acute health risk from swimming in the Bay. Ideally, a risk assessment of the virus data would be completed and sent to decision makers and risk managers. However, the data are not available to perform a quantitative risk assessment.

It was previously assumed that the storm drains were completely free of sewage inputs except in the case of sewage overflows. However, human fecal waste was in the Pico-Kenter drain during August and September, 1989. There are public health risks from swimming in human waste contaminated waters, but due to limitations of the data, it is impossible to accurately quantify the health risk from swimming in the runoff contaminated waters near the Pico-Kenter storm drain.

The following is a list of the limitations of the results for the purpose of risk assessment:

a) Problems with quantification of enteric viruses in the runoff (see above).

b) The virus analytical methods do not detect all of the enteric viral pathogens.

c) Runoff is a flowing medium that is extremely variable. Physical (flow, pH, total suspended solids, etc.), chemical (oil and grease, heavy metals, etc.) and biological (bacterial indicator densities) parameters vary greatly over time. Virus concentrations were expected to vary over time as well.

d) At low virus densities, one can not assume that the viruses are normally distributed throughout the runoff or the surfzone after discharge. Also, there are large uncertainties

in developing an accurate dilution factor for storm drains and runoff in the ocean.

e) Without knowing what viruses were in the storm drain, it is impossible to estimate the minimum infectious dose for people exposed to virus contaminated sea water, unless it is assumed that exposure to one virus would result in infection.

RECOMMENDATIONS

A decision table was completed before the study for the purpose of determining the future course of this research (Table 5). Recommendations were based upon applying the results to the decision table. The following recommendations should be implemented:

1) Investigate potential sources of human fecal input to the Pico-Kenter storm drain.
A survey for the Pico-Kenter drain should be designed, tested, and implemented in order to find the source(s) of human fecal inputs to the storm drain system.

2) Conduct enteric virus sampling at an expanded number of storm drains along Santa Monica Bay.
Enteric virus sampling should be completed at a series of storm drains along Santa Monica Bay. The results of this monitoring effort would provide information on the prevalence of human fecal contamination of the storm drains. Ocean sampling for virus is not recommended until methods are better established.

3) Assess the dispersion of runoff in the shoreline environment.
One possible method of assessing the dispersion of storm drain runoff in the shoreline environment would be the completion of a runoff dye study followed by expanded surfzone monitoring. The results of the runoff dye study could be compared to the results of an expanded surfzone bacterial indicator monitoring study in order to confirm the dye study results and to provide information on the spatial variability of indicator densities.

4) Assess the number of people bathing near storm drains in order to estimate the number of people exposed to storm drain runoff.
Characterization of the beach going population is necessary before an epidemiology study can occur. Observations should be made on the number of people who wade and swim in storm drain contaminated waters. The swimming and beach going populations should be further characterized by age, sex, and ethnicity.

REFERENCES

APHA. 1985. Standard Methods for the Analysis of Wastewater. 16th Edition: Sections 909, 909a, and 913-A.

Bitton, G. 1980. Introduction to Environmental Virology. published by John Wiley and Sons. N.Y., N.Y.

Cabelli, V.J., Dufour, A.P., McCabe, L.J., Levin, M.A. and P.W. Haberman. 1979. Relationship of Microbial Indicators to Health Effects at Marine Bathing Beaches. AJPH. V.69(7):690-696

Cabelli, V.J., Dufour, A.P., McCabe, L.J., and M.A. Levin. 1982. Swimming Associated Gastroenteritis and Water Quality. Am. J. Epidemiology. V.115(4):606-616

Centers for Disease Control. 1987. Outbreak of viral gastroenteritis: Pennsylvania and Delaware. MMWR 36:710-711

City of Los Angeles, Environmental Monitoring Division. 1989. Santa Monica Bay Annual Assessment Report. Bacteriology section. 12-36.

Elliot, E.L. and R.R. Colwell. 1985. Indicator Organisms for Estuarine and Marine Waters. FEMS Microbiology Reviews. V.32:61-79

Fattal, B., Vasl, R.J., Katznelson, E. and H.I. Shuval. 1983. Survival of Bacterial Organisms and Enteric Viruses in the Mediterranean Coastal Waters of Tel-Aviv. Wat. Res. V.17(4):397-402

Glass, J.S., van Sluis, R.J., and W.A. Yanko. 1978. Practical Method for Detecting Poliovirus in Anaerobic Digester Sludge. Appl. Env. Micro. V.35:983

Katznelson, E., Fattal, B., and T. Hostovesky. 1976. Organic Flocculation: an Efficient Second-Step Concentration Method for the Detection of Viruses in Tap Water. Appl. Env. Micro. V.32:638

Kebabjian, R. 1988. Letter with data entitled, "Enterococci Levels Adjacent to Storm Drains from 1987-1988". L.A. County Department of Health Services.

Lennette, E.H. and N.J. Schmidt. 1969. Diagnostic Procedures for Viral and Rickettsial Infections. APHA publishers. N.Y., N.Y.

Lim, K.A. and Benyesh-Melnick, M. 1960. Typing of viruses by combinations of anti-serum pools. Application to typing of enteroviruses (coxsackie and echo). J. Immunol. V.84:309-317

Rao, V.C. and J.L. Melnick. 1986. Environmental Virology. ASM publishers. Washington D.C.

Salas, H.J. 1987. History and Application of Microbiological Water Quality standards in the Marine Environment. Wat. Sci. Tech. V.18(11):47-57

Southern California Association of Governments. 1988. State of the Bay: Scientific Assessment. section by V.J. Cabelli on Microbial Risk Assessment. 5-30 to 5-53.

Standard Methods: See APHA

State Water Resources Control Board. 1990a. Water Quality Control Plan for Ocean Waters of California (California Ocean Plan). State Board Resolution No. 90-27. 23 pp

State Water Resources Control Board. 1990b. Functional Equivalent Document: Amendment of the Water Quality Control Plan for Ocean Waters of California (California Ocean Plan). State Board Resolution No. 90-27. 179 pp

USEPA. 1985. Test Methods for E. coli and Enterococci. EPA.600/4-85/076.

USEPA. 1984. The USEPA Manual of Methods for Virology. EPA-600/4-84-013.

Yates and Gerba. 1985. Virus Persistence in Groundwater. Appl. Env. Micro. V.49:(4):778-781

TABLE I.

Percentage of Days where Excessive Levels of Indicator Bacteria Were Exceeded at Ankle Depth for Pico-Kenter and Ashland at 25 and 150 Yards from the Drains.

Single samples were taken on each date.

	Pico-Kenter		Ashland	
	25 yds n=7 days	150 yds n=3 days	25 yds n=6 days	150 yds n=3 days
Total	86%	67%	50%	33%
Fecal	43%	33%	17%	0%
Entero.	100%	33%	50%	67%

TABLE 2.

Seed Virus Recovery Experiments.

Runoff was seeded with attenuated poliovirus

Date/Loc	Virus (pfu/ml) Start	End	% Loss	Recoverable Virus (pfu)	Amount Recov.	% Recov.
8-2-89 Pico-Kntr	520	540	0	1.4×10^8	2.9×10^7	21
8-3-89 Pico-Kntr	260	190	27	6.0×10^7	1.6×10^7	27
8-4-89 Ashland	92	80	13	1.8×10^7	4.5×10^6	2.5

pfu = plaque forming units

TABLE 3.

Results of Enteric Virus and F-male Specific Coliphage Collection
Values for F-male specific coliphage are
geometric means of three replicate samples.

Sample date	Enteric Virus Pico	Ashland	F+ Coliphage/100 ml Pico	Ashland
8/10	+	ND	2600	80
8/17	+	-	2400	100
8/18	+	-	4000	200
8/24	+	-	4000	800
8/25	-	-	100	200
8/31	+	-	600	40
9/1	-	-	300	20
9/7	-	-	15000	200
9/14	+	-	5000	<12
9/15	+	-	4000	<10
9/22	+	-	1600	200
9/25	+	-	3000	600
9/27	+	-	2400	20
9/28	-	-	3000	4000
9/29	+	-	5000	4000

Geometric mean (- or + 2 standard errors) of F-male specific coliphage densities for:
All days at Pico-Kenter = 2,200 (1500 - 3200)
All days at Ashland = 140 (80 - 240)

TABLE 4.

Correlation Matrix for Indicators in the Storm Drains

Pico-Kenter

	Coliphage	Total	Fecal	Entero.
Coliphage	1.00			
Total	-0.41	1.00		
Fecal	-0.10	0.59*	1.00	
Entero.	-0.18	0.65*	0.84**	1.00

* = $p<0.05$
** = $p<0.01$

Ashland

	Coliphage	Total	Fecal	Entero.
Coliphage	1.00			
Total	0.09	1.00		
Fecal	0.60*	0.30	1.00	
Entero.	0.21	0.27	0.32	1.00

* = $p<0.05$

Spearman rank correlation coefficients (Rho values) for Ashland and Pico-Kenter drain were determined using the geometric means of the three replicates for each sampling date. The upper limit of the countable range was substituted for those mean densities that exceeded the maximum countable range. There were fifteen different sampling dates for Pico-Kenter and 14 different dates for Ashland.

TABLE 5.

DECISION TABLE
POSSIBLE OUTCOMES OF SURFZONE PATHOGEN ASSESSMENT

Result	Virus in Drain	Indicator in Drain	Indicator in Surf	Decision
1	-	-	-	Repeat following summer
2	-	+	-	Repeat following summer
3	+	-	-	Sanitary survey; repeat following summer. Sample for virus in surf if no controllable source
4	+	+	-	
5	+	+	+	Sanitary survey, sample for virus in surf; expanded surf study in following summer*
6	-	+	+	Sample for virus in surf; expanded surf study in following summer*

- indicates below acceptable microbial levels;
+ indicates above acceptable microbial levels.
* expanded surfzone study

3-630

Figure 1. Location of sampling sites.

Figure 2. Station locations in the surfzone and storm drain where monitoring took place. Samples were taken on eight days in August and September of 1989.

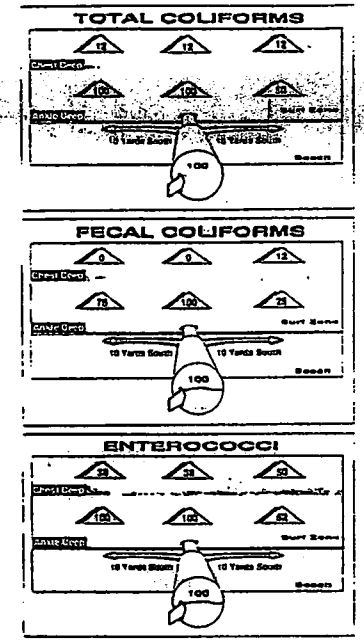


Figure 3. Percentage of sampling days where excessive levels of bacterial indicators were exceeded near the Pico-Kenter storm drain (excessive levels: total coliforms = 1000 CFU /100 ml, fecal coliforms = 200 CFU/100 ml, enterococci = 24 CFU/100 ml). Triplicate samples were collected for eight days from the surfzone and on 15 days from the storm drain.

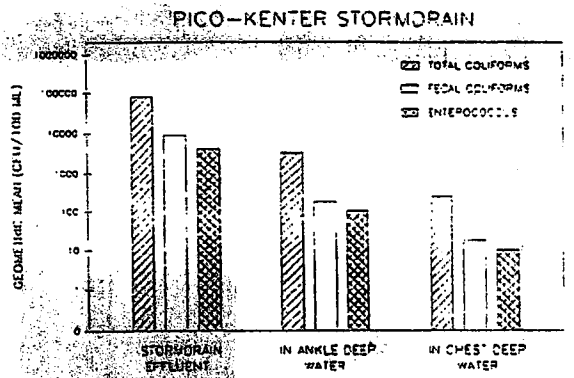


Figure 4. Geometric means of bacterial indicator densities (colony forming units - CFU per 100 ml) at Pico-Kenter storm drain are represented. The storm drain runoff and ankle depth surfzone means may represent underestimations because the data included many values outside the extensive range (greater than, >). The chest depth means may represent overestimations because the data often included values less than (<) the countable range. Geometric means were calculated from data collected on eight sampling days with three replicates per station.

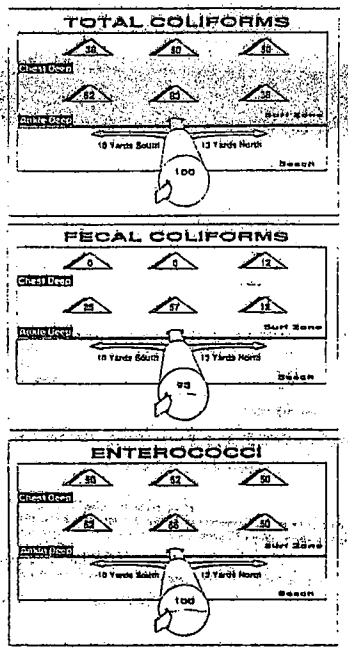


Figure 5. Percentage of sampling days where excessive levels of bacterial indicators were exceedent near the Ashland storm drain (excessive levels: total coliforms = 1000 CFU /100 ml, fecal coliforms = 200 CFU/100 ml, enterococci = 24 CFU/100 ml). Triplicate samples were collected for eight days from the surfzone and on 13 days from the storm drain.

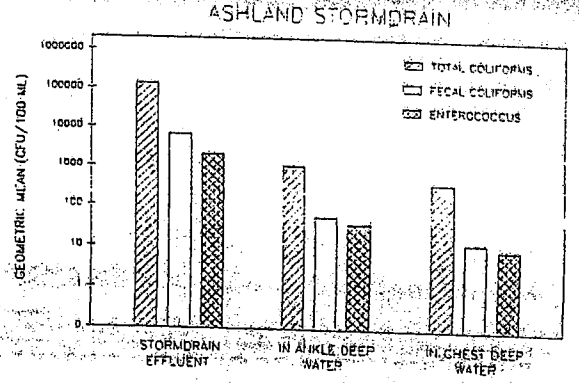


Figure 6. Geometric means of bacterial indicator densities (colony forming units - CFU per 100 ml) at Ashland storm drain are represented. The storm drain runoff and ankle depth surfzone means may represent underestimations because the data included many values outside the countable range (greater than, >). The chest depth means may represent overestimations because the data often included values less than (<) the countable range. Geometric means were calculated from data collected on eight sampling days with three replicates per station.

APPENDIX I. PERTINENT INFORMATION ON f2 BACTERIOPHAGE

The proprietary aspect to this methodology is the host strain of Escherichia coli which contains an F+ plasmid carrying resistances to ampicillin and streptomycin. The host used in this study was the V.J. Cabelli host. Media and procedures were also from Cabelli et. al. and they should be credited.

f2 Bacteriophage Water Concentration Technique

1. Allow sample to come to room temperature.

2. In a 250 ml centrifuge bottle add 1 g powdered tryptone (Difco Laboratories, Inc., Detroit, MI) and 1 g powdered beef extract (Small Laboratories, Inc., Fiskville, RI).

3. Add 100 ml sample to centrifuge bottle, and mix.

4. Add 10 ml of host (F amp) culture grown 3-4 h in tryptone broth.

5. Incubate at 37°C on a rotary shaker set on low (very slow) for 50 minutes.

6. Centrifuge at 9000 x g for 15 min. at 3-4°C.

7. Aspirate all except 10 ml out of centrifuge bottle.

8. Resuspend pellet in the remaining 10 ml volume.

9. Assay these 10 ml by adding 2.5 ml volumes to 2.5 ml amounts of double strength top (soft) agar, tempered to 45-50°C, for each of 4 plates.

10. Mix immediately, pour top agar on bottom agar plates, and spread over entire plate surfaces by gentle swirling.

11. Incubate 18-24 h at 35°C.

12. Count plaques and calculate f2 per 100 ml.

Note: Do not shake host (F amp) culture vigorously. Vigorous mixing of host strain cells will remove pili and inhibit f2 infection.

The 3-4 hour culture added in step 4 can be established by adding a few milliliters of an overnight grown broth culture. The broth used for the overnight culture should contain ampicillin and streptomycin at the same concentration as bottom agar.

Media for f2 phage procedure

Tryptone Broth for 3-4 h host strain (F amp) cultures and for all dilutions involving f2 Bacteriophage.

Ingredient	Amount per liter
Tryptone	10 g
Dextrose	1 g
NaCl	5 g

Note: Tryptone broth is used for dilutions because it helps to disperse bacteriophage and minimizes clumping of f2.

Top Agar for f2 Bacteriophage Plaque Assay

Prepare double strength (2 x) as follows:

Ingredient	Amount per liter
Tryptone	20 g
Dextrose	2 g
NaCl	10 g
agar	14 g
1 ml of 1 M $CaCl_2$ solution	

Heat to dissolve and dispense 2.5 ml volumes per tube.
Store frozen.
Autoclave 15 min., 121°C and cool to 45-50°C before adding equal volume (2.5 ml) sample.

Bottom Agar for f2 Bacteriophage Plaque Assay and Stock Cultures of Host Strain (F amp)

Ingredient	Amount per liter
Tryptone	10 g
Dextrose	1 g
NaCl	5 g
agar	12 g

Add magnetic stirring bar to flask. Autoclave 15 min., 121°C
Cool to 45-50°C.
Add antibiotics:

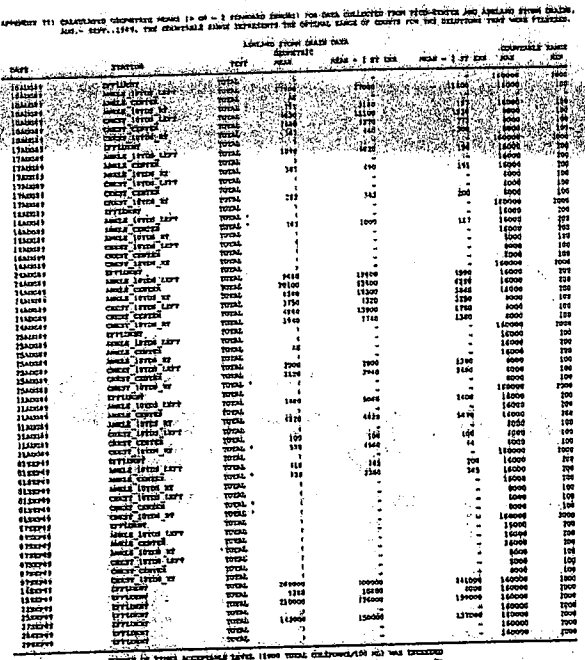
ampicillin	0.015 g
streptomycin sulfate	0.015 g

Magnetically mix gently, then pour plates.

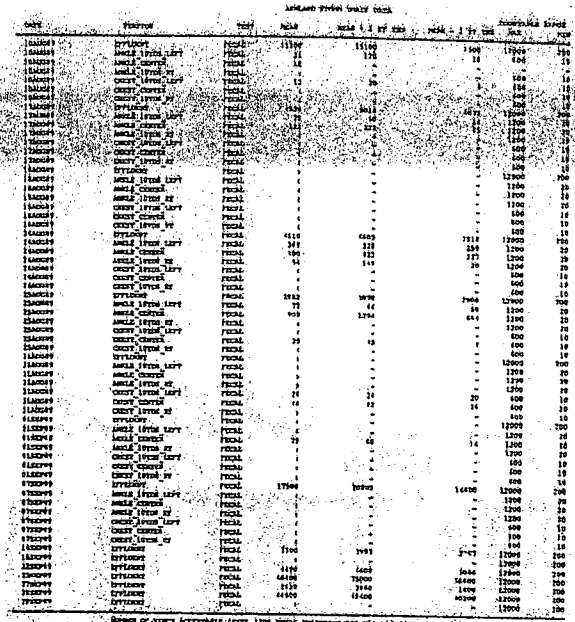
Note: Maintain the host strain on tryptone bottom agar plates containing 15 microgram per ml each ampicillin and streptomycin sulfate. Grow overnight at 35°C, then store in a refrigerator (2-6) for up to several weeks. Use this working stock culture to inoculate tryptone broths when assays are to be performed.

Stock cultures of the host strain must be maintained on antibiotic-containing media to insure the cells contain the F+ plasmid.

3-634



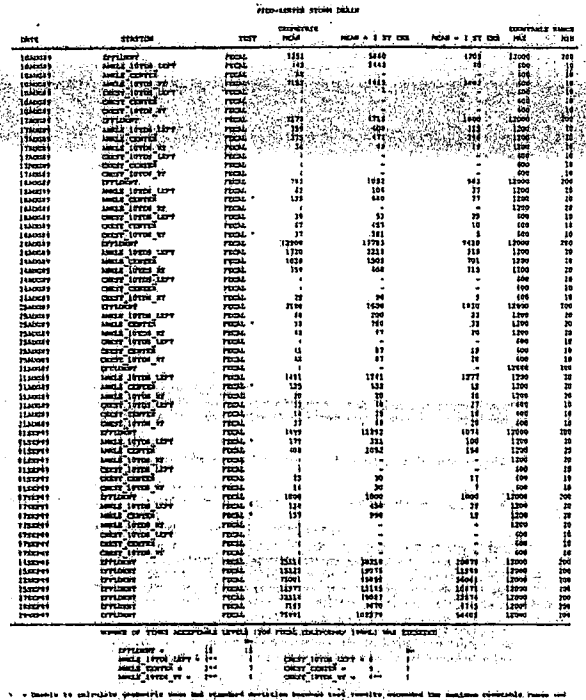
145

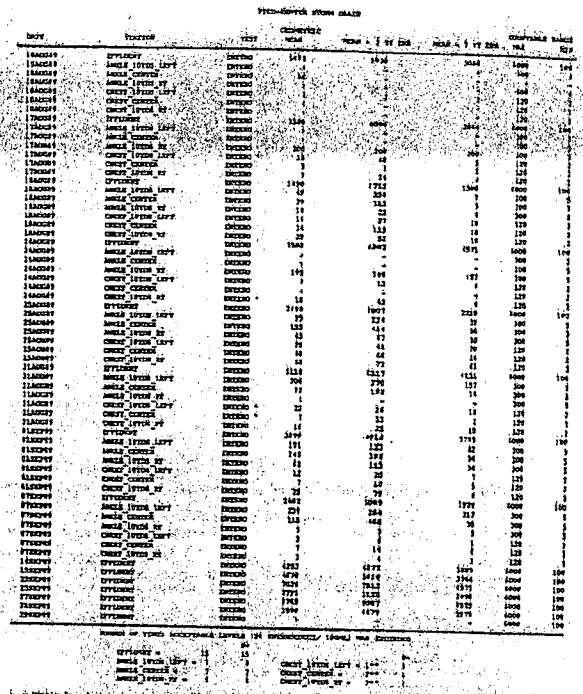


146

147

148





APPENDIX 3. GLOSSARY OF SCIENTIFIC TERMS

Bacteriophage: A virus replicating in, and destroying bacteria.

Coliform: (fecal coliform) a large group of bacteria that has the ability to ferment the disaccharide sugar lactose. The group includes members of the Enterobacteriaceae family including the genera Escherichia, Enterobacter, Klebsiella, Aerobia, and Citrobacter. Other genera within the family Enterobacteriaceae and have biotypes that may occasionally ferment lactose.

Coliphage: A virus that infects coliform bacteria.

Colony forming unit (cfu): A visible mass of organisms developing from one or a group of bacteria. The mass results from the bacterial cells reproducing themselves on an agar plate.

Cytopathic effect (CPE): An analytical technique in which virus may be detected by the microscopically visible changes the virus causes in the host cells as the result of the virus reproducing itself.

Enteric virus: Any of over 110 different types of virus which are transient inhabitants of the human gastro-intestinal tract.

Enterococcus: A group of bacteria consisting of a number of species of the genus Streptococcus, such as S. faecalis, S. faecium, S. avium, S. bovis, S. equinus and S. salivarius. They all give a positive reaction with Lancefield's Group D antisera and have been isolated from the feces of warm-blooded animals.

Epidemiology: A branch of medical science that deals with the incidence, distribution, and control of disease in a population. An epidemiology study is to sum the factors controlling the presence or absence of a disease or pathogen.

F-male specific coliphage: A specific type of coliphage that will only infect a bacterium possessing a receptor for the virus on the bacterium's conjugation tube (F pilus or sex pilus). Genetic material may be exchanged between organisms through the conjugation tube.

Fecal coliform: A subgroup of the total coliform group. Separation into this subgroup is based upon the fecal coliforms' ability to ferment lactose at elevated temperatures as well at 35°C, the optimum for total coliform. Members of the fecal coliforms are found in the feces of various warm-blooded animals, and have been used as a more definitive indicator for recent fecal pollution. The fecal subgroup defines primarily Escherichia coli and occasionally Klebsiella sp.

Geometric mean: The sum of log-transformed values of all the measurements divided by the total number of measurements.

Humic acid: Any of various organic acids produced during partial decomposition of plant or animal matters.

Indicator bacteria: The bacteria which are consistently associated with a particular environmental condition, e.g., presence of human pathogen. Their presence is indicative of the existence of these conditions.

Infectious dose: The level or concentration of a contaminant (bacterial or viral) that is necessary to cause an infection.

Meningitis: A disease caused either by virus or bacteria in which inflammation of the brain membranes occurs.

mmhos: A unit of measurement of electrical conductance of a given substance (liquid, gas or solid) expressed in thousandths.

Seed study: In this context, a calibration experiment in which a known amount of virus was added to storm drain water, the mixture was processed through the virus concentration equipment and the final sample assayed. This type of study allows for a gauge on how efficiently the equipment is working, given the conditions of the water being tested.

Pathogen: An organism that causes illness.

Polio: Short for poliovirus, or poliomyelitis.

Poliomyelitis: An acute infectious disease affecting the spinal cord or brain stem. The destruction of motor neurons in the spinal cord results in flaccid paralysis.

Poliovirus: An enteric virus of the Picornavirus group, Enterovirus subgroup. There are three separate antigenic types of poliovirus. The causative agent for poliomyelitis.

Plaque-forming unit (pfu): An infectious virus or group of viruses that replicates in an indicator system, such as those of bacteria, causing a localized lysis or destruction of the cells in that area. The technique is quantitative for infectious viruses.

QA/QC: Quality assurance (QA) is a system of activities to evaluate the effectiveness of the laboratory's quality control program. Quality control (QC) is a system of activities designed to generate the quality of data necessary to meet the needs of the laboratory, usually referring to consistency and reliability of the data.

Sewage: Refuse liquids or waste matter usually carried off by underground conduits.

Storm drain: Pipes and/or channels running either on the surface or underground which collect and divert storm water of urban runoff into the ocean, rivers, lakes, or treatment facilities.

Surfzone: Not a well-defined scientific term. It usually refers to the intertidal area of sandy beaches where sea water levels change between high and low tide.

Watershed: A region or area bounded peripherally by geographical features causing rainfall to drain to a particular body of water.

Appendix 2

STORM DRAINS AS A SOURCE OF SURF ZONE BACTERIAL INDICATORS AND HUMAN ENTERIC VIRUSES TO SANTA MONICA BAY

by

Mark Gold, Melinda Bartlett, John Dorsey, Charles McGee

August 1991

EXECUTIVE SUMMARY

Based on the public's perception that recreational activities in Santa Monica Bay increase their health risks, the Santa Monica Bay Restoration Project (SMBRP) has decided that quantification of the health risks of swimming in nearshore waters is a priority area of concern. In 1990, a pilot study on bacterial indicator densities in the surf zone near storm drains and human enteric viruses in two Santa Monica storm drains was completed. This year's study was necessary to provide additional information on the distribution of bacterial indicators in the surf zone adjacent to flowing storm drains, the prevalence of human fecal inputs (enteric virus) in three storm drains that discharge to the bay, and a characterization of the bathing population around a flowing drain.

Surf zone indicator bacteria distribution - Elevated densities of indicator bacteria were prevalent in the surf zone around the Pico-Kenter storm drain. These densities frequently exceeded levels of concern, especially at ankle depth. Levels of concern for bacterial densities were based on standards and recommended values found in the California Ocean Plan (SWRCB, 1990). Elevated densities frequently were measured as far as 100 yards from the drain. Bacterial densities generally fell by one order of magnitude from ankle to chest depth. Future work on bacterial distributions should focus on how far from the drain, at ankle depth, background densities are consistently reached.

Enteric virus prevalence - Human enteric viruses were detected for the second year in a row in effluent from the Pico-Kenter storm drain. Vaccine strain poliovirus was found on three of the four sampling dates. No viruses were detected in the runoff from the Santa Monica Canyon or Sullona Creek storm drains. Virus sampling should continue over a longer period of time at Sullona Creek, because the drain receives a wide variety of contaminant inputs. In order to assess the prevalence of human fecal inputs to storm drains, sampling for viruses in the runoff from drains that discharge into the bay during dry weather should continue.

Bather characterization - Results of the bather characterization study at the Santa Monica Canyon storm drain indicated that nearly 100 people per day swam within 100 yards of the drain, the majority of swimmers were 50 to 100 yards from the drain. This information will be necessary for design of an epidemiology study on swimmers in waters contaminated by storm drain runoff. The epidemiology study will be designed in the third year work.

I. INTRODUCTION

A primary goal of the Santa Monica Bay Restoration Project (SMBRP) is to find out if there are health risks from swimming in the Bay. Has recreational waters, the issue of bare swimming in the Bay has been questioned by the public and environmental managers based on numerous anecdotal reports of illnesses associated to swimming in the Bay, and from measurements of elevated densities of indicator bacteria from around storm drains where their effluents enter the surf zone (SCAG, 1988; CRA EMD, 1989, 1990, 1991). Ultimately, these concerns should be addressed through an epidemiology study to evaluate swimming in the Bay as a risk factor for acute illness.

A number of questions still need to be addressed prior to deciding to conduct a large scale epidemiology study, such as study location, duration, number of swimmers needed, and cost. The epidemiological study should be conducted on recreational bathers in waters with high indicator bacteria densities, but no human fecal input. These conditions would provide information on the health risks from swimming in waters contaminated only by urban runoff contaminated with animal wastes. Previous studies associated health risks with bacterial densities of the indicator, enterococcus, in sewage contaminated waters (Cabelli et al. 1982). However, the densities of the indicator bacteria, fecal and total coliforms, did not correlate with the incidence of adverse health effects in recreational bathers.

This report is the second in a series to characterize densities of virus and indicator bacteria (total and fecal coliforms, enterococcus) in and around flowing storm drains discharging into Santa Monica Bay. In the first report (Gold et al., 1990), a pilot study was performed to determine levels of indicator microorganisms in the surf zone near two storm drains and human enteric viruses in the same drains. This study revealed that indicator microorganism densities in the surf zone frequently exceeded California Ocean Plan bacterial standards (SWRCB, 1990) in the vicinity of both the Pico-Kenter and Ashland Avenue storm drains. In this study, bacterial "levels of concern" were exceeded when:

a. total coliforms were greater than 1000 colony forming units per 100 ml of water (cfu/100 ml);

b. fecal coliforms were greater than 200 cfu/100 ml; and,

c. enterococci were greater than 24 cfu/100 ml.

Also, human enteric viruses were found in the Pico-Kenter storm drain on 11 out of 15 sampling dates in August and September of 1990. These viruses are pathogenic, causing illnesses from gastroenteritis to meningitis, and are specific to human waste (Lennette and Schmidt, 1969). Their presence demonstrated water in the drain had been contaminated by human sewage on those 11 days. A later investigation revealed that a broken sewer line and an illegal sewage dumper were found discharging material into the drain. Since the release of the 1990 study, the City of Santa Monica has kept the beach closed 100 yards north and south of the Pico-Kenter drain.

A group of studies were performed during the second year of the project, and are reported herein. They were designed to gather additional information needed prior to conducting an epidemiology study. Three studies were completed:

1. Further evaluation of dispersion of indicator bacteria around the Pico-Kenter storm drain;

Further work was done in the first study to refine the distribution of indicator bacteria around the Pico-Kenter drain. Beach warning signs posted next to flowing drains could include a recommended protective distance for bathers to swim from the drains, so better definition of how levels of bacteria diminish with distance from a drain is needed. In this case, the Pico-Kenter drain was chosen because of the historically high levels of indicator bacteria measured adjacent to the drain.

2. Testing for human enteric virus in the Pico-Kenter, Ballona Creek and Santa Monica Canyon storm drains;

In the second study, we continued to survey various storm drain effluents for the presence of human enteric viruses. Pico-Kenter effluents were again sampled to determine if enteric viruses still were present.

3. Characterization of the bather population around the Santa Monica Canyon storm drain.

The third study focused on obtaining an estimate of the number of people bathing near the Santa Monica Canyon storm drain, a potential site of an epidemiological study. This estimate is needed in order to assess the bather risk of illness from swimming in runoff contaminated waters. Characterization of the beach going population is necessary before an epidemiology study can occur. If very few people swim in runoff contaminated waters, then an epidemiological study is less feasible.

II. STUDY SITES

A. Pico-Kenter Storm Drain

The Pico-Kenter drain is located where Pico Boulevard meets the beach. The storm drain system drains a large area that includes much of Santa Monica and part of West L.A. and Brentwood. There are two drains that discharge to the beach: one is owned by Los Angeles County Department of Public Works, and the other by Cal-Trans. Dry weather

There is no text for this page.

flow is conveyed in a single pipe underneath the beach. Flow exits from the pipe at a zone close to the mean high tide line. The storm drain flows year round with a typical dry flow of approximately 0.2 cubic feet per second (Mitchell, pers. comm., 1990).

The Pico-Kenter storm drain was sampled again for human enteric virus to confirm the previous year's findings (Gold et al., 1990). Samples of drain effluent were collected where the bike path crosses the storm drain channel, approximately 200 yds from the surf zone. The distribution of total and fecal coliforms and enterococcus bacteria in the surf zone was further characterized to better define the distribution of these bacteria. Based on the first year's study, sampling points needed to be further away from the drain to reach background levels of bacteria. The bather population was characterized at this site on four separate days.

In September, 1991, a pipe will be activated to convey dry weather runoff from the drain to a point 600 ft offshore. This structure will prevent pooling of effluent on the beach, and direct discharge of dry weather flow into the surf zone. Concentrations and dispersion of bacteria around the drain prior to building this pipe can be compared with distribution patterns after activation of the pipe; this "before and after" comparision will be presented in a future report on studies done during the third year.

B. Santa Monica Canyon Channel

This drain is located where West Channel Road and Chatauqua Boulevard intersect with the Pacific Coast Highway. The storm drain system drains much of the Santa Monica Canyon area, which has predominantly residential and open space land uses. Flow exits from a large concrete channel and then drains across the beach. The puddle that forms on the beach is heavily with extensive tidal input. The storm drain flows year round with a typical dry flow of approximately 0.5 cubic feet per second (Mitchell, pers. comm., 1990).

Samples of drain effluent were collected from the Short Street bridge where it crosses the channel. This position is approximately 400 yards from the surf zone.

Because this drain is a candidate for an epidemiological study, virus testing was conducted along with estimates of bather populations.

C. Ballona Creek

Ballona Creek empties into the ocean from a large channel at a point just south of the Marina Del Rey channel. The storm drain system drains a substantial area that includes some of downtown Los Angeles, Beverly Hills, Hollywood, Westwood, Culver City and Westchester. The tidal prism goes as far east as Centinela Ave. The storm drain flows year round with an average dry flow of approximately 10 million gallons per day (Mitchell, pers. comm., 1990).

Virus sampling was conducted in the creek because its effluent mix with bathing waters of adjacent Playa Del Rey and Venice beaches, both popular bathing areas. Sampling was conducted at the mouth of the Ballona Creek Bridge, this location was chosen because it is the upper reaches of the tidal prism. Samples collected at this location therefore had minimal seawater dilution.

III. Sampling

A. Indicator Bacteria

1. Sampling Design and Frequency

The study was carried out over a thirteen week period from late July to mid October, 1990. Ideally, sampling would have occurred during weekends when the most people were using the beach. However, because of the logistical requirements of the microbiology laboratories, sampling was conducted during morning hours on weekdays. All bacterial samples were tested within six hours of sampling.

Sampling in the surf zone around the Pico-Kenter drain occurred on twenty days over a ten week period. Samples for bacterial analyses were collected at ten sites in the surf zone where the drain effluent flows into the Bay (Figure 2):

1. Seven stations were positioned at ankle depth at 0, 25, 50, and 100 yard intervals: the "0" position was located directly west of the drain.

2. Three stations were positioned at chest depth at 0, and 25 yard intervals.

All samples were taken from the incoming breaking surf. The ankle depth samples were taken as the surf foam reached the sample bottle at the height of the sampler's ankle. The chest samples were taken where the breaking waves reached the chest height (approximately 3 to 4 ft) of a medium sized adult. Chest depth sampling usually occurred between 30 and 50 yards further away from the drain than ankle depth sampling.

Samples of drain effluent were collected for bacterial analyses on each of the surf zone sampling days at the Pico-Kenter drain. Likewise, bacterial samples were collected during each day of viral sampling at the Santa Monica Canyon drain and Ballona Creek.

Samples were collected in either 125 ml or 1 liter, high-density, sterile polypropylene bottles. After collection, samples were placed on ice and transferred to the Environmental Monitoring Division's (EMD) microbiology laboratory at the City of Los Angeles' Hyperion Treatment Plant.

2. Analyses

Densities of fecal and total coliforms were determined according to Standard Methods (APHA, 1985) using the membrane filtration techniques (Section 909). The nutrient enrichment procedure was used for total coliform analyses as recommended in Standard Methods, Section 909A. Tests for enterococci followed recommended EPA (1985) procedures using m-E and Esculin Iron Agar media. Results were reported in colony forming units (cfu/100 ml).

B. Viruses

1. Sampling Design and Frequency

Virus sampling occurred on five different days at Ballona Creek and Santa Monica Canyon drains, and four days at the Pico Kenter drain. During each day, a single sample was collected at each drain. Approximately 100 gallons of water was filtered for each sample. The limited number of runoff samples that were analyzed makes it impossible to answer, with certainty, that enteric virus was not present in the drains.

Early construction of the extension for the Pico-Kenter drain prevented the collection of a fifth sample at this site. The sampling period was from August 28 to October 15, 1990. In addition to enteric virus, samples were analyzed for total and fecal coliforms and enterococcus indicator bacteria, and F-male specific coliphage.

2. Seed Study

Seed studies were performed to test toxic effects of the storm drain effluent on virus, and to measure the effectiveness (i.e. percent of recovery) of the process to concentrate and analyze for virus. These studies were done at the two drains and Ballona Creek using adsorption and elution techniques described in Standard Methods, modified Section 913-A APHA, (1985).

Prior to virus sampling, two 35 gal containers were filled with storm drain effluent. A known quantity of attenuated poliovirus (vaccine strain) was added to each container. Prior to concentrating the sample, a set of three replicate grabs were taken from each container. Each grab consisted of 1 ml of sample diluted with 9 ml of sterile diluent water. The seeded effluent then was run through a concentrator (described below). At the end of the run, a second set of replicate grab samples were collected from the second 35 gal container.

Grab samples were diluted tenfold again and analyzed for concentrations of the poliovirus. Concentrations of virus in the first set of grab samples yielded baseline levels. Any toxic effects of the effluent then would be assessed by comparing differences in viral concentrations between the first and second set of grab samples. The

3-642

percent recovered by the concentration procedure was measured by comparing virus levels in the final concentrate with baseline levels.

3. Sampling and Analysis

a. F-RNA Specific Coliphage

Replicate grab samples (n=3) were obtained on four days at the Pico-Kenter drain and on five days at the other storm drain sites (from splits of the bacterial samples) and analyzed for F male-specific coliphage by the Los Angeles County Sanitation Districts' virology laboratory. The F-male specific coliphage assay methods used were obtained from Dr. V. Cabelli (personal communication) as described in Appendix I.

b. Enteric Viruses

Enteric viruses were sampled at the storm drain sites using a modified version of Standard Method 913-A (APHA, 1985). Approximately 40 to 100 gallons of effluent were filtered per sample. The field sampling was conducted by personnel from the Hyperion Environmental Monitoring Division and the Los Angeles County Sanitation Districts (LACSD). The seed studies were all completed by LACSD staff. A detailed description of the enteric virus sampling protocol is in "The USEPA Manual of Methods for Virology" (1984).

The long field processing time (approximately 1.5 hours) required that sampling began in the morning and continued until noon. Only one sample was taken per day at each of the drains. Seed studies were run on the same morning as field sampling, but with a different virus concentrator to minimize the risk of cross contamination.

One-liter eluates from the field sample were delivered to the laboratory and reconcentrated using an organic flocculation procedure (Katzenelson et al., 1976). Final concentrates were detoxified prior to assay (Gloss et al., 1978).

All of the samples were initially analyzed for human enteric viruses which develop plaque forming units (PFU) on Buffalo green monkey kidney cells (BGMK). If a sample was negative for PFU, then another fraction of the sample was assayed on BGMK cells by the liquid overlay technique, known as the cytopathic effect assay (CPE) described by Lennette and Schmidt (1969). Samples exhibiting CPE were confirmed as viral by re-infecting another flask of BGMK cells with a portion of the supernate from the original flask. In all cases, CPE positive flasks were confirmed by testing some of the original flask supernate by passage into a second set of liquid overlay cultures, or by plaque assay. A detailed description for cell culture and virus assay is presented by the EPA (USEPA, 1984).

c. Quality Assurance and Quality Control (QA/QC)

The QA/QC protocols established by Standard Methods (APHA, 1985) and USEPA (1984, 1985) were followed. In addition, the QA/QC Project Plan for the study was approved by Ken Kitchingman, a QA officer for EPA Region IX.

B. Characterization of Bather Populations

The beach characterization survey took place on 22 days from mid July through mid September, 1990 at Santa Monica Canyon drain, and on four days in August and September at the Pico-Kenter drain. Surveys took place on Friday, Saturdays, and Sundays because these are the days of peak bather use. The hours of the survey were from 11 AM to 3 PM, the four hour period when most people visit the beach.

The survey was designed to provide information on the number of swimmers, number of waders, number of swimmers and waders at various distances from the drains, and the estimated age and ethnicity of the swimmers and waders. It was assumed that if a bather had wet hair, then the bather had been swimming in the ocean. Age and ethnicity was noted because the incidence of illness could differ among these groups. Bathers were placed into "distance groups" detailing how far they were swimming or wading in the surf zone from the drain; groups included those bathing in the drain or runoff pool; 0-25 yds., 25-50 yds., or 50-100 yds. from the drain.

2. Data Analyses

Geometric means were calculated for bacterial indicators and F-male specific coliphage.

The percentage of days which exceeded levels of concern was calculated with all raw data; if any replicate on any day exceeded the level of concern, the day was considered above the level of concern for that station.

Analysis of variance (ANOVA) was used to test for significant differences among geometric means from stations at ankle and chest depths. Each station mean was calculated from all data gathered over the study period. To determine the pattern that bacterial densities decreased with distance from the drain the data were regressed and the best fit curve was found (SAS, PROC RSREG).

IV. RESULTS

A. Bacterial Indicators

Densities of indicator bacteria were greatest in the storm drain effluent, and fell with distance offshore from ankle to chest depths. Bacterial densities generally decreased along the shore with distance

from the drain in a linear fashion ($p < 0.05$) (Table 1). These densities generally fell one to two orders of magnitude from the drain effluent to chest depths (Figure 3). This decrease along beams from drain to ankle depth and from ankle to chest depth for each of the three indicator bacterial groups was significant ($p < 0.01$).

Averaging all data collected over the study period, the mean concentrations of bacteria differed significantly among stations located at ankle depth for all three indicator groups (Table 1). The greater values tended to be south of the drain, with the highest geometric mean densities located 25 yards south of the drain. Conversely, station means calculated at chest depth over the sampling period were not significantly different, nor was any discernable pattern seen (Table 1).

Figure 4 shows how often bacterial measurements at a site exceeded levels of concern. These levels were based on State Ocean Plan standards (see Introduction above). All samples of drain effluent generally had indicator bacterial densities above levels of concern for all three indicator groups. Although less frequently, levels of concern still were exceeded at ankle depth, especially to the south. Levels of concern were exceeded less frequently at chest depths.

The geometric mean bacterial densities of the runoff collected from Santa Monica Canyon and Ballona Creek during virus sampling are in Table 2. The bacterial densities in Ballona Creek and Santa Monica Canyon runoff were one to two orders of magnitude lower than Pico-Kenter runoff. The total and fecal coliform densities in Ballona Creek runoff were much higher than Santa Monica Canyon, but Santa Monica Canyon enterococcus densities were higher than Ballona Creek.

B. Viruses

1. Seeding Studies

Recovery of the seeded poliovirus averaged 31% at Pico-Kenter, 19% at Ballona Creek, and 12% at the Santa Monica drain (Table 3). Results were most variable at Pico-Kenter, ranging from 9 to 53% recovery.

2. F-Male Specific Coliphage

The Pico-Kenter indicator densities ranged from 9,700 to 15,000 coliphage/100 ml (Table 4). Densities in the samples from Ballona Creek ranged from 450 to 770 coliphage/100 ml, and were over an order of magnitude lower than those from the Pico-Kenter drain. The Santa Monica Canyon coliphage densities were very low, ranging from <10 to 200 coliphage per 100 ml.

3. Enteric Virus

Human enteric viruses were detected in Pico-Kenter runoff on three of the four sampling dates (Table 4). No enteric viruses were detected during the five days of sampling at Santa Monica Canyon or

Ballona Creek.

Quantification of virus was done for two of the three positive virus samples from Pico-Kenter. The sample collected September 5 sample had an estimated 0.6 pfu/gal while the September 6 sample had 0.3 pfu/gal.

C. Characterization of Bather Population

Over the 22 days of the survey at the Santa Monica Canyon drain, 1781 swimmers and 1779 waders were within 100 yards of the drain (Table 5). Over this period, the number of swimmers around the drain ranged from 21 to 174, while bathers ranged from 20 to 205. An average of 81.0 swimmers and 80.9 waders per day were in the water from 11 AM to 3 PM at varying distances from the drain, including the pooled effluent (Table 4). The population spanned a variety of ages (Table 6), but was represented mostly by caucasians (Table 7).

There was only a four day survey completed at Pico-Kenter drain. The beach 100 yds. north and south of the drain was closed for the entire summer after the end of June, 1990. Over these four days, the number of swimmers around the drain ranged from 8 to 39, while bathers ranged from 85 to 143. There were 76 swimmers and 431 waders at the close section of beach during the four days (Table 4). An average of 19.8 swimmers and 107.8 waders were at the beach between 11 AM and 3 PM, and were represented by a variety of ages (Table 6) of mostly caucasians and hispanics (Table 7).

IV. DISCUSSION

A. Bacterial Dispersion

During the bacterial dispersion study it was found that levels of concern were exceeded frequently at distances of 100 yards from the Pico-Kenter drain at ankle depth. From 20% to 53% of the samples at 100 yards exceeded levels of concern for the three groups of indicator bacteria. Bathing water standards in the California Ocean Plan are exceeded if total coliform exists more than 1000 cfu/100 ml 20% of the time at a sampling site. This situation was the case at all ankle depth stations over the entire 13 week sampling period (Figure 4).

Until this study, it was assumed that the bacterial densities dropped off drastically at distances much closer to flowing drains than 100 yards. In fact, the L.A. County Department of Health Services has stated that the bacterial counts often do not exceed levels of concern at distances over 25 yards from flowing drains (Kebabjian, 1988). Although the Pico-Kenter results are probably the worst case scenario for bacterial densities in the surf zone, the findings of the study may cause policy makers to reword the beach warning signs to include a warning for swimmers to stay at least one hundred yards from flowing drains.

3-644

Unfortunately, the study design did not allow for an assessment of the distance at which indicator densities always drop below levels of concern. However, the City of Los Angeles' Environmental Monitoring Division (CLA-EMD) conducts daily shoreline indicator bacteria monitoring at a site (Station 58) approximately 500 yards south of the Pico-Kenter drain. The densities at Station 58 were far below state standards on all twenty days of the sampling period, indicating that the bacterial plume did not reach this point.

The results confirmed that the densities of indicators drop off drastically with depth. The chest depth indicator densities did not exceed levels of concern more than 10%; 30% and 40% for fecal coliforms, total coliforms and enterococcus, respectively. Also, the geometric means of the indicators at chest depth were far below levels of concern, which demonstrates that the high bacterial densities are predominantly encountered by bathers in shallow water. This information has implications for targeting children in a future epidemiology study because they are exposed to the highest densities of indicators.

The number of samples collected for bacterial indicator densities in Santa Monica Canyon and Ballona Creek drains (only five days) did not provide enough information to determine the sites for an epidemiological study. However, the CLA-EMD does daily sampling at 17 different shoreline locations; Ballona Creek and Pico-Kenter storm drains, and twice weekly sampling at Santa Monica Canyon drain. This data, along with the LACDHS weekly ocean monitoring data (LACDHS, 1987-91), will provide most of the information needed to determine the sites for the epidemiology study.

B. Viruses

1. F-Male Specific Coliphage

Mean male specific coliphage densities in the Pico-Kenter drain were over twenty times greater than those found in the Ballona Creek (620 to 13,700 pfu/100 ml) and nearly 200 times greater than the coliphage values found in Santa Monica Canyon runoff (64 pfu/100 ml). Higher densities of male specific coliphage are expected in sewage contaminated waters than in waters without human fecal inputs (Cabelli, pers. comm., 1989). Data in Table 3 tend to support this observation in that the highest densities of coliphage generally corresponded with the presence of enteric virus in the drain. This trend was noted in the previous year's work at the Pico-Kenter drain (Gold et al., 1990).

Unlike last year's study, none of the runoff samples were highly diluted with sea water. The ranges of the conductivities were from 1.07 mmhos at Pico-Kenter to 5.10 mmhos at Ballona Creek; these for seawater are approximately 35 mmhos.

2. Seeding Study

Typically, virus recoveries of 20 to 30% are achieved during

environmental virus sampling of water and wastewater (Rao and Melnick, 1986). Recoveries from the Pico-Kenter drain averaged 31%, indicating typical recovery, but the range was quite variable. Lower recovery rates were measured from the other two drains, the lowest being at the Santa Monica Canyon drain (Average = 14%).

One possible reason for the variability in recovery was that materials in the runoff may have hampered the efficiency of the filter. Oil, grease, and humic acid in runoff can bind to the adsorption sites on filters in the virus concentrator, thus causing the virus adsorbing filters to function poorly. The Santa Monica Canyon watershed is predominantly residential and rural; so vegetation (a potential source of humic acid) in the storm drain would be common.

3. Enteric Viruses

No enteric viruses were detected in effluents sampled from Ballona Creek or Santa Monica Canyon storm drain. The Ballona Creek results were somewhat surprising because of the size and complexity of the watershed and that samples noted fecal contamination (unknown, large mammalian source) only a few feet downstream from the sampling site, close to the edge of the water.

Only five samples were taken at each drain, so if there were small densities of enteric virus in the runoff, then there was a high probability that the sampling and analytical methods did not detect the virus. Other factors that may have affected the results were runoff toxicity, low virus recoveries, temporal variation in contaminant sources, organic loadings to the storm drain, and the documented oil inputs into Ballona Creek from the La Brea tar pits upstream (C. Mitchell, pers. comm.).

The isolated virus from the Pico-Kenter drain were tested in order to help answer some concerns whether they were contaminants from the seed virus studies or isolates from the storm drain effluent. These isolates were placed on a medium with monovalent anti polio 1 antiserum. After incubation, it was determined that they were polio 1. They were then subjected to the "d" and "t" marker tests (Hsiung, 1973) to differentiate naturally occurring "wild" types of poliovirus from strains that have been attenuated for vaccine use. Results showed that the isolates did plaque similarly to the vaccine strain.

Attenuated poliovirus 1, an enteric virus, was detected at Pico-Kenter on three out of four days. Last year, a coxsackievirus and an echovirus were found in Pico-Kenter runoff. Because the only virus identified during multiple procedures to form plaques was poliovirus 1, questions arise about the potential of cross contamination of the samples with the seeded virus. Although the possibility of contamination cannot ever be eliminated, there are strong reasons to believe that the isolates were from the Pico-Kenter runoff:

1. Poliovirus was found only in Pico-Kenner runoff even though seed

studies were performed three times each at the other two drains.

2. Poliovirus was found in Pico-Kenter runoff on three separate days. All of the samples were assayed on different days. The probability of this occurring from cross contamination was slight.

3. A separate virus concentrator was used to collect the seeded samples. None of the same equipment was used in both the seed study and runoff sampling.

4. Seeded samples were processed in the laboratory following the reconcentration of the natural virus sample in order to minimize the risk of cross contamination. Also, the lab was cleaned extensively after each sample was reconcentrated.

5. A separate set of laboratory equipment was used for the two types of samples with the exception of a pH electrode. However, since the natural sample was always processed first, any residual virus on this electrode would not have survived overnight exposure to a solution of Cidex, a virucidal agent used for decontaminating equipment.

6. Historically, levels of attenuated strains of poliovirus typically peak in wastewater during the late summer to early fall when children entering school for the first time are required to be vaccinated for polio. Live virus is used for vaccination which replicates in the lower intestinal tract. High concentrations of attenuated vaccine clones are then released in the feces of the vaccinated person. The sampling period corresponded to the beginning of the school year.

Detection of enteric viruses in the storm drains established that Pico-Kenter was receiving human fecal inputs during the two week sampling period. The estimated virus concentrations were 0.5 pfu/gal and 0.6 pfu/gal for 6od of the three samples. A sampling error on estimating the volume collected for the first positive sample made it impossible to estimate the poliovirus concentration. These estimates are rough estimates for the following reasons:

1. At low densities, viruses are not normally distributed throughout the sample. Also, only a portion of the total sample was tested for virus.

2. One of the basic limitations of virus testing is that no cell line can detect all of the enteric viruses present in the sample.

3. The results of the seeding studies demonstrated that the density of viruses in the samples were estimated. Poliovirus recovery at Pico-Kenter ranged from 9% to 53%, demonstrating the large uncertainty in the accuracy of the sampling method.

4. Toxicity to cultured cells was noted in the first year study, so

concentrates had to be diluted prior to assay. Toxic effects of the runoff concentrate on viability of the enteric viruses could not be assessed. The viruses may have been inactivated or experienced a loss of infectivity, so none of the viruses that may have been present would have formed plaques during the test.

5. It is not appropriate to extrapolate viral densities based on an aliquot taken from a sample having low concentrations. Only 10% of the sample was used in plaque screening. When that 10% was negative, the remaining sample was assayed by the more sensitive, but qualitative CPE technique.

6. A plaque forming unit may be either one single virion or an aggregate of the virus (Bitton, 1980).

This is the second year that evidence of human fecal inputs into the Pico-Kenter drain was discovered. The beach proximate to the drain has remained closed for the last year, so the continual risk of illness to recreational bathers has been minimized. Also, the possibility of swimmer illness will be reduced, to some extent, in August, 1991, when the 600 ft extension of the drain will be activated. The effect of the extension on the surf zone bacterial densities has yet to be evaluated.

Ideally, a risk assessment of the virus data would be completed and sent to decision makers and risk managers. The enteric virus data will be given to the L.A. County Department of Health Services for their use. However, the following is a list of the limitations of the results for the purpose of performing an accurate risk assessment:

1. Problems with quantification of enteric viruses in the runoff (see above).

2. Current detection techniques cannot detect some of the viruses which could cause swimming associated illnesses such as gastroenteritis.

3. Runoff is a flowing medium that is extremely variable. Physical (flow, pH) total suspended solids, etc.), chemical (oil and grease, heavy metals, etc.) and biological (bacterial indicator densities) parameters vary greatly over time. Virus concentrations were expected to vary over time as well.

4. At low virus densities, one can not assume that the viruses are normally distributed throughout the runoff or the surf zone after discharge. Also, there are large uncertainties in developing an accurate dilution factor for storm drains and runoff in the ocean.

5. Without knowing what viruses were in the storm drain, it is impossible to estimate the minimum infectious dose for people exposed to sea water contaminated with virus. However, one could assume that exposure to one virus would result in infection (Bitton, 1980).

3-646

c. Characterization of Bather Population

The bather characterization survey provided information that will be used to design the large scale epidemiology study during the third year work. It takes approximately 12 weekend days to see 1,000 swimmers within 100 yds of the Santa Monica Canyon drain from 11 AM to 3 PM. The majority of the swimmers were between 50 and 100 yards from the drain. However, based on the bacterial dispersion data at Pico-Kenter, waders from 50 to 100 yards from the drain could still be exposed frequently to indicator densities above levels of concern.

Far less swimmers were near the Pico-Kenter drain (19.5 per day) compared to the Santa Monica Canyon drain (80.9 per day). This result was not surprising because the beach near Pico-Kenter was closed during the survey period. However, there were more waders at the Pico-Kenter drain per day (107.8) than at the Santa Monica Canyon drain per day.

VI. CONCLUSION

Elevated densities of indicator bacteria were prevalent in the surf zone around the Pico-Kenter storm drain. These densities frequently exceeded levels of concern, especially at ankle depth. Elevated densities frequently were measured as far as 100 yd from the drain. Bacterial densities generally fell by one order of magnitude from ankle to chest depths.

Human enteric viruses were detected for the second year in a row in effluent from the Pico-Kenter storm drain. No viruses were detected in effluents from the Santa Monica Canyon storm drain or Ballona Creek. Virus sampling should continue in Ballona Creek, because this drain receives a variety of contaminant inputs. Further work should be done to search for viruses over a longer period of time.

Results of the bather characterization study at the Santa Monica Canyon drain indicated that nearly 100 people per day swam within 100 yd of the drain. This information will be necessary for design of an epidemiological study on bathers in water contaminated by storm drain runoff.

VII. RECOMMENDATIONS

1. Future work on bacterial distributions should focus on how far from the drain, at ankle depth, background levels are consistently reached.

2. Although bacterial densities in the surf zone near Pico-Kenter drain represent the potential worst case exposure scenario for recreational bathers, based on this report and LACSD bacterial monitoring data (1988-1991), storm drain warning signs should state that people should not swim within at least 100 yds from a flowing drain. This cautious, public health recommendation was made although there are uncertainties in extrapolating these results to densities and flow rates like Pico-Kenter and Ballona Creek. Most extensive bacterial contamination in the surf zone than drains with lower bacterial densities (Santa Monica Canyon) or less flow.

3. Sampling for viruses in the effluents of drains that discharge into the Bay during dry weather should continue.

4. Design an epidemiological study on people swimming in waters contaminated by storm drain effluents uncontaminated by human fecal wastes. One of the primary objectives of the study should be to determine if there are health risks from swimming in the Bay. If there are health risks, they should be quantified. Another major objective is to find out if there is a correlation between pathogen indicator densities and the incidence of adverse health effects in swimmers. The final design should include locations for the study, number of swimmers and bathers of the control population needed for the study, sampling scheme for the pathogen indicators, estimated cost for the study, and a time line for completion.

5. Begin seeking funds for the epidemiological study. The study should begin during the summer of 1993.

VIII. ACKNOWLEDGMENTS

The City of Santa Monica provided funds to support two part-time biologists to help collect and analyze samples, and equipment necessary to collect samples from the field.

The Santa Monica Bay Restoration Project thanks the following for their voluntary contributions on the study. The microbiology staff at the Los Angeles County Sanitation Districts' (LACSD) virology lab for sample analysis of enteric virus and coliphage, the microbiology staff at the City of Los Angeles' Environmental Monitoring Division (EMD) for analysis of indicator bacteria, and sampling of enteric virus. Special thanks go to: John Mitchell, chief water quality engineer for the L.A. County Department of Public Works; William Yanko, Supervisor of the LACSD microbiology laboratory; and to Craig Wilson, chair of the Santa Monica Bay Restoration Project Technical Advisory Committee for review of this report. The designated outside reviewers were Al Dufour, Director of the Microbiology Research Division at USEPA in Cincinnati, and Frank Sorvillo, epidemiologist in the Acute Communicable Disease Control section of the LACSD. Rob DeGiovanni deserves special thanks for his role in virus sampling. In addition, special thanks go to volunteers from Heal the Bay for their work at sampling the surf zone and performing the bather characterization survey. Greg Poets and Mike Mullis of the EMD prepared graphics for this report. Scott Johnson of the EMD completed the statistical analyses for the study.

VII. REFERENCES

APHA. See American Public Health Association.

APHA. 1985. Standard Methods for the Analysis of Wastewater, 16th Edition: Sections 909, 909A, and 913-A.

Bitton, G. 1980. Introduction to Environmental Virology. published by John Wiley and Sons. N.Y., N.Y.

Cabelli, V.J., A.P. Dufour, L.J. McCabe, and M.A. Levin. 1982. Swimming associated gastroenteritis and water quality. Amer. J. Epidem. 115: 606-616.

City of Los Angeles, Environmental Monitoring Division. 1989. Santa Monica Bay Annual Assessment Report, 1987-88. Report submitted to EPA and RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 189 pp.

City of Los Angeles, Environmental Monitoring Division. 1990. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1988 through June, 1989. Report submitted to EPA and RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 215 pp.

City of Los Angeles, Environmental Monitoring Division. 1991. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1989 through June, 1990. Report submitted to EPA and RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 220 pp.

CLA EMD. See City of Los Angeles, Environmental Monitoring Division.

Glass, J.S., van Oluis, B.J., and W.A. Yanko. 1978. Practical Method for Detecting Poliovirus in Anaerobic Digester Sludge. Appl. Env. Micro. 35:983

Gold, M., Bartlett, M., Dorsey, J. and C. McGee. 1990. An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses From Two Santa Monica Bay Storm Drains. A technical report prepared for the Santa Monica Bay Restoration Project.

Hsiung, G.D. 1973. Diagnostic Virology. Yale University Press. New Haven, CT.

Katzenelson, E., Fattal, B., and T. Hostovesky. 1976. Organic Flocculation: An Efficient Second-Step Concentration Method for the Detection of Viruses in Tap Water. Appl. Env. Micro. 32:638.

Kebabjian, R. 1988. Letter with data entitled, "Enterococcus Levels Adjacent to Storm Drains from 1987-1988". L.A. County Department of Health Services.

Lennette, E.H. and N.J. Schmidt. 1969. Diagnostic Procedures for Viral and Rickettsial Infections. APHA publishers. N.Y., N.Y.

Lim, K.A. and Benyesh-Melnick, M. 1960. Typing of viruses by combinations of anti-serum pools. Application to typing of enteroviruses (coxsackie and echo). J. Immunol. 84:309-317

Los Angeles County Department of Health Services. 1988-1990. Unpublished bacterial monitoring data from the surf zone weekly monitoring program.

Rao, V.C. and J.L. Melnick. 1986. Environmental Virology. ASM publishers. Washington D.C.

Salas, H.J. 1987. History and Application of Microbiological Water Quality Standards in the Marine Environment. Wat. Sci. Tech. 19:47-57.

Southern California Association of Governments. 1988. State of the Bay: Epidemiology Assessment. Section by V.J. Cabelli on Microbial Risk Assessment. 5-30 to 5-53.

Standard Methods. See APHA.

State Water Resources Control Board. 1990a. Water Quality Control Plan for Ocean Waters of California (California Ocean Plan). State Board Resolution No. 90-27. 23 pp.

United States Environmental Protection Agency. 1985. Test Methods for *E. coli* and *Enterococci*. EPA.600/4-85/076.

United States Environmental Protection Agency. 1984. The USEPA Manual of Methods for Virology. EPA-600/4-84-013.

USEPA. See United States Environmental Protection Agency.

FIGURE CAPTIONS

Figure 1. Map of the shoreline in northern Santa Monica Bay showing the three storm drain study sites.

Figure 2. Station positions for the surf zone monitoring study adjacent the Pico-Kenter storm drain.

Figure 3. Geometric means over entire sampling period for each of the bacterial indicators measured in drain effluent, and surf water at ankle and chest depths. Results of one way ANOVAs are presented beneath each corresponding histogram.

Figure 4. Percent of time levels of concern were exceeded at each sampling site around the Pico-Kenter storm drain. See text (Introduction) for description of levels of concern.

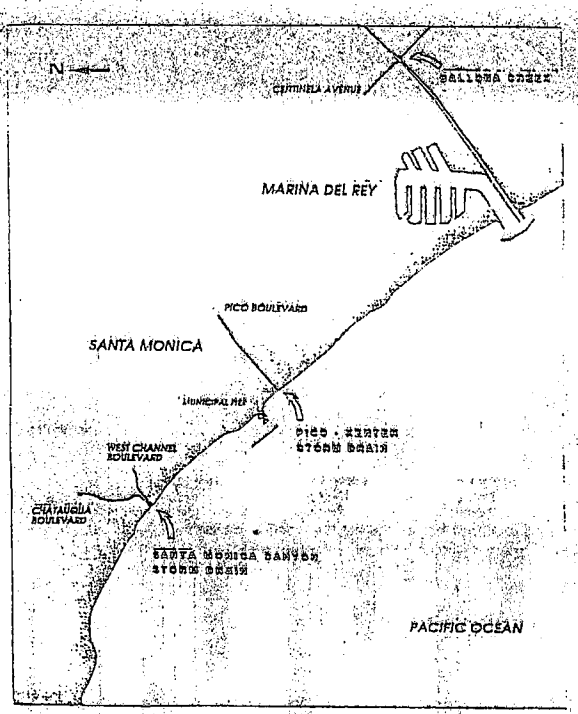


Figure 1:

Figure 3:

176

Figure 3:

175

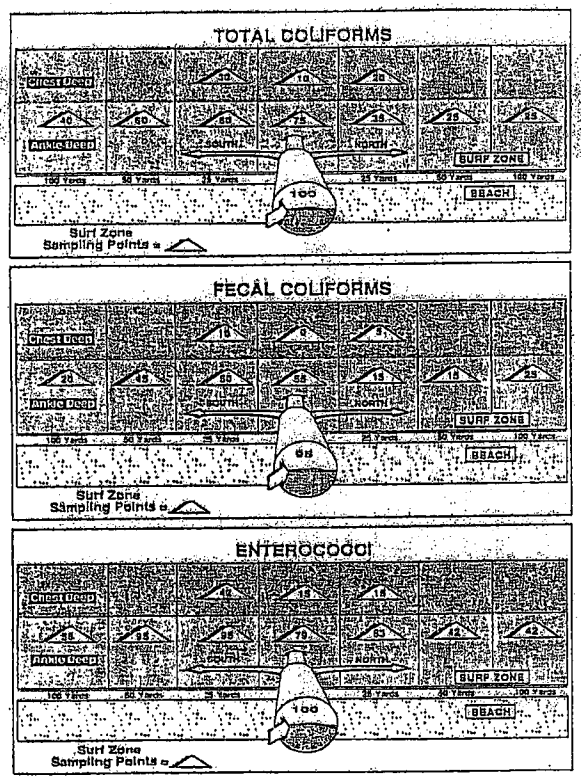


Figure 4:

Table 1: Mean bacterial density at each station over entire sampling period (n=20) plus results of one-way ANOVA tests for each bacterial indicator group at ankle and chest depths.

VARIABLE	SAMPLING SITES 100S	50S	25S	0	25N	50N	100N	d.f.	F	p
ANKLE DEPTH:										
Enterococcus	36	160	123	108	39	23	21	6	7.27	0.0001
Fecal Coliforms	47	145	217	187	65	54	48	6	3.81	0.0015
Total Coliforms	891	2378	4588	4065	953	438	475	6	6.36	0.0001
CHEST DEPTH:										
Enterococcus	-	-	12	9	11	-	-	2	0.22	0.8047
Fecal Coliforms	-	-	24	14	27	-	-	2	1.38	0.3149
Total Coliforms	-	-	278	189	236	-	-	2	0.24	0.7885
STORM DRAIN:										
Enterococcus	-	-	-	13000	-	-	-	-	-	-
Fecal Coliforms	-	-	-	15000	-	-	-	-	-	-
Total Coliforms	-	-	-	920000	-	-	-	-	-	-

Note: d.f. = degrees of freedom
F = F statistic
p = probability; considered significant when < 0.05.
S = Yds South
N = Yds North

Table 2. Geometric means (N=5) for bacterial samples (CFU/100mL) collected simultaneously with virus samples at Ballona Creek and Santa Monica Canyon storm drains.

SAMPLE SITE:	TOTAL COLIFORMS	FECAL COLIFORMS	ENTEROCOCCUS
BALLONA CREEK	29,000	3,500	605
SANTA MONICA CANYON	4,300	160	1,100

Table 3. Results of virus seeding experiment. Runoff was seeded with attenuated poliovirus.

Location/ Date	Virus (pfu/ml) Start	End	% Change	Recoverable Virus	Amount Recovered	% Recovered
Pico-Kenmar:						
8-30	13	17	+ 31	1.5×10^9	4.8×10^8	32
9-05	16	22	+ 38	1.8×10^9	1.7×10^8	9
9-06	20	30	+ 50	3.0×10^9	1.6×10^9	53
Ballona Creek:						
9-18	32	34	+ 6	3.6×10^9	8.9×10^8	38
9-25	33	33	0	2.5×10^9	8.3×10^7	19
10-11	21	14	- 33	3.3×10^9	3.5×10^8	11
Santa Monica Canyon:						
9-12	33	28	- 15	3.2×10^9	4.2×10^8	14
9-13	28	17	- 39	3.7×10^9	2.9×10^8	8
9-19	28	27	- 4	2.7×10^9	3.6×10^8	13

Table 4. Results of tests for human enteric virus in the Pico-Kenter and the Santa Monica Canyon storm

Storm Drain	Date	Coliphage (pfu/100mL)	Enteric Virus Isolation
Pico-Kenter:	8/28/90	9,700	negative
	8/30/90	15,000	positive
	9/05/90	13,000	positive
	9/06/90	13,000	positive
Ballona Creek:	9/18/90	740	negative
	9/25/90	730	negative
	10/02/90	770	negative
	10/11/90	400	negative
	10/15/90	450	negative
Santa Monica Cyn:	9/12/90	<10	negative
	9/13/90	200	negative
	9/19/90	10	negative
	9/26/90	100	negative
	10/03/90	<10	negative

Table 5. Number of swimmers and bathers observed within 100 yds of the Pico-Kenter and Santa Monica storm drains. Observations at the Santa Monica Canyon storm drain was made during 22 days from July through September, 1990, and those at Pico-Kenter during four days from August through September, 1990. Values in parantheses are percentages of swimmers or bathers; see text for for definition of these two variables.

Variable	Distance from Drain (yds) 50-100 yds	25-50 yds	0-25yds	Pooled Effluent
Pico-Kenter:				
No. swimmers	45 (57.7%)	15 (19.2%)	18 (23.1%)	0 (0.0%)
No. waders	183 (42.5%)	104 (24.1%)	129 (29.9%)	15 (3.5%)
Santa Monica Canyon:				
No. swimmers	955 (53.8%)	486 (27.3%)	310 (17.4%)	30 (1.7%)
No. waders	773 (43.4%)	434 (24.4%)	332 (18.7%)	240 (13.5%)

Table 6. Ages of swimmers and bathers observed at the Pico-Kenter and Santa Monica Canyon storm drains.

Variable	Age (years)			
	0-10	11-20	21-40	> 40
Pico-Kenter:				
No. swimmers	16 (20.5%)	17 (21.8%)	36 (46.2%)	9 (11.5%)
No. waders	82 (19.0%)	78 (18.1%)	180 (41.8%)	91 (21.1%)
Santa Monica Canyon:				
No. swimmers	202 (11.3%)	525 (29.5%)	861 (48.3%)	193 (10.8%)
No. waders	296 (16.7%)	379 (21.3%)	816 (45.9%)	816 (16.1%)

Table 7. Ethnic Groups for swimmers and bathers observed at the Pico-Kenter and Santa Monica Canyon storm drains.

Variable	Ethnic Groups			
	Caucasian	Hispanic	Asian	Black
Pico-Kenter:				
No. swimmers	36 (46.2%)	37 (47.4%)	2 (2.6%)	3 (3.8%)
No. waders	217 (50.3%)	157 (36.4%)	20 (4.6%)	37 (8.6%)
Santa Monica Canyon:				
No. swimmers	1570 (88.2%)	137 (7.7%)	41 (2.3%)	33 (1.8%)
No. waders	1531 (86.1%)	158 (8.9%)	50 (2.8%)	40 (2.2%)

Appendix 3

Pathogens and Indicators in Storm Drains Within the Santa Monica Bay Watershed

June 1992

A document prepared for the:

Santa Monica Bay Restoration Project
101 Centre Plaza Drive
Monterey Park, CA 91754

by

Mark Gold,[1] Melinda Bartlett,[2]
Charles McGee,[3] Greg Deets,[4]

[1] Staff Scientist, Heal the Bay, Suite 112
1640 5th St., Santa Monica, CA 90401

[2] Environmental Affairs Officer, City of Los Angeles
Environmental Affairs Office
City Hall, 200 N. Spring St.
Los Angeles, CA 90012

[3] Laboratory Supervisor
Orange County Sanitation Districts
10844 Ellis Ave., Fountain Valley, CA 92728

[4] Water Biologist, City of Los Angeles
Environmental Monitoring Division
Hyperion Treatment Plant
12000 Vista Del Mar, Playa del Rey, CA 90293

EXECUTIVE SUMMARY

Based on the public's perception that recreational activities in Santa Monica Bay increase their health risks, the Santa Monica Bay Restoration Project (SMBRP) has decided that quantification of the health risks of swimming in sensitive waters is a priority area of concern. Previous studies completed under the auspices of the SMBRP demonstrated that high densities of indicator bacteria were present in inlet storm waters were found 100 yards from the Pico-Kenter storm drain. In addition, human enteric viruses were found on two consecutive days in runoff from the same storm drain.

This year's research was designed to further evaluate dispersion of indicator bacteria around the Pico-Kenter storm drain after the completion of a 600 foot pipe extension. Also, further testing for the presence of human enteric virus was completed at the Pico-Kenter and Herondo storm drains, and Malibu Lagoon.

Surf zone indicator bacteria distribution - Low densities of indicator bacteria in the surf zone around the Pico-Kenter storm drain seldom were found when the 600 foot pipe extension was functioning as designed. These results were significantly different from the previous year's study on indicator bacteria distribution that was completed before the pipe extension was completed. When the effluent was discharged further off shore, dilution and near shore currents were effective in reducing indicator bacterial densities in the surf zone. Although drain extensions do not reduce pollution loads to nearshore waters, a properly designed and maintained extension can prove effective in reducing health risks to bathers and swimmers.

Enteric virus prevalence - Human enteric viruses were found at all five virus sampling sites: Pico-Kenter and Herondo storm drains; and all three virus sampling locations within the Malibu Lagoon. The only specific viruses identified were Coxsackie B viruses which can cause illnesses ranging from gastroenteritis to, on rare occasions, pericarditis and meningitis. The results confirm that human fecal contamination of storm drains is far more prevalent than originally assumed. Even though the storm drain system in Los Angeles County is completely separate from the sewer system, the storm drains are not free of human fecal inputs.

Based on the results of the virus studies, recommendations for further research include:
1) An investigation of the health risks associated with various levels of indicators of water quality or with swimming at various distances from flowing drains should move forward;
2) A human specific indicator that correlates with the densities and presence or absence of human pathogens is needed;
3) Tools need to be developed for the easy detection and quantification of specific human pathogens. Models could then be used to demonstrate health risks associated with the specific pathogen; and
4) A sanitary survey needs to be developed and implemented to trace low to moderate sewage contamination in addition to large sewer leaks and spills. A concerted effort to identify and abate the sources of pathogens to the watersheds should be undertaken immediately.

I. INTRODUCTION

A primary goal of the Santa Monica Bay Restoration Project (SMBRP) is to quantify the health risks of swimming in the Bay's recreational waters. The issue of safe swimming in the Bay has been determined by the public and environmental managers to be of primary concern. A variety of illnesses associated with swimming in the Bay and ocean environments of elevated densities of indicator bacteria found around storm drains have been reported in the surf zone (Southern California Association of Governments, 1989; City of Los Angeles Environmental Monitoring Division (LA EMD), 1988, 1990, 1991; SMBRP, 1990). Ultimately, these illnesses could be addressed through an epidemiology study associating rates of illness with swimming in the Bay.

A pilot study on levels of indicator microorganisms in the surf zone near two storm drains and human enteric viruses in the storm drains was completed during the first year of a multi-year study (Gold et al., 1990). This study revealed that indicator microorganism densities in the surf zone frequently exceeded California Ocean Plan bacterial water quality objectives (State Water Resources Control Board (SWRCB), 1990) in the vicinity of both the Pico-Kenter and Ashland Avenue storm drains. In this and subsequent studies, bacterial "levels of concern" were based on three water quality objectives presented in the State's Ocean Plan. Levels of concern were exceeded when:

a. total coliforms were greater than 1000 colony forming units per 100 ml of water (cfu/100 ml); or

b. fecal coliforms were greater than 200 cfu/100 ml; or

c. enterococci were greater than 24 cfu/100 ml.

The SWRCB numerical limits for bacterial densities were applied as individual values for each sample instead of geometric means for samples collected over a 30 day period as stated in the Ocean Plan. The indicator bacteria standards in the Ocean Plan are predominantly used for compliance monitoring for permitted dischargers, whereas the research performed by the SMBRP was not designed to determine compliance.

In addition to surf zone sampling, water in storm drains was analyzed for densities of a bacteriophage, F-male specific coliphage. Coliphage are currently being considered as an indicator of pathogenic virus survival in marine waters. Standards have not been set for coliphage.

During the first study, human enteric viruses were found in the Pico-Kenter storm drain in 1989 on 11 out of 15 sampling dates (Gold et al., 1990) and in 1990 during the second study, on three out of four dates (Gold et al., 1991). These viruses are pathogenic, causing illnesses like gastroenteritis, and are specific to human waste (Lennette and Schmidt, 1969). Their presence demonstrated that water in the drain had been contaminated by human sewage. Since

the release of the 1990 study, the City of Santa Monica has kept the beach closed, 100 yards north and south of the Pico-Kenter drain, and implemented measures to reduce or eliminate ponding of runoff on the beach.

A number of questions still need to be addressed prior to deciding whether or not to conduct a large scale epidemiology study. This study should be conducted at recreational bathers in waters with large variability in indicator bacteria densities adjacent to flowing storm drains. These conditions would provide information on the health risks from swimming in waters contaminated only by urban runoff.

In this report, results are presented from two studies performed during the third year of the project. They were designed to:

1. Further evaluate dispersion of indicator bacteria around the Pico-Kenter storm drain after the completion of the 600 foot pipe extension; and

2. Testing for the presence of human enteric virus in the Pico-Kenter and Herondo storm drains, and Malibu Lagoon.

Further work was done in the first study to refine our knowledge on the distribution of indicator bacteria around the Pico-Kenter drain. Gaining an understanding of indicator bacteria distribution in the surf zone is an essential component to deciding which portion of the beach and the swimming public is exposed to excessive indicator densities resulting from storm drain effluent. In this case, the Pico-Kenter drain was chosen because of the historically high levels of indicator bacteria measured in the surf adjacent to the drain. The drain was also chosen because it offered a unique opportunity to test the efficacy of storm drain extensions in reducing indicator bacteria densities in the surf zone.

In the second study, we continued to survey various storm drain effluents for the presence of human enteric viruses. The two storm drains and lagoon studied, like the sampling locations from previous studies, were chosen because they historically have been associated with high densities of indicator bacteria in the surf zone when the drains flow directly to the ocean. This year's viral study was the first time that such a large section of Santa Monica Bay was covered. The information from this study will be used to help determine the potential sites and need for an epidemiology study.

II. STUDY SITES

A. Pico-Kenter Storm Drain

The Pico-Kenter drain is located where Pico Boulevard meets the beach (See figure 1). The storm drain system drains a large area that includes much of Santa Monica and part of West L.A. and Brentwood. There are two drains that discharge to the beach: one is owned by Los

There is no text for this page.

Angeles County Department of Public Works, and the other by Cal-Trans. Dry weather flow is usually transported 600 feet off shore through a pipe extension. When the pipe is clogged, runoff flows across the beach. The storm drain flows year round with a typical dry flow of approximately 0.1 cubic feet per second (Greene, pers. comm., 1991).

The Pico-Kenner storm drain was sampled again for fecal indicator viral to determine if viruses were present for the third consecutive year. Samples of runoff emptied from the drain were collected where the Prohaska creosol the storm drain channel, at a point approximately 200 yards from the surf zone.

In August, 1991, a pipe extension was activated to convey dry weather runoff from the drain to a point 600 ft offshore. This structure was designed to prevent pooling of effluent on the beach, and direct discharge of dry weather flow beyond the surf zone. The distribution of total and fecal coliforms and enterococcus bacteria in the surf zone was further characterized to better define the distribution of these bacteria. Bacterial densities around the drain prior to building this pipe (Gold et al., 1990) will be compared with distribution patterns after activation of the pipe; this "before and after" comparison will be presented in the Discussion section of this report.

B. Herondo Storm Drain

The end of the drain is located at a popular surfing beach where Herondo Blvd. intersects the ocean on the Hermosa Beach-Redondo Beach border (See figure 1). Samples were collected at the intersection of Herondo Blvd. and Harbor Drive from a manhole on the bike path on the west side of Harbor Drive. The storm drain system drains a large area in Hermosa Beach, Redondo Beach and Torrance which is predominantly residential and commercial land uses. Flow exits from a small concrete structure located near the mean high tide line and then drains across the beach. The puddle that forms on the beach is brackish with extensive tidal input. The storm drain flows intermittently throughout the year (Mitchell, pers. comm., 1991).

C. Malibu Creek

The Malibu Creek watershed, containing over 105 square miles, is the largest watershed draining into Santa Monica Bay. Parts of five cities are contained within the watershed: Malibu, Calabasas, Thousand Oaks, Agoura Hills and Westlake Village. Malibu Creek is a soft bottomed stream terminating in Malibu Lagoon. This lagoon is the only remaining brackish water lagoon adjacent to Santa Monica Bay (See figure 1).

All bacteria and viral samples were collected in the 13 acre Malibu Lagoon, adjacent to one of the most popular surfing beaches in California, Surfrider Beach. There were four different sampling sites in the lagoon (See figure 2):

1) The location near Surfrider Beach where the sand berm is typically breached

artificially by the California Department of Parks and Recreation (Breach);

2) At the bridge over the C-channel which is the western most channel of the lagoon, next to the Malibu Colony (C-channel);

3) In the soft bottomed stream (approximately 150,000 gallons per day) formed by the discharge of treated contaminated groundwater from the Texaco gas station treatment facility and runoff from the adjacent Cross Creek Road shopping center parking lot. The sampling point was three to five yards north of Malibu Creek, just east of the Pacific Coast Highway bridge (Texaco); and

4) At a point on the north bank of the creek, 100 yards upstream of the Texaco discharge (Upstream).

III. SAMPLING

A. Indicator Bacteria

1. Sampling Design and Frequency

The study was carried out over a six month period from mid- May to mid-November, 1991. Ideally, sampling would have occurred during weekends when the most people were using the beach. However, because of the logistical requirements of the microbiology laboratories, sampling was conducted during morning hours on weekdays. All bacterial samples were tested within six hours of sampling.

Sampling in the surf zone around the Pico-Kenner drain occurred on seventeen days over a five week period. Samples for bacterial analyses were collected at the same ten sites as the 1990 surf zone study (Figure 3):

1. Seven stations were positioned at ankle depth at 0, 25, 50, and 100 yard intervals; the "0" position was located directly west of the drain.
2. Three stations were positioned at chest depth at 0, and 25 yard intervals.

All samples were taken from the incoming breaking surf. The ankle depth samples were taken as the surf foam reached the sample bottle at the height of the sampler's ankle. The chest samples were taken where the breaking waves reached the chest height (approximately 3 to 4 ft) of a medium sized adult. Chest depth sampling usually occurred between 30 and 50 yards further away from the drain than ankle depth sampling.

Samples of drain effluent were only collected for bacterial analyses on each of the thirteen enteric virus sampling days. Because of logistical problems after the pipe was extended 600 feet, there was no sampling directly from the Pico-Kenner drain on days where surf zone

bacterial monitoring took place. Likewise, bacterial samples were collected during each day of viral sampling at the Herondo drain and Malibu Lagoon.

2. Analyses

Samples were collected in either 125 ml or 1 liter, high-density, sterile polypropylene bottles. After collection, samples were placed on ice and transferred to the Environmental Monitoring Division's (EMD) microbiology laboratory at the Hyperion Treatment Plant.

Densities of total and fecal coliforms were determined according to Standard Methods (American Public Health Association (APHA), 1985) using the membrane filtration techniques (Section 909). The nutrient enrichment procedure was used for total coliform analyses as recommended in Standard Methods Section 909a. Tests for enterococci followed recommended Environmental Protection Agency (USEPA, 1985) procedures using m-E and Esculin Iron Agar media. Results were reported in colony forming units (cfu/100 ml).

B. Viruses

1. Sampling Design and Frequency

The virus sampling period was from June 3 to October 23, 1991. In addition to enteric virus, samples were analyzed for total and fecal coliforms, enterococcus indicator bacteria, and F-male specific coliphage.

Virus sampling occurred on five different days at Herondo drain, thirteen days at the Pico Kenter drain, and twenty six days at Malibu Lagoon. At Malibu Lagoon, nine virus samples each were taken at the C-channel bridge and the upstream station. Eight samples were taken from the breach location.

A single sample was collected on each day. Field sampling was conducted by the Hyperion Environmental Monitoring Division (EMD) and Heal the Bay.

2. Seed Study

Seed studies were performed at the two drains and Malibu Creek using adsorption and elution techniques described in Standard Methods, modified Section 913-A (APHA, 1985). A minimum of three seed experiments were completed at each study location, and these were separated temporally by a minimum of two weeks from field studies in order to prevent the possibility of contamination of field samples with laboratory virus. These studies were done to measure the effectiveness (i.e. percent of recovery) of the process to concentrate and analyze for virus and secondarily, to test toxic effects of the storm drain effluent on virus. Samples for the seed experiments were collected in November, 1991 and the seed studies were all completed by the Orange County Sanitation Districts (OCSD) staff.

Two 55 gal containers were filled with storm drain effluent. The effluent was adjusted to pH 3.5, $AlCl_3$ was added to a final concentration of 0.005 M, and a known amount of attenuated poliovirus (vaccine strain) was added to each container. Triplicate grab samples were taken at the beginning and end of the filtration period. Each grab consisted of 1 ml of sample diluted with 9 ml of sterile Hank's Balanced Salt Solution (HBSS) to minimize any toxic effect to the virus inactivation when samples are frozen and thawed. Effluent in each container then was run through a concentrator (described below).

Grab samples before and after concentration were analyzed for densities of the poliovirus. Concentrations of virus in the first set of grab samples yielded baseline amounts. Any toxic effects of the effluent then could be assessed by comparing differences in viral concentrations between the first and second set of grab samples. The percent of recovery was measured by comparing virus levels in the final concentrate with baseline levels. The results of the seed study were used to give recovery estimates, but to adjust the densities of enteric viruses recovered from field samples.

3. Sampling and Analysis

a. F-Male Specific Coliphage

Grab samples were obtained on 14 days at the Pico-Kenter drain, five days at the Herondo drain, 25 days at the Malibu Lagoon breach site, 24 days at the C-channel site, 23 days at the Texaco site, and 26 days at the upstream site (from splits of the bacterial samples). Nearly all of the samples were collected on the same dates that virus sampling occurred. The samples were analyzed for F male-specific coliphage by the Orange County Sanitation Districts' (OCSD) virology laboratory. The F-male specific coliphage assay methods and E. coli host bacteria were obtained from Dr. V. Cabelli as described in Appendix I.

b. Enteric Viruses

Enteric viruses were sampled at the storm drain sites using a modified version of Standard Method 913-A (APHA, 1985) and "The USEPA Manual of Methods for Virology," 1984 (EPA-600/4-84-013). Adsorption conditions were pH 3.5 with an $AlCl_3$ molarity of 0.005. The eluent was 3% beef extract adjusted to pH 7.2. Approximately 50 to 140 gallons of effluent were filtered per sample. A detailed description of the enteric virus sampling protocol is in "The USEPA Manual of Methods for Virology" (1984).

Travel set up and the long field processing time (approximately 1.5 hours) required that sampling began in the morning and continued until noon. Only one sample was taken per day at each of the drains.

One-liter aliquots from the field sample were delivered to the laboratory and reconcentrated in the afternoon using an organic flocculation procedure (Katzenelson et al.,

1976). Final concentrates were detoxified prior to assay (Glass et al.,1978).

All of the samples were initially analyzed for human enteric viruses on Buffalo green monkey kidney cells (BGMK) by the plaque assay technique. Ten percent of the sample was tested in this manner to determine if there was a quantifiable number of viruses present. If the sample was negative for Plaque Forming Units (PFU), then the remainder of the sample was analyzed by using the liquid overlay technique known as the cytopathic effect assay (CPE) (Lennette and Schmidt, 1969). If the samples were positive in the PFU assay, then the remainder of the sample was not analyzed by using the CPE assay. The CPE assay generally detects a greater number of viruses but is not quantitative. Samples exhibiting CPE were confirmed as viral by re-infecting another flask of BGMK cells with a portion of the supernate from the original flask. In all cases, CPE positive flasks were confirmed by testing some of the original flask supernate as well as passage into liquid overlay cultures. A detailed description for cell culture and virus assay is presented by EPA (1984).

Fractions of samples positive for enteric virus were sent to the Centre de Recherche en Virologie in Laval, Quebec for identification by the laboratory of Dr. Pierre Payment. Identification by the Lim Pool antisera neutralization technique were not successful. Isolates were eventually identified using monospecific antisera.

C. Physical Measurements

Conductivity, temperature, and pH of the runoff were measured when virus samples were collected. Lagoon heights were measured because there is a common perception that there is the potential for septic system failure in the nearby Malibu Colony area when the water table is high and the lagoon height is over 3.5 feet.

D. Quality Assurance and Quality Control (QA/QC)

The QA/QC protocols established by Standard Methods (APHA, 1985) and USEPA (1984, 1985) were followed. Also, the OCSD primary effluent was assayed for coliphage periodically for quality control purposes. In addition the QA/QC project plan for the study was approved by Ken Klemm, a QA officer for EPA Region IX.

E. Data Analyses

Geometric means and 95% confidence intervals were calculated for bacterial indicators. Geometric means were calculated for F-male specific coliphage. Values that were greater than or less than the countable range were not used to calculate geometric means of indicator microorganisms. Arithmetic means were calculated for pH, temperature, and conductivity data.

The percentage of days where surf zone samples exceeded levels of concern was calculated with all raw data. If any replicate on any day exceeded the level of concern, the day was considered above the level of concern for that station.

Analysis of variance (ANOVA) was used to test for significant differences among means from stations at ankle and chest depths. Each station mean was calculated from all data gathered over the study period. The geometric means from the 1990 bacterial distribution study were compared to the 1991 data using separate t-tests.

ANOVA with protected multiple comparisons were run to test for the differences in geometric means. Tukey's studentized range test (HSD method; SAS, 1990, Steel and Torrie, 1960) was used for the geometric mean comparisons.

IV. RESULTS

A. Bacterial Indicators

1. Bacterial Distribution

Densities of indicator bacteria were low at all ankle and chest depth stations in the surf zone (Table 1) and extremely high in the Pico-Kenter effluent (Table 2). During each sampling period, indicator densities in drain effluent exceeded levels of concern for all three bacterial groups (Figure 4). In the surf zone, however, levels of concern were seldom exceeded at all ankle and chest depth stations for these indicators. The geometric means of the bacterial densities at all surf zone sites were not significantly different from each other. Ankle depth geometric means were not significantly different from chest depth means.

2. Bacterial Densities in Runoff

The geometric means and 95% Confidence Intervals of bacterial densities measured in runoff samples collected from the Malibu Lagoon, and the Pico-Kenter and Herondo storm drains are given in Table 2. Bacterial densities in the Pico-Kenter drain were approximately three to five times higher than the Herondo drain and one to two orders of magnitude higher than the densities at the four Malibu Lagoon sites. This trend held for all three bacterial indicators. In Malibu Lagoon, the densities were generally lowest to highest from C-channel to the breach to Upstream to Tenaco.

The geometric mean densities at the Malibu Lagoon C-Channel and Breach stations were significantly different ($P \leq 0.5$) from the other four stations for total coliforms and enterococcus (Table 2). The geometric means for the Breach and C-Channel stations were not significantly different ($P \geq 0.5$) for all three indicators. The geometric means for the Pico-Kenter and Herondo drains were not significantly different from each other, but they were significantly higher than all other sampling sites for total coliforms and than the C-Channel and Breach sites for enterococcus.

B. Viruses

3-669

1. Seeding Studies

Recovery of the seeded poliovirus generally was poor. Results ranged from 6.9 to 30% for Pico-Kenter drain on four days, 0.0 to 18.0% for Herondo on three days, and 2.9 to 7.7% for two days at Malibu Lagoon (Table 3).

2. F-Male Specific Coliphage

The geometric mean of the F-male specific coliphage densities at Herondo and Pico-Kenter drains were similar and they were approximately one order of magnitude greater than the mean densities measured at the Malibu Lagoon sites (Table 4 , Appendix 2). The Malibu Lagoon sites all had low to very low coliphage densities. Unlike samples from the Pico-Kenter and Herondo drains, many of the samples from the Malibu Lagoon (approximately 39%) were below the method detection limits for coliphage.

3. Enteric Virus

Human enteric viruses were detected in runoff on at least one day at all six sampling locations (Table 5; Appendix 3). Quantification of virus was completed for all ten positive virus samples (Table 5). Only three samples were positive in the plaque forming unit assay while seven samples were positive using cytopathic effect assays. The rough estimates of viral densities ranged from 1 pfu/ 2.8 gallons to 1 pfu/ 141 gallons for the plaque assays and $\geq$ 1 infectious unit (iu)/ 10.6 gallons to $\geq$ 1 iu/ 80 gallons for the cytopathic effect assays.

Confirmed virus isolates were sent to Dr. Pierre Payment at the Centre de Recherche en Virologie in Laval, Québec for identification. Identification by the Lim Pool antisera neutralization technique was not successful. Isolates were eventually identified using monotypic antisera. Enteric viruses were identified in nine of the ten samples that were positive for virus. Due to a laboratory accident, the virus isolate from the 6/5/91, Malibu Lagoon C-channel station sample was lost.

All isolates were identified as Coxsackie B. The isolate from Pico-Kenter on 9/25/91 contained Coxsackie B3 virus while the isolate from Pico-Kenter on 8/13/91 contained Coxsackie B4 virus. The remaining seven isolates contained Coxsackie B5 virus. Coxsackie B viruses can cause pleurodynia and on rare occasions, pericarditis and meningitis.

C. Physical Measurements

Mean temperatures, conductivities and pHs for runoff from the six sample sites are summarized in Table 6 (All data in Appendix 4). Mean temperatures were similar at all sites ranging from 20.1 to 21.2 C, while the pH at Herondo drain was more acidic averaging 6.5, compared to the other five sites that averaged 7.7 to 8.2. The mean conductivity of runoff was low at Pico-Kenter drain (1.7 mmhos), similar to brackish water at the Herondo drain and Texaco sites, and nearly saline at the breach and C-channel sites. Other than at Pico-Kenter,

the conductivity of runoff varied over a wide range from nearly fresh water to salt water.

The height of Malibu Lagoon above sea level and the tide height at the time of sampling at the Lagoon are also listed in Appendix 4. Lagoon height ranged from two feet (the lowest possible measurement with the measuring stick near the C-Channel station) to 5.4 feet above sea level. Of the 26 days where samples were collected and analyzed for enteric virus, 11 occurred when the lagoon was at its lowest at two feet and nine occurred when the lagoon elevation was over 3.5 feet. Tidal heights ranged from plus 1.5 to six feet during virus sampling at the lagoon.

In general, the conductivity of the samples was high when the lagoon mouth was open and/or when there was a very high tide. The sample conductivity was seldom below ten mmhos at the Breach, C-Channel and Upstream stations when the tide was higher than the lagoon height. The Texaco station was less susceptible to the impacts of the tide because samples collected there were predominantly treated discharge and runoff, and the sampling site was not directly in the lagoon.

IV. DISCUSSION

A. Bacterial Dispersion

1. After Storm Drain Pipe Extension

Only 11 of the 17 sampling dates were ideal for assessing the effectiveness of the drain extension for reducing indicator bacteria densities in the surf zone. The last six days of the sampling period produced different results because a nearby sewer replacement project contributed a large volume of water to the Pico-Kenter drain. The flow from dewatering was discharged into the Pico-Kenter drain where it then flowed across the beach and into the surf zone.

Bacterial levels of concern were always exceeded in the drain itself, but rarely if ever exceeded at ankle or chest depth in the surf zone on days when the pipe extension was operating as designed. Because of the logistical problems of sampling directly from the Pico-Kenter drain after the pipe extension, samples of drain effluent were only collected on days during enteric virus sampling. These dates were not usually the same days as the bacterial dispersion study, based on the results of the bacterial dispersion study, the runoff plume either did not travel back to shore or the plume was diluted sufficiently to cause indicator densities to be low.

2. Comparison with Storm Drain Before Pipe Extension

The results of the 1991 dispersion study were drastically different from the results of the 1990 dispersion study. In 1990, bacterial levels of concern were frequently exceeded at ankle depth stations at distances of up to 100 yards from the drain (See Figure 5). Chest depth samples also exceeded levels of concern 10%, 30% and 40% for fecal coliforms, total coliforms, and

enterococci, respectively. In contrast, bacterial levels of concern were only exceeded a maximum of one out of 11 days at the 10 surf zone samples in the 1991 dispersion study. Also, unlike the 1990 data, there were no significant differences between the bacterial densities at ankle depth versus chest depth for all three indicators.

A comparison of the 1990 and 1991 geometric means and 95% Confidence Intervals over the sampling grid further demonstrates the difference in the data sets (Figures 5a-c). For all three indicators, the geometric means at nearly every surf zone site in 1991 were significantly different than the means in 1990 (Table 7).

Although the data were not representative of conditions before or after the pipe extension was completed and functioning correctly, the geometric means and the percentage of times that bacterial levels of concern were exceeded for six additional sampling dates are included in Appendix 5. The predominant source of the runoff during these six days was the dewatering operation that was occurring in conjunction with a sewer replacement nearby.

It is clear that extending the Pico-Kenter drain 600 feet from shore was effective in reducing the indicator densities of bacteria in the surf zone where potential human exposure to pathogens is highest. However, the drain extension was seldom functioning as designed because of frequent blockage of the extension pipe inlet by debris. This situation caused ponding of effluent on the beach and consequently, direct discharge to the surf zone. Overall, as a Best Management Practice (BMP) to reduce bather exposure to undiluted runoff, the pipe extension appeared to work well. However, the BMP would require some operational, maintenance and design changes to ensure that it works consistently and effectively.

3. Bacterial Densities in Runoff

As in the 1989 and 1990 studies, indicator bacterial densities in the storm drains were high. The geometric mean densities of the indicators at the Pico-Kenter and Hercules drains were two to three orders of magnitude above levels of concern. The mean densities at the Lagoon sites ranged from the low end of levels of concern to over twenty times the levels of concern.

The mean densities at the Lagoon sites further from the ocean (Texaco and Upstream) were two to ten times higher than the densities at the sampling sites close to the beach (Breach and C-Channel). This result was not surprising because of the salinity gradient in the Lagoon. Sites closer to the ocean were more influenced by the tidal flux and usually had higher conductivity than the sites on the east side of the Pacific Coast Highway (PCH) bridge. Sea water dilution of bacterial densities probably accounted for most of the differences between sites in the Lagoon, although the prevalence of waterfowl in the upstream portions of the Lagoon likely augmented these differences.

For well over a decade, there has been an assumption that the Malibu Colony septic system begins to experience failure if there is heavy residential use when the water table is high and the water level within the Lagoon channels is above 3.5 feet. In this study, water level

within the Lagoon appeared to have little impact on bacterial densities in the Lagoon (Table 1 and bacterial density data). In general, bacterial densities were high all the time throughout the lagoon, regardless of the water level within the Lagoon. These results do not rule out septic systems within the watershed as a potential source of bacterial contamination, but they imply that bacterial densities are independent of the water level within the Lagoon in dry weather, when the water table is lower. These results support conclusions reached by Marshall et al., (1992) on Malibu Lagoon water quality.

Possible other sources of indicator bacteria to the lagoon are warm blooded wild and domestic animals, vegetation and soil for total coliforms, numerous storm drains including three that discharge into the Lagoon and lower reaches of the watershed, and many other diffuse sources including campers, temporary residents, and picnickers within the watershed. Little information exists regarding potential sources of indicator bacterial contamination in this watershed. However, monthly monitoring reports on water quality in Malibu Creek are submitted to the Regional Water Quality Control Board (RWQCB) by the Las Virgenes Metropolitan Water District (LVMWD).

A review of one potential source of bacterial indicators, the LVMWD's Tapia Water Reclamation Facility, indicates that the plant could be discounted as a direct source because levels of bacteria in the effluent during the study were very low; in over 90% of the samples, total coliforms were not detected ($\leq$ 1 Most Probable Number (MPN)/100ml (LVMWD, 1991). The highest reported value during the study period was 4 MPN/100 ml. However, the issue of bacterial regrowth in the watershed has never been investigated. In contrast to the Tapia plant's effluent, bacterial densities from Malibu Creek and its tributaries were well above levels of concern at the ten monitoring stations throughout the watershed in the Santa Monica Mountains. Total Coliform densities were high everywhere, while fecal coliform and enterococci densities were generally higher at lagoon stations than at upstream stations (LVMWD, 1991). It appears that many of the sources listed above, especially non-point sources, are contributing bacterial indicators to the lagoon.

B. Viruses

1. F-Male Specific Coliphage

Higher densities of male specific coliphage are expected in sewage contaminated waters than in waters without human fecal inputs (Cabelli, pers. comm., 1989). The trend predicted by Cabelli was not supported by these results. Enteric viruses were found at all five sampling locations despite the fact that mean coliphage densities were approximately an order of magnitude higher at the Pico-Kenter and Hercules drains than the Malibu Lagoon sites. Enteric virus was found at all three Malibu Lagoon sites, yet coliphage densities were always low in the lagoon. The coliphage densities on the days that virus was found were comparable to the mean densities. Also, virus was never found on days where coliphage densities were highest for the site.

The purpose of obtaining the coliphage data was to further investigate the efficacy of using this indicator organism to indicate the presence of human waste without the disadvantages of high cost, slow sample analysis, and extensive training associated with human pathogen detection. Field sample coliphage densities from this study demonstrate that this indicator is not a reliable measure of human pathogen contamination and underscores the need for better methods to identify human specific organisms.

2. Seeding study

Typically, virus recoveries of 20 to 30% are achieved during environmental sampling of water and wastewater (Rao and Melnick, 1986). Recoveries from all sampling sites in this study were far below expected recoveries for environmental samples with seven out of ten seed studies achieving recoveries of less than 10%.

One possible reason for the variability and low levels of recovery was that organic materials in the runoff may have hampered the efficiency of the filter. Oil, grease, and humic acid in runoff can bind to the adsorption sites on filters in the virus concentrator, thus causing the virus adsorbing filters to function poorly. Because most of the virus samples were collected in the summer and all of the seed studies were performed weeks later in the late fall, the question of whether the organic content significantly varied from month to month or between the seasons is an important consideration. The recoveries found in the seed experiments may not have accurately reflected the method recoveries on days of field sampling.

Virus was detected at every site, so the seed data were not important in determining the presence or absence of human waste. The seed data were important because they demonstrated that the procedure had a low precision under field conditions for poliovirus. However, the method may have variable recoveries for different types of enteric viruses. With such low precision in the method, it cannot be assumed that there was no human waste present on days when samples were negative. If viruses were not found at a certain sampling location, one still couldn't determine with certainty the presence or absence of enteric virus because of the low virus recoveries. The fact that virus was detected in the field with such low sample recovery rates reflects on the prevalence of human fecal inputs to Malibu Creek, Herondo and the Pico-Kenter drains.

3. Enteric Viruses

Despite the low recovery of the virus concentration methods, enteric viruses were detected at all sampling locations by either the PFU or CPE methods. This result meant that water in the two storm drains, and the Malibu Lagoon, had been contaminated with human sewage. Contamination was probably at a low to moderate level given that the bacterial densities measured in the drains and lagoon sites were below those densities often seen after a sewage spill or leak (Table 2). Typically, runoff contaminated with raw sewage will have densities of total and fecal coliforms ranging from 10^6 to 10^7 cfu/100 ml with the ratio of

Total:Fecal usually ≤.10 (City of Los Angeles, Environmental Monitoring Division, unpublished data).

Indicator bacteria are useful for sanitary surveys when there is gross or undiluted sewage contamination (e.g. large sewage spill or leak) in the storm drains. In other situations, such as the conditions seen at the two drains and Malibu Lagoon, indicator densities provide little information on the source of virus contamination. Even in Malibu Lagoon, where the Total:Fecal coliform ratio was less than four in the virus sampling locations, indicator densities provided little information on the source(s) of bacterial and viral contamination. However, the intent of this study was only to determine if there was virus contamination, not to determine sources of viral contamination. Studies designed specifically to trace the source(s) of human fecal contamination to the drains are needed.

The only type of viruses detected were the Coxsackie B viruses which are often found in sewage contaminated waters. None of the positive isolates were poliovirus, so there was no cross contamination of the samples from the seed studies. In addition, any potential cross contamination was eliminated because all field samples were collected prior to performing the seed studies. Also, the virus concentrator used for collecting samples had never been used previously for seed studies.

Sources of the contamination to the storm drains are unknown. For the two drains, sources could include illegal connections to the sewage system, illegal discharges (e.g. from mobile homes or recreational vehicles), or leaks from the sewer system. The Malibu Lagoon also could be contaminated by these sources in addition to discharges to the watershed from septic tanks and diffuse sources such as campers and picnickers.

When the Lagoon was sampled, the Tapia Water Reclamation Plant was discharging tertiary treated water into Malibu Creek, about six miles upstream from the lagoon. According to the LVMWD, flows from Tapia during sampling periods in the lagoon were 1.04 MGD and ranged from 0 to 4.6 MGD (LVMWD, 1991). As stated earlier, levels of bacteria in the effluent were very low. A study of enteric virus in water produced by the Tapia plant was conducted in 1987 using similar virus sampling and analytical techniques. Only a single virus on one sampling day (90 gallon sample when the chlorination unit was not functioning) was detected out of 25 days of sampling (James M. Montgomery Engineers, Inc., 1990). However, Tapia does not have an enteric virus monitoring program, so the efficacy of the tertiary filters in virus removal has not been determined in over four years. Although Tapia can not be ruled out as a possible source of virus, it seems unlikely that this facility would represent a source of detectable virus in the Malibu Lagoon system unless the tertiary filters were not functioning properly.

The amount of viruses per volume of water presented in Table 5 must be considered as rough estimates given the following reasons:

1. At low densities, viruses are not normally distributed throughout the sample. It is not

3-663

appropriate to extrapolate viral densities based on an aliquot taken from a sample having low concentrations. Only 10% of the sample was used in plaque screening. When that 10% was negative, the remaining sample was assayed by the more sensitive, but more qualitative CPE technique.

2. One of the basic limitations of virus testing is that no cell line can detect all of the enteric viruses that are present in the sample.

3. The results of the seeding studies demonstrated that the density of viruses in the samples were underestimated. Poliovirus recovery at the three drain locations ranged from 0% to 48%, demonstrating the large uncertainty in the accuracy of the sampling method.

4. Toxicity to cultured cells was noted in the first year study at the Ashland Avenue drain, so concentrates had to be diluted prior to assay. Toxic effects of the runoff concentrate on viability of the enteric viruses could not be assessed. The viruses may have been inactivated or experienced a loss of infectivity, so fewer, or even no viruses would have formed plaques during the test.

5. A plaque forming unit may be either one single virion or an aggregate of the virus (Bitton, 1980).

Ideally, a risk assessment of the virus data would be completed and sent to decision makers and risk managers. The enteric virus data will be given to the L.A. County Department of Health Services to perform the risk assessment. The following is a list of the limitations of the results for the purpose of performing an accurate risk assessment:

1. Problems with quantification of enteric viruses in the runoff (see above).

2. The virus analytical methods do not detect all of the enteric viral pathogens.

3. Runoff is a flowing medium that is extremely variable. Physical (flow, pH, total suspended solids, etc.), chemical (oil and grease, heavy metals, etc.) and biological (bacterial indicator densities) parameters vary greatly over time. Virus concentrations are expected to vary over time as well.

4. At low virus densities, one can not assume that the viruses are normally distributed throughout the runoff of the surf zone after discharge. Also, there are large uncertainties in developing accurate dilution factors for storm drains and runoff in the ocean.

5. Without knowing what types of viruses were in the storm drain, it is impossible to estimate the minimum infectious dose for people exposed to test water contaminated with virus. However, for a conservative risk assessment, one could assume that exposure to

one virus would result in infection (Bitton, 1980).

6. Other than gene probes, current techniques cannot detect some of the viruses (rotavirus and Norwalk viruses) which could cause swimming associated illnesses such as gastroenteritis.

VI. CONCLUSION

Historical monitoring data were used to identify surf zone sites where indicator bacteria densities frequently exceeded levels of concern. Human enteric virus samples were taken at the sites with high bacterial densities in order to assess whether there was human waste present. Because swimming associated illnesses are generally believed to be caused by human viruses, the presence of human waste at the sites would indicate a greater risk of swimming associated illnesses than at sites without human fecal inputs (Cabelli et al 1979, 1982). The original intent of the studies was to identify sites with high indicator bacteria densities caused by flowing storm drains with no sewage inputs. These sites were needed for an epidemiology study designed to determine the health risks from swimming in storm drain contaminated water.

Three years later, human enteric viruses were found at various locations in Malibu Lagoon, Hermosa Drain, and three consecutive years at the Pico-Kenter storm drain. Human viruses were not found in limited sampling at Ballona Creek, the Santa Monica Canyon drain, and the Ashland drain, but that does not preclude them from occuring in those locations. In terms of the original study design, the enteric virus assessment has done what it was intended to do; to determine the presence or absence of human waste at the study sites. The study results can not be used to provide accurate information on potential sources of human viruses to the storm drains.

Human fecal contamination of storm drains is far more prevalent than originally assumed. Even though the sewer system in Los Angeles County is completely separate from the storm drain system, the storm drains are not free of human fecal inputs.

The results of the last three years of virus monitoring in storm drains support the following recommendations:

1) An investigation of the health risks associated with various levels of indicators of water quality or with swimming at various distances from flowing drains should move forward.
2) A human specific indicator that correlates with the densities and presence or absence of human pathogens is needed.

3) Tools need to be developed for the easy detection and quantification of specific human pathogens. Models could then be used to demonstrate health risks associated with the

3-66h

specific pathogen.

4) A sanitary survey needs to be developed and implemented to trace low to moderate sewage contamination in addition to large sewer leaks and spills. A concerted effort to identify and abate the sources of pathogens to the watersheds should be undertaken immediately.

Three years of bacterial indicator monitoring have provided new information on storm drain effluent plume dispersion behavior in the surf zone. When the storm water is discharged directly to the surf, bacterial densities are frequently above levels of concern as far as 100 yards in either direction of the drain. Densities are especially high in shallow water. When the effluent is discharged further off shore, dilution and near shore currents are effective in reducing indicator bacterial densities in the surf zone. Although drain extensions do not reduce pollution loads to nearshore waters, a properly designed and maintained extension can prove effective in reducing health risks to bathers and swimmers.

VII. ACKNOWLEDGEMENTS

The Santa Monica Bay Restoration Project thanks the following for their voluntary contributions on the study. The microbiology staff at the Orange County Sanitation Districts' virology lab for sample analysis of enteric virus and coliphage; the microbiology staff at the City of Los Angeles' Environmental Monitoring Division (EMD) for analysis of indicator bacteria, and sampling of enteric virus. Cindy Mayer, Maria Aparicio and Jerry Shiet of the EMD and Roger Gorin of Heal the Bay completed most of the virus sampling and transportation of samples to the OCSD laboratory. Marilyn Gulliet of the OCSD assisted in the sample analysis for human enteric virus and F-male specific coliphage. Some of the data analysis was completed by Eco-Analysis in Ojai. John Dorsey from the EMD provided thorough review of the study.

VII. REFERENCES

APHA: See American Public Health Association.

APHA: 1985. Standard Methods for the Analysis of Wastewater. 16th Edition: Sections 909, 909a, and 913-A.

Bitton, G. 1980. Introduction to Environmental Virology. published by John Wiley and Sons. N.Y., N.Y.

Cabelli, V.J., Dufour, A.P., McCabe, L.J., Levin, M.A., and P.W. Haberman. 1979. Relationship of Microbial Indicators to Health Effects at Marine Bathing Beaches. AJPH. V.69(7):690-696

Cabelli, V.J., Dufour, A.P., McCabe, L.J. and M.A. Levin. 1982. Swimming Associated Gastroenteritis and Water Quality. Am. J. Epidemiology. V.115(4):606-616

City of Los Angeles, Environmental Monitoring Division. 1989. Santa Monica Bay Annual Assessment Report, 1987-88. Report submitted to EPA and RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 189 pp.

City of Los Angeles, Environmental Monitoring Division. 1990. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1988 through June, 1989. Report submitted to EPA and RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 215 pp.

City of Los Angeles, Environmental Monitoring Division. 1991. Marine Monitoring in Santa Monica Bay: Annual Assessment Report for the Period July, 1989 through June, 1990. Report submitted to EPA and RWQCB (Los Angeles). Department of Public Works, Bureau of Sanitation, Hyperion Treatment Plant, Playa del Rey, CA. 220 pp.

CLA EMD. See City of Los Angeles, Environmental Monitoring Division.

Glass, J.S., van Sluis, R.J., and W.A. Yanko. 1978. Practical Method for Detecting Poliovirus in Anaerobic Digester Sludge. Appl. Env. Micro. 35:983

Gold, M., Bartlett, M., Dorsey, J. and C. McGee. 1990. An Assessment of Inputs of Fecal Indicator Organisms and Human Enteric Viruses From Two Santa Monica Bay Storm Drains. A technical report prepared for the Santa Monica Bay Restoration Project.

Gold, M., Bartlett, M., Dorsey, J. and C. McGee. 1991. Storm Drains as a Source of Indicators to the Nearshore Waters of Santa Monica Bay. A technical report prepared for the Santa Monica Bay Restoration Project.

Greene, Gerry. 1991. Personal communication on Pico-Kenter drain flow. City of Santa Monica Department of Engineering.

James M. Montgomery Engineers, Inc., 1988. Filtration-Disinfection Study. Part II: Virus Monitoring Final Report. Prepared for the Las Virgenes Metropolitan Water District.

Katznelson, E., Fattal, B., and T. Hostovesky. 1976. Organic Flocculation: an Efficient

Second-Step Concentration Method for the Detection of Viruses in Tap Water. Appl. Env. Micro.32:638.

Kebabjian, R. 1988. Letter with data entitled, "Enterococcus Levels Adjacent to Storm Drains from 1987-1988." L.A. County Department of Health Services.

Los Virgenes Metropolitan Water District Monthly Monitoring reports for the Tapia Water Reclamation Facility. 1991. Submitted to the Los Angeles Regional Water Quality Control Board.

Lennette, E.H. and N.J. Schmidt. 1969. Diagnostic Procedures for Viral and Rickettsial Infections. APHA publishers. N.Y., N.Y.

Lim, K.A. and Benyesh-Melnick, M. 1960. Typing of viruses by combinations of anti-serum pools. Application to typing of enteroviruses (coxsackie and echo). J. Immunol. 84:309-317.

Los Angeles County Department of Health Services. 1988-1991. Santa Monica Bay surf zone bacterial monitoring data.

Rao, V.C. and J.L. Melnick. 1986. Environmental Virology. ASM publishers. Washington D.C.

Salas, H.J. 1987. History and Application of Microbiological Water Quality standards in the Marine Environment. Wat. Sci. Tech. 18:47-57.

SAS 1990. SAS/STAT User's Guide, Volume 2, GLM-VARCOMP. Version 6, Fourth Edition. SAS Institute Inc., Cary, NC.

Southern California Association of Governments. 1988. State of the Bay: Scientific Assessment. Section by V.J. Cabelli on Microbial Risk Assessment. 5-30 to 5-53.

Standard Methods: See APHA.

State Water Resources Control Board. 1990a. Water Quality Control Plan for Ocean Waters of California (California Ocean Plan). State Board Resolution No. 90-27. 23 pp.

Steel, R.G.D. and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw Hill. New York. 481 pp.

United States Environmental Protection Agency. 1985. Test Methods for E. coli and Enterococci. EPA 600/4-85/076.

United States Environmental Protection Agency. 1984. The USEPA Manual of Methods for

Virology. EPA-600/4-84-013.

USEPA. See United States Environmental Protection Agency.

Warrnall, P. and R. Coats. 1992. Malibu Wastewater Management Study. Prepared by Peter Warnhill and Assoc. and Phil Williams and Assoc. for the city of Malibu.

3-666

FIGURE CAPTIONS

Figure 1. Map of the shoreline in northern Santa Monica Bay showing the three storm drain study sites.

Figure 2. Map of the four sampling sites at Malibu Lagoon.

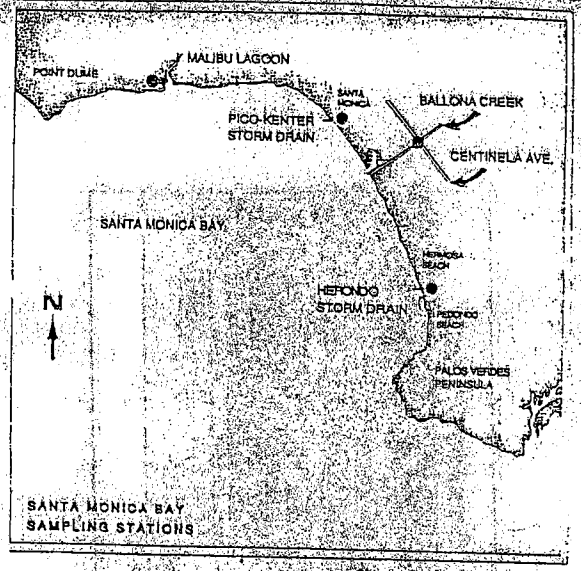
Figure 3. Station positions for the surf zone monitoring study adjacent to the Pico-Kenter storm drain.

Figure 4. Percent of time levels of concern were exceeded at each sampling site around the Pico-Kenter storm drain. See text (Introduction) for description of levels of concern.

Figure 5. Percent of time levels of concern were exceeded at each sampling site around the Pico-Kenter storm drain in 1990 and 1991.

Figure 6 a-f. Plots of geometric means and 95% Confidence Intervals for each of the bacterial indicators measured in the surf zone at ankle and chest depths in 1990 and 1991.

Figure 1.



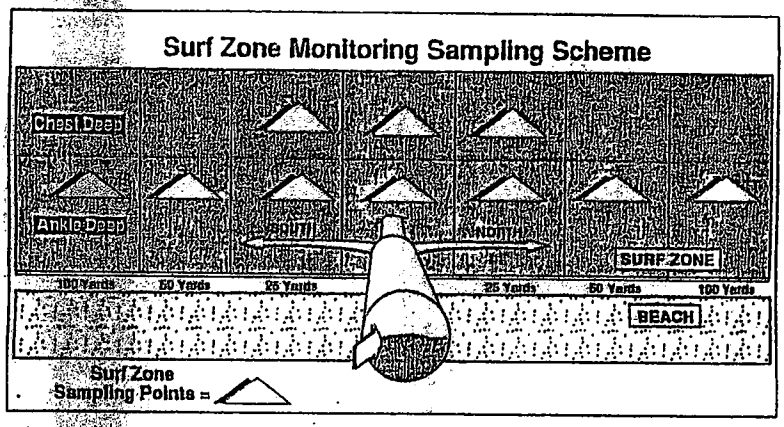


Figure 3.1

212

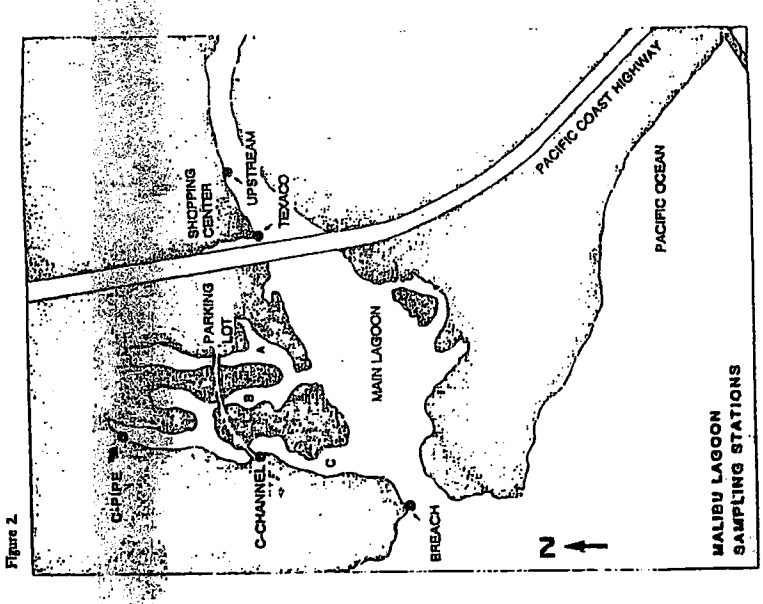


Figure 2

211

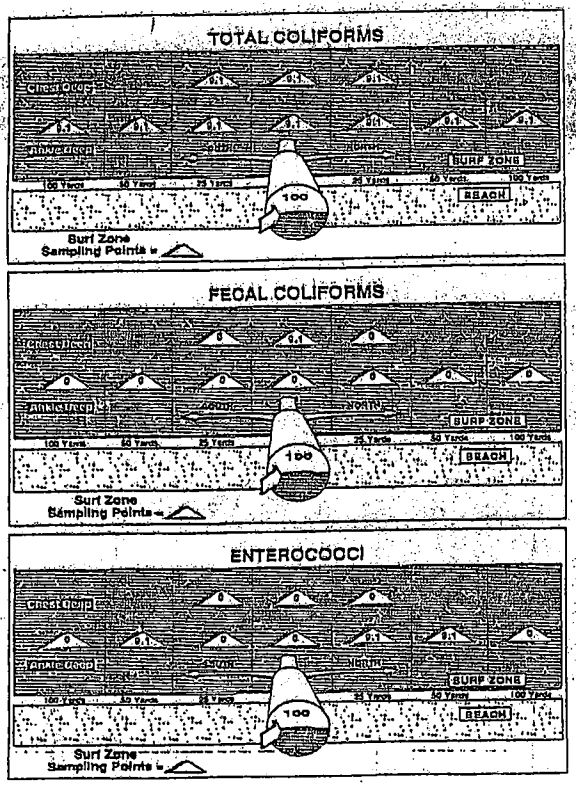


Figure 4.

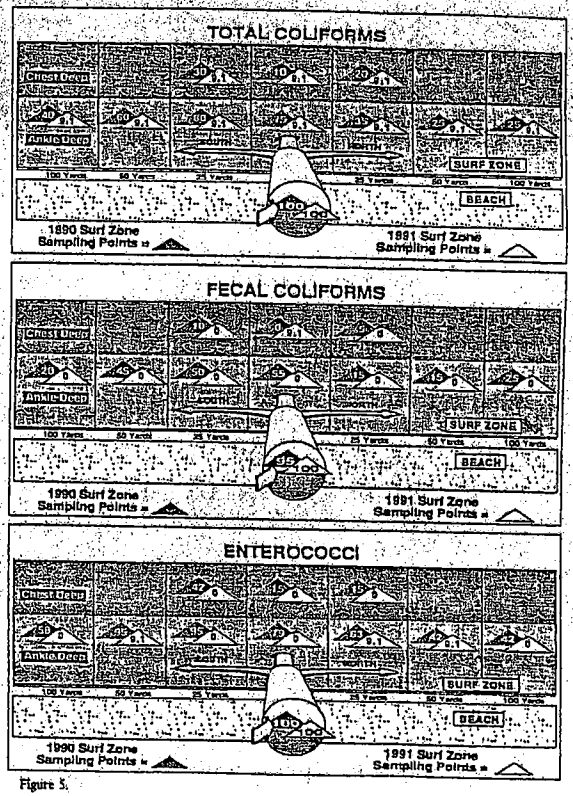


Figure 5.

ENTEROCOCCUS
ANKLE DEPTH

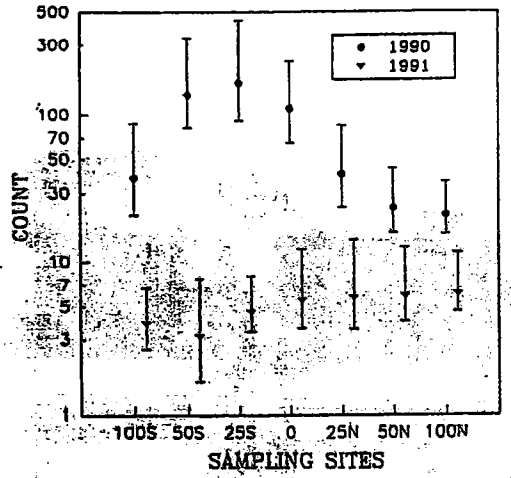


Figure 6a.

ENTEROCOCCUS
CHEST DEPTH

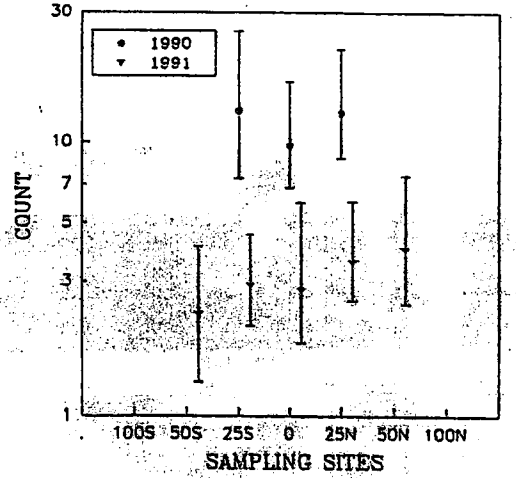


Figure 6b.

FECAL COLIFORMS
ANKLE DEPTH

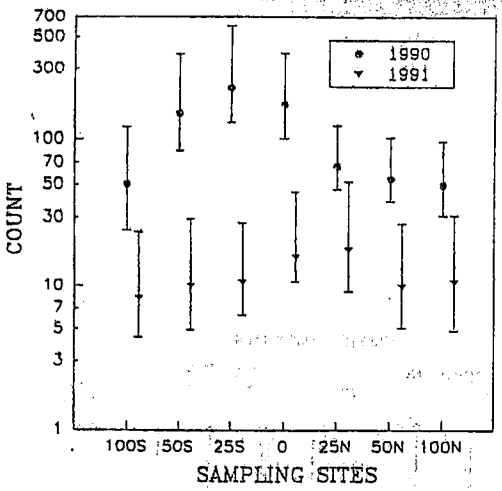


Figure 6c

FECAL COLIFORMS
CHEST DEPTH

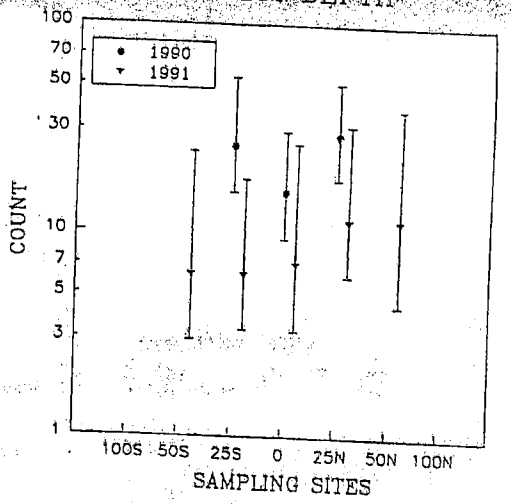


Figure 6d.

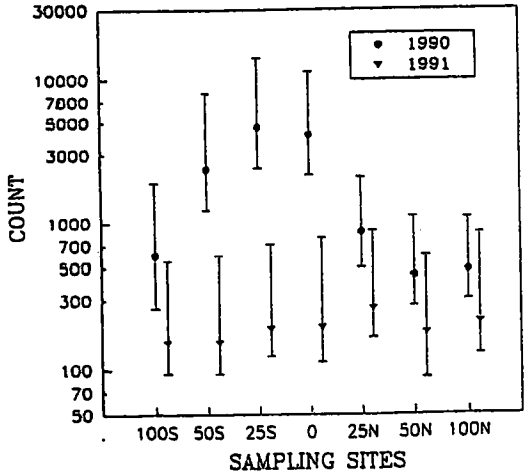


Figure 6 e.

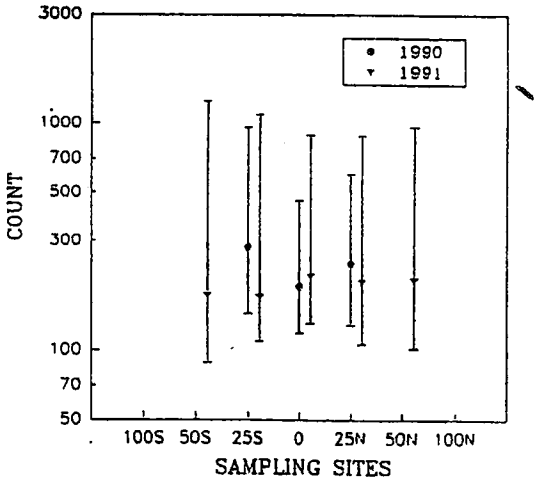


Figure 6f.

TABLE 1. Geometric means and 95% confidence limits for each station. All data included. Types are E = Enterococcus, F = fecal coliform, T = Total coliform. Depths are A = wade depth, C = Chest depth. Dist is distance up or down coast from Scars Creek, and Dir is the direction with N = North or Upcoast, and S = South or Downcoast.

TYPE	YEAR	DEPTH	DIR	DIST	GEOMETRIC MEAN	LOWER 95% CI	UPPER 95% CI
E	1988	A	N	100	137.39	81.14	232.63
E	1988	A	N	50	134.60	82.14	220.51
E	1988	A	N	0	199.81	121.11	329.59
E	1988	A	S	50	329.76	214.49	506.88
E	1988	A	S	100	221.85	142.22	346.18
E	1988	C	N	100	170.97	85.20	343.11
E	1988	C	N	50	111.11	58.87	209.81
E	1988	C	N	0	12.77	7.55	21.59
E	1988	C	S	50	9.66	6.38	14.63
E	1988	C	S	100	12.72	8.49	21.94
E	1991	A	N	100	3.78	2.59	6.73
E	1991	A	N	50	3.08	1.86	7.73
E	1991	A	N	0	4.51	3.38	6.88
E	1991	A	S	50	5.41	3.84	12.26
E	1991	A	S	100	5.48	3.59	14.16
E	1991	C	N	100	5.81	3.55	12.78
E	1991	C	N	50	5.05	4.66	11.64
E	1991	C	N	0	2.28	1.31	4.56
E	1991	C	S	50	2.76	1.78	6.01
E	1991	C	S	100	3.30	2.26	6.67
E	1992	A	N	100	5.31	3.42	12.33
E	1992	A	N	50	29.89	24.48	120.04
E	1992	A	N	0	147.37	94.01	381.45
E	1992	A	S	50	218.98	139.24	681.52
E	1992	A	S	100	166.33	108.66	384.89
E	1992	C	N	100	85.69	66.18	122.34
E	1992	C	N	50	54.13	38.64	112.26
E	1992	C	N	0	47.16	30.85	94.78
E	1992	C	S	50	41.15	19.42	94.15
E	1992	C	S	100	41.58	7.36	97.77
E	1993	A	N	100	17.59	12.97	31.43
E	1993	A	N	50	9.13	6.66	22.88
E	1993	A	N	0	9.28	6.93	22.16
E	1993	A	S	50	10.56	9.26	22.39
E	1993	A	S	100	15.57	10.77	34.19
E	1993	C	N	100	17.81	12.14	32.58
E	1993	C	N	50	9.82	5.16	27.24
E	1993	C	N	0	10.58	6.85	31.28
E	1993	C	S	50	6.19	2.97	23.77
E	1993	C	S	100	8.18	3.51	37.95
E	1994	A	N	100	7.08	3.36	26.68
E	1994	A	N	50	11.53	6.28	31.09
E	1994	A	N	0	11.41	6.40	30.72
E	1994	A	S	50	260.84	263.14	1032.15
E	1994	A	S	100	339.80	1237.72	2653.57
E	1994	C	N	100	332.68	2432.46	2653.88
E	1994	C	N	50	255.55	2358.88	1125.29
E	1994	C	N	0	85.66	301.78	1147.97
E	1994	C	S	50	439.53	275.65	1166.61
E	1994	C	S	100	474.34	303.69	1242.41
E	1995	A	N	100	186.97	145.18	662.76
E	1995	A	N	50	114.15	116.77	661.78
E	1995	A	N	0	128.52	98.22	351.76
E	1995	A	S	50	98.36	123.84	378.14
E	1995	A	S	100	152.12	112.87	737.94
E	1995	C	N	100	260.16	149.12	971.14
E	1995	C	N	50	317.79	188.28	537.98
E	1995	C	N	0	194.88	129.15	841.93
E	1995	C	S	50	88.45	124.98	1247.98
E	1995	C	S	100	159.73	159.59	1957.53
E	1996	A	N	100	159.73	159.73	888.37
E	1996	A	N	50	129.85	129.85	875.16
E	1996	A	N	0	161.12	161.12	865.65

Fig. Bathing beach bacterial data. Results of Tukey's studentized range test (= method) see 1990, short and terrible 1962) comparing geometric means of the up. This method controls the experimentwise type-I error rate at .05. Asterisk (*) indicates that the sites represented by the respective rows and ... are significantly different.

a. Enterococci

	GEOMETRIC MEAN	LOWER 95% CI	UPPER 95% CI	CHANNEL	BREACH	UPSTREAM	TOWARD	REFUGIO	PICO CENTER
DEL	61.50	49.04	144.44			*	*	*	*
ELM	113.23	68.72	195.07			*	*	*	*
BEAR	677.01	364.88	1190.65	*	*				*
ED	804.38	484.29	1336.03	*	*				*
MAR	1157.63	443.24	2907.09	*	*				
CENTER	6830.56	2693.45	17382.11	*	*	*	*		

b. Coliforms

	GEOMETRIC MEAN	LOWER 95% CI	UPPER 95% CI	CHANNEL	BREACH	TOWARD	UPSTREAM	REFUGIO	PICO CENTER
DEL	277.65	158.07	487.68				*	*	*
ELM	564.12	316.73	998.68						*
ED	948.28	488.86	1726.06	*					*
BEAR	1804.30	1167.32	2819.19	*					
MAR	2511.60	955.69	9065.93						
CENTER	7529.32	3185.32	17792.78	*	*	*			

c. Coliforms

	GEOMETRIC MEAN	LOWER 95% CI	UPPER 95% CI	CHANNEL	BREACH	UPSTREAM	TOWARD	REFUGIO	PICO CENTER
DEL	1004.56	574.77	1755.10			*	*	*	*
ELM	1290.66	759.10	2210.22						*
BEAR	3254.24	2287.55	7352.15	*	*			*	*
ED	7873.58	3665.63	15664.64	*	*			*	*
MAR	174220.62	27915.82	1087407.37	*	*	*	*		
CENTER	416431.73	147472.16	1176032.53	*	*	*	*		

Levels of concern were exceeded when:

a. total coliforms were greater than 1000 colony forming units per 100 ml of water (cfu/100 ml);

b. fecal coliforms were greater than 200 cfu/100 ml; and,

c. enterococci were greater than 24 cfu/100 ml.

Table 3. Seed Virus Recover Experiments.
Runoff was seeded with attenuated poliovirus.

Location	Virus Added	Virus Recovered	% Recovery
Pico-Kenter	3.4×10^5	2.7×10^5	79.5
Pico-Kenter	3.5×10^5	2.4×10^5	68.9
Pico-Kenter	3.8×10^6	2.7×10^5	7.1
Pico-Kenter	2.5×10^6	7.6×10^5	30.4
Herondo	6.3×10^3	1.4×10^4	2.2
Herondo	7.4×10^5	None	0
Herondo	2.7×10^6	1.3×10^6	48
Malibu Lagoon	2.9×10^6	8.4×10^4	2.9
Malibu Lagoon	2.6×10^6	2.0×10^5	7.7
Malibu Lagoon	2.9×10^6	4.9×10^5	16.9

TABLE 4. Geometric means and range of densities for F-male specific coliphage (coliphage/100 ml) collected simultaneously with virus samples at Pico-Kenter drain, Herondo drain and Malibu Lagoon.

SAMPLE SITE:	MEAN COLIPHAGE DENSITIES	RANGE OF COLIPHAGE DENSITIES
PICO-KENTER	1,040	25 TO 67,000
HERONDO	990	Below detection limit to 22,000
BREACH	100	Below detection limit to 1,700
C-CHANNEL	60	Below detection limit to 1,300
TEXACO	100	Below detection limit to 1,300
UPSTREAM	30	Below detection limit to 600

3-674

TABLE 5. Estimated densities of positive plaque assay (plaque forming units) and cytopathic effect (estimated infectious units) assays for human enteric viruses in the Pico-Kenter drain, Herondo drain, and Malibu Lagoon.

SAMPLE SITES:	DATE	PLAQUE ASSAY RESULTS	CYTOPATHIC EFFECT RESULTS
PICO-KENTER	8/13/91	1 pfu/87 gal	no CPE done
	9/25/91	1 pfu/2.8 gal	no CPE done
	10/2/91	none detected	≥1 Iu/23.2 gal
HERONDO	7/31/91	none detected	≥1 Iu/79.5 gal
	9/4/91	none detected	≥1 Iu/26.2 gal
BREACH	8/17/91	none detected	≥1 Iu/80 gal
C-CHANNEL	8/5/91	1 pfu/141 gal	no CPE done
	10/9/91	none detected	≥1 Iu/10.6 gal
UPSTREAM	9-3-91	none detected	≥1 Iu/28.7 gal
	9-30-91	none detected	≥1 Iu/83 gal

TABLE 6. The mean and range of values for conductivity (mmhos), pH and temperature (degrees Celsius) of samples collected simultaneously with virus samples at Pico-Kenter drain, Herondo drain, and Malibu Lagoon.

SAMPLE SITES:	CONDUCTIVITY	pH	TEMPERATURE
PICO-KENTER	1.7 0.5 to 2.9	7.8 5.6 to 8.3	20.1 17.0 to 22.0
HERONDO	6.8 1.2 to 23.0	6.8 3.0 to 7.8	21.2 20.0 to 22.1
BREACH	22.9 1.6 to 51.5	8.1 6.3 to 9.2	20.3 17.5 to 24.5
C-CHANNEL	23.7 3.0 to 50.4	8.2 7.0 to 9.4	20.3 17.5 to 24.5
TEXACO	6.9 2.1 to 28.1	7.7 6.0 to 8.5	20.3 17.5 to 24.5
UPSTREAM	12.5 0.5 to 48.0	7.8 5.9 to 8.9	20.3 17.5 to 24.5

[1] Temperatures were only measured at one sample site per day at Malibu Lagoon.

3-675

BLE 7. Results of separate t tests comparing geometric means in 1990 with those in 1991. All data included. The symbols at each site indicate the results of the t test as follows:

*** P ≤ .0001
** P ≤ .001
* P ≤ .005
. P ≤ .05
blank P > .05
- no test

To control the experimentwise type-I error to P ≤ .05, use P ≤ .005 (*) as the critical level.

ENTEROCOCCUS

TR	100S	50S	25S	0	25N	50N	100N
LB	**	***	***	***	**	**	**
ST	-	-	**	*	**	.	.

AL COLIFORMS

TR	100S	50S	25S	0	25N	50N	100N
LB	*	***	***	**	*	**	.
ST	-	-	.			-	-

COLIFORMS

TR	100S	50S	25S	0	25N	50N	100N
LB	.	**	***	***	.	.	.
ST	.	-				-	-

APPENDIX 1. Pertinent Information on f2 Bacteriophage.

The proprietary aspect to this methodology is the host strain of Escherichia coli which contains an f1 plasmid carrying resistances to ampicillin and streptomycin. The host used in this study was the Y.J. Cabelli host. Media and procedures were also from Cabelli et. al. and they should be credited.

f2 Bacteriophage-Water Concentration Technique

1. Allow sample to warm to room temperature.
2. In a 250 ml centrifuge bottle add 1 g powdered tryptone (Difco Laboratories, Inc., Detroit, MI) and 1 g powdered beef extract (Scott Laboratories, Inc., Fiskville, RI).
3. Add 100 ml sample to centrifuge bottle, and mix.
4. Add 10 ml of host (F amp) culture grown 3-4 h in tryptone broth.
5. Incubate at 32 C on a rotary shaker set on low (very slow) for 50 minutes.
6. Centrifuge at 9000 x g for 15 min. at 3-4 C.
7. Aspirate all except 10 ml out of centrifuge bottle.
8. Resuspend pellet in the remaining 10 ml volume.
9. Assay these 10 ml by adding 2.5 ml volumes to 2.5 ml amounts of double strength top (soft) agar, tempered to 46-50 C, for each of 4 plates.
10. Mix immediately, pour top agar on bottom agar plates, and spread over entire plate surfaces by gentle swirling.
11. Incubate 18-24 h at 35 C.
12. Count plaques and calculate f2 per 100 ml.

Note: Do not shake host (F amp) culture vigorously. Vigorous mixing of host strain cells will remove pili and inhibit f2 infection.

The 3-4 hour culture added in step 4 can be established by adding a few milliliters of an overnight grown broth culture. The broth used for the overnight culture should contain ampicillin and streptomycin at the same concentration as bottom agar.

3-676

Note: Maintain the host strain on tryptone bottom agar slants containing 15 microgram per ml each ampicillin and streptomycin sulfate. Grow overnight at 35 C, then store in a refrigerator (2-6) for up to several weeks. Use this working stock culture to inoculate tryptone broths when assays are to be performed.

Stock cultures of the host strain must be maintained on antibiotic-containing media to insure the cells contain the F' plasmid.

Media for f2 phage procedure

Tryptone Broth for J-4 h host strain (2 amp) cultures and for all dilutions involving f2 bacteriophage.

Ingredient	Amount per liter
Tryptone	10 g
Dextrose	1 g
NaCl	5 g

Note: Tryptone broth is used for dilutions because it helps to disperse bacteriophage and minimizes clumping of f2.

Top Agar for f2 Bacteriophage Plaque Assay

Prepare double strength (2 x) as follows:

Ingredient	Amount per liter
Tryptone	20 g
Dextrose	2 g
NaCl	10 g
agar	14 g
1 ml of 1 M CaCl2 solution	

Heat to dissolve and dispense 2.5 ml volumes per tube.
Store frozen.
Autoclave 15 min., 121 C and cool to 45-50 C before adding equal volume (2.5 ml) sample.

Bottom Agar for f2 Bacteriophage Plaque Assay and Stock Cultures of Host Strain (F' amp):

Ingredient	Amount per liter
Tryptone	10 g
Dextrose	1 g
NaCl	5 g
agar	12 g

Add magnetic stirring bar to flask. Autoclave 15 min., 121 C.
Cool to 45-50 C.
Add antibiotics:

ampicillin	0.015 g
streptomycin sulfate	0.015 g

Magnetically mix gently, then pour plates.

3-677

APPENDIX C PHAGE ANALYSIS SUMMARY

Sample	Date	Phage/100 mL
Malibu Tesoro	5/13/91	<5 pfu
Malibu Tesoro	5/14/91	<5 pfu
Malibu Tesoro	5/22/91	<5 pfu
Malibu Tesoro	6/3/91	35 pfu
Malibu Tesoro	7/3/91	15 pfu
Malibu Tesoro	7/22/91	<5 pfu
Malibu Tesoro	7/30/91	<13 pfu
Malibu Tesoro	8/14/91	8×10^3 pfu
Malibu Tesoro	8/23/91	6×10^3 pfu
Malibu Tesoro	8/26/91	1.2×10^3 pfu
Malibu Tesoro	9/3/91	15 pfu
Malibu Tesoro	9/16/91	8.0×10^3 pfu
Malibu Tesoro	9/18/91	3.0×10^3 pfu
Malibu Tesoro	9/23/91	TNTC (> 161/mL)
Malibu Tesoro	9/30/91	70 pfu
Malibu Tesoro	10/01/91	15 pfu
Malibu Tesoro	10/09/91	50 pfu
Malibu Tesoro	10/09/91	3.0×10^3 pfu
Malibu Tesoro	10/15/91	2.2×10^3 pfu
Malibu Tesoro	10/16/91	<5 pfu
Malibu Tesoro	10/21/91	1.1×10^3 pfu
Malibu Tesoro	10/22/91	5.8×10^3 pfu
Malibu Tesoro	10/23/91	20 pfu
Malibu Tesoro - 100 yards East	5/13/91	<5 pfu
Malibu Tesoro - 100 yards East	5/15/91	<5 pfu
Malibu Tesoro - 100 yards East	5/22/91	5 pfu
Malibu C Channel	5/13/91	<5 pfu
Malibu C Channel	5/15/91	<5 pfu
Malibu C Channel	5/22/91	<5 pfu
Malibu C Channel	6/3/91	5 pfu
Malibu C Channel	6/3/91	<5 pfu
Malibu C Channel	7/3/91	<5 pfu
Malibu C Channel	7/22/91	5 pfu
Malibu C Channel	7/30/91	<13 pfu

PHAGE ANALYSIS SUMMARY (cont.)

Malibu Beach	10/01/91	15 pfu
Malibu Beach	10/09/91	40 pfu
Malibu Beach	10/15/91	1×10^3 pfu
Malibu Beach	10/16/91	2×10^3 pfu
Malibu Beach	10/18/91	<5 pfu
Malibu Beach	10/21/91	6.4×10^3 pfu
Malibu Beach	10/22/91	2.5×10^3 pfu
Malibu Beach	10/23/91	80 pfu
Malibu Station 8	5/13/91	<5 pfu
Malibu Upstream	5/15/91	5 pfu
Malibu Upstream	5/15/91	<5 pfu
Malibu Upstream	5/12/91	<5 pfu
Malibu Upstream	7/29/91	<5 pfu
Malibu Upstream	7/17/91	<5 pfu
Malibu Upstream	7/22/91	<5 pfu
Malibu Upstream	7/30/91	<13 pfu
Malibu Upstream	8/05/91	<5 pfu
Malibu Upstream	8/14/91	<5 pfu
Malibu Upstream	8/23/91	<5 pfu
Malibu Upstream	9/03/91	10 pfu
Malibu Upstream	9/16/91	15 pfu
Malibu Upstream	9/18/91	55 pfu
Malibu Upstream	9/23/91	2×10^3 pfu
Malibu Upstream	9/30/91	1×10^3 pfu
Malibu Upstream	10/01/91	65 pfu
Malibu Upstream	10/09/91	20 pfu
Malibu Upstream	10/09/91	4×10^3 pfu
Malibu Upstream	10/15/91	20 pfu
Malibu Upstream	10/16/91	<5 pfu
Malibu Upstream	10/21/91	1×10^3 pfu
Malibu Upstream	10/22/91	10 pfu
Malibu Upstream	10/23/91	10 pfu
Neranda	5/13/91	1000 pfu
Neranda	7/1/91	2.2×10^3 pfu
Neranda	7/10/91	Not recorded
Neranda	7/31/91	2×10^3 pfu

PHAGE ANALYSIS SUMMARY (cont.)		
Herondo	6/21/91	1.1×10^4 pfu
Herondo	6/04/91	33 pfu
Herondo	6/18/91	43 pfu
Imperial Highway	6/18/91	48 pfu
Imperial Hwy. - Slide Stream	6/24/91	9.2×10^3 pfu
Pico	6/25/91	1.2×10^5 pfu
Pico	7/09/91	40 pfu
Pico	7/15/91	20 pfu
Pico	7/24/91	7×10^4 pfu
Pico	7/23/91	28 pfu
Pico dup.	7/23/91	33 pfu
Pico	8/07/91	8.2×10^3 pfu
Pico dup.	8/07/91	8.0×10^3 pfu
Pico	8/12/91	5.5×10^4 pfu
Pico dup.	8/12/91	6.7×10^3 pfu
Pico 24 hour die-off	8/12/91	9.0×10^4 pfu
Pico 24 hour die-off dup.	8/12/91	1.1×10^5 pfu
- 39 -	8/13/91	8×10^3 pfu
Pico dup.	8/13/91	6×10^3 pfu
Pico	8/19/91	4.8×10^3 pfu
Pico	8/27/91	2×10^3 pfu
Pico	8/28/91	5×10^3 pfu
Pico	8/28/91	8×10^3 pfu
Pico dup.	8/28/91	5×10^3 pfu
Pico	9/25/91	1.5×10^4 pfu
Pico	10/02/91	1.2×10^4 pfu
Pico dup.	10/02/91	2×10^4 pfu
Ballona Creek	9/11/91	

PHAGE ANALYSIS SUMMARY				
1° Effluent	6/03/91	1.4×10^4 pfu		
1° Effluent	6/12/91	3.2×10^3 pfu		
1° Effluent	6/19/91	7.5×10^3 pfu		
1° Effluent	6/26/91	1.4×10^4 pfu		
1° Effluent	7/3/91	1.2×10^4 pfu		
1° Effluent	7/8/91	1×10^4 pfu		
1° Effluent	7/17/91	8.0×10^3 pfu		
1° Effluent	7/16/91	8.0×10^3 pfu		
1° Effluent	7/24/91	1.4×10^4 pfu		
1° Effluent dup	7/24/91	2.0×10^4 pfu		
1° Effluent	7/25/91	8.1×10^3 pfu		
1° Effluent dup	7/25/91	8.4×10^3 pfu		
1° Effluent	8/20/91	8.3×10^3 pfu		
1° Effluent	8/28/91	1×10^4 pfu		
1° Effluent	9/04/91	9.3×10^3 pfu		
1° Effluent	9/11/91	8.6×10^3 pfu		
1° Effluent	9/24/91	7.5×10^3 pfu		
Effluent	9/25/91	2×10^4 pfu		
1° Effluent	10/09/91	1.3×10^4 pfu		
1° Effluent	10/15/91	1.7×10^4 pfu		
1° Effluent	10/23/91	1.6×10^4 pfu		
1° Effluent dup.	10/23/91	7.7×10^3 pfu		

SAMPLE LOCATION	DATE	PLAQUE ASSAY RESULTS	CPE ASSAY RESULTS
Malibu C Channel	06/28/91	41 pfu/2 mL	<1 iu/3 mL
Pico	06/27/91	<1 pfu/2 mL	<1 iu/3 mL
Pico	06/28/91	<1 pfu/2 mL	<1 iu/2 mL
Malibu Upstream	06/03/91	<1 pfu/2 mL	<1 iu/3 mL
Herondo	06/04/91	<1 pfu/2 mL	<1 iu/3 mL
Bolsa	06/11/91	<1 pfu/2 mL	<1 iu/4 mL
Malibu Upstream	06/16/91	<1 pfu/2 mL	<1 iu/3 mL
Malibu Breach	06/18/91	<1 pfu/2 mL	<1 iu 10 mL
Malibu Breach	06/23/91	Todo	<1 iu/4 mL
Pico	06/25/91	[illegible]	<5 iu/10 mL
Malibu Upstream	06/30/91	<1 pfu/2 mL	[illegible]
Malibu Breach	10/01/91	<1 pfu/2 mL	<1 iu/ 8 mL
Pico	10/02/91	<1 pfu/2 mL	[illegible]
Malibu Breach	10/08/91	<1 pfu/2 mL	<1 iu/8 mL
Malibu C Channel	10/09/91	<1 pfu/2 mL	[illegible]
Malibu Breach	10/15/91	<1 pfu/2 mL	<1 iu/10 mL
Malibu C Channel	10/16/91	<1 pfu/2 mL	<1 iu/10 mL
Malibu C Channel	10/21/91	<1 pfu/2 mL	<1 iu/12 mL
Malibu Upstream	10/22/91	<1 pfu/2 mL	<1 iu/14 mL
Malibu C Channel	10/23/91	<1 pfu/2 mL	<1 iu/10 mL

SAMPLES GROUPED BY LOCATION

SAMPLE LOCATION	DATE	PLAQUE ASSAY RESULTS	CPE ASSAY RESULTS
Malibu C Channel	06/03/91	<1 pfu/3 mL	<1 iu/16 mL
Malibu C Channel	06/05/91	[illegible]	<1 iu/16 mL
Malibu C Channel	07/03/91	<1 pfu/3 mL	<1 iu/2 mL
Malibu C Channel	07/22/91	<1 pfu/2mL	No data
Malibu C Channel	08/25/91	<1 pfu/2 mL	<1 iu/3 mL
Malibu C Channel	10/09/91	<1 pfu/2 mL	[illegible]
Malibu C Channel	10/16/91	<1 pfu/2 mL	<1 iu/16 mL

APPENDIX 3. Santa Monica Bay Virus Sampling Results

SAMPLE LOCATION	DATE	PLAQUE ASSAY RESULTS	CPE ASSAY RESULTS
Malibu C Channel	06/05/91	<1 pfu/3 mL	<1 iu/16 mL
Malibu C Channel	06/05/91	[illegible]	<1 iu/16 mL
Malibu Upstream	06/10/91	<1 pfu/3 mL	<1 iu/3 mL
Malibu Upstream	06/12/91	<1 pfu/3 mL	<1 iu/4 mL
Malibu Breach	06/17/91	<1 pfu/3 mL	[illegible]
Malibu Breach	06/19/91	<1 pfu/3 mL	<1 iu/4 mL
Pico	06/24/91	<1 pfu/3 mL	<1 iu/8 mL
Pico	06/26/91	<1 pfu/3 mL	<1 iu/16 mL
Herondo	07/01/91	<1 pfu/3 mL	<1 iu/4 mL
Malibu C Channel	07/03/91	<1 pfu/3 mL	<1 iu/2 mL
Pico	07/08/91	<1 pfu/3 mL	<1 iu/2 mL
Herondo	07/10/91	<1 pfu/3 mL	<1 iu/10 mL
Pico	07/15/91	<1 pfu/2mL	No data
Malibu Upstream	07/17/91	<1 pfu/2mL	No data
Malibu C Channel	07/22/91	<1 pfu/2mL	No data
Pico	07/24/91	<1 pfu/2 mL	<1 iu/16 mL
Pico	07/29/91	<1 pfu/2 mL	<1 iu/8 mL
Pico	07/30/91	<1 pfu/2 mL	----------
Herondo	07/31/91	<1 pfu/2 mL	[illegible]
Malibu Upstream	08/05/91	<1 pfu/2 mL	<1 iu/8 mL
Malibu Breach	08/06/91	----------	----------
Pico	08/07/91	----------	----------
Pico	08/12/91	<1 pfu/2 mL	<1 iu/14 mL
Pico	08/13/91	[illegible]	No CPE done
Malibu Breach	08/14/91	<1 pfu/2 mL	<1 iu/13 mL
Pico	08/19/91	<1 pfu/2 mL	<1 iu/13 mL
Malibu Upstream	08/20/91	<1 pfu/2 mL	<1 iu/19 mL
Herondo	08/21/91	<1 pfu/2 mL	<1 iu/3 mL

3-689

SAMPLE LOCATION	DATE	PLAQUE ASSAY RESULTS	CPE ASSAY RESULTS
Malibu C Channel	10/21/91	<1 pfu/2 mL	<1 iu/12 mL
Malibu C Channel	10/23/91	<1 pfu/2 mL	<1 iu/10 mL
Malibu Upstream	06/10/91	<1 pfu/3 mL	<1 iu/8 mL
Malibu Upstream	06/12/91	<1 pfu/3 mL	<1 iu/4 mL
Malibu Upstream	07/17/91	<1 pfu/2mL	No data
Malibu Upstream	08/05/91	<1 pfu/2 mL	<1 iu/8 mL
Malibu Upstream	08/20/91	<1 pfu/3 mL	<1 iu/19 mL
Malibu Upstream	09/03/91	<1 pfu/2 mL	<1 iu/16 mL
Malibu Upstream	09/16/91	<1 pfu/2 mL	<1 iu/6 mL
Malibu Upstream	09/30/91	<1 pfu/2 mL	<1 iu/6 mL
Malibu Upstream	10/22/91	<1 pfu/2 mL	<1 iu/14 mL
Malibu Breach	06/17/91	<1 pfu/3 mL	<1 iu/4 mL
Malibu Breach	06/19/91	<1 pfu/3 mL	<1 iu/4 mL
Malibu Breach	08/06/91	----------	----------
Malibu Breach	08/14/91	<1 pfu/2 mL	<1 iu/13 mL
Malibu Breach	09/18/91	<1 pfu/2 mL	<1 iu 10 mL
Malibu Breach	09/23/91	Toxic	<1 iu/4 mL
Malibu Breach	10/09/91	<1 pfu/2 mL	<11 iu/8 mL
Malibu Breach	10/15/91	<1 pfu/2 mL	<1 iu/10 mL
Pico	06/24/91	<1 pfu/3 mL	<1 iu/8 mL
Pico	06/26/91	<1 pfu/3 mL	<1 iu/16 mL
Pico	07/08/91	<1 pfu/3 mL	<1 iu/2 mL
Pico	07/15/91	<1 pfu/2mL	No data
Pico	07/24/91	<1 pfu/2 mL	<1 iu/16 mL
Pico	07/30/91	<1 pfu/2 mL	----------
Pico	08/07/91	----------	----------
Pico	08/12/91	<1 pfu/2 mL	<1 iu/14 mL
Pico	09/13/91	2 pfu/2 mL	No CPE done
Pico	08/16/91	<1 pfu/2 mL	<1 iu/10 mL
Pico	08/27/91	<1 pfu/2 mL	<1 iu/8 mL

Estimated Virus Densities in Positive CPE Assays

Sample	6/05/91	Malibu C Channel	1 Infectious Unit per 141 Gal
Sample	6/17/91	Malibu Breach	≥1 Infectious Unit per 80 Gal
Sample	7/31/91	Herondo Storm Drain	≥1 Infectious Unit per 79.5 Gal
Sample	8/13/91	Pico Storm Drain	≥2 Infectious Unit per 114 Gal
Sample	9/03/91	Malibu Upstream	≥3 Infectious Units per 66 Gal
Sample	9/04/91	Herondo Storm Drain	≥5 Infectious Units per 131 Gal
Sample	9/25/91	Pico Storm Drain	5 Infectious Units per 14 Gal
Sample	9/30/91	Malibu Upstream	≥1 Infectious Unit per 63 Gal
Sample	10/02/91	Pico Storm Drain	≥5 Infectious Units per 139.5 Gal
Sample	10/09/91	Malibu C Channel	≥11 Infectious Units per 117 Gal

APPENDIX 4 - PHYSICAL MEASUREMENT DATA FOR THE SIX SAMPLING SITES

DATE	FLOW RATE	pH	CONDUCTIVITY (mS/cm)	TEMPERATURE (DEGREES)	SAMPLE DEPTH	SAMPLE TUBE
13 MAY 91	TEXACO UPSTREAM C-CHANNEL C-PIPE BREACH	7.6 6.1 6.3 6.5	2.6 2.6 4.0 3.4	- - - -	6'-6"	3.7'
15 MAY 91	TEXACO UPSTREAM C-CHANNEL C-PIPE BREACH	- - - -	- - - -	17.5 16.5 17.6 16.6	8'-6"	3.4'
19 MAY 91	DESERTED	-	-	-	-	-
16 MAY 91	IMPERIAL	-	-	-	-	-
22 MAY 91	TEXACO UPSTREAM C-CHANNEL C-PIPE BREACH	8.0 7.9 8.3 8.6 8.2	6.1 6.1 21.0 16.1 21.7	- - - - -	3'-0"	0.8"
29 MAY 91	TEXACO UPSTREAM C-CHANNEL BREACH	- - - -	- - - -	- - - -	4'-0"	3.3'
3 JUNE 91	TEXACO UPSTREAM C-CHANNEL* BREACH	7.9 8.9 8.4 8.3	5.2 6.5 9.4 11.1	-	5'-2"	1.3'
5 JUNE 91	TEXACO UPSTREAM C-CHANNEL* BREACH	8.0 7.9 8.6 8.3	7.7 6.2 6.9 11.1	-	3'-0"	1.2'
10 JUNE 91	TEXACO UPSTREAM* C-CHANNEL BREACH	8.2 8.3 8.5 9.0	2.5 3.2 4.5 6.4	- - - -	3'-0"	2.0'

LOCATION	DATE	FLOW RATE	TOTAL COLIFORM BACTERIA
Arvida	07/01/91	<1 plu/3 mL	<1 tb/16 mL
Pico	07/02/91	<1 plu/2 mL	<1 tb/16 mL
Pico	08/28/91	<1 plu/2 mL	<1 tb/12 mL
Arvida	08/29/91	<1 plu/3 mL	<1 tb/16 mL
Arvida	07/10/91	<1 plu/3 mL	<1 tb/16 mL
Hiranda	07/10/91	<1 plu/2 mL	<1 tb/2 mL
Hiranda	07/31/91	<1 plu/2 mL	<1 tb/2 mL
Hiranda	08/21/91	<1 plu/2 mL	<1 tb/16 mL
Hiranda	09/04/91	<1 plu/2 mL	<1 tb/4 mL
Balboa	08/11/91	<1 plu/2 mL	<1 tb/4 mL

NOTES: Samples collected on 08/08/91 and 08/07/91 and part of 7/09/91 were lost when the glass centrifuge tubes broke during high speed centrifugation in the dessication procedure.

There are no CFE data on samples from 7/16, 7/17, and 7/22.

13 JUNE 91	TEXACO UPSTREAM* C-CHANNEL BREACH	7.7 7.6 7.9 7.9	4.0 3.0 26.0 25.0	- - - -	2.0*	3.9*
17 JUNE 91	TEXACO UPSTREAM C-CHANNEL BREACH*	7.1 8.1 7.9 7.9	2.8 2.6 23.9 20.6	- - - 17.9	2.2*	1.5*
19 JUNE 91	TEXACO UPSTREAM C-CHANNEL BREACH*	7.6 7.6 7.7 7.8	1.2 2.4 23.3 8.8	- - - -	2.0*	1.2*
24 JUNE 91	PICO	6.5	1.84	17.0	NA	NA
26 JUNE 91	PICO	8.3	-	17.5	NA	NA
1 JULY 91	HERONDO	7.78	-	20.0	NA	NA
3 JULY 91	TEXACO UPSTREAM C-CHANNEL* BREACH	7.91 7.78 8.30 8.16	2.06 46.00 5.46 10.96	-	2.0*	2.4*
8 JULY 91	PICO	7.80	.307	21	NA	NA
10 JULY 91	HERONDO	8.0	23	-	NA	NA
15 JULY 91	PICO	7.77	-	21.5	NA	NA
17 JULY 91	TEXACO UPSTREAM* C-CHANNEL BREACH	7.66 7.46 7.72 7.54	3.93 .472 20.9 1.61	18.6	2.0*	2.6*
22 JULY 91	TEXACO UPSTREAM C-CHANNEL BREACH	7.97 7.95 8.68 7.87	4.2 12.5 38.4 28.9	18.0	2.0*	3.2*
24 JULY 91	PICO	7.69	1.84	19.0	NA	NA
29 JULY 91	PICO	7.87	1.71	20.0	NA	NA

241

30 JULY 91	TEXACO UPSTREAM C-CHANNEL* BREACH	7.37 7.46 7.59 7.81	4.8 4.10 24.9 49.3	20.0		4.2*
31 JULY 91	HERONDO	7.11	1.15	22.0	NA	NA
5 AUGUST 91	TEXACO UPSTREAM* C-CHANNEL BREACH	7.72 7.77 7.85 7.90	3.38 9.53 12.70 15.00	19.5	2.0*	2.8*
6 AUGUST 91	TEXACO UPSTREAM C-CHANNEL BREACH*	7.86 7.65 8.04 7.72	7.5 16.7 37.4 39.4	20.0	2.0*	2.9*
7 AUGUST 91	PICO	8.31	1.75	20.0	NA	NA
12 AUGUST 91	PICO	7.16	1.55	20.5	NA	NA
13 AUGUST 91	PICO	8.02	1.87	21.5	NA	NA
14 AUGUST 91	TEXACO UPSTREAM C-CHANNEL BREACH*	7.86 7.66 8.92 7.55	7.01 7.17 30.4 37.5	20.5	2.0*	4.4*
19 AUGUST 91	PICO	8.00	1.81	20.0	NA	NA
20 AUGUST 91	TEXACO UPSTREAM* C-CHANNEL BREACH*	7.33 7.27 8.02 7.03	28.1 23.2 30.7 41.7	21.0		3.3*
21 AUGUST 91	HERONDO	7.46	7.58	22.1	NA	NA
26 AUGUST 91	TEXACO UPSTREAM C-CHANNEL* BREACH	7.57 7.40 7.47 7.62	3.15 22.1 37.6 51.3	22.5	2.0*	5.0*
27 AUGUST 91	PICO	7.38	1.8	20.0	NA	NA
28 AUGUST 91	PICO	6.57	2.89	22.0	NA	NA

242

3 SEPTEMBER 91	TEXACO UPSTREAM* C-CHANNEL RESEARCH	7.01 7.49 7.66 7.56	3.66 40.1 36.3 36.3	24.5		3.0"
6 SEPTEMBER 91	RESEARCH	7.46	1.39	20.9		NA
11 SEPTEMBER 91	BALLONA	7.85	1.61	17.0	NA	NA
16 SEPTEMBER 91	TEXACO UPSTREAM* C-CHANNEL RESEARCH	7.49 8.12 8.33 7.38	5.16 16.11 22.4 12.28	19.2	2.0"	3.9"
18 SEPTEMBER 91	TEXACO UPSTREAM C-CHANNEL RESEARCH*	7.67 8.09 8.15 8.32	4.9 8.84 39.0 37.9	19.3	2.5"	3.2"
23 SEPTEMBER 91	TEXACO UPSTREAM C-CHANNEL RESEARCH*	8.34 8.50 8.09 9.22	10.83 16.92 23.30 33.30	23.5	3.0"	4.0"
25 SEPTEMBER 91	PICO	7.76	1.46	20.5	NA	NA
30 SEPTEMBER 91	TEXACO UPSTREAM* C-CHANNEL RESEARCH	7.79 8.36 8.09	9.34 17.65 23.20 20.60	23.0	3.0"	4.2"
1 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL RESEARCH*	8.08 8.11 8.35 8.19	20.7 172.47 19.44 21.00	22.0	3.0"	3.2"
2 OCTOBER 91	PICO	7.97	3.18	21.5	NA	NA
7 OCTOBER 91	BALLONA	9.36	1.26	23.5	NA	NA
8 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL RESEARCH*	6.03 5.87 7.46 6.61	9.0 11.3 21.2 21.9	20.0	3.0"	5.7"

9 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL* RESEARCH	7.26 7.33 8.04 8.18	17.7 17.4 16.3 26.2	-	3.0"	6.0"
13 OCTOBER 90	TEXACO UPSTREAM C-CHANNEL RESEARCH*	8.06 7.90 8.02 8.55	8.06 13.54 22.0 17.7	20.5	3.0"	6.0"
16 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL* RESEARCH	7.90 7.90 8.43 8.37	9.76 12.52 19.79 16.80	20.5	3.0"	3.2"
21 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL* RESEARCH	8.36 8.09 9.12 8.37	8.04 11.56 19.92 18.13	21.0	4.0"	3.0"
22 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL RESEARCH	7.00 8.23 6.38 8.47	7.0 10.4 19.7 18.0	21.0	4.0"	4.2"
23 OCTOBER 91	TEXACO UPSTREAM C-CHANNEL* RESEARCH	8.48 8.48 8.00 8.37	8.47 10.16 20.00 18.41	20.0	4.2"	5.2"

* Indicates specific locality of mailbu vitro sample.
NA - Not applicable.

APPENDIX 5 Geometric mean bacterial densities and percent exceedances of bacterial levels of concern at each station during the six days when the Pico-Kenter drain was discharging directly to the surfzone.

	SAMPLING SITES							
VARIABLE	DRAIN	100N	50N	25N	0	25S	50S	100S
ANKLE DEPTH:								
TOTAL COLIFORMS	360000 83%	220 17%	370 17%	520 17%	860 67%	1080 50%	1000 33%	540 17%
FECAL COLIFORMS	28000 83%	80 17%	160 33%	150 50%	220 67%	270 83%	280 83%	110 33%
ENTEROCOCCUS	12000 83%	28 83%	33 83%	56 83%	94 83%	100 83%	100 83%	57 83%
CHEST DEPTH:								
TOTAL COLIFORMS		94 0%	180 0%	100 0%	110 0%	190 25%		
FECAL COLIFORMS		27 0%	33 20%	24 20%	17 0%	29 25%		
ENTEROCOCCUS		11 40%	18 20%	14 20%	12 20%	18 50%		

The predominant source of the Pico-Kenter runoff during these six sampling dates was the dewatering operation from a sewer replacement project nearby.

This Page Intentionally
Left Blank

Draft Resolution
Oct, 21, 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Resolution No. R4-2009-xx

Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties
to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

WHEREAS, the California Regional Water Quality Control Board, Los Angeles Region (hereinafter Regional Board), finds that:

1. In the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (hereafter *Basin Plan*), the Regional Board designated beneficial uses and established water quality objectives for the following water resources in the Civic Center area of the City of Malibu:

   Groundwater: Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

   Malibu Lagoon: Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

   Malibu Creek: Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

   Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach: Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.

2. In the 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses were formally identified for the following water resources:

   Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
   Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
   Malibu Beach: impaired by Indicator Bacteria.
   Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
   Carbon Beach: impaired by Indicator Bacteria.

DRAFT OCT 21 2009

DRAFT OCT 21 2009

3. To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

   i. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential land use activities. The TMDL specifies a load allocation for on-site wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

   ii. **Malibu Creek and Lagoon Bacteria TMDL**: The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, on-site wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for on-site wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

   iii. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for on-site wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including on-site wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

4. Pursuant to California Water Code section 13243, the Regional Board may, in its *Basin Plan*, specify certain conditions or areas where the discharge of waste, or certain types of

waste, will not be permitted. During a public meeting on December 14, 1998, the Regional Board directed the Executive Officer to prepare a prohibition of on-site wastewater disposal systems (OWDS) for consideration by the Regional Board. During a public meeting on November 13, 2008, the Regional Board discussed the need for a firm time schedule to address water quality problems in the Malibu Civic Center area and again directed staff to prepare a prohibition of on-site wastewater disposal systems for Board consideration.

5. For the purposes of this *Basin Plan* amendment, the "Malibu Civic Center area" is defined as the area within the Winter Canyon and Malibu Valley watersheds and adjacent coastal strips between and including Amarillo Beach and Surfrider Beach. A map depicting the boundaries of the Malibu Civic Center area is area is attached hereto as Exhibit 1.

6. In accordance with the California Water Code, sections 13280, 13281 and 13283, Regional Board staff presented technical evidence in a public hearing on November 5, 2009, demonstrating that discharges of wastewater from OWDSs in the Civic Center area fail to meet water quality objectives established in the *Basin Plan,* contribute to impairments of present or future beneficial uses of water resources, and cause pollution, nuisance or contamination. Section 13280 states that a determination that discharges from OWDSs should not be permitted shall be supported by substantial evidence. The evidence, as summarized in the Technical Staff Report, leads to the following conclusions:

   i. Dischargers in the Civic Center area subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance.

   ii. Discharges of wastewaters released from OWDSs in the Civic Center area to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water.

   iii. Discharges of wastewaters released from OWDSs in the Civic Center area to groundwater that are in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation.

   iv. Discharges of wastewaters released from OWDSs in the Civic Center Area to groundwater that are in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the nutrient TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.

   v. Wastewater flows from OWDSs in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and

DRAFT OCT 21 2009

many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

7. Peer reviews of the scientific portions of the technical staff report were conducted pursuant to California Health and Safety Code section 57004. The peer reviewers confirmed that the technical staff report was based upon sound scientific knowledge, methods and practices.

8. No authorized public agency has offered satisfactory assurance that discharge systems are appropriately designed, located, sized, spaced, constructed, and maintained, such that they are adequate to protect the quality of water for beneficial uses in the Malibu Civic Center area, pursuant to the California Water Code section 13282.

9. Pursuant to the California Water Code section 13283, the State Water Resources Control Board (State Board) is required to include a preliminary review of possible alternatives necessary to achieve protection of water quality and present and future beneficial uses of water, and prevention of nuisance, pollution, and contamination, including, but not limited to, community collection and waste disposal systems which utilize subsurface disposal, and possible combinations of individual disposal systems, community collection and disposal systems which utilize subsurface disposal, and convention treatment systems. The Regional Board has conducted a preliminary review of possible alternatives, as documented in the staff report.

10. The basin planning process has been certified as functionally equivalent to the California Environmental Quality Act (CEQA), including preparation of an initial study, negative declaration, and environmental impact report (California Code of Regulations, title 14, section 15251(g)). As this amendment is part of the basin planning process, staff has prepared an Environmental Staff Report, which is considered a substitute to an initial study, negative declaration, and/or environmental impact report. This Environmental Staff Report satisfies the substantive requirements of the California Code of Regulations, title 23, section 3777(a), and includes a project description, environmental checklist, reasonable alternatives, alternative methods of compliance with the Basin Plan amendment, and mitigation measures. The Environmental Staff Report, together with this resolution and the responses to comments constitute the Substitute Environmental Documents, as specified in California Code of Regulations, title 23, section 15252. The Regional Board hereby determines that depending upon the compliance project selected, there could be significant adverse impacts, as specified in the Substitute Environmental Documents. However, there are also impacts that can be mitigated and be less than significant. The potential mitigation measures are set forth in the Environmental Staff Report and checklist incorporated therein.

DRAFT OCT 21 2009

THEREFORE, be it resolved that:

1. Pursuant to sections 13240 and 13241 of the California Water Code, the Regional Board, after considering the entire record including oral testimony at the hearing, finds the evidentiary requirements specified in section 13280 et seq. have been satisfied and that discharges from septic systems in the Malibu Civic Center area fail to meet water quality objectives and impair both existing and potential beneficial uses of water, as documented in the Final Technical Staff Report, dated November 5, 2009. Pursuant to section 13240 of the California Water Code, the Regional Board hereby adopts and amends the *Basin Plan* to include a prohibition on discharges from on-site wastewater disposal systems in the Civic Center area. This amendment, as set forth in Exhibit 2, will:

   - Prohibit all new discharges.

   - Prohibit discharges from existing systems within five years from the date of adoption by the Regional Board of this *Basin Plan* amendment.

2. The Regional Board has reviewed and considered the information contained in the Substitute Environmental Documents, as described in Finding 10, above, and hereby adopts and certifies them.

3. Pursuant to California Code of Regulations, tit.14 section 15091(a)(2), the Regional Board hereby finds, as more fully set forth in the Environmental Staff Report, that there are potentially significant impacts from implementation projects to comply with the proposed prohibition on OWDSs, but notes that there are mitigation measures available to reduce potentially significant environmental impacts to less than significant levels. However, implementation of these mitigation measures are not under the control or discretion of the Regional Board, but are within the responsibility and jurisdiction of other (responsible) agencies, which will be required to comply with or assist affected citizens in complying with the provisions of this prohibition (e.g., the City of Malibu). These agencies have the ability to implement these mitigation measures, can and should implement these mitigation measures, and are required under CEQA to consider whether to implement the mitigation measures when they undertake their own evaluation of impacts associated with compliance with the prohibition. (See Pub. Res. C. § 21159.2.) This finding is made pursuant to Title 14, California Code of Regulations, section 15091(a)(2).

4. Pursuant to California Code of Regulations, tit.14, section 15093, the Regional Board hereby finds that the project's benefits significant adverse impacts override and outweigh its potential unavoidable impacts, for the reasons more fully set forth in the Environmental Staff Report. Specific economic, social, and environmental benefits justify the adoption of this project despite the project's potential significant adverse environmental impacts. These benefits, which include contributing to the present and future restoration of beneficial water uses, and reducing or eliminating pollution, nuisance and contamination, warrant approval of the project, despite each and every

DRAFT OCT 21 2009

unavoidable impact. Upon review of the environmental information generated for this prohibition and in view of the entire record supporting the need for a prohibition, staff has determined that specific economic, legal, social, technological, environmental, and other benefits of this proposed prohibition outweigh the unavoidable adverse environmental effects, and that such adverse environmental effects are acceptable under the circumstances. This determination is based upon the fact that most of the identified significant adverse impacts from the reasonably foreseeable means of compliance are temporary nuisance impacts associated with abatement of the use of OWDSs, and/or the construction of compliance projects. The foreseeable means of compliance are generally accepted beneficial infrastructure amenities in most municipal jurisdictions, and typically installed for the benefit of the community irrespective of their potential growth inducing and other impacts associated with their construction and operation. Furthermore, the reasonably foreseeable means of compliance with the prohibition are expected to result, over the long term, in positive environmental improvements to the environment, including water quality and restoration of beneficial uses of water resources (including decreased instances of associated illness), and economic benefits associated with increased use from their restoration. This is particularly important at the Malibu beaches which are generally considered to be some of best beach environments in the State of California. Enhancement of recreational uses of beaches, aquatic habitat in Malibu Lagoon, and drinking water potential in groundwater will have positive social and economic effects.

5. In making the determination in paragraph 1 above, the Regional Board has considered all of the factors set forth in California Water Code section 13281, including but not limited to, the factors set forth in section 13241.

6. The Executive Officer is directed to forward this *Basin Plan* amendment to the State Board in accordance with the requirements of sections 13245 of the California Water Code.

7. If, during the approval process, the State Board or Office of Administrative Law determines that minor, non-substantive corrections to the language of the amendment are needed for clarity or consistency, the Executive Officer may make such changes, and shall inform the Board of any such changes.

8. The Regional Board requests that the State Board approve the *Basin Plan* amendment in accordance with the requirements of sections 13245 and 13246 of the California Water Code and forward it to the Office of Administrative Law.

9. This prohibition is not intended to prevent repairs and maintenance to existing septic/disposal systems, provided that repairs and maintenance do not expand the capacity of the systems and increase flows of wastewaters.

10. Pursuant to Water Code section 13225 (or such other authority as may be appropriate), the Executive Officer is directed to require the City to submit quarterly written reports to

DRAFT OCT 21 2009

the Executive Officer, summarizing the strategy and progress toward meeting the 2014 prohibition deadline. In the quarterly progress reports, the City shall document progress, to the satisfaction of the Executive Officer, toward the following interim and final deadlines:

May 1, 2010:	Completion of 25% of a master facilities plan for possible projects to comply with the prohibition, including initiation of a strong public participation program.
November 1, 2010:	Completion of 50% of a master facilities plan and initiation of environmental review, with strong, on-going public participation. Concurrently, initiation of preliminary engineering and a feasibility study for possible projects to comply with the prohibition.
May 1, 2011:	Substantial completion of a master facilities plan, preliminary engineering and a feasibility study, and engagement of the public in selection of a project to comply with the prohibition.
November 1, 2011:	Completion of a master facilities plan, preliminary engineering and a feasibility study, and selection of a project to comply with the prohibition.
November 1, 2012:	Completion of final design for selected project.
November 1, 2013:	Completion of 50% of construction of selected project.
November 5, 2014:	Completion of project to comply with prohibition, including successful startup of facilities, residential and commercial connections to the project facilities, and cease discharge from OWDSs.

The first progress report is due March 31, 2010, and subsequent quarterly progress reports are due on March 31st, June 30th, September 30th, and December 31st until such time that the Regional Board determines that compliance with the prohibition has been achieved.

The City may, upon approval from the Executive Officer, transfer this responsibility to another public agency.

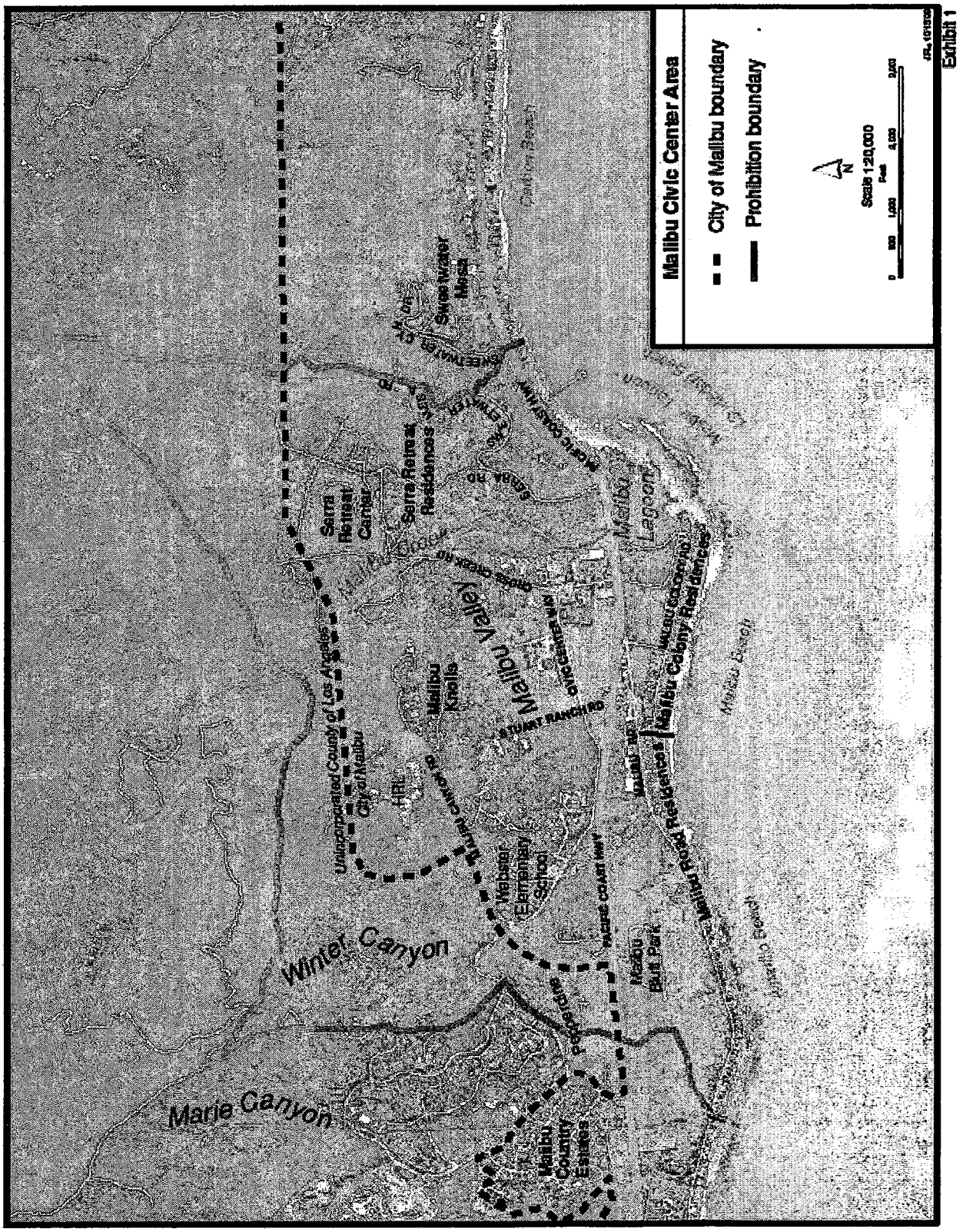
DRAFT OCT 21 2009

I, Tracy J. Egoscue, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of a resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on November 5, 2009.

_____

Tracy J. Egoscue
Executive Officer

DRAFT OCT 21 2009



DRAFT OCT 21 2009

Resolution No. R4-2009-xx

Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties
to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Exhibit 2: Language to be revised in the *Basin Plan*

The *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties* (*Basin Plan*) contains a section entitled "Septic Systems" in Chapter 4.[1] This amendment to the *Basin Plan* revises that section, as indicated by italicized, underlined text for additions, and text strikeouts for deletions.

Regulating Septic Systems

The California Water Code, Chapter 4, Article 5, sets forth criteria for prohibiting individual disposal systems (i.e., residential septic tanks). Alternatively, the Regional Board has authority to regulate discharges, including discharges from residential units, multiple-dwelling units, non-domestic septic tank systems, and large developments. ~~The California Water Code, Chapter 4, Article 5, sets forth criteria for regulaprohibiting individual disposal systems (i.e., residential septic tanks). Prior to the 1950s, the Regional Board placed certain types of septic tank systems under individual WDRs. In the 1950s, the regional Board delegates local health or public works departments jurisdiction to permit and regulate septic tank disposal systems, typically for single-family dwellings. However, Alternatively, the Regional Board has authority to regulatecould exercise jurisdiction over discharges, including discharges from residential units, multiple-dwelling units, some non-domestic septic tank systems, and large developments in certain problem areas, as well as in any situation where systems are creating or have the potential to create a water quality problem.~~

Oxnard Forebay Septic Prohibition

On August 12, 1999, the Regional Board amended the Basin Plan to include a prohibition on septic systems in the Oxnard Forebay (figure 4-xx~~2axx~~), pursuant to Section 13280 of the California Water Code. The prohibition applies to both future and existing septic systems in the Oxnard Forebay. As of August 12, 1999, new septic systems in the Oxnard Forebay were prohibited. By January 1, 2008, discharges from existing septic systems must cease. This action was taken in view of:

[1] Language to be revised will go into the *Basin Plan*, starting on page 4-17 (in the 1994 version) with the section currently entitled 'Septic Systems.'

DRAFT OCT 21 2009

- The conclusion that discharges of wastewaters from residential and commercial facilities to groundwater underlying the Oxnard Forebay do not meet water quality objectives specified in the Basin Plan, and are impairing the present and future beneficial uses of underlying resources of ground water.

- The need to ensure long-term protection of ground water underlying both the Oxnard Forebay and the Oxnard Plain. Alternatives to replace these supplies of local water, or to treat the water before beneficial use, would be costly and would violate the requirement to protect the water for beneficial uses.

The prohibition is not intended to prevent repairs to existing septic systems in the Oxnard Forebay prior to January 1, 2008, provided that the purpose of such repairs is not to increase capacity.

An exemption to this prohibition or a time extension of the effective date of the prohibition may be granted in the event the Regional Board determines that such an exemption or extension is in the best interest of water quality, in accordance with Water Code Section 13241 and the correction of water quality problems associated with the wastewater discharges from septic systems in the Oxnard Forebay.

Individual disposal systems that dispose of domestic wastewater that are located on lot sizes equal to or greater than five acres are not subject to this prohibition.

Malibu Civic Center Area Prohibition

On November 5, 2009, the Regional Board amended this Basin Plan *to prohibit on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area (figure 4-xx), pursuant to section 13280 of the California Water Code. Effective [insert effective date of Basin Plan amendment]:*

- *All new on-site wastewater disposal system discharges are prohibited.*
- *All wastewater discharges from existing on-site wastewater disposal systems are prohibited on November 5, 2014.*

The prohibition is not intended to prevent repairs, maintenance, and upgrades to existing on-site wastewater disposal systems prior to November 5, 2014, provided that repairs, maintenance, and upgrades do not expand the capacity of the systems or increase flows of wastewaters.

Other Areas

In other areas, where ground water constitutes an important source of drinking water, the Regional Board has adopted general WDRs (Order 91-94) for certain private residential subsurface sewage disposal systems. A lot with size less then 1 acre is not eligible for these general WDRs; for those lots between one and less than five acres in size, the General WDRs

DRAFT OCT 21 2009

require either a hydrogeologic study or mitigation measures. WDRs are not required for lot sizes greater than five acres.

DRAFT OCT 21 2009

Draft Technical Staff
Report, Oct, 21,2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Item 9
(Volume 1 of 2)

Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Staff Report

presenting evidence for the amendment

Environmental Staff Report

containing substitute environmental documentation in accordance with the California Environmental Quality Act in support of the amendment

Drafts dated October 21, 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

DRAFT

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

OCT 21 2009

October 21, 2009

Table of Content

Page Numbers

Technical Staff Report Overview.....1-19
Wendy Phillips

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.....TM1-1 to TM1-10
Rebecca Chou

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water
David Koo.....TM2-1 to TM2-7

Attachment 2-1 Data Tables for 59 Individual Wells.....TM2-8 to TM2-63
Attachment 2-2 Graphs for 59 Individual Well.....TM2-64 to TM2-119

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment to Body Contact Recreation.....TM3-1 to TM3-39
Elizabeth Erickson

Staff Peer Review Memorandum.....TM3-40 to TM3-76
Robert Arnold Peer Review.....TM3-77 to TM3-81
Jörg E. Drewes Peer Review.....TM3-82 to TM3-86
Joann Silverstein Peer Review.....TM3-87 to TM3-91

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life...TM4-1 to TM4-35
Toni Callaway and Orlando Gonzalez

Attachment 4-1 Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loading from OWDS to the Lagoon.....TM4-36 to TM4-45
C. P. Lai

Staff Peer Review Memorandum.....TM4-46 to TM4-52
Robert Arnold Peer Review.....TM4-53 to TM3-59
Jörg E. Drewes Peer Review.....TM4-60 to TM3-66
Joann Silverstein Peer Review.....TM4-67 to TM3-72

Technical Memorandum #5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.....TM5-1 to TM5-11
Dionisia Rodriguez and Ryan Thacher

Appendix A: Septic Waste Flow and Hauling Data.....TM12-12 to TM5-15
Appendix B: Inspection Report, City of Malibu Haulers.....TM5-16 to TM5-20
Appendix D: Inspection Report, Surfrider Beach.....TM5-21 to TM5-22
Appendix E: Malibu Potable Water Consumption Trends / Population Analysis.....TM5-23 to TM5-25

DRAFT OCT 2 1 2 0 0 9

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an
Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties
to Prohibit On-site Wastewater Disposal Systems
in the Malibu Civic Center Area

Technical Staff Report

Overview

DRAFT

OCT

2

1

2

0

0

9

3-702

DRAFT OCT 21 2009

Introduction

The purpose of this Technical Staff Report is to present evidence in support of an amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)*, to prohibit subsurface disposal systems (on-site wastewater disposal systems, or OWDSs), used in a developed and developing portion of the Malibu coast along the Santa Monica Bay. This area, referred to as the Malibu Civic Center area (Figure 1), has a residential population estimated at almost 2,000. The area also serves as the core of the City of Malibu's business, cultural, and commercial activities, and the population estimate of 2,000 does not include significant daytime and evening workers and visitors who travel to the area – in particular, visitors to the renowned Surfrider Beach. [1]

Without community sewers and wastewater treatment infrastructure, residents, businesses, and public facilities in the City of Malibu use thousands of on-site disposal systems to discharge their sewage to the subsurface and underlying groundwater. In several areas of the City, high flows of wastewaters coupled with unfavorable hydrogeologic conditions have raised concerns about reliance on this wastewater disposal strategy. In one of those areas, namely the Malibu Civic Center area, relatively intensive land use activities by more than 400 dischargers result in the release of wastewaters to the subsurface at a rate that Regional Board staff estimates to be as high as 270,000 gallons per day (gpd).

Description of the Proposed Prohibition

Prohibition Boundary

The area that would be affected by the proposed prohibition is referred to as the Malibu Civic Center area, and is delineated by the red line shown in Figure 1. The area is not defined according to municipal borders or parcel lines. Rather, the area subject to the prohibition is delineated according to hydrogeologic parameters and drainage patterns; as groundwater flow roughly mimics surface drainage, the prohibition boundary follows a topographic high surrounding both the Winter Canyon and lower Malibu Creek (also known as Malibu Valley) watersheds. All property extending seaward of this boundary to the ocean is subject to the prohibition, including the coastal strips along the Pacific Coast Highway stretching from Amarillo Beach to Surfrider Beach. This entire area, which is referred to as the "Malibu Civic Center area,"[2] totals 2.2 square miles of which 1.5 square miles and 0.7 square miles are within

[1] The population estimate of 2,000 does not include daytime and evening workers who are employed in the Malibu Civic Center area, and daytime and evening visitors who enjoy the beaches and patronize the businesses and public facilities in the area, and that the visitor population to Malibu area beaches (not limited to the area within the prohibition boundary) has substantially increased, from 233,500 per month in August of 1999 to 355,000 per month in August of 2006.

[2] As the prohibition area covers a small portion of the City of Malibu and an even smaller portion of unincorporated County of Los Angeles, staff avoided designating this as a 'Malibu' prohibition. Nor did staff select hydrologic terms to designate the prohibition area, out of concern that such terminology may not be readily recognized by the affected community. Rather, the designation of 'Malibu Civic Center area' was selected for broad name recognition.

the City of Malibu and the unincorporated area of County of Los Angeles, respectively. Figure 2 shows the civil boundaries and parcels.

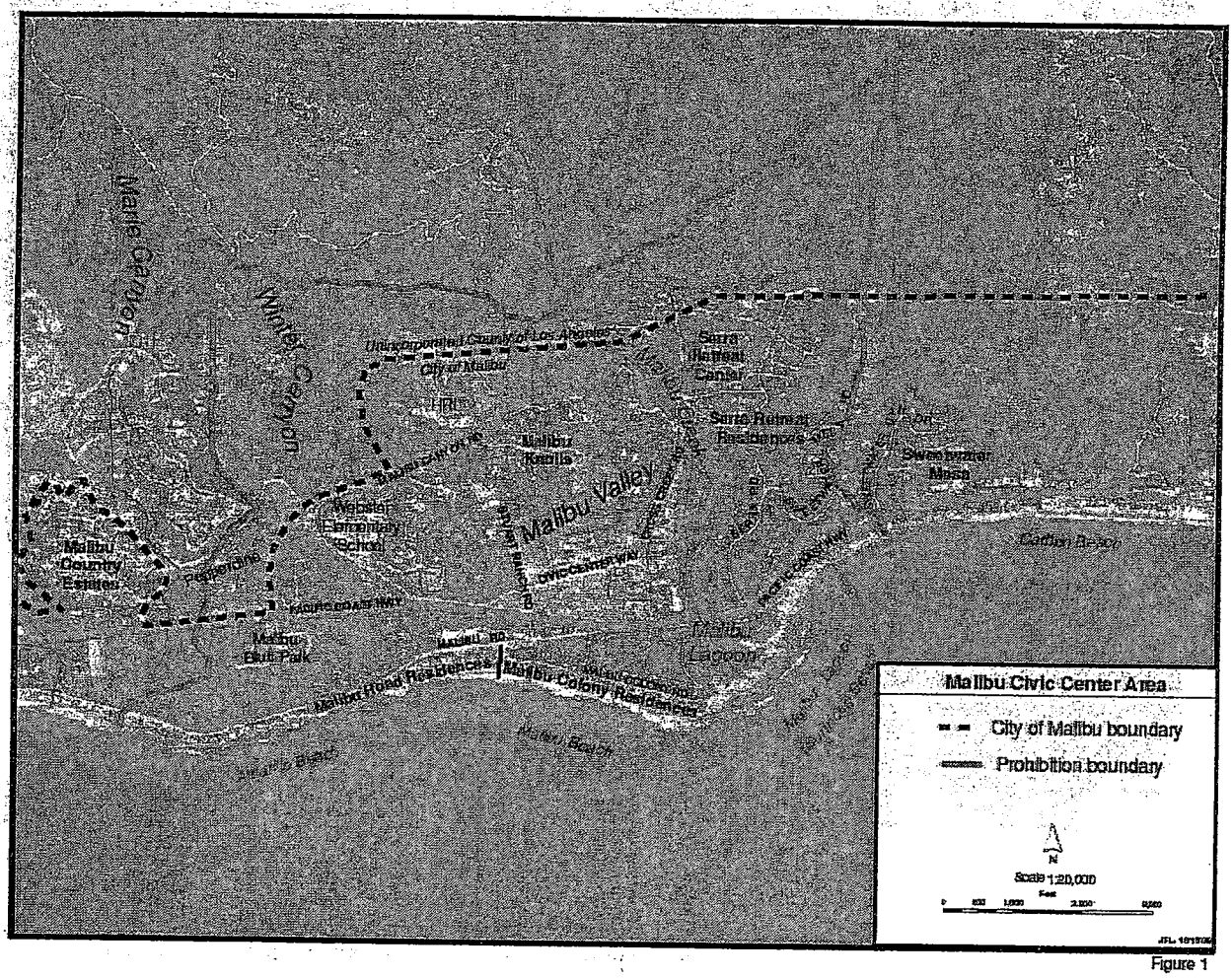


Figure 1

To the west, the prohibition boundary encompasses Winter Canyon not only because this watershed is heavily developed and discharges almost 50,000 gallons per day of wastewater (about 20% of the wastewater in the prohibition area), but also because wastewater management strategies for many commercial activities in the coastal strip adjacent to the Colony – as well as proposed strategies for managing future wastewaters from Malibu Valley – rely on disposal capacity in Winter Canyon, which is severely strained. Note that the prohibition area includes

DRAFT OCT 21 2009

only a small sliver of the Pepperdine University campus, as this sliver is the only portion of Pepperdine that falls within the topographically-defined Winter Canyon watershed.

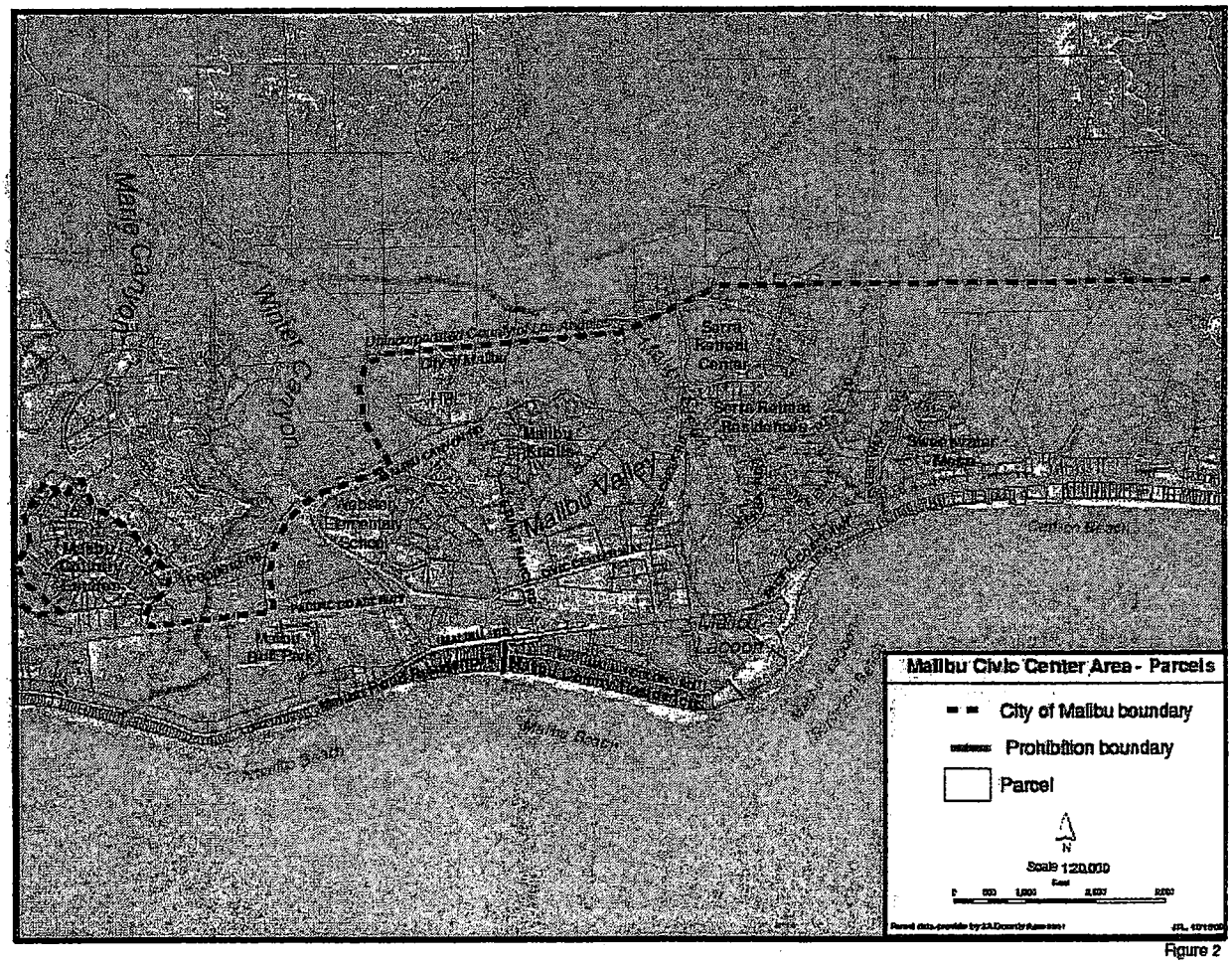


Figure 2

To the east, the prohibition boundary encompasses the Serra Retreat neighborhood, and follows Sweetwater Mesa Road along the eastern topographic high. The boundary was not extended eastward, as the Sweetwater Mesa neighborhood is a lower density residential development. Nor was the boundary extended eastward along the Pacific Coast Highway to capture a stretch of significant commercial development, as the intent of this proposed regulatory action is encompass priority areas that affect groundwater and are hydraulically connected to impaired surface water resources, including Surfrider, Malibu, and Amarillo Beaches and Malibu Lagoon. Additional areas, such as the stretch of the Pacific Coast Highway eastward of the boundary, may be subject to future regulatory actions.

DRAFT OCT 2109

Types of Dischargers Subject to Prohibition

All property owners, including existing residences, businesses, and public facilities that discharge wastes through an OWDS in the Malibu Civic Center area, would be affected by the proposed prohibition as well as future dischargers who may plan to discharge in this area. The regulatory action would immediately prohibit all new discharges from OWDS in the Malibu Civic Center area, and establish a schedule to cease discharges from existing systems by 2014.

Types of Discharges Subject to Prohibition

Collectively, the systems from which wastewaters discharge are referred to as OWDSs. Types of subsurface disposal systems, or OWDSs, that would be prohibited range from passive systems with conventional septic tanks to active systems with equipment that more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would cover an OWDS that serves an individual property (residential, commercial, industrial, and public properties) as well as a group of properties. The prohibition would apply to all OWDSs and regulated discharges (whether they are regulated by the City of Malibu, County of Los Angeles, or State) as well as any unregulated discharges that may exist.

Water Resources

Surface Waters and Groundwater

Surface waters in the Malibu Civic Center area include Malibu Creek, Malibu Lagoon (a fresh/saltwater habitat used by numerous species, some endangered), and ocean beaches, which are heavily used by residents as well as visitors. Groundwater in the area was historically used as a source of drinking water, and is a potential source of drinking water for a portion of the community, or a reserve source of drinking water during times of emergency when deliveries of imported supplies of drinking water could be interrupted. In the *Basin Plan*,[3] the Regional Board has formally designated these plus other beneficial uses for the water resources in the area as follows:

> **Malibu Lagoon:** Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.
>
> **Malibu Creek:** Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.
>
> **Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach:** Navigation; Water Contact Recreation; Non-contact Water Recreation;

[3] Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties, adopted by the Board on June 13, 1994, and as subsequently amended.

DRAFT OCT 2 1 2009

Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.

Groundwater: Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

Also in the *Basin Plan,* the Regional Board has established water quality objectives to protect the beneficial uses identified above.

Impairments to Beneficial Uses of Water Resources

In the 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses are formally identified for the following water resources:

Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
Malibu Beach: impaired by Indicator Bacteria.
Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
Carbon Beach: impaired by Indicator Bacteria.

To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

a. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for on-site wastewater disposal systems (OWDSs) of 6 lbs/day during the summer months and 8 mg/L during winter months.

b. **Malibu Creek and Lagoon Bacteria TMDL:** The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, OWDSs, and animal wastes. The TMDL specifies load allocations for on-site wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

DRAFT OCT 21 2009

c. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for OWDSs, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including on-site wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

DRAFT

<u>Summary of Evidence</u>

Staff investigations focused on five areas, the results of which are presented in five technical memoranda that comprise this staff report and that meet the requirements of the California Water Code, sections 13280 and 13281[4] for determination that discharges of OWDSs in the Malibu Civic Center area result in violation of water quality objectives, will impair present or future beneficial uses of water, will cause pollution, nuisance, or contamination, or will unreasonably degrade the quality of any water of the state.

OCT

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.

For the privilege of discharging wastewater to a water of the state (including both surface water and groundwater), dischargers must comply with waste discharge requirements (WDRs) that are specified in Orders issued by the Regional Board. The WDRs generally incorporate monitoring and reporting programs that rely on self-monitoring by dischargers. The reports of self-monitoring are used by the Regional Board to determine compliance and to ensure that the quality of the water into which wastes are discharged is not degraded and that beneficial uses, such as drinking water and swimming (body contact recreation) are protected.

2

In the Malibu Civic Center area, the Regional Board regulates 20 discharges, all of which are from commercial, industrial, or public facilities. In a review of the compliance records for the 20 discharges, each discharger had a record of violations from 2004 through 2008. Among the most serious violations are repeated failures to achieve effluent and flow limits specified in WDRs; in particular, limits for pathogens and nutrients (species of nitrogen and phosphorus) that are identified as pollutants in nearby waters that the Regional Board and EPA have designated as impaired under Clean Water Act section 303(d). Also, several dischargers 'failed to submit'

2009

[4] See appendix for a summary of the findings in the technical staff report, organized by sections in regulatory codes.

monitoring reports, and thus compliance with technical requirements in their WDRs could not be determined.

Among the violations included in Table 1-4 in Tech Memo #1 are late submittal of reports of self-monitoring required by the WDRs and improper certifications of those monitoring reports – e.g. a perjury statement executed by a party not authorized to certify the accuracy of the results on behalf of the discharger, and/or modifications to the language of the perjury statement that is specified in a WDR.

Dischargers have poor records of compliance with Orders issued by Regional Board, and that discharges, in general, are not meeting requirements prescribed to protect water quality and beneficial uses.

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water.

Although groundwater in the Malibu Valley Groundwater Basin is not an existing source of drinking water to the community, groundwater was the community's source of drinking water until the 1960s. Groundwater production in the area gradually ceased as a newly formed special district – Los Angeles County Waterworks District No. 29, Malibu – started delivering imported water to the Malibu area and Topanga Canyon in the early 1960s. As a future resource – and also in the event of a disruption of deliveries of imported water, groundwater in the Malibu Valley Groundwater Basin is an important local resource, which the community may need to use to meet a portion of its demand for potable water or in the event that deliveries of imported water are interrupted during emergencies. The Regional Board recognized this beneficial use, in designating groundwater as a potential source of drinking water in the *Basin Plan.*

To evaluate impacts from OWDSs on groundwater as a potential source of drinking water, staff identified 59 groundwater wells, all of which were designed and constructed for monitoring the quality of groundwater, and compiled analytical data for pathogen indicators and nitrogen. To examine the extent of impairment of this groundwater for drinking water, staff compiled all available analytical results of sampling for pathogen indicators and nitrogen species during the period April 1999 to June 2009 and compared these results with drinking water standards for these pollutants. As summarized in graphs and tables for each well:

- ***Pathogens in Groundwater do not meet the Drinking Water Standard:*** Fifty wells, or 85% of the 59 wells, failed to meet the maximum contaminant level (MCL) for fecal coliform during at least one sampling event. Of the 1,016 fecal coliform samples collected from the 59 wells during the review period, 383 samples (38%) tested positive and failed to meet the MCL of 0 MPN/100ml (Most Probable Number per 100 milliliters).

- ***Nitrogen in Groundwater does not meet the Drinking Water Standard:*** Twenty-six wells, or 44% of the 59 wells, failed to meet the MCL of 10 mg/L for nitrate plus nitrite (as nitrogen) during at least one sampling event. Of the 1,012 samples collected from the 59 wells during the review period, 322 (32%) were above the MCL. Although there is no drinking water standard for ammonia, staff also reviewed analytical data for ammonia in

DRAFT OCT 2 1 2009

view of the likelihood that the ammonia species of nitrogen will nitrify. Assuming conversion of the ammonia to nitrite or nitrate, the results indicate that 400 samples (40%) were above the MCL, and that 36 wells (51%) of the 59 wells had levels above the MCL of 10 mg/L during at least one sampling event.

As indicated by coliform results, pathogens are present in groundwater at levels that elevate the risk of infectious disease should this groundwater be used for potable purposes. As indicated by the nitrogen results, species of nitrogen are present in groundwater at levels that can cause health problems in humans should this groundwater be used for potable purposes. Infants and fetuses are particularly sensitive and can develop methemoglobinemia (blue-baby syndrome) from ingestion of water with nitrate at levels that deplete oxygen in the blood stream.

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment to Water Contact Recreation.

Malibu Creek, Malibu Lagoon, and nearby beaches are popular not only within the local community but as a destination for visitors as well. In the *Basin Plan,* the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, consistently failing to meet standards set to protect swimmers and surfers from infectious disease resulting from direct exposure to or incidental ingestion of polluted waters during recreation. Repeated failures to meet standards have resulted in a 'beach bummer'[5] reputation for the renowned Surfrider Beach. Historic and recent documentation compiled by the Regional Board, US Environmental Protection Agency, other agencies, and environmental groups and presented in Technical Memo #3 demonstrates that indicators of pathogens in groundwater, surface waters and beaches in the Malibu Creek Civic Center exceed human health standards. Evidence from a 1995 epidemiology study at Surfrider Beach translates this failure to meet water quality criteria into a specific increase in human illness rates: 39 of every 1,000 swimmers at Surfrider Beach are expected to contract gastrointestinal illnesses. This illness rate is in excess of a standard[6] of 19 illnesses per 1,000 people.

The fecal indicator bacteria, enterococcus, which is shown to discharge from OWDSs into the groundwater, also appears along pathways from the Civic Center through the groundwater basin and beaches to the ocean waves. Well data show enterococcus densities exceed the ocean water quality standard in a majority of wells in the Civic Center area, a significant finding because the City of Malibu previously found that 42% of that groundwater comes from OWDSs and 92% of groundwater (78,000 to 126,000 ft ^{3} per day) enters the water at the beach.

[5] 'Beach Bummers' are designated in report cards issued annually by Heal the Bay.

[6] Environmental Protection Agency (1986), *Ambient Water Quality Criteria for Bacteria* stating "EPA's evaluation of the bacteriological data indicated that using the fecal coliform group at a maximum geometric mean of 200 per 100 ml, recommended in Quality Criteria for Water, would cause an estimated 8 illnesses per 1,000 swimmers at fresh water beaches and 19 illnesses per 1,000 swimmers at marine beaches.The E.Coli and enterococci criteria presented in Table 4 were developed using these currently acceptable illness rates (pg. 9)."

3-710

DRAFT OCT 21 2009

To evaluate possible other sources of pathogens, staff evaluated four years of summer beach data. These data show that enterococcus concentrations at Civic center beaches have consistent trends, suggesting source control through stormwater and OWDS management will be successful, and conflicting with claims that significant amounts of bacteria come from variable sources such as the homeless, birds, or trash.

Staff also reviewed 57 previous studies and found conclusions from these studies to be consistent with staff's determination that dry weather impairment to the beneficial use of water contact recreation can be attributable to subsurface migration from OWDSs to surface waters.

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.

Malibu Lagoon supports a valuable wetland ecosystem and nearby plant communities such as the coastal salt marsh and the coastal strand, and also serves as refuge for migrating birds (with over 200 observed species). These beneficial uses are impaired by excessive nutrients levels in the lagoon, stimulating aquatic growth (algae) and resulting in large daily fluctuations of dissolved oxygen and pH that may increase levels of the highly toxic un-ionized form of ammonia. As established in the nutrient TMDL[7] adopted by the US EPA on March 21, 2003 for Malibu Lagoon, nitrogen from OWDSs in hydraulic connection with the lagoon are subject to a load allocation of six pounds per day (lb/d).

To quantify current nitrogen loads from OWDSs in the Malibu Civic Center area to the lagoon, staff compiled an inventory of all 38 commercial dischargers and 392 residential dischargers. Using real data where available and reasonable assumptions (based on published literature and best professional judgment) for data gaps, staff calculated that the dischargers release about 270,000 gpd through OWDSs and estimated nitrogen loading factors. Applying these nitrogen loading factors to update an existing numerical model designed and calibrated by Questa 2005 for an earlier investigation, staff estimates that nitrogen loads released from OWDSs and transmitted via groundwaters to Malibu Lagoon total 30 lb/day. As a check, staff used the same flows and loading factors to a 'spreadsheet' model which characterized wastewater transport by hydrogeologic sector. Based on the 'spreadsheet' model, staff estimates that wastewaters transport 35 lb/day into Malibu Lagoon.

Staff's estimates of 30 lb/day to 35 lb/day from the numeric and 'spreadsheet' models are greater than two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies, and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

[7] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003), the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential land use activities. The TMDL specifies a load allocation for on-site wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

DRAFT OCT 21 2009

- Commercial Flows: The third-party models did not capture the entire OWDS inventory and used significantly lower assumptions for commercial wastewater flows.
- Nitrogen Concentrations – Residential: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are about one-half of what staff determined is a reasonable assumption.
- Nitrogen Concentration – Commercial: Staff determined that the average nitrogen concentration of commercial wastewater discharges has decreased since 2004, as OWTSs with greater treatment capabilities has been brought on-line. However, this declining trend in this subset of OWTSs is not great enough to meet the TMDL goal.

Regardless of differing assumptions and models used, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the load allocation of 6 lb/day for OWDSs established in a TMDL for restoration of water quality and protection of beneficial uses in the Malibu Lagoon. Accordingly, staff concludes that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon.

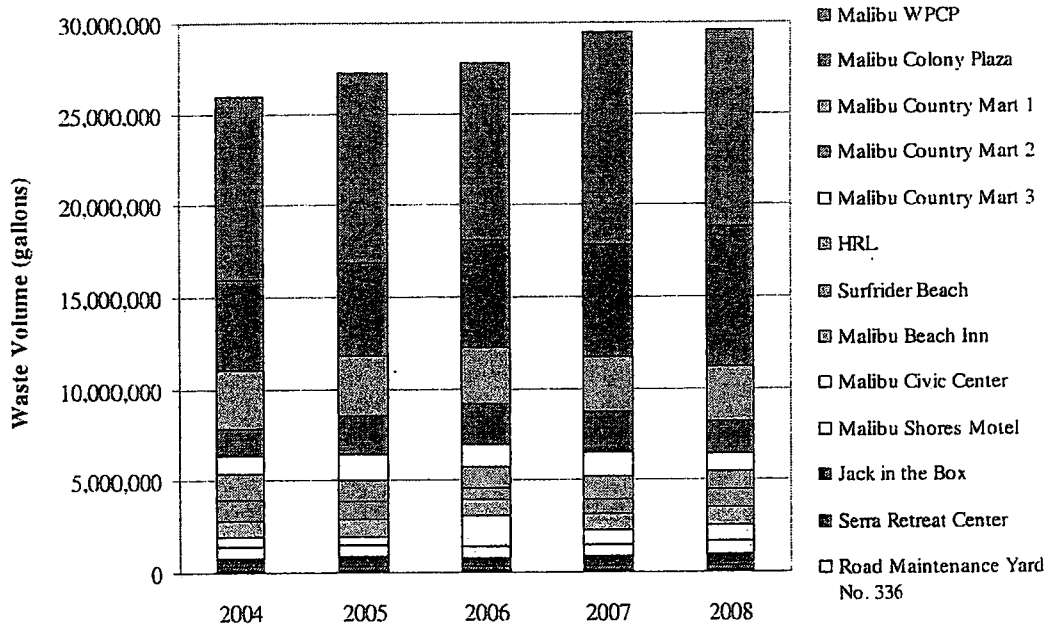
Technical Memorandum No. 5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.

Intensive land use activities on many properties in the Malibu Civic Center area generate wastewater flows at rates that exceed the capacity of OWDSs to transmit the wastewaters into the subsurface. While some dischargers are limited by treatment equipment that has inadequate capacity and/or treatment capabilities, many dischargers do not have adequate disposal capacity on their properties to transmit the wastewaters into the subsurface. Their disposal rates can be constrained not only by lack of space, or area, for on-site disposal fields, but by hydrogeologic constraints as well, such as a high water table or tight soils. Consequently, in order to avoid failure of the OWDSs, a significant number of large dischargers resort to hauling liquid sewage and sludge to communities that have infrastructure to accept their liquid wastes.

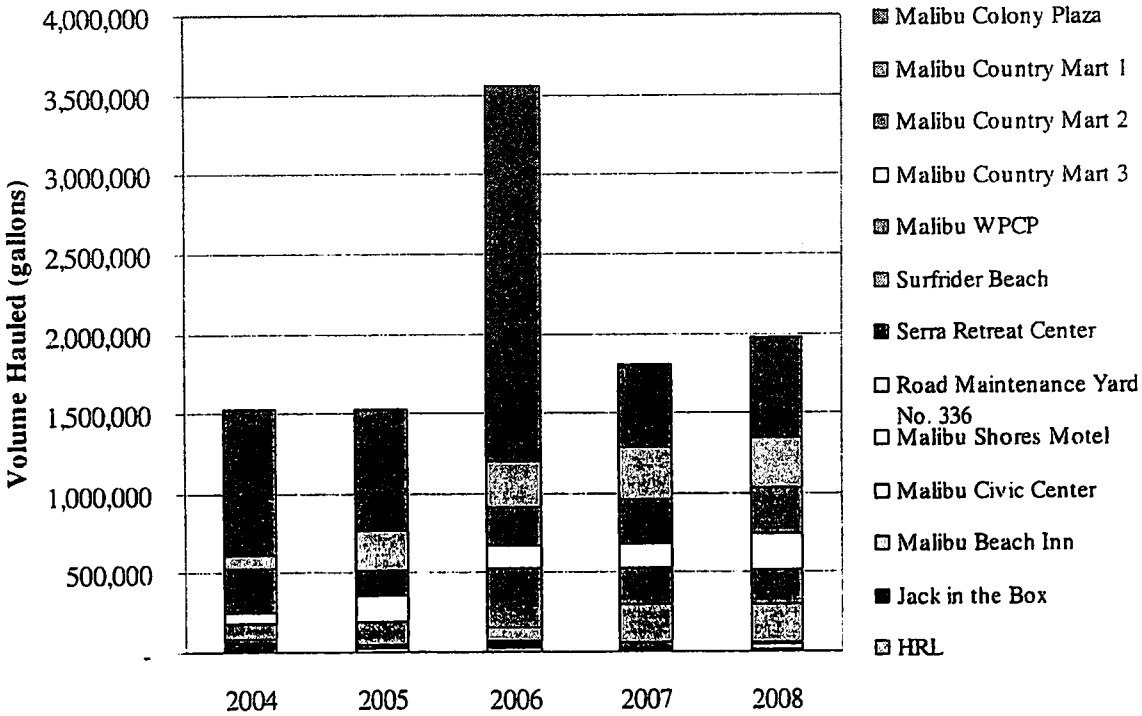
To quantify reliance on the practice of hauling, staff reviewed reports of self-monitoring submitted by 20 commercial dischargers. Based on volumes of waste generated, staff identified a subset of 13 of the 20 dischargers for further analysis. In 2008, these thirteeen dischargers, whose activities generated a total of approximately 28 million gallons of wastewater (77,000 gpd), hauled almost 2 million gallons (5,500 gpd), or about 6%, of their raw sewage to off-site disposal facilities. Furthermore, staff quantified trends from 2004 through 2008, which indicate that these 13 dischargers cumulatively increased their rate of wastewater generation by 13% and their rate of hauling by 29%. (Staff was not able use existing data from dischargers to analyze seasonal hauling trends – e.g. hauling trends during the wet season, and also during warm summer holidays when populations have high peaks.)

DRAFT OCT 21 2009

Combined Annual Waste Flows for Select Dischargers



Combined Annual Septic Waste Hauling for Select Dischargers



DRAFT OCT 2 1 2 0 0 9

Staff also considered the carbon footprint of hauling practices, which generally use large diesel-powered tanker trucks that have to travel between 60 and 180 miles round trip to transport sewage. Staff estimates that hauling by these vehicles releases over 250 tons of carbon dioxide each year. Eliminating the need for sewage waste hauling would contribute toward the goals of California's Global Warming Solution Act (AB 32, Pavley) by decreasing greenhouse gas emissions. Also, elimination of excessive hauling can help reduce public nuisances, such as traffic, noise, and odor resulting from these practices.

Conclusions

Discharges of wastewaters to the subsurface through OWDSs have degraded water resources and impaired existing and potential beneficial uses of these waters, as determined by the following conclusions from the technical memoranda.

i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) and Time Schedule Orders (TSOs) have poor records of compliance.

ii. Discharges of wastewaters contain elevated levels of pathogens and nitrogen that impair the underlying groundwater as a potential source of drinking water.

iii. Discharges of wastewaters to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds contain levels of pathogens that elevate risks of infectious disease for water contact recreation.

iv. Discharges of wastewaters that flow through groundwater and recharge Malibu Lagoon transport a nitrogen load significantly in excess of the allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.

v. Generation of wastewater flows in the Civic Center area has been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

Recommendation

Staff recommends that the Regional Board adopt Resolution R4-2009-xx to immediately prohibit all future discharges of wastewaters and to prohibit existing discharges of wastewater by November 5, 2014.

DRAFT OCT 21 2009

Staff has prepared a draft resolution to amend the *Basin Plan* to prohibit OWDSs, in order to protect the quality of water resources and to restore beneficial uses of water resources in the Malibu Civic Center area. In order to adopt this prohibition, the Regional Board must make several determinations, in accordance with the California Water Code (CWC) 13280. Also, staff considered factors set forth in CWC 13281[1] and other regulatory codes. This information is summarized below, organized by sections in the codes.

1. **CWC 13280[2] – Discharges from OWDSs violate water quality objectives and impair present or future beneficial uses of water:** As detailed in the technical staff report, staff demonstrates that OWDSs impair water resources as follows:

   - Groundwater: In Tech Memo #2, staff evaluates nitrogen and pathogen levels in groundwater against drinking water standards, and concludes that OWDSs impair groundwater that the Board has designated as a potential source of drinking water.
   - Beaches: In Tech Memo #3, staff demonstrates that pathogens released from OWDSs in hydraulic connection with the ocean impair swimming, surfing, and other recreational activities (e.g. wading).
   - Lagoon: In Tech Memo #4, staff evaluates nitrogen levels from OWDSs in groundwater that is in hydraulic connection with Malibu Lagoon, and concludes that discharges from OWDSs fail to meet a load allocation of 6 pounds per day, specified in the nutrient TMDL in order to prevent accelerated eutrophication and restore aquatic and riparian habitat and wildlife.

   Furthermore, as described in Tech Memo #1, many dischargers under Orders specifying Waste Discharge Requirements (WDRs) and Time Schedule Orders (TSOs) from the Board have failed to meet effluent limits that the Board set at levels protective of beneficial uses.

2. **CWC 13280 – Discharges from OWDSs cause nuisance:** As detailed in the technical staff report, staff demonstrates that OWDSs cause nuisance:

   - Hauling: In Tech Memo #5, staff analyzes a subset of 13 dischargers who, due to relatively large flows coupled with unsuitable hydrogeologic conditions, hold their raw sewage for pumping into tanker trucks that haul the liquid wastes to other communities

---

[1] 13281. (a) In making a determination pursuant to Section 13280, except as specified in subdivision (b), the regional board shall consider all relevant evidence related to the discharge, including, but not limited to, those factors set forth in Section 13241, information provided pursuant to Section 117435 of the Health and Safety Code, possible adverse impacts if the discharge is permitted, failure rates of any existing individual disposal systems whether due to inadequate design, construction, maintenance, or unsuitable hydrogeologic conditions, evidence of any existing, prior, or potential contamination, existing and planned land use, dwelling density, historical population growth, and any other criteria as may be established pursuant to guidelines, regulations, or policies adopted by the state board.

[2] 13280. A determination that discharge of waste from existing or new individual disposal systems or from community collection and disposal systems which utilize subsurface disposal should not be permitted shall be supported by substantial evidence in the record that discharge of waste from such disposal systems will result in violation of water quality objectives, will impair present or future beneficial uses of water, will cause pollution, nuisance, or contamination, or will unreasonably degrade the quality of any waters of the state.

that have sewer and wastewater treatment facilities. This practices result in nuisance (odors and noise).[3]

- Additional Nuisances: At beaches, persistent failures to meet water contact standards result not only in elevated risks of human illness, but also in nuisance for beachgoers expecting to recreate in unpolluted waters. At Malibu Lagoon, odors and color problems from accelerated eutrophication can cause odor and color problems in and near the lagoon.

3. **CWC 13241(a) – Past, present, and probable future beneficial uses of water:** In analyzing evidence for a prohibition, staff relied upon designations of beneficial uses in the *Basin Plan*, as summarized below:

   - Groundwater, designated as a potential source of drinking water. Also, staff considered past uses of groundwater to meet historic demands for drinking water. Staff acknowledges that groundwater is not a current source of drinking water. Nevertheless, staff – in accordance with the Board's designation of groundwater as a 'potential' source of drinking water and the State Board's *Sources of Drinking Water Policy* – considered the potential for groundwater to be used as a future source of water to meet a portion of the community's demand, or to meet demand in times of emergency. (See Tech Memo #2.)
   - Malibu Lagoon, designated for providing habitat for aquatic life and wildlife. Also, staff considered recent regulatory actions that designated (in accordance with section 303(d) of the Clean Water Act) this waterbody as impaired, and that allocated loads from all significant point and nonpoint sources, including OWDSs. (See Tech Memo #4.)
   - Malibu Beach, Malibu Lagoon Beach (Surfrider), and Amarillo Beach, designated for water contact recreation. Also, staff considered recent regulatory actions that designated Malibu Beach and Surfrider Beach as impaired, and that specified dry and wet weather pathogen loads. (See Tech Memo #3.)

4. **CWC 13241(b) – Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto:** Staff considered environmental characteristics, including water quality and impairments to beneficial uses, throughout the technical and environmental staff reports and also in previous regulatory actions by the Board and US EPA to designate beneficial uses and establish water quality objectives, to designate impaired waters, and to issue TMDLs.

5. **CWC 13241(c) – Water quality conditions that could reasonably be achieved through coordinated control of all factors which affect water quality in the area:** In previous regulatory actions by the Board and US EPA, strategies to control pollutants from point and nonpoint sources were considered.

   - In the nutrient TMDL for Malibu Lagoon, numeric targets are established for all significant sources of nitrogen, including a numeric target of six pounds per day from OWDSs. (See nutrient TMDL for numeric targets for all significant sources of nitrogen; see Tech Memo #4 for an evaluation of nitrogen released from OWDSs.)

[3] Although staff also estimated the carbon footprint of hauling practices, staff did not quantify impacts to traffic from the tanker truck routes.

- The Santa Monica Bay Beaches Bacterial TMDLs require responsible agencies to achieve the numeric targets and waste load allocations for fecal indicator bacteria at the beaches through implementation of coordinated control strategies to address all bacterial sources. In the administrative records for the TMDLs, the Regional Board identifies myriad point and nonpoint sources of fecal indicator bacteria to the beaches, including sanitary sewer and sewage plant overflows and spills, septic systems, urban runoff, animal fecal matter, illegal discharges from boats, and illicit discharges from private drains among other sources. The Regional Board anticipated that responsible agencies would employ a variety of control strategies, including diverting storm drain flows to treatment plants, where possible; controlling sources of bacteria, including groundwater sources such as from malfunctioning or improperly placed septic systems; eliminating illicit discharges; or implementing "end-of-pipe" treatment to address these sources and, ultimately, achieve the TMDL targets.

6. **CWC 13241(d) – Economic considerations:** This section requires consideration of costs associated with establishment of water quality objectives. The proposed prohibition does not establish water quality objectives – rather, it is a proposed action to achieve existing objectives. Nevertheless, staff analyzed the costs of possible projects that the city, a utility, or a water authority could implement to comply with the prohibition. These projects, which were evaluated on a conceptual basis, have estimated costs ranging from $17 million to $80 million. (See Environmental Staff Report, section entitled Summary of Economics.)

7. **CWC 13241(e) – Need for developing housing within the region:** Although staff did not find that there is a need to develop additional housing in the City of Malibu, staff did consider impacts to housing that could arise from projects constructed to comply with the prohibition deadline. (See Environmental Staff Report, Environmental Checklist, Item 12.)

8. **CWC 13241(f) – Need to develop and reuse recycled water:** Although through this regulatory action the Regional Board is not determining method of compliance, staff assumed that the community would recycle as much treated wastewater as possible in planning and designing a project to achieve compliance with the prohibition. (See Environmental Staff Report, section entitled Options for Compliance Projects including Summary of Economics, and the Environmental Checklist, Item 3.)

9. **CWC 13281 – Health & Safety Code, section 117435, providing health officers with the authority to require reports from businesses that clean septic tanks, seepage pits, and cesspools:** Staff consulted with the health officer for the County of Los Angeles to get this information, and determined that the County does not require reports on the location of septic tanks/seepage pits/cesspools being cleaned, the locations of the disposal points, the frequencies of cleanouts, and any observed violations.[4] In the past, the County did require such reports. However, due to limited resources, the County has had trouble

[4] Staff is aware that the City provides contact information for five hauling firms, registered with the County; however, the City does not endorse any of these firms. Also, the City provides recommendations for pumping frequencies for properly functioning OWDSs. The City does not require 'section 117435' information (paragraph above), as this oversight would duplicate the County's oversight. Also, concerns have been raised by the City about the transporters' level of cooperation in providing such information to the City, as well as privacy issues.

reviewing all reports and, as a result, dropped the requirement for submittal for the past two years. The health officer still requires an annual inspection of all registered tanker trucks. (See Tech Memo #5, section entitled 'Septic Pumping and Hauling Regulations.')

Staff did have access, in Regional Board files, to pumping and hauling information for many of the dischargers who operate under WDRs specified in Orders issued by the Board. In Tech Memo #5 staff compiled and considered this information, and concluded that a high level of pumping and hauling occur due to limitations of treatment systems or hydrogeologic limitations, or both, that preclude on-site disposal.

10. **CWC 13281 – Possible adverse impacts if the discharge is permitted:** Swimmers are already exposed to elevated health risks at beaches in the Civic Center area. Habitat in Malibu Lagoon is already degraded by accelerated eutrophication. Much of the groundwater in the area fails to meet standards for drinking water. Continued and/or additional discharges will further pollute these water resources and be inconsistent with goals of the *Basin Plan* and other state plans and policies. In the Technical Staff Report as well as though previous regulatory actions by the Board, staff has demonstrated adverse impacts to the following water resources:

    - Groundwater: Pollution from OWDSs violates water quality objectives for drinking water use.[5] (See Tech Memo #2.)
    - Malibu Beach, Malibu Lagoon Beach (Surfrider), and Amarillo Beach: Pollution from OWDSs in hydraulic connection with these beaches is a significant source of impairment to water contact recreation.[6] (See Tech Memo #3.)
    - Malibu Lagoon: Pollution from OWDSs in hydraulic connection with the lagoon impairs aquatic and wildlife beneficial uses fails to meet a pollutant load for nitrogen is impaired by nitrogen from OWDSs as well as other sources.[7] (See Tech Memo #4.)

11. **CWC 13281 – Failure rates of any existing ....systems whether due to inadequate design, construction, maintenance, or unsuitable hydrogeologic conditions:** All 20 dischargers subject to Orders issued by the Board have violated those Orders at least once during the period from the fourth quarter of 2004 through the fourth quarter of 2008 (except Malibu Lumber, which didn't start discharge until April 2009[8]). While a few of the violations were for reporting problems (e.g. late submittal of a monitoring report), most were for serious violations, such as failure to meet pollutant concentration limits that the Board sets at levels protective of beneficial uses. Failure to meet limitations on

[5] See the *Basin Plan*, in which the Board designates groundwater as 'potential MUN;' the State Board 'Sources of Drinking Water Policy'[5]; and Tech Memo #2, in which staff presents evidence that groundwater fails to meet MCLs for nitrate, nitrite, and pathogens.

[6] See the *Basin Plan*, in which the Board has designates water contact recreation as a beneficial use for these beaches; the 303(d) list, in which the Board and US EPA designate these beaches as impaired; the beach pathogen TMDL, in which the Board specifies dry and wet weather targets for pathogens; and Tech Memo #3, in which staff presents evidence of impairment to water contact recreation activities from OWDSs.

[7] See the *Basin Plan*, in which the Board has designates aquatic and wildlife beneficial uses for the lagoon; the 303(d) list, in which the Board and US EPA designate Malibu Lagoon as impaired; and the nutrient TMDL for the lagoon, in which the Board allocates nitrogen loads for various sources of nitrogen, including OWDSs.

[8] Malibu Lumber, since beginning discharge in April 2008, also has a record of serious violations of its WDR.

flow is another example of serious violations, and indicates design limitations and/or siting and hydrogeologic limitations.

Dischargers also experience start-up and maintenance problems, as indicated in reports of self-monitoring and the record of violations. (See Tech Memo #1.) A recent example is Malibu Lumber, which started treatment and discharge in April 2009. The discharger has experienced many unanticipated start-up problems. (See Tech Memo #1.) The discharger has yet to achieve full compliance with its WDR.

Many dischargers resort to a high level of pumping and hauling (almost 2 million gallons per year, from a subset of 13 dischargers) due to the limitations of treatment systems or hydrogeology, or both, which preclude on-site disposal. Such pumping and hauling practices have been needed to prevent further stress on sites and systems that already fail to properly function for the flow of wastewater generated from on-site activities, especially during periods of peak activity, such as summer weekends and holidays. (See Tech Memo #5.)

12. **CWC 13281 – Evidence of existing, prior, or potential contamination:** For Malibu Lagoon, the Board has already considered evidence of impairment, and designated that waterbody as impaired. (See 303(d) list.) Furthermore, targets for nitrogen loads have been allocated through a TMDL for nitrogen loads from various sources, including OWDSs. (See Malibu Lagoon nutrient TMDL.) In Tech Memo #4, staff demonstrates that nitrogen loads from OWDSs far exceed the TMDL target.

For Malibu Lagoon (Surfrider) Beach and Malibu Beach, the Board already considered evidence of impairment from pathogens, and designated these beaches as impaired. (See 303(d) list.) The Board already set dry weather targets for these beaches through a TMDL for pathogens TMDL. In Tech Memo #3, staff demonstrates that pathogen indicators released from OWDSs in hydraulic connection with beaches fail to meet water contact recreation standards and the dry weather target.

For groundwater, comments were received regarding seawater intrusion into groundwater resources, and staff acknowledges that seawater intrusion may have contributed to degradation of water quality (along with other sources of pollutants, such as OWDSs). Nevertheless, such problems do not preclude restoration of water quality. And in restoring water quality, staff is not suggesting that it is feasible for groundwater resources to completely replace the City's other supplies of drinking water. Rather, staff suggests that groundwater could meet a portion of drinking water demand, and could also serve as an emergency supply of water in the event that deliveries of imported water were interrupted. In restoring and managing potential future groundwater production, the storage and operational yield of the aquifer should be evaluated, and community leaders should ensure that pumping patterns and replenishment with high quality waters are properly designed and managed. Early studies of water resources were of limited scope, and past production of groundwater does not appear to have been managed in a manner to establish sustainable pumping patterns and sources of replenishment. in order to prevent over-pumping of the aquifer and degradation of water quality from seawater intrusion and discharges of wastewaters.

13. **CWC 13281 – Existing and planned land use and dwelling density:** The entire prohibition area covers 2.2 square miles, and includes approximately 400 dischargers who cumulatively generate wastewater at a rate of about 270,000 gallons per day (gpd).

Staff did not average the total existing flow over the entire 2.2 square miles. Most activity and the flows generated from these activities are concentrated along the beach and in the Civic Center area, which serves as the core of the City's business and civic activities. (See Tech Staff Report – Overview, sections entitled Introduction and Prohibition Boundary, and Tech Memo #4.) Many of the existing commercial dischargers already exceed flow limits established in WDRs. (See Tech Memo No. 1.) Many of these dischargers rely on hauling their wastewaters off-site. (See Tech Memo No. 5.) In lower Winter Canyon, high density development – namely four multi-family units – generate significant flows that rely on the Malibu Water Pollution Control Plant, a small, high-cost plant that has a problematic compliance history. (See Tech Memo #1.) Lower Winter Canyon also receives flows of wastewater from the coastal area, namely Malibu Colony Plaza, which lifts its wastewater over to four acres in Winter Canyon.

Significant properties in the City's core may be developed in the future, including La Paz and Malibu Towing; activities on these future developments may generate additional flows. Significant redevelopment also may occur in the future; intensified activities from redevelopment will likely generate additional flows. For example, Malibu Lumber is expected to generate up to 17,000 gpd – over a ten-fold increase in flows from the previous site activities.

14. **CWC 13281 – Historical population growth:** A census value is not available for the population within the prohibition boundary, and staff initially estimated the current residential population at about 1,000.[9] Staff revised this estimate to almost 2,000, using information on buildings, such as numbers of bedrooms and bathrooms (see Tech Memo #4, Table 2). Also, staff used information on wastewater flows (see Tech Memo #4, Table 1) as a rough cross-check of the population estimate. See also the Environmental Staff Report, section on Growth-Inducing Impacts. Staff also considered trend data (see Tech Memo #5, Appendix E), available for the City as a whole, and determined that, as with many areas in the County, Malibu has experienced growth; since 1990, prior to incorporation of the area that would become the City of Malibu, the population increased by 30%, from 10,500 to 13,700[10] in 2008 – an annual growth rate of 1.5%.

Furthermore, the population estimate of 2,000 does not include daytime and evening visitors who use the beaches and patronize the businesses and public facilities in the area. The visitor population appears to be substantially increasing, as indicated by beach activity statistics for beaches – e.g. beach activity (throughout the area – not just limited to the prohibition area) appears to be increasing at an annual rate of 6% based on an increase in monthly beach counts from 233,500 in August 1999 to 355,000 in August 2006. (See Tech Memo #3, Appendix E.) Although the monthly totals are for all Malibu

[9] Staff's population estimate of 1,000, presented in the July 31, 2009 drafts, was based on information in Stone, *Final Report – Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California*, 2004, funded by the Santa Monica Bay Restoration Commission and the California State Coastal Conservation.

[10] The 2008 population estimate is for the entire City of Malibu, not just the Malibu Civic Center area.

area beaches, staff believes that it is likely that beach activity for the beaches in the Civic Center area have shown a similar – and likely greater – increase, given the proximity of commercial and public facilities in the area.

Nor do the above population estimates include daytime and evening workers employed in the Malibu Civic Center area. As indicated by increasing wastewater flows from 13 commercial and public facilities (see Tech Memo #5, Figure 2), economic activity in the Civic Center area appears to be increasing with intensified development. Rates for discharges of wastewater will likely increase with intensified development – e.g. the redevelopment of the Malibu Lumber site which, when fully operational, is expected to discharge up to 17,000 gallons per day (over a ten-fold increase from the prior activity on the site).

Staff also considered growth inducing impacts. (See Environmental Staff Report, CEQA Analysis, section entitled Other Environmental Considerations.)

15. **CWC 13282 – Has an authorized public agency provided satisfactory assurance that systems will be appropriately designed, located, sized, spaced, constructed, and maintained?** No – The City has not given such assurance to the satisfaction of the Regional Board. However, the City has commented that it believes it can provide the assurances required by this section, as summarized below.

    - The City has started a wastewater management database.[11] However, staff has expressed concerns to the City of Malibu about the accuracy of information identifying each property listed in IWIMS, and also the extent to which entries for each property have been populated with data needed to regulate discharges to achieve protection of both public health as well as the quality of underlying groundwater and nearby surface waters. (See attachments to Tech Memo #1, letters dated May 28, 2009 and June 23, 2009.)

    - The City discussed, during the October 2008 public meeting of the Board, an Operating Permit Program initiated as of March 10, 2008 and other terms of the MOU. The Board directed staff to prepare a prohibition. Concurrent with staff efforts to prepare a prohibition, a meeting to discuss the MOU was held among three Regional Board members, including the Chair, and City officials. However, there was no progress towards re-negotiating the MOU.

[11] IWIMS – Integrated Wastewater Information System.

TM #1

State of California
California Regional Water Quality Control Board, Los Angeles Region

DRAFT OCT 2 1 2009

Draft Technical Staff Report

Evidence in support of an
Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

to Prohibit On-site Wastewater Disposal Systems
in the Malibu Civic Center Area

Technical Memorandum #1:
Dischargers Have Poor Records of Compliance with Regional Board Orders

by
Rebecca Chou,* Ph.D., P.E.
Chief, Groundwater Permitting Unit

* *The author would like to thank Regional Board staff, Joe Luera and interns Albert Chu and Shannon Liou for their assistance in preparing map, tables and graphs.*

Technical Memorandum 1: *Dischargers Have Poor Records of Compliance with Regional Board Orders*

by
Rebecca Chou, Ph.D., P.E.
Chief, Groundwater Permitting Unit

Background

Without community sewers and wastewater treatment facilities and infrastructure, dischargers in the Malibu Civic Center area (Figure 1[1]) use on-site disposal systems for discharge of wastewaters from residential, commercial, and other facilities.

The Regional Water Quality Control Board for the Los Angeles Region (Regional Board) and City of Malibu share oversight for discharges of wastewater in the City of Malibu, including the Civic Center area.[2] Pursuant to a memorandum of understanding (MOU) dated August 12, 2004, the Regional Board regulates discharges from commercial land use activities (including discharges from industrial, research, and public facilities) that have wastewater flows that exceed 2,000 gallons per day (gpd), by issuing Orders that specify waste discharge requirements (WDRs) for the privilege of discharging waste to waters of the State. Also pursuant to this MOU, the City regulates discharges from small commercial facilities with wastewater flows equal to or less than 2,000 gpd and from residential land uses.

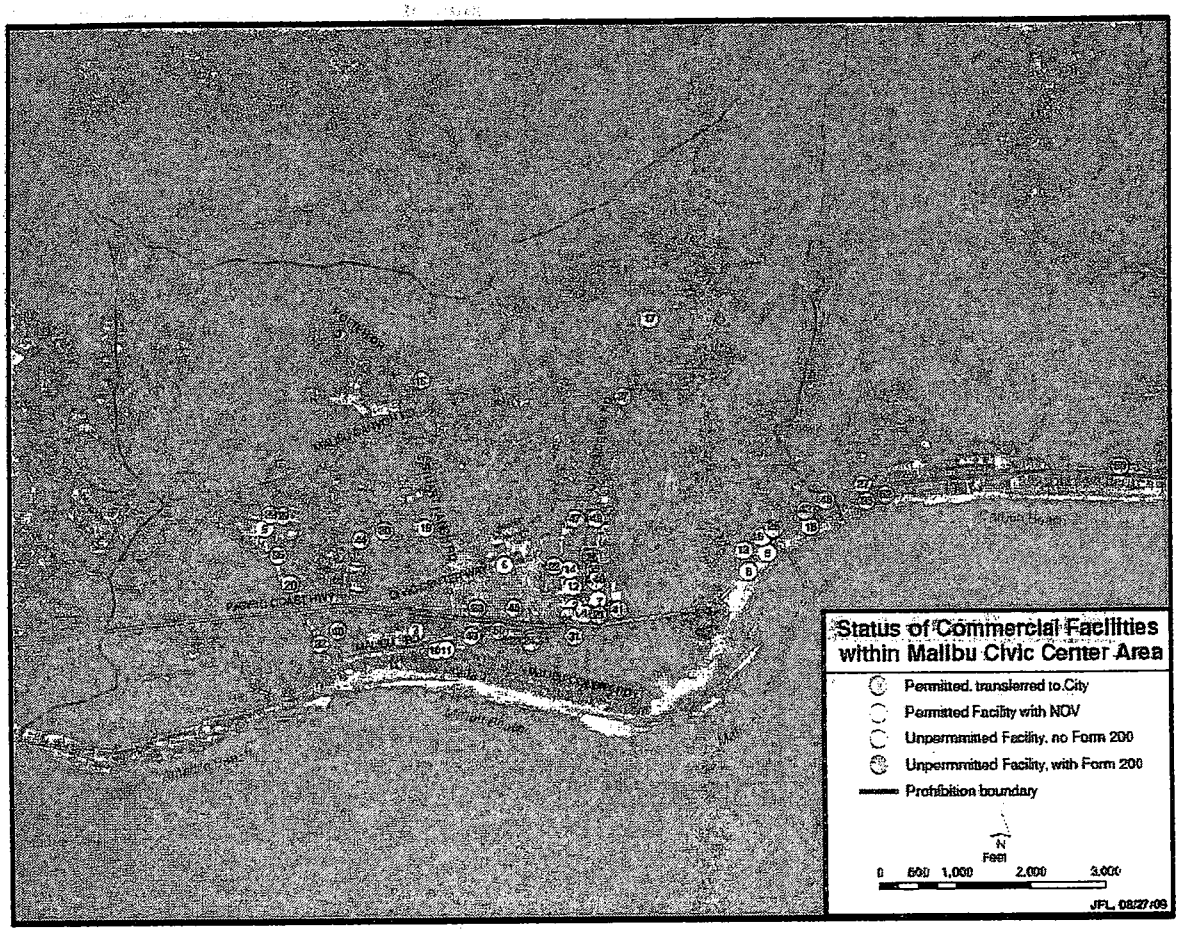
[1] The area subject to the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1). The area was defined using topographic features and drainage patterns, and encompasses the hydrologic areas of Malibu Valley (also referred to as the lower Malibu Creek watershed), Winter Canyon, and adjacent coastal strips including Amarillo Beach, Malibu Beach, Malibu Lagoon, and Malibu Lagoon Beach (aka Surfrider Beach, including First, Second, and Third Points at Surfrider). For more discussion on the prohibition boundaries defining the Malibu Civic Center area, refer to the Technical Staff Report Overview and the Environmental Staff Report.

[2] In 1952, when the Regional Water Quality Control Board for the Los Angeles Region (Regional Board) delegated authority for permitting septic systems to local land use agencies, the County of Los Angeles assumed responsibility for oversight of septic systems incorporated areas, including the area that subsequently incorporated as the City of Malibu in 1991. In the early 2000s, during re-assessments by all nine Regional Boards of permitting authorities delegated to local agencies, the Regional Board chose not to renew delegation (i.e. waivers of requirements to submit a Report of Waste Discharge) of permitting authority to local agencies. Rather, the Regional Board adopted a strategy of entering into Memoranda of Understanding (MOUs) with each municipality in the Los Angeles Region.

3-723

DRAFT OCT 21 2009

Figure 1: Commercial Facilities within Malibu Civic Center Area



DRAFT OCT 2 1 2009

Purpose and Methodology

The purpose of this memorandum is to provide an analysis of compliance with Orders issued by the Regional Board. (With limited exceptions, compliance information for dischargers under oversight by the City of Malibu was not available.)

To conduct the analysis, staff, including a team of college-level and graduate-school–level interns, reviewed 224 reports of self-monitoring submitted during the period starting with the fourth quarter 2004 through the fourth quarter 2008 from 19 dischargers except Malibu Lumber based on April 2009 monthly report. Dischargers who submitted reports of self-monitoring include government organizations (state, county, and special districts) and privately-owned organizations (commercial and industrial organizations) listed in the following Tables 1 and 2.

Table 1 - Permitted Discharges from the Public Sector

Discharger	Facility	Start of Permitted Discharge	# Reports Analyzed	
			Quarterly	Annual
California Department of Parks and Recreations	Malibu Pier State Park	9/26/2002	15	3
Los Angeles County Department of Public Works (LA DPW)	Malibu Administrative Center	10/8/2002	17	5
LA DPW	Fire Station No. 88	8/19/2003	17	5
LA DPW	Surfrider Beach	2/25/2003	17	5
LA DPW	Road Maintenance Yard 336	10/25/2002	17	4
LA DPW	Malibu Water Pollution Control Plant (Winter Canyon)	11/2/1998	17	5

Table 2 - Permitted Discharges from the Private Sector

Discharger	Facility	Start of Permitted Discharge	# Reports Analyzed	
			Quarterly	Annual
HRL	Hughes Research Lab	1/26/1998	17	4
Malibu Beach Inn	Malibu Beach Inn	3/13/2003	16	3
Malibu Bay Company	Malibu Colony Plaza	12/7/2000	17	2
Malibu Country Mart Limited	Malibu Country Mart I	1/30/2003	17	0
Malibu Cross Creek, LTD	Malibu Country Mart II	1/30/2003	17	0
Malibu Country Mart Limited	Malibu Country Mart III	12/12/2002	17	0
Malibu Creek Preservation	Malibu Creek Plaza Shopping Center	1/11/2001	17	5
City of Malibu and Malibu Lumber LLC[3]	Malibu Lumber	April 2009[4]	1*	NA
Dave Whitehead	Malibu Shores Motel	12/19/2003	16	4
Morton Gerson	23730 Malibu Road	3/24/2003	16	1
Prudential Malibu Realty	Prudential Malibu Realty	8/28/2002	17	5

* April 2009 monthly report

[3] Although the City owns the land on which the Malibu Lumber development is sited, this discharger is grouped with private sector instead of public sector.

[4] A discharge from Malibu Lumber did not start until April 2009.

DRAFT OCT 2 1 2009

Three permitted dischargers, listed in Table 3, failed to submit any reports of self-monitoring as of April 2009. Although staff identified these cases of 'failure to submit' violations, staff was unable analyze compliance by these dischargers with technical requirements in their WDRs.

Table 3 – Permitted Dischargers from Private Sector-Failure to Submit Reports

Discharger	Start of Permitted Discharge	# Delinquent Reports	
		Quarterly	Annual
Jack in the Box # 160	1/23/2004	20	5
Miramar Building[5]	3/18/2004	19	5
Serra Retreat Center	4/28/2004	19	5

Results

Each one of the 20 dischargers under Orders issued by the Regional Board has a record of violations, summarized in Table 4, including 8 facilities with advanced treatment systems. Among the most serious violations are repeated failures to achieve effluent limits specified in WDRs; in particular, limits for pathogens and nutrients (species of nitrogen and phosphorus) that are identified as pollutants in nearby waters that the Regional Board and EPA have designated as impaired.

Among the other violations included in Table 4 is tardy submittal of reports of self-monitoring required by the WDRs, and improper certifications of those monitoring reports – e.g. a perjury statement executed by a party not authorized to certify the accuracy of the results on behalf of the discharger, and/or modifications to the perjury statement language specified in a WDR.

Conclusion

Permitted and unpermitted facilities are listed in Table 5 and shown in Figure 1. Permitted dischargers of wastewaters with wastewater flows of more than 2,000 gpd in the Malibu Civic Center area – including both public and private organizations – have poor records of compliance with Regional Board Orders.

The compliance status for dischargers under oversight by the City of Malibu[6], including small commercial dischargers and residential dischargers, has not been analyzed.

[5] Although the Miramar Investment Company is landlord to offices occupied by the City of Malibu, staff has included this discharger with the commercial group of dischargers.

[6] Although acknowledging that the City is compiling an Integrated Wastewater Management Information System (IWMIS), the Regional Board has expressed concern to the City of Malibu, in letters dated May 28, 2009 and June 23, 2009 (Appendix 1-1), about the accuracy of information identifying each property listed in IWMIS, and also the extent to which entries for each property have been populated with data needed to regulate discharges to achieve both protection of both public health as well as the quality of underlying groundwater and nearby surface waters.

DRAFT OCT 2 1 2 0 0 9

Table 4 - Summary of Violations ***

Facility	TSO**	Non Submittal	Late Submittal	Non-reported Parameters	Discharge Violations	Perjury Statement	Material Change	Total Violation Counts
Fire Station No. 88*					**77**	**1**	**1**	**79**
HRL Laboratories		3	2			1		6
Jack In The Box		**25**						**25**
Malibu Administrative Center*					44	1	1	46
Malibu Colony Plaza	**2**	**3**	**9**		**39**	**1**	**1**	**55**
Malibu Beach Inn	**2**	**3**		**4**	**33**	**1**		**43**
Malibu Country Mart I	1	5	13	133		1		153
Malibu Country Mart II	1	5	14	133		1		154
Malibu Country Mart III	1	5	13	133		1		153
Malibu Lumber					**18**	**1**	**1**	**20**
Malibu Pier State Park*		**4**	**7**		**1**	**1**	**1**	**14**
Malibu Shores Motel		2	9		13	1	1	26
Malibu Creek Plaza Shopping Center (Malibu Village)	**1**		**3**		**38**			**42**
Malibu Water Pollution Control Plant*			**9**	**400**	**235**			**644**
Miramar Investment Co.		24						24
Morton Gerson Property		5	16		2			23
Prudential Malibu Realty			4					4
LA County Public Works Road Maintenance Yard*		1		3	120	1	1	126
Serra Retreat Center		24						24
Surfrider Beach*			4		3	1		8

*Public Sector
** Time Schedule Order
*** From quarterly reports during fourth quarter 2004 to fourth quarter 2008 for 19 dischargers, except Malibu Lumber from April 2009 monthly report. Bolded facilities have advanced treatment systems.

DRAFT DOCT 2 1 2 0 0 5

Table 5 Commercial Facilities within Malibu Civic Center Area as of April 2009

Map No	Facilities	Address	CI No.	Status
1	Prudential Malibu Realty	23405 W. Pacific Coast Highway (Hwy)	8447	Permitted Facility with NOV
2	Malibu Lumber & Hardware	23479 Pacific Coast Hwy	8695	Permitted Facility with NOV
3	Malibu Colony Plaza/ colony LLC	23705-23841 Malibu Road	8158	Permitted Facility with NOV
4	Cross Creek Plaza/Malibu Creek Preservation	3822 Cross Creek Road	8226	Permitted Facility with NOV
5	Malibu Pier State Park*	23000 Pacific Coast Hwy	8456	Permitted Facility with NOV
6	Malibu Admin. Center	23519 W. Civic Center Way	8469	Permitted Facility with NOV
7	Malibu Country Mart III	3900 Cross Creek Road	8512	Permitted Facility with NOV
8	Surfrider Beach	23060 W. Pacific Coast Hwy	8532	Permitted Facility with NOV
9	LACo. Dept. of Public Works - Road Maintenance Yard	3637 Winter Canyon Road	8471	Permitted Facility with NOV
10	Morton Gerson	23730 Malibu Road	8542	Permitted Facility with NOV
11	County of LA - Fire Station #88	23720 W. Malibu Road	8621	Permitted Facility with NOV
12	Malibu Country Mart I	3835 Cross Creek Road	8518	Permitted Facility with NOV
13	Malibu Shores Motel	23033 Pacific Coast Hwy	8693	Permitted Facility with NOV
14	Malibu Country Mart II	23410 Civic Center Way	6325	Permitted Facility with NOV
15	Malibu Beach Inn*	22878 Pacific Coast Hwy	8559	Permitted Facility with NOV
16	Hughes Research Lab Inc	3011 Malibu Canyon Road	6939C	Permitted Facility with NOV
17	Serra Retreat Center	3401 Serra Road	8743	Permitted Facility with NOV
18	Jack in the Box (Checker Board Properties Inc)	23017 Pacific Coast Hwy	8710	Permitted Facility with NOV
19	Mira Mar Properties-Office Bldg. W/ City Hall	23805 Stuart Ranch Road	8631	Permitted Facility with NOV
20	Malibu Water Pollution Control Plant	3260 Vista Pacifica Street	4673	Permitted Facility with NOV
21	Malibu Shell (Equilon)	23387 Pacific Coast Hwy	8513	Perm, transferred to City
22	Partners LLC	23440 Civic Center way	8587	Perm, transferred to City
23	Malibu Road, LLC	23700 Malibu road		Perm, transferred to City
24	23676-23712 Malibu rd	23700 Malibu road	8535	Perm, transferred to City
25	The Malibu Animal Hospital	23421 Pacific Coast Hwy	8711	Perm, transferred to City
26	Partnership	3806 Cross Creek Road	8361	Perm, transferred to City
27	Kentucky Fried Chicken*	22751 Pacific Coast Hwy		Unpermitted Facility, no Form 200
28	Malibu Inn Restaurant & nightclub*	22969 Pacific Coast Hwy		Unpermitted Facility, no Form 200
29	Webster Elementary School	3602 Winter Canyon		Unpermitted Facility, no Form 200
30	Rackett Club	23847 Stuart Ranch		Unpermitted Facility, no Form 200
31	Malibu Colony HOA	23554 Malibu Road		Unpermitted Facility, no Form 200
32	Mesa LLC	23915 Malibu Road		Unpermitted Facility, no Form 200
33	Lisa Krasnoff	23655 Malibu Road		Unpermitted Facility, no Form 200
34	Aqua Lion Unique	23700 Malibu Road		Unpermitted Facility, no Form 200
35	So. Cal. Edison	3808 Cross Creek Road		Unpermitted Facility, no Form 200
36	Malibu Canyon Village Owners Associates	23901 Civic Center		Unpermitted Facility, no Form 200
37	Mariposa Land Company LTD	3728 Cross Creek		Unpermitted Facility, no Form 200
38	Casa Malibu at the Beach (310)456-2219	22752 Pacific Coast Hwy		Unpermitted Facility, no Form 200
39	Our Lady of Malibu Catholic Church	3625 Winter Canyon Road		Unpermitted Facility, no Form 200
40	Land Corp.	23900 Pacific Coast Hwy		Unpermitted Facility, no Form 200
41	Malibu Retail Acquisition Co.	23359 Pacific Coast Hwy		Unpermitted Facility, no Form 200

DRAFT OCT 2 1 2009

Map No	Facilities	Address	CI No.	Status
42	American Commercial Equities LLC	22917 Pacific Coast Hwy		Unpermitted Facility, no Form 200
43		23755 Malibu Road		Unpermitted Facility, no Form 200
44	Wave Property Inc	3542 Coast View Drive		Unpermitted Facility, no Form 200
45	Land Corp.	23641 Pacific Coast Hwy		Unpermitted Facility, no Form 200
46	JP Morgan Chase Bank National Association	3854 Cross Creek Road		Unpermitted Facility, no Form 200
47	Verizon South Inc,.	3705 Cross Creek Road		Unpermitted Facility, no Form 200
48	Allegria Restaurant	22821 Pacific Coast Hwy		Unpermitted Facility, no Form 200
49	Mariposa Land Company LTD	3738 Cross Creek Road		Unpermitted Facility, no Form 200
50	Chevron USA Inc.	23614 Pacific Coast Hwy		Unpermitted Facility, no Form 200
51	Malibu Surfrider Hotel	22541 Pacific Coast Hwy	pending	Unpermited Facility, with Form 200
52	The Pier View	22718 Pacific Coast Hwy	pending	Unpermited Facility, with Form 200
53	Malibu Sand Shopping Center	22333 Pacific Coast Hwy	pending	Unpermited Facility, with Form 200

DRAFT
OCT 21 2009

California Regional Water Quality Control Board
Los Angeles Region
Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Arnold Schwarzenegger
Governor

DRAFT OCT 2 1 2009

May 28, 2009

Mr. Jim Thorsen
Manager, City of Malibu
23815 Stuart Ranch Road
Malibu, CA 90265-0950

Dear Mr. Thorsen:

Integrated Wastewater Management Information System (IWIMS) Notebooks

Your staff submitted several notebooks containing IWIMS Exhibits on May 7, 2009 during a public meeting of the Regional Water Quality Control Board for the Los Angeles Region. With this letter, we are returning these notebooks to you.

Staff's review of the notebooks, as well as reliance on data generated from IWIMS to identify commercial properties with on-site wastewater disposal systems, raises concern. These concerns include the accuracy of the information identifying each property listed in the IWIMS, and also the extent to which entries for each property have been populated with the data needed to regulate discharges from on-site wastewater disposal systems to achieve both protection of public health as well as protection of the underlying groundwater and nearby surface waters. We look forward to discussing these concerns, as wells as other issues related to a Memorandum of Understanding, approved August 5, 2004, between the City of Malibu and the Regional Board. We have publicly noticed this meeting for June 17, 2009, and understand that you have issued similar public notice.

Also, we continue to wait for the modeling files for the City's risk assessment,[1] as requested several times by our staff. As most recently discussed with Craig George, we hope to have these data by May 29, 2009. Should you have questions about this request, please contact Ms. Elizabeth Erickson at (213) 610-2264.

Please do not hesitate to contact me, at (213) 576-6605, should you have questions about this letter.

Sincerely,

Tracy J. Egoscue
Executive Officer
Enclosures

[1] "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu," prepared by Stone Environmental, August 2004.

California Regional Water Quality Control Board

Los Angeles Region

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Arnold Schwarzenegger
Governor

DRAFT OCT 2 1 2009

June 23, 2009

Mr. Jim Thorsen
Manager, City of Malibu
23815 Stuart Ranch Road
Malibu, CA 90265-0950

Dear Mr. Thorsen:

Integrated Wastewater Management Information System (IWIMS) Notebooks

Your staff submitted several notebooks containing IWIMS Exhibits on May 7, 2009 during a public meeting of the Regional Water Quality Control Board for the Los Angeles Region (Regional Board). As the Memorandum of Understanding with the City of Malibu, including the information you presented in the notebooks, had not been publicly noticed, we returned these notebooks to you on May 28, 2009. Subsequently, during a public meeting of the Regional Board on June 4, 2009, your staff re-submitted the notebooks. Per your request at the meeting and in your letter dated June 3, 2009, we have forwarded the notebooks to our board members.

We are pleased that the City of Malibu has taken significant steps toward design and compilation of a database system to track the use of thousands of on-site wastewater disposal systems. However, as mentioned in our letter dated May 28, 2009, staff's review of the notebooks plus reliance on data generated from IWIMS to identify commercial properties with on-site wastewater disposal systems, raises concern. These concerns include the accuracy of the information identifying each property listed in the IWIMS, and also the extent to which entries for each property have been populated with the data needed to regulate discharges from on-site wastewater disposal systems to achieve both protection of public health as well as protection of the underlying groundwater and nearby surface waters.

In your letter dated June 4, 2009, you expressed a concern about the City's constitutional right to express its viewpoint. Please be assured that staff at the Regional Board do not intent to limit your constitutional rights. However, we suggest that a more appropriate time to have submitted the notebooks would have been when we agendized the topic of the Memorandum of Understanding (MOU), approved August 5, 2004, between the City of Malibu and the Regional Board. In this regard, the public would have had notice of this issue and an ability to review information presented to the Board. We are sensitive to the legal requirement that all interested parties have access to the same information that is given to the Regional Board on matters that the Regional Board has discussed, is discussing, or will discuss at Board meetings.

As a legal matter, Government Code section 11125.1 deals with the fact that documents given to the Board members are considered disclosable pursuant to the Public Records Act and should be made available to the public who request copies of any such documents. This section does not address or support your concerns. Title 18, California Code of Regulations section 5572 refers to the Board of Equalization, so we assume you made that reference by mistake. However, even if that applied to the Regional Board, the substance of that section merely restates that documents submitted to government

agencies are public records. We agree that destruction of public records is a crime, but we returned the documents to you and did not steal, remove, secrete, destroy, mutilate, deface, alter or falsify the documents in any way.

We agree that your monthly presentations to the Board have been helpful and educational. Please be aware that we must all be careful that those presentations do not cross into matters that the Board will be considering and taking action upon in the near future.

Please do not hesitate to contact me, at (213) 576-6605, should you have questions.

Sincerely,

Tracy J. Egoscue
Executive Officer

DRAFT OCT 21 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

by
David Koo*

DRAFT

OCT

2

1

2

0

0

9

* *The author would like to thank Regional Board staff, Joe Luera and interns Yifei Tong, Ryan Thacher, Shentong Lu, and Justin Tang for their assistance in preparing map, tables and graphs.*

Staff revised Table 1, Table 2, Figure 1, and Figure 2, For Attachment 2-1, all tables have been revised and 12 new tables were added. For Attachment 2-2, all graphs have been revised and 12 new graphs were added. These tables and graphs, listed below, have been revised or replaced from the draft dated August 6, 2009:

Corrected Tables	Page
Table 1: Summary of Groundwater Pollution	TM2-5
Table 2: Summary of Groundwater Wells in Malibu Civic Center Area	TM2-7
Malibu Administrative Center Well #7b	TM2-9
Malibu Administrative Center Well #8	TM2-10
Malibu Country Mart I Well MW-1	TM2-11
Malibu Country Mart I Well MW-2	TM2-12
Malibu Country Mart I Well MW-3	TM2-13
Malibu Country Mart II Well MW-1	TM2-14
Malibu Country Mart II Well MW-2	TM2-15
Malibu Country Mart II Well MW-3	TM2-16
Malibu Country Mart III Well MW-1	TM2-17
Malibu Country Mart III Well MW-2	TM2-18
Malibu Country Mart III Well MW-3	TM2-19
Malibu Creek Plaza Well #1	TM2-20
Malibu Creek Plaza Well #2	TM2-21
Malibu Creek Plaza Well #3	TM2-22
Malibu Creek Plaza Well #4	TM2-23
Malibu Creek Plaza Well #5	TM2-24
Malibu Creek Plaza Well #6	TM2-25
Malibu Lumber ML MW-1, ML MW-2, ML MW-3, ML MW-4, ML MW-5	TM2-26
Malibu Colony Plaza Well #1	TM2-27
Malibu Colony Plaza Well #2	TM2-28
Malibu Colony Plaza Well #3	TM2-29
Malibu Colony Plaza Well #4	TM2-30
Malibu Colony Plaza Well #5	TM2-31
Malibu Civic Center Area Well C-1	TM2-32
Malibu Civic Center Area Well C-2	TM2-33
Malibu Civic Center Area Well MW-5	TM2-34
Malibu Civic Center Area Well P-1	TM2-35
Malibu Civic Center Area Well P-7	TM2-36
Malibu Civic Center Area Well P-9	TM2-37
Malibu Civic Center Area Well SMBRP-1	TM2-38
Malibu Civic Center Area Well SMBRP-2	TM2-39
Malibu Civic Center Area Well SMBRP-3c	TM2-40
Malibu Civic Center Area Well SMBRP-6	TM2-41
Malibu Civic Center Area Well SMBRP-7b	TM2-42
Malibu Civic Center Area Well SMBRP-8	TM2-43
Malibu Civic Center Area Well SMBRP-9	TM2-44
Malibu Civic Center Area Well SMBRP-10c	TM2-45
Malibu Civic Center Area Well SMBRP-11	TM2-46
Malibu Civic Center Area Well SMBRP-12	TM2-47
Malibu Civic Center Area Well SMBRP-13	TM2-48
Malibu Civic Center Area Well SMBRP-14	TM2-49
Malibu Civic Center Area Well SMBRP-15b	TM2-50
Malibu Civic Center Area Well SMBRP-16	TM2-51
Malibu Water Pollution Control Plant Well WPCP-1	TM2-52
Malibu Water Pollution Control Plant Well WPCP-2	TM2-53
Malibu Water Pollution Control Plant Well WPCP-3	TM2-54
Malibu Water Pollution Control Plant Well WPCP-4	TM2-55
Malibu Water Pollution Control Plant Well WPCP-5	TM2-56
Malibu Water Pollution Control Plant Well WPCP-6	TM2-57

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant Well WPCP-7 TM2-58
Surfrider Beach Well SB-1 TM2-59
Surfrider Beach Well SB-2 TM2-60
Malibu Beach Inn Well MW-1 TM2-61
Malibu Beach Inn Well MW-2 TM2-62
Malibu Beach Inn Well MW-3 TM2-63

Corrected Graphs
Figure 1 – Groundwater wells in the Malibu Civic Center Area TM2-2
Figure 2 – Groundwater Quality Compliance Status TM2-6
Malibu Administrative Center Well #7b TM2-65
Malibu Administrative Center Well #8 TM2-66
Malibu Country Mart I Well MW-1 TM2-67
Malibu Country Mart I Well MW-2 TM2-68
Malibu Country Mart I Well MW-3 TM2-69
Malibu Country Mart II Well MW-1 TM2-70
Malibu Country Mart II Well MW-2 TM2-71
Malibu Country Mart II Well MW-3 TM2-72
Malibu Country Mart III Well MW-1 TM2-73
Malibu Country Mart III Well MW-2 TM2-74
Malibu Country Mart III Well MW-3 TM2-75
Malibu Creek Plaza Well #1 TM2-76
Malibu Creek Plaza Well #2 TM2-77
Malibu Creek Plaza Well #3 TM2-78
Malibu Creek Plaza Well #4 TM2-79
Malibu Creek Plaza Well #5 TM2-80
Malibu Creek Plaza Well #6 TM2-81
Malibu Lumber ML MW-1, ML MW-2, ML MW-3, ML MW-4, ML MW-5 TM2-82
Malibu Colony Plaza Well #1 TM2-83
Malibu Colony Plaza Well #2 TM2-84
Malibu Colony Plaza Well #3 TM2-85
Malibu Colony Plaza Well #4 TM2-86
Malibu Colony Plaza Well #5 TM2-87
Malibu Civic Center Area Well C-1 TM2-88
Malibu Civic Center Area Well C-2 TM2-89
Malibu Civic Center Area Well MW-5 TM2-90
Malibu Civic Center Area Well P-1 TM2-91
Malibu Civic Center Area Well P-7 TM2-92
Malibu Civic Center Area Well P-9 TM2-93
Malibu Civic Center Area Well SMBRP-1 TM2-94
Malibu Civic Center Area Well SMBRP-2 TM2-95
Malibu Civic Center Area Well SMBRP-3c TM2-96
Malibu Civic Center Area Well SMBRP-6 TM2-97
Malibu Civic Center Area Well SMBRP-7b TM2-98
Malibu Civic Center Area Well SMBRP-8 TM2-99
Malibu Civic Center Area Well SMBRP-9 TM2-100
Malibu Civic Center Area Well SMBRP-10c TM2-101
Malibu Civic Center Area Well SMBRP-11 TM2-102
Malibu Civic Center Area Well SMBRP-12 TM2-103
Malibu Civic Center Area Well SMBRP-13 TM2-104
Malibu Civic Center Area Well SMBRP-14 TM2-105
Malibu Civic Center Area Well SMBRP-15b TM2-106
Malibu Civic Center Area Well SMBRP-16 TM2-107
Malibu Beach Inn Well MW-1 TM2-108
Malibu Beach Inn Well MW-2 TM2-109
Malibu Beach Inn Well MW-3 TM2-110

DRAFT OCT 2 1 2 0 0 9

Surfrider Beach Well SB-1	TM2-111
Surfrider Beach Well SB-2	TM2-112
Malibu Water Pollution Control Plant Well WPCP-1	TM2-113
Malibu Water Pollution Control Plant Well WPCP-2	TM2-114
Malibu Water Pollution Control Plant Well WPCP-3	TM2-115
Malibu Water Pollution Control Plant Well WPCP-4	TM2-116
Malibu Water Pollution Control Plant Well WPCP-5	TM2-117
Malibu Water Pollution Control Plant Well WPCP-6	TM2-118
Malibu Water Pollution Control Plant Well WPCP-7	TM2-119

For comparison purposes, the incorrect tables also are included and marked with a red X. These corrections do not affect the results, as summarized in Attachment 2-2, and conclusions of Tech Memo #2. Please contact David Koo at (213) 620-6155 (dkoo@waterboards.ca.gov) with any questions or comments you may have.

DRAFT

OCT 21 2009

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

by
David Koo

D R A F T O C T 2 1 2 0 0 9

INTRODUCTION

The City of Malibu (Malibu) is located in Los Angeles County on the north shore of the Santa Monica Bay, northwest of the City of Los Angeles, California. The boundaries of the Malibu Civic Center area are shown in Figure 1[1]. There are 392 residential properties and 38 commercial properties located in the study area. Surface water includes the lower portion of Malibu Creek, Malibu Lagoon, and Malibu Beach to Malibu Pier State Park.

Wastewater disposal in the City of Malibu falls within the jurisdiction of the Los Angeles Regional Water Quality Control Board (LARWQCB). The regional application of the Porter-Cologne Act is through the *Water Quality Control Plan – Los Angeles Region (Basin Plan)* for the Coastal Watersheds of Los Angeles and Ventura Counties.

According to the *Basin Plan*, the Malibu Civic Center area lies within the Malibu Valley Groundwater Basin. The *Basin Plan* designates this area as having a Potential Beneficial Use for Municipal and Domestic Supply (MUN) and Industrial Service Supply (IND).

PURPOSE

The purpose of this study is to determine the extent and severity of contamination of groundwater that is designated as a potential source of drinking water.

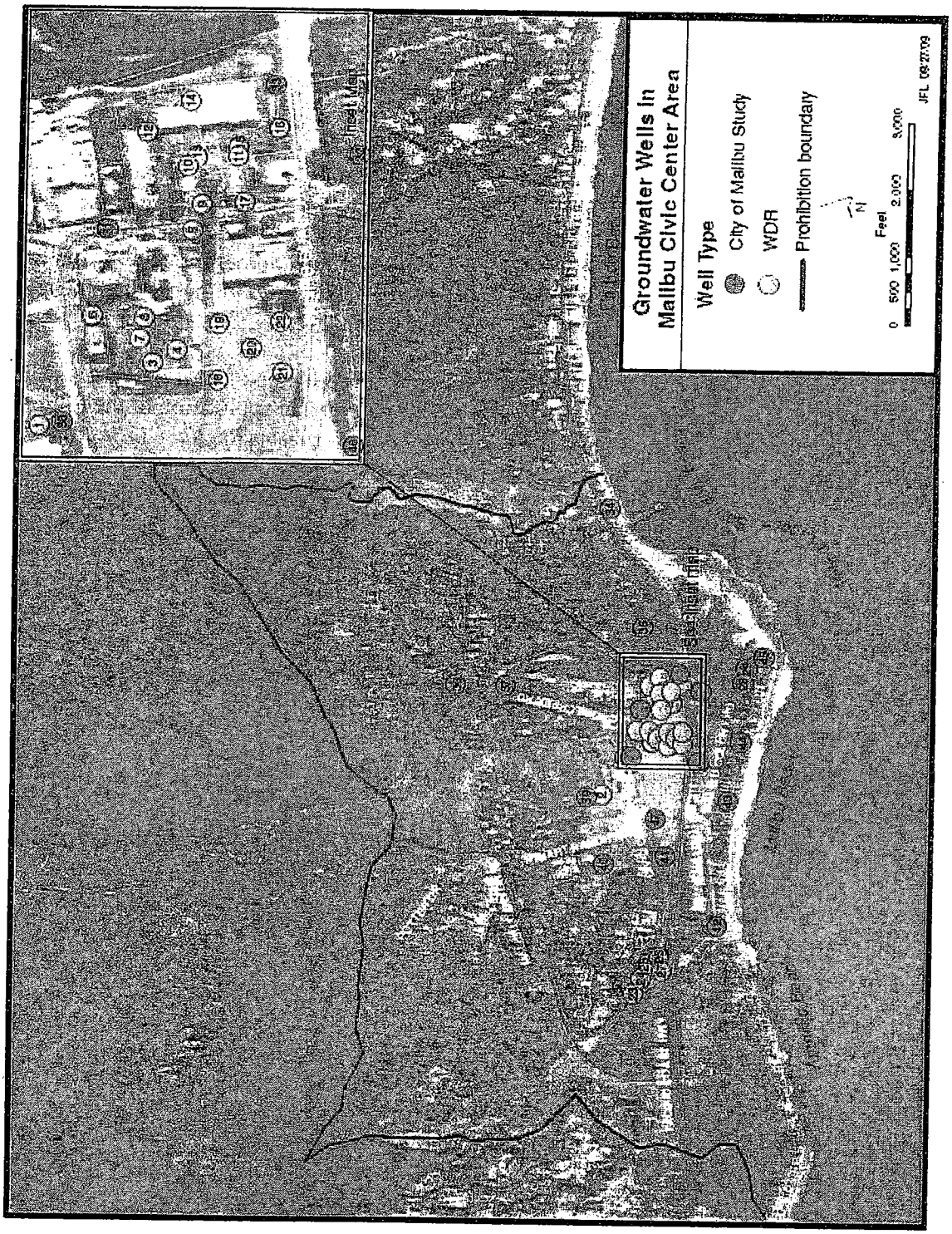
BACKGROUND

In addition to 27 miles of coastline which forms the northwest boundary of Santa Monica Bay and includes internationally famous Surfrider Beach, Malibu is home to two regionally significant aquatic resources, Malibu Creek, which drains the southern slope of the mountains, draining 109 square miles of watershed, and Malibu Lagoon, one of two significant remaining freshwater estuaries in southern California. Both the creek and lagoon have been identified as impaired for bacteria and nutrients under section 303(d) of the Clean Water Act.

---

[1] The area subject to the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1). The area was defined using topographic features and drainage patterns, and encompasses the hydrologic areas of Malibu Valley (also referred to as the lower Malibu Creek watershed), Winter Canyon, and adjacent coastal strips including Amarillo Beach, Malibu Beach, Malibu Lagoon, and Malibu Lagoon Beach (aka Surfrider Beach, including First, Second, and Third Points at Surfrider). For more discussion on the prohibition boundaries defining the Malibu Civic Center area, refer to the Technical Staff Report Overview and the Environmental Staff Report.

Figure 1 – Groundwater wells in the Malibu Civic Center Area



DRAFT OCT 21 2009

Malibu Civic Center area consists of a low-lying plain along Santa Monica Bay, plus adjacent steep uplands that rise from sea level to 100 feet, with additional upland areas that rise 500 feet into the foothills to the Santa Monica Mountains. The area contains some undeveloped parcels but sustains the largest commercial development in Malibu along with multi-family and single-family residences that include Malibu Colony, a dense subdivision where houses are built close together directly on the beach. The Los Angeles County courthouse and library, the county fire department and county sheriff"s offices are also located in this area, which effectively functions as Malibu's town center. Contemporary development is built on what was naturally an estuary-lagoon and wetlands established within an alluvial plain at the mouth of Malibu Creek. Generally the water table is 3 to 36 feet below ground surface and depths fluctuate with tidal and seasonal hydrologic variations.

There are 429 on-site wastewater disposal systems (OWDSs) that serve Malibu Civic Center area. The LARWQCB, which is responsible for regulating waste discharge in the Los Angeles and Ventura County, has evidence that OWDSs in proximity to Malibu's water resources may be among the factors contributing to poor water quality. There are a total of 38 commercial and 392 residential OWDSs in the Malibu Civic Center area. Some of the systems are old; other systems are operated at a much greater wastewater flow capacity than what they were originally designed for.

METHODS AND PROCEDURES

The main steps of this study include the following:

- Collect and review existing information from a variety of sources on groundwater quality in proximity to the OWDSs from April 19, 1999 to June 12, 2009.
- Analyze the data, for pollutants that are indicators of wastewater – specifically for fecal coliform, total coliform, ammonia, and nitrogen (nitrate + nitrite).
- Determine the frequency that the groundwater failed to meet drinking water standards – i.e., Maximum Contaminant Levels (MCLs)[2] for fecal coliform, total coliform, ammonia, and nitrate + nitrite.

[2] The United States Environmental Protection Agency (USEPA) provides Drinking Water Health Advisories for organics, inorganics, radionuclides, and microbiology including total coliform. The MCL goal and MCL for total coliform is zero and 5%, respectively. In a well used for drinking water, no more than 5% samples analyzed each month can test positive for total coliform. Every sample that has total coliform must be analyzed for fecal coliform; no fecal coliform is allowed.
According to Title 22 of the California Code of Regulations, Section 64426.1 Total Coliform MCL " .....(b) A public water system is in violation of the total coliform MCL when any of the following occurs: ...(2) For a public water system which collects fewer than 40 samples per month, more than one sample collected during any month is total coliform-positive; or (3) Any repeat sample is fecal coliform-positive .....", the MCL for total coliform and fecal coliformis zero.
The Water Quality Control Plan – Los Angeles Region or Basin Plan provides that "In ground waters used for domestic or municipal supply (MUN). the concentration of coliform organisms over any seven day period shall be less than 1.1 MPN/100 ml.
Although the MCL for total coliform and fecal coliform is zero, the detection limit used by a majority of laboratories for total coliform and fecal coliform is 1.1 MPN/100 ml. Therefore, unless the sample has a zero concentration for total coliform and fecal coliform, any detection above 1.1 MPN/100 ml means that the sample is above the MCL.

DRAFT OCT 21 2009

Staff used two sources of groundwater quality data for this study. They are: (1) the compliance files under Waste Discharge Requirements (WDRs) issued by the LARWQCB; and (2) "Final Report – Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California" prepared by Stone Environmental, Inc. in August 2004 (2004 Stone Report).

In all, data from a total of 59 groundwater wells shown in Figure 2 are used for this study. Among the 59 wells, 39 of them are identified in the WDR compliance files and the other 20 are identified in the 2004 Stone Report. The two sources of data provided a total of 1,016 groundwater sampling results with 7,112 individual analyses.

Groundwater quality data for each well was then entered into spreadsheets. Results were compared to drinking water standards. Using these spreadsheets, two graphs – one for fecal and total coliform and the other for nitrogen species – were generated for each well to illustrate the exceedance from the MCL.

RESULTS

Staff reviewed data for 59 wells in the Malibu Civic Center area that were designed and constructed for monitoring the quality of groundwater. To examine impairment of groundwater as a source of drinking water, staff compiled analytical results of testing for pathogen indicators and nitrogen species, and summarized these results in Table 1. In addition, tables and graphs summarizing the analytical results of each well are provided in Attachments 2-1 and 2-2, respectively.

Fecal Coliform
For the 59 groundwater monitoring wells in the Malibu Civic Center area, from April 19, 1999 to June 12, 2009, a total of 1,016 samples were collected and analyzed for fecal coliform. Results indicated that out of the 1,016 samples, 383, or 38%, of the samples failed to meet the MCL. Fifty (50) out of 59, or 85%, of the wells detected fecal coliform that failed to meet the MCL of 0 MPN/100 ml (Most Probable Number per 100 milliliters).

Total Coliform
For the 59 groundwater monitoring wells in the Malibu Civic Center area, from April 19, 1999 to June 12, 2009, a total of 1,016 samples were collected and analyzed for total coliform. Results indicated that out of the 1,016 samples, 576, or 57%, of the samples failed to meet the MCL. All 59, or 100%, of the wells detected total coliform that failed to meet the MCL of 1.1 MPN/100 ml.

Nitrate and Nitrite
For the 59 groundwater monitoring wells in Malibu Civic Center area, from April 19, 1999 to June 12, 2009, a total of 1,012 samples were collected and analyzed for nitrate-nitrogen and nitrite-nitrogen. Results indicated that out of the 1,012 samples, 322, or 32%, of the samples failed to meet the MCL of 10 mg/L. Twenty-six (26) out of 59, or 44%, of the wells detected nitrogen (nitrate and nitrite) that failed to meet theMCL.

DRAFT OCT 21 2009

Ammonia plus Nitrate and Nitrite

For the 59 groundwater monitoring wells in the Malibu Civic Center area, from April 19, 1999 to June 12, 2009, a total of 1,012 samples were collected and analyzed for ammonia. Results indicated that out of the 1,012 samples, 400, or 40%, of the samples failed to meet the MCL of 10 mg/L. Thirty-six (36) out of 59, or 61%, of the wells detected total nitrogen (ammonia, nitrate and nitrite) that failed to meet the MCL.

In at least one point in time, all 59 wells demonstrated the presence of pathogens and nitrogen at levels that exceeded the MCL for drinking water as summarized in Table 2. Although not all wells were contaminated for each sampling event, of the 59 wells, 50 or 85% of them had fecal coliform that failed to meet the MCL and all 59 or 100% had total coliform that failed to meet the MCL. Twenty-six (26) or 44% of the wells had nitrate and nitrite that failed to meet the MCL. Staff also did an analysis including ammonia plus nitrite and nitrate; when using all three nitrogen species, 36 or 61% of the wells had nitrogen present that failed to meet the MCL.

Table 1: Summary of Groundwater Pollution

	Fecal Coliform	Total Coliform	Nitrate+Nitrite	Ammonia + Nitrate+Nitrite
	MPN/100mL	MPN/100mL	mg/L	mg/L
MCL	0	0	10	10
Concentration Range	0 - 140,000	0 - 16,000,000	0 - 120	0 - 120
Total Samples Analyzed	1,016	1,016	1,012	1,012
# Samples Failing to Meet MCL	383	576	322	400
% Samples Failing to Meet MCL	38%	57%	32%	40%

CONCLUSION

Pathogens and nitrogen in wastewaters released from OWDSs impair underlying groundwater as a potential source of drinking water.

Indicators of pathogen and nitrogen contaminants released by OWDSs substantially impair the potential use of groundwater as a source of drinking water.

Although groundwater in the Malibu Valley Groundwater Basin and Winter Canyon is not an existing source of drinking water to the community, groundwater was the community's drinking water source up until the early 1960s. In 1963, the County of Los Angeles started delivering imported water to the area. As a future resource, and also in the event of a disruption of deliveries of imported water, groundwater in Malibu Civic Center area is an important local source that the community may need to use. However, continued degradation jeopardizes use of this local resource for beneficial use of potential MUN (drinking water use).

DRAFT OCT 2 1 2 0 0 9

DRAFT OCT 21 2009

Figure 2 - Groundwater Quality Compliance Status

Table 2: Summary of Groundwater Wells in Malibu Civic Center Area

Location	Well Numbers	Well Names	Fecal Coliform Fail to Meet MCL	Total Coliform Fail to Meet MCL	Nitrate+Nitrite Fail to Meet MCL	Ammonia+Nitrate +Nitrite Fail to Meet MCL
Malibu Administrative Center	1	Well #7b	Yes	Yes	Yes	Yes
	2	Well # 8	Yes	Yes	Yes	Yes
Malibu Country Mart I	3	Well MW-1	Yes	Yes	Yes	Yes
	4	Well MW-2	Yes	Yes	No	No
	5	Well MW-3	Yes	Yes	Yes	Yes
Malibu Country Mart II	6	Well MW-1	No	Yes	No	Yes
	7	Well MW-2	Yes	Yes	No	Yes
	8	Well MW-3	Yes	Yes	No	Yes
Malibu Country Mart III	9	Well MW-1	Yes	Yes	No	No
	10	Well MW-2	Yes	Yes	No	Yes
	11	Well MW-3	Yes	Yes	No	No
Malibu Creek Plaza	12	Well #1	Yes	Yes	No	No
	13	Well #2	Yes	Yes	Yes	Yes
	14	Well #3	Yes	Yes	No	No
	15	Well #4	Yes	Yes	Yes	Yes
	16	Well #5	Yes	Yes	No	Yes
	17	Well #6	Yes	Yes	Yes	Yes
Malibu Lumber	18	ML MW-1	Yes	Yes	No	No
	19	ML MW-2	Yes	Yes	No	No
	20	ML MW-3	Yes	Yes	No	Yes
	21	ML MW-4	Yes	Yes	No	No
	22	ML MW-5	Yes	Yes	No	No
Malibu Colony Plaza	23	Well #1	Yes	Yes	No	Yes
	24	Well #2	Yes	Yes	Yes	Yes
	25	Well #3	Yes	Yes	Yes	Yes
	26	Well #4	Yes	Yes	Yes	Yes
	27	Well #5	Yes	Yes	Yes	Yes
Malibu Study Area	28	C-1	Yes	Yes	No	No
	29	C-2	Yes	Yes	No	No
	30	Well MW-5	Yes	Yes	Yes	Yes
	31	Well P-1	No	Yes	No	No
	32	Well P-7	Yes	Yes	No	No
	33	Well P-9	Yes	Yes	No	No
	34	Well SMBRP-1	Yes	Yes	No	No
	35	Well SMBRP-2	Yes	Yes	No	No
	36	Well SMBRP-3c	Yes	Yes	No	No
	37	Well SMBRP-6	Yes	Yes	No	No
	38	Well SMBRP-7b	Yes	Yes	No	No
	39	Well SMBRP-8	Yes	Yes	Yes	Yes
	40	Well SMBRP-9	Yes	Yes	Yes	Yes
	41	Well SMBRP-10c	Yes	Yes	No	No
	42	Well SMBRP-11	Yes	Yes	No	No
	43	Well SMBRP-12	Yes	Yes	No	Yes
	44	Well SMBRP-13	Yes	Yes	No	No
	45	Well SMBRP-14	Yes	Yes	No	Yes
	46	Well SMBRP-15b	Yes	Yes	No	No
	47	Well SMBRP-16	No	Yes	No	Yes
Malibu Beach Inn	48	MW1	Yes	Yes	Yes	Yes
	49	MW2	Yes	Yes	Yes	Yes
	50	MW3	Yes	Yes	Yes	Yes
Surfrider Beach	51	Well SB-1	No	Yes	Yes	Yes
	52	Well SB-2	Yes	Yes	Yes	Yes
Malibu Water Pollution Control Plant	53	MW-1	No	Yes	Yes	Yes
	54	MW-2	No	Yes	Yes	Yes
	55	MW-3	No	Yes	Yes	Yes
	56	MW-4	Yes	Yes	Yes	Yes
	57	MW-5	No	Yes	Yes	Yes
	58	MW-6	No	Yes	Yes	Yes
	59	MW-7	Yes	Yes	Yes	Yes
Total Number of Wells			59	59	59	59
Number of Wells Fail to Meet MCL			50	59	26	36
Percentage of Wells Fail to Meet MCL			85%	100%	44%	61%

DRAFT OCT 2109

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

Attachment 2-1

Data Tables for 59 Individual Wells

DRAFT OCT 21 2009

Malibu Administrative Center
Well #7b

Parameter	Enterococcous	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/24/2003	2419.2	0	0	0.474	0.18	0	0.278	0.752	0.18	0.654
3/25/2003	2419.21	0	0	0.608	0.063	0	1.29	1.898	0.063	0.671
6/12/2003	0	0	0	0.43	0.368	0	0.29	0.72	0.368	0.798
7/30/2003	0	0	0	0.179	0.045	0	0.313	0.492	0.045	0.224
8/15/2003	0	0	230	0.243	0	0	0	0.243	0	0.243
10/28/2003	0	0	300	0.598	0.14	0.155	0.478	1.076	0.295	0.893
11/19/2003	0	0	80	0	66.161	0.292	0.197	0.197	66.453	66.453
12/19/2003	0	40	230	0.419	0	0.791	10.9	11.319	0.791	1.21
1/16/2004	0	140	140	0.292	0.79	2.06	0	0.292	2.85	3.142
2/20/2004	0	0	0	0	0.19	2.95	0.18	0.18	3.14	3.14
3/24/2004	0	0	20	0.622	0	0	1.704	2.326	0	0.622
4/27/2004	0	0	3000	0.126	0.24	2.36	0.676	0.802	2.6	2.726
5/21/2004	0	0	2100	0.184	0	0	0	0.184	0	0.184
9/1/2004	0	0	0	0.139	0.126	0	0.483	0.622	0.126	0.265
12/6/2004	300	0	900	0	1.1	0	1.06	1.06	1.1	1.1
3/9/2005	40	0	340	0	0.359	0	0.407	0.407	0.359	0.359
6/10/2005	0	0	130	0	0.133	0	1.16	1.16	0.133	0.133
9/9/2005	3500	0	20	0.261	0.11	0	0.879	1.14	0.11	0.371
11/18/2005	10111	0	1700	0.286	0.176	0	0.274	0.56	0.176	0.462
3/3/2006	3990	20	24000	0.15	0.294	0	0.41	0.56	0.294	0.444
6/2/2006	763	0	20	0.24	0.183	0	0.94	1.18	0.183	0.423
9/8/2006	0	0	0	0.241	0	0	0.359	0.6	0	0.241
12/1/2006	0	0	0	0.4	0	0	0.24	0.64	0	0.4
3/9/2007	0	0	20	0	0.124	0	0.59	0.59	0.124	0.124
6/13/2008	0	0	0	0	0.37	0	1.22	1.22	0.37	0.37
9/12/2008	0	0	0	0.11	0.15	0	0.49	0.6	0.15	0.26

DEPARTMENT OF HEALTH SERVICES 2006 12 TM2-9 3-745

Malibu Administrative Center
Well # 8

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/24/2003	14.1	0	0	0	92.3	1.95	0	0	94.25	94.25
3/25/2003	2419.21	0	985	0	65.9	0	0	0	65.9	65.9
6/12/2003	31	0	0	0	72.5	0	0	0	72.5	72.5
7/30/2003	30000	0	0	0	61.4	0	0	0	61.4	61.4
8/15/2003	0	0	130	0	65	0.873	0	0	65.873	65.873
10/28/2003	20	2300	2300	0	0.302	0.36	0.758	0.758	0.662	0.662
11/19/2003	0	0	0	0.427	0	0	0.287	0.714	0	0.427
12/19/2003	0	80	800	0	54	0.633	13.8	13.8	54.633	54.633
1/16/2004	0	0	0	0	51	0.834	0.186	0.186	51.834	51.834
2/20/2004	0	0	0	0	51.7	1.26	0.13	0.13	52.96	52.96
3/24/2004	0	0	0	0.154	57.4	0.414	1.098	1.252	57.814	57.968
4/27/2004	0	0	2800	0	60.5	0.119	0	0	60.619	60.619
5/21/2004	20	0	70	0.121	60.7	0	0	0.121	60.7	60.821
9/1/2004	20	0	0	0.072	62.77	0	0.258	0.33	62.77	62.842
12/6/2004	300	0	0	0	68.3	0	0	0	68.3	68.3
3/9/2005	220	0	17000	0	5.85	0	0.343	0.343	5.85	5.85
6/10/2005	16000000	140000	3000000	18.2	0.142	0	7.4	25.6	0.142	18.342
9/9/2005	281	0	160000	0.303	19.7	0	2.97	3.273	19.7	20.003
11/18/2005	1553	0	30000	0	26.4	1.79	0.551	0.551	28.19	28.19
3/3/2006	155	0	1700	0	27.8	0.313	0.12	0.12	28.113	28.113
6/2/2006	0	0	500000	0	37	0	0.74	0.74	37	37
9/8/2006	1600000	5000	16000000	0.881	44.9	0	3.34	4.221	44.9	45.781
12/1/2006	300	1400	1300000	0.29	31.2	0.204	0.27	0.56	31.404	31.694
3/9/2007	40	0	3000	0	40.2	0	7.17	7.17	40.2	40.2
6/13/2008	1300	0	160000	0	31.6	0	0.19	0.19	31.6	31.6
9/12/2008	40	0	30000	0.2	30.9	0	10.44	10.64	30.9	31.1

RECEIVED
2009 2012

Malibu Country Mart I
Well MW-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
12/14/2004	0	0	1601	1.05	0.1	0	0.37	1.42	0.1	1.15
3/15/2005	0	0	0	0.39	1.6	0	0.85	1.24	1.6	1.99
6/15/2005	3880	0	0	0	0.3	0	0.37	0.37	0.3	0.3
9/15/2005	0	0	0	0	5.6	0	0.32	0.32	5.6	5.6
12/14/2005	0	0	0	0.1	11.6	0	0.25	0.35	11.6	11.7
3/20/2006	0	0	23	0.22	4.35	0	0.231	0.451	4.35	4.57
6/21/2006	10	23	2220	0.334	16	0	0.346	0.68	16	16.334
9/13/2006	0	0	0	0.221	9.1	0	0.503	0.724	9.1	9.321
12/27/2006	0	0	0	0.162	5.25	0	0.33	0.492	5.25	5.412
3/20/2007	0	0	0	7.48	0.1	0	8.36	15.84	0.1	7.58
6/13/2007	0	0	0	0.115	1.95	0	0.28	0.395	1.95	2.065
9/14/2007	0	0	0	0	5.5	0	0	0	5.5	5.5
12/21/2007	0	0	0	0	2.3	0	0.474	0.474	2.3	2.3
4/4/2008	0	0	0	0	3.45	0	0.335	0.335	3.45	3.45
7/2/2008	0	0	0	0.094	2.45	0	0.122	0.216	2.45	2.544

3-747
TM2-11
9 0 0 2 2 1 2 T C O T F A R D

Malibu Country Mart I
Well MW-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
12/14/2004	17	2	220	5.8	0	0	2.84	8.64	0	5.8
3/15/2005	0	0	2	5.2	0	0	6.22	11.42	0	5.2
6/15/2005	120	0	0	4.65	0	0	4.75	9.4	0	4.65
9/15/2005	0	0	4	7	0	0	8.5	15.5	0	7
12/14/2005	0	0	0	3.99	0	0	5.1	9.09	0	3.99
3/20/2006	0	0	22	3.64	0	0	3.64	7.28	0	3.64
6/21/2006	52	0	2600	0.56	1.6	0	0.589	1.149	1.6	2.16
9/13/2006	0	0	0	4.95	0	0	4.99	9.94	0	4.95
12/27/2006	0	0	0	4.23	0	0	4.33	8.56	0	4.23
3/20/2007	0	0	0	3.81	0	0	4.3	8.11	0	3.81
6/13/2007	0	0	4	6.34	0	0	6.9	13.24	0	6.34
9/14/2007	0	0	0	8.5	0	0	8.5	17	0	8.5
12/21/2007	0	0	0	7.7	0	0	7.99	15.69	0	7.7
4/4/2008	0	0	0	7.63	0	0	8.94	16.57	0	7.63
7/2/2008	0	0	0	6.5	0	0	6.95	13.45	0	6.5

3-718
TM2-12
RECEIVED
12 2009

Malibu Country Mart I
Well MW-3

Parameter	Enterococcous	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
12/14/2004	0	0	0	0.18	1.75	0	0	0.18	1.75	1.93
3/15/2005	0	0	4	0.1	3.5	0	0.272	0.372	3.5	3.6
6/15/2005	546	0	8	0	4.9	0	0.153	0.153	4.9	4.9
9/15/2005	0	0	13	0	0.6	0	0.242	0.242	0.6	0.6
12/14/2005	0	0	4	0.12	3.05	0	0.257	0.377	3.05	3.17
3/20/2006	0	0	0	0.175	2.35	0	0.19	0.365	2.35	2.525
6/21/2006	41	23	14000	0.7	12	0	0.797	1.497	12	12.7
9/13/2006	0	0	0	0	1.05	0	0	0	1.05	1.05
12/27/2006	0	0	0	0.102	2.05	0	0.166	0.268	2.05	2.152
3/20/2007	0	0	0	0	1.7	0	0.42	0.42	1.7	1.7
6/13/2007	0	0	0	0.149	1.7	0	0.354	0.503	1.7	1.849
9/14/2007	0	0	0	0.08	2	0	0.1	0.18	2	2.08
12/21/2007	0	0	0	0	1.65	0	0.178	0.178	1.65	1.65
4/4/2008	0	0	0	0	1.65	0	0.165	0.165	1.65	1.65
7/2/2008	0	0	0	0.088	2.1	0	0.309	0.397	2.1	2.188

EXHIBIT NO. 12
2009

Malibu Country Mart II
Well MW-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
12/14/2004	11	0	0	0.17	1.75	0	0.15	0.32	1.75	1.92
3/15/2005	0	0	4	0.23	7.4	0	0.317	0.547	7.4	7.63
6/15/2005	2	0	0	0	7.65	0	0.3	0.3	7.65	7.65
12/14/2005	0	0	0	0.06	3.9	0	0.151	0.211	3.9	3.96
3/20/2006	0	0	2	0.36	2.75	0.05	0.36	0.72	2.8	3.16
6/21/2006	52	0	70	0.54	2.9	0	0.55	1.09	2.9	3.44
9/13/2006	0	0	0	0.128	3.4	0	0.128	0.256	3.4	3.528
12/27/2007	0	0	0	0.065	2.55	0	0.207	0.272	2.55	2.615
3/20/2007	0	0	0	11.2	0	0	11.7	22.9	0	11.2
6/13/2007	0	0	0	0.17	1.2	0.05	0.254	0.424	1.25	1.42
9/14/2007	0	0	0	0	1.2	0.05	0	0	1.25	1.25
12/21/2007	0	0	0	0	1.25	0.1	0.178	0.178	0.7	1.35
7/2/2008	0	0	0	0.054	1.75	0.05	0.169	0.223	0.7	1.854

3-759
TM2-14
9 0 0 2 1 2 T C O T F A R D

Malibu Country Mart II
Well MW-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
12/14/2004	0	0	0	18.8	0	0	15.5	34.3	0	18.8
3/15/2005	0	13	22	0.96	0	0	1.15	2.11	0	0.96
6/15/2005	30.5	0	500	13.7	0	0	15.7	29.4	0	13.7
12/14/2005	0	0	17	11.7	0	0	14.1	25.8	0	11.7
3/20/2006	0	0	2	9.1	0	0	9.2	18.3	0	9.1
6/21/2006	52	0	130	8.59	0	0	8.65	17.24	0	8.59
9/13/2006	0	0	0	1.92	0	0	4.37	6.29	0	1.92
12/27/2007	0	0	220	10.6	0	0	11.7	22.3	0	10.6
3/20/2007	0	0	0	9.2	0	0	11.9	21.1	0	9.2
6/13/2007	0	0	2	12	0	0	12.8	24.8	0	12
9/14/2007	0	0	0	3.61	0	0	3.81	7.42	0	3.61
12/21/2007	0	22000	90000	7.24	0	0	7.59	14.83	0	7.24
7/2/2008	0	16000	16001	14.1	0	0	15.9	30	0	14.1

3-751
TM2-15
9 0 0 2 2 1 2 T C O T E A R D

Malibu Country Mart II
Well MW-3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
12/14/2004	0	0	0	66	0.1	0	44.3	110.3	0.1	66.1
3/15/2005	0	30	30	55	0	0	58.6	113.6	0	55
6/15/2005	0	0	14	32	0	0	58.3	90.3	0	32
12/14/2005	0	0	7	49.3	0	0	52	101.3	0	49.3
3/20/2006	10	2	17	57	0	0	57.6	114.6	0	57
6/21/2006	52	0	240	8.6	0	0	8.7	17.3	0	8.6
9/13/2006	0	0	0	42.1	0	0	44.5	86.6	0	42.1
12/27/2006	0	0	0	47.3	0	0	49.2	96.5	0	47.3
3/20/2007	0	0	30	53.9	0	0	63	116.9	0	53.9
6/13/2007	0	0	0	55.4	0	0	56.4	111.8	0	55.4
9/13/2007	0	0	0	46.4	0	0	46.4	92.8	0	46.4
12/21/2007	0	0	0	35	0	0	35.3	70.3	0	35
7/2/2008	0	300	16001	28.3	0	0	29.8	58.1	0	28.3

3-752
TM2-16
9 0 0 2 2 1 2 T C O T F E A R D

Malibu Country Mart III
Well MW-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
3/8/2004	3	17	1601	0.084	1.57	0	1.25	1.334	1.57	1.654
7/9/2004	0	0	0	0.12	1.6	0	1.33	1.45	1.6	1.72
9/23/2004	0	0	0	0.11	1.15	0	0.8	0.91	1.15	1.26
12/14/2004	0	0	0	0	1.6	0	0	0	1.6	1.6
3/15/2005	0	0	0	0.063	2.6	0	0.103	0.166	2.6	2.663
6/15/2005	31	0	0	0	3.15	0	0.169	0.169	3.15	3.15
9/15/2005	0	4	6	0	3.3	0	0.3	0.3	3.3	3.3
3/20/2006	0	0	0	0.17	2.5	0.1	0.181	0.351	2.6	2.77
6/21/2006	96	0	0	0.1	2.25	0	0.1	0.2	2.25	2.35
9/13/2006	0	0	0	0.079	2.2	0	0.08	0.159	2.2	2.279
12/27/2006	0	0	0	0.177	1.9	0	0.212	0.389	1.9	2.077
3/20/2007	0	0	4	0	1.55	0	0.285	0.285	1.55	1.55
6/13/2007	0	0	0	0.079	1.75	0	0.15	0.229	1.75	1.829
9/14/2007	0	2	2	0	1.4	0	0	0	1.4	1.4
12/21/2007	0	0	0	0	1.5	0	0.35	0.35	1.5	1.5
4/4/2008	0	0	0	0	1.9	0	0.235	0.235	1.9	1.9
7/2/2008	0	0	0	0	2.35	0	0.091	0.091	2.35	2.35

3-753
TM2-17
2009 2012 TCO DEARF

Malibu Country Mart III
Well MW-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
3/8/2004	0	0	1601	0.8	2.32	0	1.07	1.87	2.32	3.12
7/9/2004	0	0	0	30.5	0.6	0	2.5	33	0.6	31.1
9/23/2004	4.1	1601	1601	34	0.55	0	12.4	46.4	0.55	34.55
12/14/2004	500	8	22	2.9	1.35	0	1.64	4.54	1.35	4.25
3/15/2005	0	4	22	0.72	3.1	0	0.826	1.546	3.1	3.82
6/15/2005	230	0	9	0.153	3.45	0	0.252	0.405	3.45	3.603
9/15/2005	63	2	2	0.9	2.75	0	1	1.9	2.75	3.65
3/20/2006	10	1100	1100	0.148	2.25	0	0.156	0.304	2.25	2.398
6/21/2006	84	1601	90000	0.291	2.2	0	0.294	0.585	2.2	2.491
9/13/2006	0	0	130	2.25	1.2	0	2.51	4.76	1.2	3.45
12/27/2006	23	0	9000	0.648	1.5	0	0.793	1.441	1.5	2.148
3/20/2007	0	0	0	0	1.2	0	0.231	0.231	1.2	1.2
6/13/2007	0	0	30	0.2	1.05	0	0.201	0.401	1.05	1.25
9/14/2007	0	23	23	0	3.3	0	0	0	3.3	3.3
12/21/2007	0	0	0	0	1.15	0	0.502	0.502	1.15	1.15
4/4/2008	0	0	0	0	1.8	0	0.276	0.276	1.8	1.8
7/2/2008	0	0	0	0.074	2.1	0	0.075	0.149	2.1	2.174

3-754
TM2-18
9 0 0 2 1 2 F C O T E A R D

Malibu Country Mart III
Well MW-3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
3/8/2004	0	0	1601	0.086	1.35	0	0.58	0.666	1.35	1.436
7/9/2004	0	0	4	0.12	1.35	0	1.74	1.86	1.35	1.47
9/23/2004	0.99	23	50	0.15	0.25	0	1	1.15	0.25	0.4
12/14/2004	13	1601	1601	0	1.8	0	0	0	1.8	1.8
3/15/2005	0	0	0	0.063	1.9	0	0.135	0.198	1.9	1.963
6/15/2005	1860	0	2	0	4.8	0	0.23	0.23	4.8	4.8
9/16/2005	0	0	0	0	3.2	0.05	0.16	0.16	3.25	3.25
3/20/2006	0	2	2	0.107	2.45	0.1	0.1	0.207	2.55	2.657
6/21/2006	97	1601	90000	0.302	2.25	0	0.305	0.607	2.25	2.552
9/13/2006	0	0	8	2.25	1.2	0	2.51	4.76	1.2	3.45
12/27/2006	23	0	8000	0.102	1.35	0	0.106	0.208	1.35	1.452
3/20/2007	0	0	0	0	1.2	0	0.345	0.345	1.2	1.2
6/13/2007	0	0	90	0.093	1.2	0	0.185	0.278	1.2	1.293
9/14/2007	0	0	0	0	1.7	0.05	0	0	1.75	1.75
12/21/2007	0	0	0	0	1.45	0	0.33	0.33	1.45	1.45
4/4/2008	0	0	0	0	1.95	0	0.32	0.32	1.95	1.95
7/2/2008	0	0	0	0	1.75	0	0	0	1.75	1.75

3-755
TM2-19
9 0 0 2 1 2 ECO EFEARD

Malibu Creek Plaza
Well #1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
7/12/2002	7.4	0	1600	0.26	2.77	0.03	1.4	1.66	2.8	3.06
9/5/2002	8.4	0	6	0.08	2.47	0.11	1.62	1.7	2.58	2.66
11/6/2002	4.1	0	4	1.2	0.47	0.03	6.47	7.67	0.5	1.7
3/12/2004	20.2	0	22	0.03	3.3	0.03	0.21	0.24	3.33	3.36
5/28/2004	344.8	8	23	0.17	3.8	0	0.05	0.22	3.8	3.97
8/13/2004	15.3	0	8	0.23	3.9	0.03	0.28	0.51	3.93	4.16
11/12/2004	0	4	8	0.15	2.06	0.14	0.44	0.59	2.2	2.35
2/15/2005	231.8	0	13	0.08	4	0	1.18	1.26	4	4.08
5/1/2005	0	0	0	0	5.66	0.2	0.2	0.2	5.86	5.86
9/1/2005	4.1	0	0	0.08	2.21	0	0.19	0.27	2.21	2.29
11/22/2005	7.4	4	240	0	1.73	0	0.05	0.05	1.73	1.73
2/15/2006	0	0	0	0.26	2.32	0.13	0.05	0.31	2.45	2.71
5/3/2006	0	0	0	0	3.4	0	0.49	0.49	3.4	3.4
8/22/2006	0	0	0	0	1.99	0	0.05	0.05	1.99	1.99
11/15/2006	6.2	0	0	0.15	1.46	0	1.29	1.44	1.46	1.61
2/13/2007	11.6	7	50	0.1	1.52	0	0.81	0.91	1.52	1.62
5/11/2007	0	0	7	0.92	1.63	0	0.26	1.18	1.63	2.55
8/18/2007	42.4	0	8	0.02	1.72	0	0.64	0.66	1.72	1.74
11/7/2007	0	0	12	0.11	1.92	0	0.23	0.34	1.92	2.03
2/14/2008	84.5	13	50	0.02	2.29	0	0.44	0.46	2.29	2.31
5/13/2008	50.5	0	0	0.07	1.97	0	0.17	0.24	1.97	2.04
8/26/2008	9.8	0	0	0.05	1.68	0	1.02	1.07	1.68	1.73
11/18/2008	7.2	0	23	0.09	1.2	0	0.26	0.35	1.2	1.29

3-756
TM2-20
2009 2012 FOOTHILL BLVD

Malibu Creek Plaza
Well #2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
7/12/2002	2419.2	80	1600	0.5	0.7	0.03	0.86	1.36	0.73	1.23
9/5/2002	4.1	0	4	1.2	0.47	0.03	6.47	7.67	0.5	1.7
11/6/2002	51.9	0	4	0	2.39	0.04	1.07	1.07	2.43	2.43
3/12/2004	0	0	0	0.5	2.09	0	0.39	0.89	2.09	2.59
5/28/2004	10.8	0	0	0.05	1.39	0	0.11	0.16	1.39	1.44
8/13/2004	98.1	0	0	0.36	1.96	0.06	0.81	1.17	2.02	2.38
11/12/2004	31.8	0	0	0.47	1.67	0.14	0.43	0.9	1.81	2.28
2/15/2005	866.4	0	8	1.86	1.72	0	0.94	2.8	1.72	3.58
5/1/2005	64.5	0	0	0.6	0	0	0.28	0.88	0	0.6
9/1/2005	214.3	11	50	1.49	1.5	0	0.63	2.12	1.5	2.99
11/22/2005	0	2	80	0.25	2.84	0	0.1	0.35	2.84	3.09
3/2/2006	0	500	1600	0.28	0	0	0.05	0.33	0	0.28
5/3/2006	18.3	0	0	0.27	2.06	0	0.25	0.52	2.06	2.33
8/22/2006	0	0	0	0.08	1.35	0	0.05	0.13	1.35	1.43
11/15/2006	0	0	30	0.59	1.46	0	0.18	0.77	1.46	2.05
2/13/2007	32.9	0	4	0.74	1.81	0	0.78	1.52	1.81	2.55
5/11/2007	0	4	4	2.63	1.52	0	2.4	5.03	1.52	4.15
8/18/2007	10.8	0	0	2.71	1.9	0	1.56	4.27	1.9	4.61
11/7/2006	5.2	0	280	1.48	1.84	0	1.3	2.78	1.84	3.32
2/13/2008	3	0	7	0.98	1.69	0	1.31	2.29	1.69	2.67
5/13/2008	3	0	0	4.96	16	0.04	1.22	6.18	16.04	21
8/26/2008	9.7	0	23	0.55	2.28	0	0.56	1.11	2.28	2.83
11/18/2008	0	90	0	1.56	1.33	0	0.05	1.61	1.33	2.89

Malibu Creek Plaza
Well #3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
7/12/2002	2	0	0	0.17	1.16	0.03	1.11	1.28	1.19	1.36
9/5/2002	4	0	4	0.5	0.93	0.08	1.12	1.62	1.01	1.51
11/6/2002	18.3	0	4	0.26	1.09	0.03	3.16	3.42	1.12	1.38
3/12/2004	0	0	0	0.62	2.02	0	0.35	0.97	2.02	2.64
5/28/2004	17.9	8	8	0.33	2.89	0	0.15	0.48	2.89	3.22
8/13/2004	0	0	0	0.69	2.24	0	0.53	1.22	2.24	2.93
11/12/2004	0	350	1600	0.76	1.19	0.14	0.48	1.24	1.33	2.09
2/15/2005	2	280	900	0.85	1.81	0	0.67	1.52	1.81	2.66
5/1/2005	0	0	13	0.81	4.64	0	0.28	1.09	4.64	5.45
9/1/2005	0	0	0	0.74	2.05	0	0.3	1.04	2.05	2.79
11/22/2005	2	0	300	0.82	1.36	0	0.36	1.18	1.36	2.18
3/2/2006	5.2	50	50	1.43	1.86	0.13	0.05	1.48	1.99	3.42
5/3/2006	8.4	0	4	0.9	1.86	0	0.32	1.22	1.86	2.76
8/22/2006	3	0	0	0	1.53	0.03	0.05	0.05	1.56	1.56
11/15/2006	5.1	0	240	0.73	0.72	0	0.85	1.58	0.72	1.45
2/13/2007	2419.2	1600	1600	0.03	1.07	0	2.73	2.76	1.07	1.1
5/11/2007	235.9	11	26	1.98	1.31	0	1.41	3.39	1.31	3.29
8/14/2007	165	8	1600	0.63	0.74	0	1.5	2.13	0.74	1.37
12/5/2007	16	0	23	0.6	0.87	0	1.04	1.64	0.87	1.47
2/13/2008	2419.2	9	1600	0.76	1.12	0.06	2.35	3.11	1.18	1.94
5/13/2008	11.9	0	0	0.76	1.09	0	0.48	1.24	1.09	1.85
8/26/2008	0	0	8	0.13	1.46	0	0.24	0.37	1.46	1.59
11/18/2008	16.6	1600	280	0.22	0.94	0.09	1.46	1.68	1.03	1.25

EXHIBIT NO. 12
2009

Malibu Creek Plaza
Well #4

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
7/12/2002	49.6	0	11	0.17	0.34	0.03	1.18	1.35	0.37	0.54
9/5/2002	22	0	240	0.4	0.03	0.09	2.91	3.31	0.12	0.52
11/6/2002	8.2	0	4	1.13	0.06	0.03	2.61	3.74	0.09	1.22
3/12/2004	48.7	0	0	0.06	1.63	0.04	0.24	0.3	1.67	1.73
5/28/2004	0	0	0	0.48	0.09	0	0.05	0.53	0.09	0.57
8/13/2004	3	0	0	0.25	3.47	0.12	0.38	0.63	3.59	3.84
11/12/2004	0	0	13	0.26	0.85	0.28	0.18	0.44	1.13	1.39
2/15/2005	2	13	13	0.12	2.54	0.05	0.2	0.32	2.59	2.71
5/1/2005	0	0	0	0	0.38	0.95	0.51	0.51	1.33	1.33
9/1/2005	0	50	50	0.06	0.27	0.02	0.16	0.22	0.29	0.35
11/22/2005	2	4	1600	0.08	1.25	0.11	0.07	0.15	1.36	1.44
3/2/2006	0	0	0	0.26	0.02	0	0.24	0.5	0.02	0.28
5/3/2006	2	0	0	0	1.51	0.06	0.4	0.4	1.57	1.57
8/22/2006	0	0	4	0	0.04	0	0.05	0.05	0.04	0.04
11/15/2006	15.6	0	0	0	0.04	0	0.25	0.25	0.04	0.04
2/15/2007	1046.2	0	300		0.03	0		0	0.03	0.03
5/11/2007	4.1	0	26	11.1	19.5	0	2.61	13.71	19.5	30.6
8/17/2007	0	0	22	25.8	1.04	0	4.56	30.36	1.04	26.84
12/6/2007	0	23	23	10.3	0.76	0	4.71	15.01	0.76	11.06
2/14/2008	2419.2	14	1600	6.44	0.03	0	7.76	14.2	0.03	6.47
5/13/2008	2419.2	500	1600	12.6	0.07	0	17	29.6	0.07	12.67
8/26/2008	25.4	2	30	6.46	1.57	0	3.64	10.1	1.57	8.03
11/18/2008	7.1	1600	240	7.75	0.04	0	3.7	11.45	0.04	7.79

3-759
TM2-23
9 0 0 2 1 2 FCO TEARD

Malibu Creek Plaza
Well #5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
7/12/2002	2419.2	23	900	3.1	7.43	0.03	1.5	4.6	7.46	10.56
9/5/2002	104.6	0	1600	0.15	4.45	0.16	1.13	1.28	4.61	4.76
11/6/2002	184.2	240	1600	0	0.03	0.03	2.04	2.04	0.06	0.06
3/12/2004	0	0	4	7.23	0.04	0	3.22	10.45	0.04	7.27
5/28/2004	0	0	0	4.28	0	0	3.54	7.82	0	4.28
8/13/2004	2	0	0	3.61	0	0	4.3	7.91	0	3.61
11/12/2004	0	1600	1600	2.98	0	0.14	1.99	4.97	0.14	3.12
2/15/2005	0	240	240	4.58	0	0	3.42	8	0	4.58
5/1/2005	0	0	0	4.52	0.09	0	3.21	7.73	0.09	4.61
9/1/2005	0	14	22	2.73	0.25	0	1.2	3.93	0.25	2.98
11/22/2005	0	0	0	9.81	0	0	4.93	14.74	0	9.81
3/2/2006	0	0	17	6.58	0.03	0	1.06	7.64	0.03	6.61
5/3/2006	12.1	0	0	6.59	0	0	5.76	12.35	0	6.59
8/22/2006	0	0	0	1.17	0.92	0	0.12	1.29	0.92	2.09
11/15/2006	103.9	8	80	4.28	0.04	0.05	0.78	5.06	0.09	4.37
2/13/2007	488.4	0	23	4.05	0	0	0.06	4.11	0	4.05
5/11/2007	2	23	30	0.33	0	0	5.92	6.25	0	0.33
8/17/2007	49.7	1600	1600	1.23	0.28	0.03	1.76	2.99	0.31	1.54
12/5/2007	58	50	140	0.98	0	0	0.74	1.72	0	0.98
2/14/2008	2	17	110	1.18	0.11	0	0.6	1.78	0.11	1.29
5/13/2008	6.2	0	4	2.82	0.027	0	0.22	3.04	0.027	2.847
8/26/2008	5.2	500	1600	0.13	1.4	0	0.06	0.19	1.4	1.53
11/18/2008	0	130	14	0.08	1.47	0	0.36	0.44	1.47	1.55

3-769
TM2-24
9 0 0 2 1 2 J C O T E A R D

Malibu Creek Plaza
Well #6

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
7/12/2002	2	0	0	0.19	0.06	0.03	1.12	1.31	0.09	0.28
9/5/2002	2419.2	0	1600	0.72	0.19	0.06	1.21	1.98	0.25	0.97
11/6/2002	29.1	0	300	0	4.22	0.09	2.18	2.18	4.31	4.31
3/12/2004	8.2	0	7	0.03	0.73	0.04	0.73	0.76	0.77	0.8
5/28/2004	79.7	13	23	0.13	3.46	0	0	0.13	3.46	3.59
8/13/2004	32.9	0	0	0.1	3.9	0.03	0.3	0.4	3.93	4.03
11/12/2004	0	0	4	0.23	1.45	0.19	0.17	0.4	1.64	1.87
2/15/2005	65.7	0	4	0.02	1.49	0	0.58	0.6	1.49	1.51
5/1/2005	0	0	0	0	13.3	10.4	0.43	0.43	23.7	23.7
9/1/2005	23.4	0	8	0	3.99	0	0	0	3.99	3.99
11/22/2005	6.2	4	1600	0.03	0.66	0	0.11	0.14	0.66	0.69
3/2/2006	0	0	0	0.16	0.98	0	0.05	0.21	0.98	1.14
5/3/2006	2	0	4	0.12	0.9	0	0.31	0.43	0.9	1.02
8/22/2006	0	0	0	3.74	0.04	0	0.81	4.55	0.04	3.78
11/15/2006	22.1	7	7	0	1.18	0	0	0	1.18	1.18
2/13/2007	13.5	0	0	0.11	1.23	0	0.31	0.42	1.23	1.34
5/10/2007	290.9	0	4	0.16	0.82	0	0.75	0.91	0.82	0.98
8/14/2007	58.5	0	30	0	7.96	0	1.19	1.19	7.96	7.96
11/15/2007	103	0	2	0	1.67	0	1.61	1.61	1.67	1.67
2/14/2008	5.1	0	11	0	1.35	0.03	0.35	0.35	1.38	1.38
5/13/2008	0	0	0	0.03	1.25	0	0.39	0.42	1.25	1.28
8/26/2008	9.3	0	0	0	10.7	0	0	0	10.7	10.7
11/18/2008	7	0	0	0	2.92	0	0	0	2.92	2.92

Malibu Lumber
ML MW-1, ML MW-2, ML MW-3, ML MW-4, ML MW-5

Parameter		Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit		(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL			0	0					10	10
Sample Number	Sample Date									
ML MW-1	5/20/2009	6	2	2	1.55	1.8	0	1.68	1.8	3.35
ML MW-2	5/20/2009	2	2	4	1.7	2.3	0	1.86	2.3	4
ML MW-3	5/20/2009	8	0	4	8.8	1.9	0	9	1.9	10.7
ML MW-4	5/20/2009	62	0	0	0.94	2.2	0	1.02	2.2	3.14
ML MW-5	5/20/2009	84	0	0	0.65	1.7	0	0.74	1.7	2.35

E-762

2009 12 FEB 10 FEE RECD

Malibu Colony Plaza
Well # 1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/28/2003	14.8	8	8	1.59	0.45	0.09	2.96	4.55	0.54	2.13
5/22/2003	0.99	0	4	0.22	0.16	0.09	0.84	1.06	0.25	0.47
8/21/2003	1986.3	0	0	0.4	0.05	0.09	0.41	0.81	0.14	0.54
11/5/2003	0	0	0	0.59	0.04	0	0.39	0.98	0.04	0.63
2/25/2004	0	0	0	0.38	0.06	0	0.02	0.4	0.06	0.44
4/30/2004	0	0	0	0.82	0.019	0	0.26	1.08	0.019	0.839
8/18/2004	0	0	0	0.31	0.03	0	0.08	0.39	0.03	0.34
11/12/2004	0	0	0	0.36	0.03	0.14	0.31	0.67	0.17	0.53
2/15/2005	14.1	4	23	0.11	0.07	0	0.74	0.85	0.07	0.18
5/12/2005	0.99	0	0	0.04	0.1	0	0.22	0.26	0.1	0.14
8/16/2005	2	0	0	0.29	0.06	0	0.14	0.43	0.06	0.35
11/9/2005	18.9	7	500	0.13	0.04	0	0.1	0.23	0.04	0.17
2/14/2006	114.5	2	2	0.17	0	0.1	0.05	0.22	0.1	0.27
6/7/2006	4.1	13	23	0	0.03	0.02	0.15	0.15	0	0.05
9/20/2006	3	2	16	0	0.03	0.02	0.05	0.05	0	0.05
12/26/2006	10	2	2	7.5	6.5	0	7.9	15.4	6.5	14
3/8/2007	0	0	0	0.93	1.7	0.028	0.99	1.92	1.728	2.658
6/7/2007	2	2	2	0.88	1.85	0.021	0.04	0.92	1.871	2.751
9/6/2007	2	2	10	0.79	2	0.023	0.06	0.85	2.023	2.813
11/15/2007	2	34	480	0.8	1.7	0.024	0.05	0.85	1.724	2.524
2/14/2008	2	2	16	0.82	1.5	0.022	0.04	0.86	1.522	2.342
5/14/2008	2	2	2	0.87	1.9	0.024	0.07	0.94	1.924	2.794

Malibu Colony Plaza
Well # 2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/28/2003	2	0	0	11.3	2.31	0.09	6.92	18.22	2.4	13.7
5/22/2003	2419.21	2	23	7.04	0.74	0.1	3.55	10.59	0.84	7.88
8/21/2003	2419.21	0	2	7.4	0.23	0.09	7.26	14.66	0.32	7.72
11/5/2003	0	0	8	12	0.65	0	37	49	0.65	12.65
2/25/2004	0	0	0	7.51	4.59	0	12.3	19.81	4.59	12.1
4/30/2004	0	0	0	11.3	5.69	0.03	4.15	15.45	5.72	17.02
8/18/2004	0	0	0	9.36	1.5	0.07	5.68	15.04	1.57	10.93
11/12/2004	0	7	900	8.06	0.22	0.25	5.18	13.24	0.47	8.53
2/15/2005	4.1	14	50	2.16	1.79	0.005	8.87	11.03	1.795	3.955
5/12/2005	0	0	0	2.3	3.83	0	11.3	13.6	3.83	6.13
8/16/2005	0	0	0	9.69	1.34	0.06	2.16	11.85	1.4	11.09
11/9/2005	0	2	2	9.65	1.76	0.07	0.43	10.08	1.83	11.48
2/14/2006	1	2	2	23.4	0.04	0.09	0.24	23.64	0.13	23.53
6/7/2006	10.1	17	80	12.2	0.05	0.04	10.6	22.8	0.09	12.29
9/20/2006	1	2	2	20.4	0.07	0.03	1.51	21.91	0.1	20.5
12/26/2006	10	2	2	28.7	11	0.021	29.4	58.1	11.021	39.721
3/8/2007	0	0	0	22	11.5	0.024	23	45	11.524	33.524
6/7/2007	8	2	2	19.8	10.6	0.023	0.2	20	10.623	30.423
9/6/2007	2	2	10	18.1	9.9	0.027	0.9	19	9.927	28.027
11/15/2007	10	50	110	16.7	9.4	0.02	0.7	17.4	9.42	26.12
2/14/2008	2	2	2	20.4	10.2	0.021	0.6	21	10.221	30.621
5/14/2008	11	2	2	18.5	10.6	0.027	1.2	19.7	10.627	29.127

RECEIVED
12 2009

Malibu Colony Plaza
Well # 3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/28/2003	1	0	0	0.2	120	0	1.87	2.07	120	120.2
5/22/2003	101.4	0	4	0.09	21.1	0.1	0.08	0.17	21.2	21.29
8/21/2003	12	0	2	0.3	25.7	0	0.46	0.76	25.7	26
11/5/2003	2	0	0	0.38	23.4	0.012	1.25	1.63	23.412	23.792
2/25/2004	0	0	0	0.31	22	0.08	0.11	0.42	22.08	22.39
4/30/2004	16.1	0	0	0.41	30.4	0.08	0.33	0.74	30.48	30.89
8/18/2004	2	0	0	0	52.8	0.27	0.32	0.32	53.07	53.07
11/12/2004	0	0	0	0	21	1.82	0.049	0.049	22.82	22.82
2/15/2005	131.3	8	13	0	26.1	0.25	0.08	0.08	26.35	26.35
5/12/2005	0	0	0	0	24.7	0	0.16	0.16	24.7	24.7
8/16/2005	13.4	4	27	0.03	26.6	0	0.29	0.32	26.6	26.63
11/9/2005	0	7	30	0.09	22.3	0.2	0.049	0.139	22.5	22.59
2/14/2006	133.4	2	2	0.28	34.3	0.26	0.05	0.33	34.56	34.84
6/7/2006	1	23	23	0	23.3	0.26	0.05	0.05	23.56	23.56
9/20/2006	2	2	2	0	13.7	0.22	0.05	0.05	13.92	13.92
12/26/2006	10	2	2	1.05	30.5	0.251	1.2	2.25	30.751	31.801
3/8/2007	0	0	0	0.11	13.7	0	0.13	0.24	13.7	13.81
6/7/2007	2	2	2	0.1	12.5	0	0.02	0.12	12.5	12.6
9/6/2007	2	2	10	0	11.4	0	0	0	11.4	11.4
11/15/2007	2	14	170	0.1	11.6	0	0.02	0.12	11.6	11.7
2/14/2008	2	2	2	0.1	12.6	0	0	0.1	12.6	12.7
5/14/2008	9	2	2	0.1	14	0	0.02	0.12	14	14.1

D E A R H E C O 2 1 2 0 0 6

Malibu Colony Plaza
Well # 4

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/28/2003	0	0	0	0.049	99.4	0	0.99	1.039	99.4	99.449
5/22/2003	2419.21	0	50	0.08	23.1	0	0.09	0.17	23.1	23.18
8/21/2003	2419.21	0	300	0.2	24.3	0	0.049	0.249	24.3	24.5
11/5/2003	109.5	0	2	0.83	23	0.03	0.87	1.7	23.03	23.86
2/25/2004	0	0	0	0.26	18.4	0.06	0.049	0.309	18.46	18.72
4/30/2004	3.1	0	0	0.34	26.8	0.03	0.049	0.389	26.83	27.17
8/18/2004	0	0	0	0.28	30.6	0.1	0.29	0.57	30.7	30.98
11/12/2004	0	0	0	0.08	22.7	1.3	0.049	0.129	24	24.08
2/15/2005	0	2	8	0	16.5	0	0.049	0.049	16.5	16.5
5/12/2005	0	2	2	0	14.9	0	0.049	0.049	14.9	14.9
8/16/2005	2	0	0	0.04	12.5	0	0.28	0.32	12.5	12.54
11/9/2005	1	17	1600	0.02	2.16	0	0.049	0.069	2.16	2.18
2/14/2006	133.4	2	2	0.28	34.3	0.26	0.05	0.33	34.56	34.84
6/7/2006	1	23	23	0	23.3	0.26	0.05	0.05	23.56	23.56
9/20/2006	1	2	2	0	13.7	0	0.05	0.05	13.7	13.7
12/26/2006	10	2	2	30	7.5	0.026	31	61	7.526	37.526
3/8/2007	0	0	0	0.64	10	0.031	0.7	1.34	10.031	10.671
6/7/2007	2	2	2	0.59	9.7	0.035	0.03	0.62	9.735	10.325
9/6/2007	2	2	10	0.52	9.5	0.03	0.06	0.58	9.53	10.05
11/15/2007	2	6	90	0.52	8.5	0.029	0.06	0.58	8.529	9.049
2/14/2008	2	2	2	12.8	0.52	9.4	0.027	12.83	9.92	22.72
5/14/2008	2	2	2	0.57	9.3	0.028	0.06	0.63	9.328	9.898

3-766
TM2-30
9 0 0 2 1 2 F C O F E A R D

Malibu Colony Plaza
Well # 5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
2/28/2003	4.1	0	0	11.5	4.64	0	3.98	15.48	4.64	16.14
5/22/2003	2419.21	0	2	9.71	0.16	0	4.83	14.54	0.16	9.87
8/21/2003	103.9	0	4	11.8	0.46	0	4.56	16.36	0.46	12.26
11/5/2003	6.2	0	0	18.1	0.34	0	15.1	33.2	0.34	18.44
2/25/2004	0	0	0	7.32	0.97	0	7.32	14.64	0.97	8.29
4/30/2004	0	0	17	18	1.44	0	18	36	1.44	19.44
8/18/2004	0	0	0	16.5	3	0.04	16.5	33	3.04	19.54
11/12/2004	0	0	23	1.65	0.09	0.15	1.65	3.3	0.24	1.89
2/15/2005	2419.21	50	50	2.08	2.08	0	2.08	4.16	2.08	4.16
5/12/2005	1.1	26	110	2.17	2.17	0	2.17	4.34	2.17	4.34
8/16/2005	0	1.9	4	10.6	10.6	0.02	10.6	21.2	10.62	21.22
11/9/2005	2	4	900	7.25	7.25	0	7.25	14.5	7.25	14.5
2/14/2006	1986.3	2	2	16	0	0.02	16	32	0.02	16.02
6/7/2006	1	2	2	19.6	0.06	0.02	19.6	39.2	0.08	19.68
9/20/2006	2419.2	2	1600	21.2	0	0.02	4.79	25.99	0.02	21.22
12/26/2006	10	2	2	1.75	16.5	0	1.9	3.65	16.5	18.25
3/8/2007	0	0	0	6	1.9	0.029	6.3	12.3	1.929	7.929
6/7/2007	2	4	2	5.7	1.8	0.03	0.01	5.71	1.83	7.53
9/6/2007	2	2	10	4.8	2.1	0.025	0.2	5	2.125	6.925
11/15/2007	68	8	80	4.8	1.9	0.026	0.12	4.92	1.926	6.726
2/14/2008	2	2	2	5.4	1.7	0.025	0.2	5.6	1.725	7.125
5/14/2008	2	2	2	5	1.7	0.031	0.5	5.5	1.731	6.731

3-767
TM2-31
9 0 0 2 1 2 TECOTEAR D

Malibu Civic Center Area
Well C-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/24/2003	0	0	0	3.27	0.6	0	4.1	0.6	3.87
5/30/2003	648.8	0	22	1.97	0.05	0	3.2	0.05	2.02
6/30/2003	61.3	0	20	2.88	0	0	3.5	0	2.88
7/24/2003	178.5	0	17	0.51	0	0	5.4	0	0.51
8/19/2003	63.7	4	17	3.02	0	0	6.9	0	3.02
9/30/2003	2	6	6	8.57	0	0	9.7	0	8.57
10/21/2003	0	2	2	7.22	0	0	10	0	7.22
11/18/2003	0	0	8	3.75	0.02	0	8.3	0.02	3.77
12/16/2003	0	0	0	3.42	0	0	6.3	0	3.42
1/20/2004	0	2	2	0	0.06	0.02	7.3	0.08	0.08
2/17/2004	1	0	0	3.78	0.08	0	6.3	0.08	3.86
3/16/2004	32.3	0	0	2.65	0.04	0	4.7	0.7	2.69

2009 2012 COASTAL DRAFT

Malibu Civic Center Area
Well C-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/24/2003	200	0	14	0.11	0.61	0	0.57	0.61	0.72
5/30/2003	2	0	4	0.44	0.07	0	0.85	0.07	0.51
6/30/2003	6.3	0	0	0.76	0	0	0.88	0	0.76
7/24/2003	2419.2	7	7	0.22	0	0	0.55	0	0.22
8/19/2003	1203.3	0	50	0.47	0	0	0.77	0	0.47
9/30/2003	15.5	0	0	0.44	0	0	0.87	0	0.44
10/21/2003	0	0	0	0.27	0	0	0.79	0	0.27
11/18/2003	4	8	30	0.21	0.03	0	0.78	0.03	0.24
12/16/2003	571.7	0	0	0.3	0	0	1	0	0.3
1/20/2004	4.1	0	0	0.48	0.02	0.02	0.94	0.04	0.52
2/17/2004	7.3	0	0	0.61	0.08	0	1.3	0.08	0.69
3/16/2004	4.1	0	0	0.23	0.03	0	0.84	0.7	0.26

DEARTFICO 12 2009

Malibu Civic Center Area
Well MW-5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/24/2003	0	0	0	0.1	3.52	0	3	3.52	3.62
5/30/2003	6	0	4	0.07	15.3	0	0.13	15.3	15.37
6/30/2003	2	0	17	0.03	7.49	0	0.05	7.49	7.52
7/24/2003	0	0	4	0.39	14.9	0	0.39	14.9	15.29
8/19/2003	2	0	0	0.02	11.7	0	1.6	11.7	11.72
9/30/2003	5.2	0	0	0	6.13	0	0.16	6.13	6.13
10/21/2003	1553.1	0	0	0	6.46	0	2	6.46	6.46
11/18/2003	4.1	8	23	0	2.39	0	0.16	2.39	2.39
12/16/2003	0	0	2	0	28.5	0.39	0.19	28.89	28.89
1/20/2004	0	0	0	0	1.31	0.02	0	1.33	1.33
2/17/2004	0	0	0	0.12	1.46	0	0.28	1.46	1.58
3/16/2004	0	0	0	0.02	2.57	0	0.29	0.7	2.59

9 0 0 2 2 1 2 T C O T E A R D

Malibu Civic Center Area
Well P-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	0	0	0	0.08	6.58	0	0.15	6.58	6.66
5/29/2003	19.5	0	2	0.21	2.85	0	0	2.85	3.06
6/26/2003	0	0	4	0.08	5.49	0	0.85	5.49	5.57
7/21/2003	0	0	2	0.41	3.55	0	0.22	3.55	3.96
8/18/2003	0	0	4	0.13	7.16	0	0.18	7.16	7.29
9/29/2003	9.8	0	0	0	2.82	0	0.42	2.82	2.82
10/20/2003	1	0	2	0	4.07	0	0.1	4.07	4.07
11/18/2003	1	0	14	0.08	4.99	0	0.74	4.99	5.07
12/15/2003	1	0	0	0	2.89	0	0.18	2.89	2.89
1/19/2004	0	0	4	0	4.58	0	0	4.58	4.58
2/16/2004	0	0	2	0.25	3.53	0	0.61	3.53	3.78
3/15/2004	0	0	0	0.04	3.75	0	0.11	0.7	3.79

DRAFT COPY 12 2009

Malibu Civic Center Area
Well P-7

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	3.1	0	23	0	0.68	0	0.26	0.68	0.68
5/28/2003	66.4	2	240	0.5	0.19	0	0.29	0.19	0.69
6/27/2003	0	0	0	0.2	0.11	0	0.37	0.11	0.31
7/24/2003	65.3	0	4	0.23	0	0	65.3	0	0.23
8/19/2003	547.5	0	0	0.08	0	0	0.27	0	0.08
9/30/2003	721.5	9	9	0	0	0	0.44	0	0
10/21/2003	125.4	23	1600	0	0.07	0	0.65	0.07	0.07
11/18/2003	55.9	50	900	0.04	0.09	0.02	0.35	0.11	0.15
12/16/2003	3	8	23	0	0.57	0.03	0.23	0.6	0.6
1/20/2004	12	12	80	0.04	0.5	0.04	0.52	0.54	0.58
2/17/2004	22.5	2	23	0.02	0.54	0.05	0.24	0.59	0.61
3/16/2004	7.4	0	30	0.02	0.57	0	0.18	0.7	0.59

2009 0021 FCOFFARD

Malibu Civic Center Area
Well P-9

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/23/2003	4.1	0	0	0.88	1.51	0	1.6	1.51	2.39
5/29/2003	21.3	0	0	0.31	1.83	0	1.3	1.83	2.14
6/26/2003	4.1	0	0	3.35	0.14	0	3.4	0.14	3.49
7/21/2003	2	0	2	3	0.71	0	3.2	0.71	3.71
8/18/2003	17.1	0	4	1.69	0.42	0	3.4	0.42	2.11
9/29/2003	44.1	0	4	1.56	0.42	0		0.42	1.98
10/20/2003	13.2	0	2	1.49	0.66	0	1.5	0.66	2.15
11/17/2003	1	0	6	2.11	0.12	0	5	0.12	2.23
12/16/2003	8.5	0	0	1.17	1.11	0	2	1.11	2.28
1/20/2004	13.4	4	8	0.51	2.13	0.1	1	2.23	2.74
2/17/2004	20.9	0	0	3.09	0.15	0	3.9	0.15	3.24
3/16/2004	45.7	0	110	0.03	5.12	0.05	3.6	0.7	5.2

3-773
TM2-37
9 0 0 2 2 1 2 T C O T F A R D

Malibu Civic Center Area
Well SMBRP-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/23/2003	0	7	50	0.78	0.15	0	2.7	0.15	0.93
5/30/2003	11	0	2	0.52	0.49	0	2	0.49	1.01
6/27/2003	0	0	0	2.52	0	0	4.9	0	2.52
7/24/2003	2419.2	0	50	1.72	0.14	0	2.5	0.14	1.86

9 0 0 2 2 1 2 T C O T F A R D

Malibu Civic Center Area
Well SMBRP-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	7200	3000	3000	2.72	0	0	29	0	2.72
5/30/2003	2419.2	70	300	0.72	0.05	0	14	0.05	0.77
6/30/2003	2419.2	120	250	1.29	0.11	0	20	0.11	1.4
7/24/2003	2419.2	4	500	0.56	0	0	6	0	0.56
8/20/2003	0	0	4	0.57	0	0	10	0	0.57
9/30/2003	2419.2	0	9	0	0	0	1.1	0	0
10/21/2003	2419.2	0	0	0	0	0	1.3	0	0
11/18/2003	1119.8	0	23	0.07	0.14	0	0.9	0.14	0.21
12/16/2003	1413.6	0	2	0	0.18	0	0.93	0.18	0.18
1/20/2004	1413.6	0	0	0.25	0.06	0.02	0.81	0.08	0.33
2/17/2004	435.2	0	0	0.33	0.09	0	0.64	0.09	0.42
3/16/2004	25.7	0	30	0.17	0.07	0	0.58	0.7	0.24

9 0 0 2 2 1 2 T C O T F A R D

Malibu Civic Center Area
Well SMBRP-3c

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	30.8	0	0	0	2.82	0	0.1	2.82	2.82
5/30/2003	2419.2	0	0	0.2	2.78	0	0.37	2.78	2.98
6/27/2003	0	0	0	0.22	0.97	0	0.4	0.97	1.19
7/24/2003	4.1	0	0	0.24	0	0	0.41	0	0.24
8/19/2003	7.4	0	0	0.14	0.52	0.25	7.4	0.77	0.91
9/30/2003	1	0	0	0	0.37	0	0.44	0.37	0.37
10/21/2003	2	2	1600	0	0.37	0	1.4	0.37	0.37
11/18/2003	1	0	17	0	0.48	0	0.16	0.48	0.48
12/16/2003	1	0	0	0	1	0	0.2	1	1
1/20/2004	1	2	4	0.03	2.31	0.02	0	2.33	2.36
2/17/2004	1	0	0	0.16	3.79	0	0.38	3.79	3.95
3/16/2004	0	0	0	0.12	4.27	0	0.18	0.7	4.39

9 0 0 2 1 2 FCO EFA R' D

Malibu Civic Center Area
Well SMBRP-6

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	0	0	13	0	2.02	0	0.36	2.02	2.02
5/30/2003	16.5	11	26	0.16	0.33	0	1.2	0.33	0.49
6/27/2003	0	2	2	0.16	0.21	0	1.1	0.21	0.37
7/24/2003	1	0	2	0.36	0	0	0.44	0	0.36
8/19/2003	0	0	0	0.05	0.22	0	0.14	0.22	0.27
9/30/2003	0	4	110	0	0.17	0	0.44	0.17	0.17
10/21/2003	0	0	900	0	0.27	0	1.3	0.27	0.27
11/18/2003	2	33	34	0	0.93	0	0.2	0.93	0.93
12/16/2003	0	0	0	0	1.55	0	0.35	1.55	1.55
1/20/2004	7.4	0	2	0	4.43	0.03	0	4.46	4.46
2/17/2004	5.2	0	0	0.05	6.88	0	0.27	6.88	6.93
3/16/2004	10.7	11	110	0.11	2.74	0	0.3	0.7	2.85

3-777
TM2-41
9 0 0 2 1 2 T C O T F A R D

Malibu Civic Center Area
Well SMBRP-7b

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/23/2003	0	0	0	0.69	0.16	0	1.4	0.16	0.85
5/29/2003	0	0	0	2.29	0.56	0	0.39	0.56	2.85
6/30/2003	0	0	0	0.74	0	0	1.7	0	0.74
7/21/2003	29.3	0	0	0.53	0.06	0	1	0.06	0.59
8/18/2003	2419.2	0	300	0.33	0	0	0.91	0	0.33
9/30/2003	4.1	2	4	0.35	0.1	0	0.6	0.1	0.45
10/21/2003	0	0	0	0	0	0	0.43	0	0
11/18/2003	19.6	4	4	0.18	0	0	0.79	0	0.18
12/15/2003	0	0	0	0.17	0.03	0	0.59	0.03	0.2
1/19/2004	0	6	350	0.1	0.07	0	0.13	0.07	0.17
2/16/2004	0	0	0	0.42	0.03	0	0.49	0.03	0.45
3/15/2004	691	0	20	0.03	0.02	0	0.67	0.7	0.05

3-778

2009 2012 COTE A R D

Malibu Civic Center Area
Well SMBRP-8

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	2	2	8	0	46.3	0	0.33	46.3	46.3
5/29/2003	2419.2	2	6	0.22	55.6	0	0	55.6	55.82
6/30/2003	1	0	0	0.26	11.1	0	0.28	11.1	11.36
7/21/2003	148.5	0	11	1.44	61.5	0	1.9	61.5	62.94
8/20/2003	0	0	14	0	63.8	0	0.86	63.8	63.8
9/30/2003	3	2	300	0.04	43.1	0	0.45	43.1	43.14
10/21/2003	2419.2	0	0	0	31.6	0	0.53	31.6	31.6
11/18/2003	8.4	22	23	0	48.1	0	0.9	48.1	48.1
12/16/2003	2419.7	0	0	0	2.61	0	0.02	2.61	2.61
1/20/2004	2419.2	60	170	0	48.4	0.04	0	48.44	48.44
2/17/2004	5	0	2	0.09	48.6	0.02	0.18	48.62	48.71
3/16/2004	10.5	0	0	0.02	60.2	0	0.18	0.7	60.22

3-779
TM2-43
9 0 0 2 1 2 T C O T F A R D

Malibu Civic Center Area
Well SMBRP-9

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/23/2003	0	0	0	0.01	3.03	0	1.1	3.03	3.04
5/28/2003	4.1	0	4	0.47	32.1	0	0	32.1	32.57
6/26/2003	0	0	11	0.4	25.8	0	0.52	25.8	26.2
7/21/2003	2419.2	240	1600	0.29	21.6	0	0.22	21.6	21.89
8/18/2003	2419.2	0	500	0.02	18.7	0	0.29	18.7	18.72
9/29/2003	6.3	0	7	0	13.2	0	0.16	13.2	13.2
10/20/2003	124.5	0	0	0	31.2	0	0.1	31.2	31.2
11/17/2003	1	17	500	0.15	22.3	0	0.48	22.3	22.45
12/15/2003	0	0	0	0	21.9	0	0.48	21.9	21.9
1/19/2004	14.2	0	0	0	30.8	0	0	30.8	30.8
2/16/2004	0	0	0	0.09	34.7	0.02	0.11	34.72	34.81
3/16/2004	10.7	0	0	0.02	38.5	0	0.24	0.7	38.52

3-786

9 0 0 2 1 2 FEB 0 7 AM 9 0 0 2 1 2 FEB 0 7 AM

Malibu Civic Center Area
Well SMBRP-10c

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/24/2003	0	0	0	0.09	3.41	0	0.35	3.41	3.5
5/29/2003	157.8	0	2	0.47	1.66	0	1.1	1.66	2.13
6/26/2003	0	2	4	0.04	1.27	0	1.3	1.27	1.31
7/21/2003	770.1	2	130	0.44	0.93	0	2.3	0.93	1.37
8/18/2003	1986.3	0	0	0.11	0.65	0	1	0.65	0.76
9/29/2003	33.7	0	4	0	0.32	0	2.7	0.32	0.32
10/20/2003	125.7	2	2	0	0.67	0	2.6	0.67	0.67
11/17/2003	43.5	0	0	0.06	0.7	0	1.4	0.7	0.76
12/15/2003	5.2	0	2	0	0.59	0	1.5	0.59	0.59
1/19/2004	2	0	0	0	1.43	0	0.24	1.48	1.43
2/16/2004	1	0	0	0.26	1.31	0	1.3	1.31	1.57
3/15/2004	5.1	0	0	0.05	1.79	0.02	1.3	1.81	1.86

D R A F T
C O A S T A L
2 1 2 0 0 2
9 0 0 9

Malibu Civic Center Area
Well SMBRP-11

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	0	0	0	0.04	5.66	0	0.85	5.66	5.7
5/28/2003	2419.2	0	4	0.3	3.85	0	0.51	3.85	4.15
6/26/2003	0	0	2	0.03	2.48	0	0.49	2.48	2.51
7/21/2003	1203.3	2	110	0.37	1.48	0	0.52	1.48	1.85
8/18/2003	2419.2	2	240	0.17	1.35	0	0.98	1.35	1.52
9/29/2003	28.1	4	7	0	0.55	0	0.8	0.55	0.55
10/20/2003	3	0	0	0	0.45	0	0.16	0.45	0.45
11/18/2003	0	13	13	0.11	0.09	0	0.38	0.09	0.2
12/16/2003	7	0	0	0	0.26	0	0.29	0.26	0.26
1/20/2004	15.3	0	0	0	1.54	0.03	0.2	1.57	1.57
2/17/2004	5	0	0	0.11	0.25	0	0.28	0.25	0.36
3/15/2004	2	0	0	0.04	3.43	0	0.11	3.43	3.47

2009 0022 12 FEB 2010

Malibu Civic Center Area
Well SMBRP-12

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	2	2	50	5.14	0	0	13	0	5.14
5/28/2003	0	4	4	9.29	0	0	12	0	9.29
6/27/2003	0	0	0	10.2	0	0	12	0	10.2
7/21/2003	0	0	0	8.6	0.06	0	11	0.06	8.66
8/18/2003	1	0	0	6.45	0	0	12	0	6.45
9/29/2003	0	0	0	7.26	0	0	12	0	7.26
10/20/2003	0	0	0	6.29	0	0	6.5	0	6.29
11/17/2003	0	0	0	3.66	0.02	0	8.7	0.02	3.68
12/15/2003	1	2	4	7.19	0.02	0	9.6	0.02	7.21
1/19/2004	0	2	2	7.82	0.07	0	22	0.07	7.89
2/16/2004	1	0	0	0	0.03	0	12	0.03	0.03
3/15/2004	0	0	0	1.01	0	0	12	0	1.01

3-783
TM2-47
9 0 0 2 1 2 T C O F A R D

Malibu Civic Center Area
Well SMBRP-13

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/22/2003	34.1	0	0	0.16	1	0	0.59	1	1.16
5/28/2003	54.8	0	2	6.03	0.49	0	0.28	0.49	6.52
6/27/2003	5	0	0	0.15	0.3	0	0.35	0.3	0.45
7/21/2003	0	0	0	0.38	0.23	0	0.4	0.23	0.61
8/18/2003	2	0	8	0.09	0.09	0	0.34	0.09	0.18
9/29/2003	5.1	0	0	0.03	0.06	0	0.62	0.06	0.09
10/20/2003	2	0	0	0	0	0	0.15	0	0
11/17/2003	2	0	2	0.06	0.03	0	0.27	0.03	0.09
12/15/2003	19.9	0	0	0.14	0.02	0	1.2	0.02	0.16
1/19/2004	2	0	2	0	0.24	0	0	0.24	0.24
2/16/2004	26	2	2	0.05	0.42	0	0.4	0.42	0.47
3/15/2004	7.4	0	2	0.02	0.41	0	1.2	0.41	0.43

3-781

DEPARTMENT OF PUBLIC WORKS
2112
2009

Malibu Civic Center Area
Well SMBRP-14

Parameter →	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/22/2003	21.1	17000	17000	17.4	0	0	25	0	17.4
5/28/2003	91.4	1600	1600	0.26	0	0	15	0	0.26
6/27/2003	0	1600	1600	13.1	0	0	16	0	13.1
7/21/2003	2419.2	900	1600	23.8	0.18	0	26	0.18	23.98
8/18/2003	16.6	220	1600	8.23	0	0	28	0	8.23
9/29/2003	8.4	1600	1600	21.1	0.07	0	26	0.07	21.17
10/20/2003	1	300	1600	20.4	0	0	100	0	20.4
11/17/2003	5.2	500	1600	15.5	0.03	0.02	33	0.05	15.55
12/15/2003	2	1600	1600	16.4	0.02	0	31	0.02	16.42
1/19/2004	22.8	1600	1600	16.2	0.05	0.02	36	0.07	16.27
3/15/2004	6.3	1600	1600	0.48	0.02	0	22	0.02	0.5

E-785
TM2-49
9 0 0 2 1 2 TCO DRAFT

Malibu Civic Center Area
Well SMBRP-15b

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/25/2003	67.6	0	0	0.14	0.91	0	1	0.91	1.05
5/28/2003	2419.2	0	21	1.21	1.03	0	0.42	1.03	2.24
6/26/2003	3.1	0	0	0.05	0.94	0	0.28	0.94	0.99
7/21/2003	0	0	0	0.37	0.94	0	0.24	0.94	1.31
8/18/2003	2	0	2	0.05	1.31	0	0.18	1.31	1.36
9/29/2003	0	2	2	0	1.15	0	0.4	1.15	1.15
10/20/2003	0	0	0	0.18	1.64	0	0.48	1.64	1.82
11/18/2003	0	0	0	0	1.56	0.03	0.4	1.59	1.59
12/15/2003	0	0	0	0.02	1.7	0	0.66	1.7	1.72
1/20/2004	0	0	0	0	1.46	0.05	0	1.51	1.51
2/17/2004	9.1	0	0	0.09	1.24	0.06	0.2	1.3	1.39
3/16/2004	2	0	2	0.08	1.05	0.03	0.25	1.08	1.16

DRAFT COPY 12 2009

Malibu Civic Center Area
Well SMBRP-16

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
4/23/2003	33.3	0	0	0.2	2.88	0.49	0.64	3.37	3.57
5/28/2003	2419.2	0	4	6.08	4.02	0.31	1.2	4.33	10.41
6/26/2003	29.2	0	0	0.83	2.38	0.19	1.6	2.57	3.4
7/21/2003	5.2	0	0	0.52	4.5	0.24	0.56	4.74	5.26
8/18/2003	2419.2	0	0	0.04	4.58	0	1.1	4.58	4.62
9/29/2003	42.8	0	0	0	2.77	0.1	1.4	2.87	2.87
10/20/2003	0	0	0	0	3.66	0	0.73	3.66	3.66
11/17/2003	3.1	0	2	0.32	3	0.09	1.5	3.09	3.41
12/15/2003	1	0	0	0.04	4.11	0	1.1	4.11	4.15
1/19/2004	0	0	0	0.06	4.68	0.06	0.1	4.74	4.8
2/16/2004	0	0	2	0.04	5	0.03	0.99	5.03	5.07
3/15/2004	1	0	2	0.03	0	5.12	0.05	0.7	5.15

DRAFT COTF 12 2009

Malibu Water Pollution Control Plant
Well WPCP 1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
4/19/1999	/	0	0	0	10.3	0	0.108	0.108	10.3	10.3
1/24/2000	/	0	0	0	18.2	0	0	0	18.2	18.2
5/16/2000	/	0	0	0	18.7	0	0	0	18.7	18.7
8/8/2000	/	0	0	0.104	21	0	0.17	0.274	21	21.104
11/14/2000	/	0	0	0	15.3	0	0.168	0.168	15.3	15.3
3/13/2001	/	0	0	0	17.7	0	0	0	17.7	17.7
5/8/2001	/	0	0	0	21.4	0	0	0	21.4	21.4
8/7/2001	/	0	0	0	20.8	0	0.16	0.16	20.8	20.8
10/2/2001	/	0	0	0	16.6	0	0.12	0.12	16.6	16.6
1/22/2002	/	0	0	0.143	18.7	0	0	0.143	18.7	18.843
4/23/2002	/	0	0	0	21.9	0	0.234	0.234	21.9	21.9
7/16/2002	/	0	0	0.0809	25.7	0	0	0.081	25.7	25.7809
10/29/2002	/	0	0	1.09	23.9	0	4.89	5.98	23.9	24.99
2/25/2003	/	0	0	0	30.5	2.4	0.155	0.155	32.9	32.9
5/13/2003	/	0	0	0	22.4	0	0.15	0.15	22.4	22.4
8/26/2003	/	0	0	0	24.2	0.271	0.106	0.106	24.471	24.471
10/21/2003	/	0	0	0.11	31.4	0.353	0	0.11	31.753	31.863
1/13/2004	/	0	0	0	24.8	0.4	0.476	0.476	25.2	25.2
4/13/2004	/	0	0	0	37.9	0	0	0	37.9	37.9
7/13/2004	/	0	0	0.125	31.4	0.076	0	0.125	31.476	31.601
10/5/2004	/	0	0	0	23.26	0.18	0	0	23.44	23.44
1/18/2005	/	0	0	0	27	0	0.382	0.382	27	27
4/12/2005	/	0	0	0	21.6	0	0	0	21.6	21.6
7/19/2005	/	0	0	0	24.839	0.164	0	0	25.003	25.003
10/24/2005	/	0	0	0.108	18.5	0.849	0	0.108	19.349	19.457
1/30/2006	/	0	0	0	28.7	0	0.196	0.196	28.7	28.7
5/8/2006	/	0	0	0	23	0	0	0	23	23
7/31/2006	/	0	800	0	24.2	0.28	0	0	24.48	24.48
1/9/2007	/	0	0	0	24.2	0	0	0	24.2	24.2
4/3/2007	/	0	0	0	17.8	0.067	0.11	0.11	17.867	17.867
7/3/2007	/	0	0	0	7.43	0	0.71	0.71	7.43	7.43
10/9/2007	/	0	0	0	15.8	0	0	0	15.8	15.8
1/8/2008	/	0	0	0	16.6	0	0	0	16.6	16.6
4/22/2008	/	0	0	0	21.6	0	0	0	21.6	21.6
7/15/2008	/	0	0	0	22.5	0	0	0	22.5	22.5
10/20/2008	/	0	0	0.12	20.4	0	0.16	0.28	20.4	20.52

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant
Well WPCP 2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	/MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
4/19/1999	/	0	0	0	26	0	0	0	26	26
1/24/2000	/	0	0	0	0.657	0	1.06	1.06	0.657	0.657
5/16/2000	/	0	0	0	1.71	0	0	0	1.71	1.71
8/8/2000	/	0	0	0.174	1.09	0	0.578	0.752	1.09	1.264
11/14/2000	/	0	0	0	1.79	0	0.12	0.12	1.79	1.79
3/13/2001	/	0	0	0	0.043	0	0.156	0.156	0.043	0.043
5/8/2001	/	0	0	0	4.4	0	0.4	0.4	4.4	4.4
8/7/2001	/	0	0	0	8.5	0	0	0	8.5	8.5
10/2/2001	/	0	0	0.152	7.9	0	0	0.152	7.9	8.052
1/22/2002	/	0	0	1.61	1.7	0	0.136	1.746	1.7	3.31
4/23/2002	/	0	0	3.3	0.4	0	0.28	3.58	0.4	3.7
7/16/2002	/	0	4	0.143	0	0	5.06	5.203	0	0.143
10/29/2002	/	0	0	2.89	0.535	5.05	1.07	3.96	5.585	8.475
2/25/2003	/	0	0	0.198	4.99	0	0.116	0.314	4.99	5.188
5/13/2003	/	0	0	2.94	0.409	0.344	0	2.94	0.753	3.693
8/26/2003	/	0	0	0.165	5.78	0.405	0.339	0.504	6.185	6.35
10/21/2003	/	0	0	2.22	0.429	0.438	0	2.22	0.867	3.087
1/13/2004	/	0	0	0.343	3.5	0.7	0.481	0.824	4.2	4.543
4/13/2004	/	0	0	3.323	0	0	0	3.323	0	3.323
7/13/2004	/	0	0	0	5.62	0	0	0	5.62	5.62
12/6/2004	/	0	0	0	6.842	0	0.15	0.15	6.842	6.842
1/18/2005	/	0	170	0	9.72	0	1.7	1.7	9.72	9.72
4/12/2005	/	0	34	0	6.95	0	0	0	6.95	6.95
7/19/2005	/	0	0	0	6.684	0	0	0	6.684	6.684
10/24/2005	/	0	0	0	6.98	0	0.415	0.415	6.98	6.98
1/30/2006	/	0	300	0	6.55	0	0.251	0.251	6.55	6.55
5/8/2006	/	0	0	0	6.48	0	0.24	0.24	6.48	6.48
7/31/2006	/	0	230	0	5.76	0	0.206	0.206	5.76	5.76
1/9/2007	/	0	0	0	5.2	0	0	0	5.2	5.2
4/3/2007	/	0	80	0	0.225	0	0.1	0.1	0.225	0.225
7/3/2007	/	0	0	0	4.6	0	0.56	0.56	4.6	4.6
10/9/2007	/	0	0	0	3.6	0	0.2	0.2	3.6	3.6
1/8/2008	/	0	0	0	3.39	0	0.24	0.24	3.39	3.39
4/22/2008	/	0	40	0	2.78	0	0.55	0.55	2.78	2.78
7/15/2008	/	0	0	0	3.77	0	0	0	3.77	3.77
10/20/2008	/	0	0	0	2.8	0	0.21	0.21	2.8	2.8

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant
Well WPCP 3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
4/19/1999	/	0	0	0	16.8	0	0	0	16.8	16.8
1/24/2000	/	0	0	0	13.2	0	0	0	13.2	13.2
5/16/2000	/	0	0	0	15.78	0.23	0	0	16.01	16.01
8/8/2000	/	0	0	0	16.1	0	0.238	0.238	16.1	16.1
11/14/2000	/	0	0	0	19.7	0.47	0	0	20.17	20.17
3/14/2001	/	0	20	0	14.8	0	0.229	0.229	14.8	14.8
5/8/2001	/	0	0	0	12.8	0	0	0	12.8	12.8
8/7/2001	/	0	0	0	12.1	0	0	0	12.1	12.1
10/2/2001	/	0	0	0	10.8	0	0.13	0.13	10.8	10.8
1/22/2002	/	0	0	0.084	16.5	0	0	0.084	16.5	16.584
4/23/2002	/	0	0	0.107	15	0	0.163	0.27	15	15.107
7/16/2002	/	0	0	0	14.5	0	0	0	14.5	14.5
10/29/2002	/	0	0	0.349	14.3	0	0	0.349	14.3	14.649
2/25/2003	/	0	0	0	80.7	0	0	0	80.7	80.7
5/13/2003	/	0	0	0	65.5	0	0	0	65.5	65.5
8/26/2003	/	0	0	0	22.5	0	0	0	22.5	22.5
10/21/2003	/	0	0	0	22.8	0.453	0.38	0.38	23.253	23.253
1/13/2004	/	0	300	0	24.8	1.1	0.31	0.31	25.9	25.9
4/13/2004	/	0	0	0	24.8	0	0.229	0.229	24.8	24.8
7/13/2004	/	0	0	0	19.1	0	0	0	19.1	19.1
12/6/2004	/	0	16,000	0	9.868	0.228	0.37	0.37	10.096	10.096
1/18/2005	/	0	50,000	0	18.6	0	1.03	1.03	18.6	18.6
4/12/2005	/	0	900	0	14.8	0	0	0	14.8	14.8
7/19/2005	/	0	300	0	32.52	0	0	0	32.52	32.52
10/24/2005	/	0	170	0	23.3	0	0.161	0.161	23.3	23.3
1/30/2006	/	0	0	0	37.9	0	0	0	37.9	37.9
5/8/2006	/	0	0	0	43.6	0	0	0	43.6	43.6
7/31/2006	/	0	0	0	47.4	0	0.129	0.129	47.4	47.4
1/9/2007	/	0	0	0	25.1	0	0	0	25.1	25.1
4/3/2007	/	0	0	0	31.6	0	0.1	0.1	31.6	31.6
7/3/2007	/	0	0	0	19.9	0	0.75	0.75	19.9	19.9
10/9/2007	/	0	0	0	13.2	0	0	0	13.2	13.2
1/8/2008	/	0	0	0	11.3	0	0	0	11.3	11.3
4/22/2008	/	0	0	0	11.2	0	0	0	11.2	11.2
7/15/2008	/	0	0	0	19	0	0	0	19	19
10/20/2008	/	0	0	0	11.9	0	0.11	0.11	11.9	11.9

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant
Well WPCP 4

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
8/7/2001	/	0	2	0	23	0	0.18	0.18	23	23
10/2/2001	/	0	0	0	16.7	0	0.27	0.27	16.7	16.7
5/16/2000	/	0	0	0	18.7	0	0	0	18.7	18.7
8/8/2000	/	0	0	0.104	21	0	0.17	0.274	21	21.104
11/14/2000	/	0	0	0	15.3	0	0.168	0.168	15.3	15.3
3/13/2001	/	0	0	0	17.7	0	0	0	17.7	17.7
5/8/2001	/	0	0	0	21.4	0	0	0	21.4	21.4
8/7/2001	/	0	0	0	20.8	0	0.16	0.16	20.8	20.8
10/2/2001	/	0	0	0	16.6	0	0.12	0.12	16.6	16.6
1/22/2002	/	0	17	0.092	1.31	0.02	0	0.092	1.33	1.422
4/28/2002	/	0	700	0.12	1.46	0	0.28	0.4	1.46	1.58
7/16/2002	/	0	1,600	0.02	2.57	0	0.29	0.31	2.57	2.59
10/29/2002	/	0	140	0	20.2	0	0	0	20.2	20.2
2/25/2003	/	1,600	1,600	0	9.68	3.19	0	0	12.87	12.87
5/13/2003	/	1	55.2	0	1.75	0	0.907	0.907	1.75	1.75
8/26/2003	/	0	240	0	3.79	0	0	0	3.79	3.79
10/21/2003	/	170	1700	0.637	1.77	0.332	0	0.637	2.102	2.739
1/13/2004	/	0	24,000	0	0.8	0.4	0.367	0.367	1.2	1.2
4/13/2004	/	0	3,000	0	1.98	0	0.309	0.309	1.98	1.98
7/13/2004	/	0	0	0	1.77	0	0.13	0.13	1.77	1.77
10/5/2004	/	0	0	0	24.39	0	0	0	24.39	24.39
1/18/2005	/	0	160,000	0	21	0	0.778	0.778	21	21
4/12/2005	/	0	4	0.127	27.5	0.164	0.241	0.368	27.664	27.791
7/19/2005	/	0	220	0	25.97	0	0	0	25.97	25.97
10/24/2005	/	0	0	0.119	27.1	0.752	0	0.119	27.852	27.971
1/30/2006	/	0	500	0	35.7	0	0	0	35.7	35.7
5/8/2006	/	0	2,400	0	25.1	0	0	0	25.1	25.1
7/31/2006	/	0	9,000	0	26.8	0	0	0	26.8	26.8
1/9/2007	/	0	160,000	0	22.8	0	0	0	22.8	22.8
4/3/2007	/	0	90,000	0	18.1	0	0	0	18.1	18.1
7/3/2007	/	0	160,000	0	6.86	0.48	0.58	0.58	7.34	7.34
10/9/2007	/	0	1,300	0	11.2	0	0.1	0.1	11.2	11.2
1/8/2008	/	0	130	0	12.8	0	0	0	12.8	12.8
4/22/2008	/	0	13,000	0.14	19.4	0	0	0.14	19.4	19.54
7/15/2008	/	0	2,800	0	19.4	0	0	0	19.4	19.4
10/20/2008	/	0	230	0.1	18.2	0	0.16	0.26	18.2	18.3

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant
Well WPCP 5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
8/7/2001	/	0	6	0	13	0	0.11	0.11	13	13
10/2/2001	/	0	0	0	11.5	0	0.167	0.167	11.5	11.5
5/16/2000	/	0	0	0	18.7	0	0	0	18.7	18.7
8/8/2000	/	0	0	0.104	21	0	0.17	0.274	21	21.104
11/14/2000	/	0	0	0	15.3	0	0.168	0.168	15.3	15.3
3/13/2001	/	0	0	0	17.7	0	0	0	17.7	17.7
5/8/2001	/	0	0	0	21.4	0	0	0	21.4	21.4
8/7/2001	/	0	0	0	20.8	0	0.16	0.16	20.8	20.8
10/2/2001	/	0	0	0	16.6	0	0.12	0.12	16.6	16.6
1/22/2002	/	0	4	0.1	13.1	0	0.127	0.227	13.1	13.2
4/23/2002	/	0	50	0	7.79	0	0	0	7.79	7.79
7/16/2002	/	0	23	0	5.4	0	0	0	5.4	5.4
10/29/2002	/	0	20	0.124	10.6	0	0.268	0.392	10.6	10.724
2/25/2003	/	0	0	0	7.83	0	0.18	0.18	7.83	7.83
5/13/2003	/	0	13.4	0	4.45	0	0.142	0.142	4.45	4.45
8/26/2003	/	0	0	0	8.96	0	0.166	0.166	8.96	8.96
10/21/2003	/	0	0	0	3.41	0.545	0.242	0.242	3.955	3.955
1/13/2004	/	0	0	0	1.6	0.5	0.124	0.124	2.1	2.1
4/13/2004	/	0	0	0.103	2.82	0	0	0.103	2.82	2.923
7/13/2004	/	0	0	0	17.2	0	0	0	17.2	17.2
10/5/2004	/	0	0	0	18.58	0	0.153	0.153	18.58	18.58
1/18/2005	/	0	40	0	22.8	0	0.568	0.568	22.8	22.8
4/12/2005	/	0	0	0.159	23.9	0	0.181	0.34	23.9	24.059
7/19/2005	/	/	/	/	/	/	/	/	/	/
10/24/2005	/	0	0	0	30.3	0	0	0	30.3	30.3
1/30/2006	/	0	230	0	36.8	0	0	0	36.8	36.8
5/8/2006	/	0	0	0	27.8	0	0	0	27.8	27.8
7/31/2006	/	0	130	0	29.1	0	0	0	29.1	29.1
1/9/2007	/	0	0	0	26.4	0	0	0	26.4	26.4
4/3/2007	/	0	0	0	23.5	0	0	0	23.5	23.5
7/3/2007	/	0	0	0	14.7	0	0.56	0.56	14.7	14.7
10/9/2007	/	0	0	0	20.7	0	0	0	20.7	20.7
1/8/2008	/	0	0	0	18.8	0	0	0	18.8	18.8
4/22/2008	/	0	0	0	22.3	0	0	0	22.3	22.3
7/15/2008	/	0	0	0	20.8	0	0	0	20.8	20.8
10/20/2008	/	0	0	0	16.7	0	0.13	0.13	16.7	16.7

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant
Well WPCP 6

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
8/7/2001	/	0	30	0	14.6	0	0	0	14.6	14.6
10/2/2001	/	0	0	0	11.5	0	0.17	0.17	11.5	11.5
5/16/2000	/	0	0	0	18.7	0	0	0	18.7	18.7
8/8/2000	/	0	0	0.104	21	0	0.17	0.274	21	21.104
11/14/2000	/	0	0	0	15.3	0	0.168	0.168	15.3	15.3
3/13/2001	/	0	0	0	17.7	0	0	0	17.7	17.7
5/8/2001	/	0	0	0	21.4	0	0	0	21.4	21.4
8/7/2001	/	0	0	0	20.8	0	0.16	0.16	20.8	20.8
10/2/2001	/	0	0	0	16.6	0	0.12	0.12	16.6	16.6
1/22/2002	/	0	0	0	18.3	0	0.128	0.128	18.3	18.3
4/23/2002	/	0	8	0	15.5	0.1	0	0	15.6	15.6
7/16/2002	/	0	0	0	20.3	0.116	0	0	20.416	20.416
10/29/2002	/	0	0	0.312	22.6	0.195	0	0.312	22.795	23.107
2/25/2003	/	0	0	0.114	20.9	0	0.174	0.288	20.9	21.014
5/13/2003	/	0	1	0	24.4	0	0	0	24.4	24.4
8/26/2003	/	0	0	0	25.5	0.317	0	0	25.817	25.817
10/21/2003	/	0	2	0.113	23.9	0.268	0	0.113	24.168	24.281
1/13/2004	/	0	0	0	30	0.6	0.159	0.159	30.6	30.6
4/13/2004	/	0	80	0	28.9	0	0.232	0.232	28.9	28.9
7/13/2004	/	0	0	0	29.8	0.204	10.5	10.5	30.004	30.004
10/5/2004	/	0	0	0	23.94	0.16	0.37	0.37	24.1	24.1
1/18/2005	/	0	20	0	20.8	0	0.475	0.475	20.8	20.8
4/12/2005	/	0	0	0	19.4	0	0	0	19.4	19.4
7/19/2005	/	0	0	0	22.4	0	0	0	22.4	22.4
10/24/2005	/	0	40	0	20.6	1.19	0	0	21.79	21.79
1/30/2006	/	0	20	0	28.9	0	0	0	28.9	28.9
5/8/2006	/	0	0	0	19.5	0	0	0	19.5	19.5
7/31/2006	/	0	40	0	22.2	0	0	0	22.2	22.2
1/9/2007	/	0	0	0	23.9	0	0	0	23.9	23.9
4/3/2007	/	0	0	0	27.5	0	0	0	27.5	27.5
7/3/2007	/	0	0	0	16.5	0	0.46	0.46	16.5	16.5
10/9/2007	/	0	0	0	14.2	0	0	0	14.2	14.2
1/8/2008	/	0	0	0	13.6	0	0	0	13.6	13.6
4/22/2008	/	0	0	0	19.1	0	0	0	19.1	19.1
7/15/2008	/	0	0	0	21.7	0	0	0	21.7	21.7
10/20/2008	/	0	220	0	21.8	0	0.12	0.12	21.8	21.8

DRAFT OCT 21 2009

Malibu Water Pollution Control Plant
Well WPCP 7

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
8/7/2001	/	0	4	0	22	0	0.15	0.15	22	22
10/2/2001	/	0	0	0	10.8	0	0.215	0.215	10.8	10.8
5/16/2000	/	0	0	0	18.7	0	0	0	18.7	18.7
8/8/2000	/	0	0	0.104	21	0	0.17	0.274	21	21.104
11/14/2000	/	0	0	0	15.3	0	0.168	0.168	15.3	15.3
3/13/2001	/	0	0	0	17.7	0	0	0	17.7	17.7
5/8/2001	/	0	0	0	21.4	0	0	0	21.4	21.4
8/7/2001	/	0	0	0	20.8	0	0.16	0.16	20.8	20.8
10/2/2001	/	0	0	0	16.6	0	0.12	0.12	16.6	16.6
1/22/2002	/	0	0	0	16.5	0.438	0.121	0.121	16.938	16.938
4/23/2002	/	0	0	0	19.7	0.207	0	0	19.907	19.907
7/16/2002	/	0	0	0	21.1	0.335	0	0	21.435	21.435
10/29/2002	/	0	40	0	23	1.02	0.46	0.46	24.02	24.02
2/25/2003	/	0	0	0	26.2	0.48	0	0	26.68	26.68
5/13/2003	/	2	47.1	0	26.9	0.225	0	0	27.125	27.125
8/26/2003	/	0	0	0	15.1	0.472	0.234	0.234	15.572	15.572
10/21/2003	/	0	0	1.04	18.2	0	0	1.04	18.2	19.24
1/13/2004	/	0	0	0	19.8	0	0.288	0.288	19.8	19.8
4/13/2004	/	0	0	0	16.4	0	0	0	16.4	16.4
7/13/2004	/	0	0	0	19.7	0	7.35	7.35	19.7	19.7
10/5/2004	/	0	0	0	15.2	0	0.944	0.944	15.2	15.2
1/18/2005	/	0	0	0	15.2	0	0.628	0.628	15.2	15.2
4/12/2005	/	0	0	0	11.5	0	0.166	0.166	11.5	11.5
7/19/2005	/	0	0	0	13.03	0	0	0	13.03	13.03
10/24/2005	/	0	0	0	19.3	0	0.327	0.327	19.3	19.3
1/30/2006	/	0	500,000	0	20.5	0	0	0	20.5	20.5
5/8/2006	/	0	300	0	18.4	0	0	0	18.4	18.4
7/31/2006	/	0	0	0	15.9	0	0	0	15.9	15.9
1/9/2007	/	0	0	0	13.5	0	0.26	0.26	13.5	13.5
4/3/2007	/	0	0	0	12.03	0	0	0	12.03	12.03
7/3/2007	/	0	20	0	10.7	0	0.4	0.4	10.7	10.7
10/9/2007	/	0	0	0	9.2	0	0.11	0.11	9.2	9.2
1/8/2008	/	0	0	0	8.9	0	0	0	8.9	8.9
4/22/2008	/	0	40	0	10.4	0	0.9	0.9	10.4	10.4
7/15/2008	/	0	0	0	10	0	0.137	0.137	10	10
10/20/2008	/	0	0	0	8.76	0	0.13	0.13	8.76	8.76

DRAFT OCT 2109

Surfrider Beach
Well SB-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100 ml)	(MPN/100 ml)	(MPN/100 ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
3/24/2004	0	0	0	0.271	2.09	1.51	1.54	1.811	3.6	3.871
5/14/2004	0	0	0	0	2.17	0	0.55	0.55	2.17	2.17
9/1/2004	0	0	0	0	2.222	0	0.381	0.381	2.222	2.222
12/7/2004	0	0	0	0	5.53	0	1.63	1.63	5.53	5.53
3/9/2005	0	0	0	0	12	0.292	0	0	12.292	12.292
6/3/2005	0	0	0	1	1.33	0.615	2.38	3.38	1.945	2.945
9/9/2005	0	0	0	1.18	12.3	0	6.61	9.79	12.3	13.48
11/18/2005	549	0	800	0.396	11	1.4	1.6	1.996	12.4	12.796
3/3/2006	14,700	0	9,000	0.4	9.53	0.764	0.84	1.24	10.294	10.694
6/2/2006	0	0	0	0.466	39.3	0.928	0.154	0.62	40.228	40.694
9/8/2006	0	0	40	0.62	43.8	0.755	7.56	8.18	44.555	45.175
11/17/2006	0	0	0	0.64	42.9	0.396	3.1	3.74	43.296	43.936
3/2/2007	0	0	0	0.7	72.9	0.156	0.84	1.54	73.056	73.756
6/1/2007	0	0	0	1.5	31.1	0	2.28	3.78	31.1	82.6
9/7/2007	0	0	0	0	4.33	0	1.01	1.01	4.33	4.33
11/16/2007	0	0	0	0.92	3.61	0	1.88	2.3	3.61	4.53
5/30/2008	0	0	0	0.13	15.1	0	0.51	0.64	15.1	15.23
8/29/2008	0	0	0	0.19	16.7	0	0.39	0.58	16.7	16.89
12/5/2008	/	/	/	0	17.9	/	0	0	/	/
3/13/2009	0	0	0	0.37	14.4	/	0.12	0.49	/	/
6/12/2009	0	0	0	0.2	321	/	0.15	0.35	/	/

Surfrider Beach
Well SB-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	Organic Nitrogen	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100 ml)	(MPN/100 ml)	(MPN/100 ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0						10	10
Sample Date										
3/24/2004	0	20	40	3.81	3.14	1.84	79.4	83.21	4.98	8.79
5/14/2004	0	0	0	1.63	63.7	0.13	36.6	38.23	63.83	65.46
9/1/2004	0	0	0	2.02	76.32	0.24	1.28	3.3	76.56	78.58
12/7/2004	0	0	0	0.34	15.8	0.158	0.58	0.92	15.958	16.298
3/9/2005	0	0	0	1.8	51.7	0	0.4	2.2	51.7	53.5
6/3/2005	0	0	0	0	10.2	0.231	1.67	1.67	10.431	10.431
9/9/2005	0	0	0	0.127	4.56	0	1.02	1.147	4.56	4.687
11/18/2005	3	0	230	0	0.869	0.724	0.541	0.541	1.593	1.593
3/3/2006	41	0	130	0.12	3.23	0	4.66	4.78	3.23	3.35
6/2/2006	0	0	40	0	0.045	0	1.11	1.11	0.045	0.045
9/8/2006	0	0	300	0	7.47	0	0.451	0.451	7.47	7.47
11/17/2006	0	0	0	0.17	9.03	0	0.91	1.08	9.03	9.2
3/2/2007	0	0	0	0.1	4.43	0	0.5	0.6	4.43	4.53
6/1/2007	0	0	0	0	0.9	0	0.17	0.17	0.9	0.9
9/7/2007	0	0	0	0	2.03	0	2.22	2.22	2.03	2.03
11/16/2007	0	0	0	0	2.08	0	0.13	0.13	2.08	2.08
5/30/2008	0	0	0	0.12	0.3	0	0.32	0.44	0.3	0.42
8/29/2008	70	0	0	0.11	3	0	0.25	0.36	3	3.11
12/5/2008	/	/	/	0	4.81	/	0.42	0.42	/	/
3/13/2009	0	0	0	0	1.88	/	0.42	0.42	/	/
6/12/2009	0	0	0	0.17	0.27	/	0.11	0.28	/	/

3-796
TM2-60
9 0 0 2 1 2 F C O E E A R D

Malibu Beach Inn
MW1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
2/11/2009	0	2	8	3	1.7	0	3.15	1.7	4.7
6/9/2009	2	0	10	2.05	3.9	0	2.2	3.9	5.95
2/11/2009	0	2	8	3	1.7	0	3.15	1.7	4.7
2/14/2008	0	0	0	1.5	15.1	0.09	1.63	15.19	16.69
5/15/2008	0	0	110	2.65	39	0.147	2.8	39.147	41.797
9/30/2008	/	2	24	2.3	18.1	0.201	2.47	18.301	20.601
12/3/2008	0	0	0	2.26	10.3	0.184	2.4	10.484	12.744
11/15/2007	/	0	0	16.5	8.5	0.635	17.5	9.135	25.635
2/15/2007	/	/	/	/	/	/	/	/	/
5/1/2007	/	/	/	/	/	/	/	/	/
2/15/2006	/	/	/	/	/	/	/	/	/
5/25/2006	/	/	/	/	/	/	/	/	/
8/18/2006	/	/	/	/	/	/	/	/	/
12/8/2006	/	/	/	/	/	/	/	/	/
2/23/2005	/	/	/	/	/	/	/	/	/
5/18/2005	/	/	/	/	/	/	/	/	/
9/27/2005	/	/	/	/	/	/	/	/	/
11/18/2005	/	/	/	/	/	/	/	/	/
6/25/2004	/	/	/	/	/	/	/	/	/
8/17/2004	/	/	/	/	/	/	/	/	/
11/8/2004	/	/	/	/	/	/	/	/	/

3-797
TM2-61
D R A F T C O 2 1 2 0 0 9

Malibu Beach Inn
MW2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
2/11/2009	/	/	/	/	/	/	/	/	/
6/9/2009	/	/	/	/	/	/	/	/	/
2/11/2009	/	/	/	/	/	/	/	/	/
2/14/2008	0	0	0	2.6	1.4	0.07	1.63	1.47	4.07
5/15/2008	0	0	48	1.85	9.5	0.029	2.83	9.529	11.379
9/30/2008	/	2	10	2.54	2.4	0	1.9	2.4	4.94
12/3/2008	0	0	0	2.15	3.2	0.028	2.68	3.228	5.378
11/15/2007	/	/	/	/	/	/	/	/	/
2/15/2007	2	2	0	0.01	0.18	0	0.06	0.18	0.19
5/1/2007	4.1	2	0	0	0.63	0	4.14	0.63	0.63
2/15/2006	33.6	0	0	0.01	0.15	0.04	1.47	0.19	0.2
5/25/2006	5.2	2	0	0.06	0.08	0	3.49	0.08	0.14
8/18/2006	0	2	0	0.12	5.14	0	0.56	5.14	5.26
12/8/2006	0	0	0	0.12	5.14	0	0.56	5.14	5.26
2/23/2005	2419.2	0	2	0.49	6.3	0.18	5.93	6.48	6.97
5/18/2005	63.2	2	4	0.7	28.9	0.28	2.44	29.18	29.88
9/27/2005	44.7	2	17	0.6	1.1	0	1.1	1.1	1.7
11/18/2005	13.2	0	0	0.34	0.32	0	0.42	0.32	0.66
6/25/2004	93.3	30	50	3.02	4.95	0.07	15.32	5.02	8.04
8/17/2004	128.7	2	2	1.82	3.83	0.13	6.71	3.96	5.78
11/8/2004	9.8	0	0	2.67	15.6	0.34	7.64	15.94	18.61

3-798
TM2-62
9 0 0 2 2 1 2 FCOE HEARD

Malibu Beach Inn
MW3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10
Sample Date									
2/11/2009	0	0	0	1.55	12.2	1.56	1.64	13.76	15.31
6/9/2009	0	0	0	0.68	16	0.119	0.73	16.119	16.799
2/11/2009	0	0	0	1.55	12.2	1.56	1.64	13.76	15.31
2/14/2008	/	/	/	/	/	/	/	/	/
5/15/2008	/	/	/	/	/	/	/	/	/
9/30/2008	/	/	/	/	/	/	/	/	/
12/3/2008	/	/	/	/	/	/	/	/	/
11/15/2007	/	/	/	/	/	/	/	/	/
2/15/2007	15.8	2	0	2.36	1.47	0.06	40.16	1.53	3.89
5/1/2007	18.7	2	11	16.3	0.88	0	19.48	0.88	17.18
2/15/2006	13.2	2	2	21	5.41	0.38	28.02	5.79	26.79
5/25/2006	5.2	17	17	10.9	15.4	0.06	13.05	15.46	26.36
8/18/2006	66.2	0	0	19.9	3.02	0	28.05	3.02	22.92
12/8/2006	0	0	0	65.1	0.9	0	88.7	0.9	66
2/23/2005	22.6	2	8	4.53	0.04	0.11	9.01	0.15	4.68
5/18/2005	5.1	4	4	6.19	1.34	0.06	19.59	1.4	7.59
9/27/2005	47.2	2	2	50.1	3.4	0.02	67.6	3.42	53.52
11/18/2005	7.4	0	0	26.8	1.22	0	31.73	1.22	28.02
6/25/2004	2419.2	7	30	22.4	0	1.29	40.1	1.29	23.69
8/17/2004	31.4	0	0	23.6	0	0.1	28.87	0.1	23.7
11/8/2004	9.7	0	0	12	0.07	0.14	13.44	0.21	12.21

3-799
TM2-63
2009 2012 COASTAL BOARD

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

Attachment 2-2

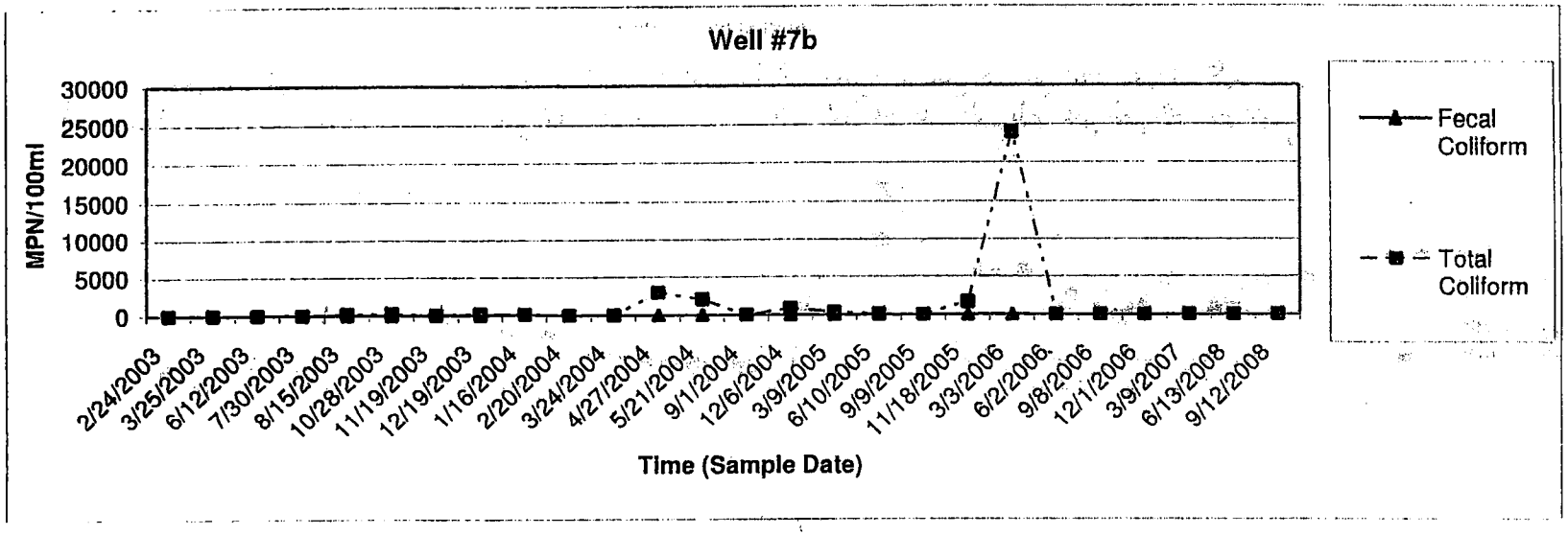
Graphs for 59 Individual Wells

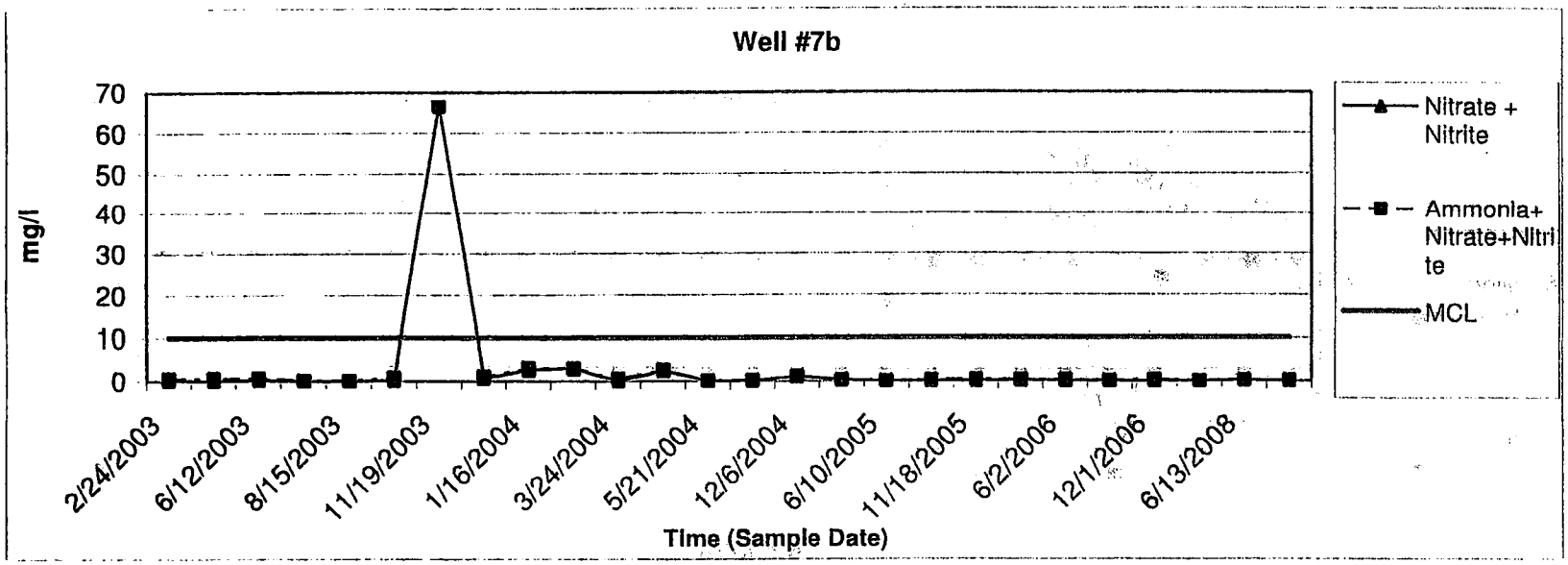
DRAFT OCT 21 2009

3-801

TM2-65

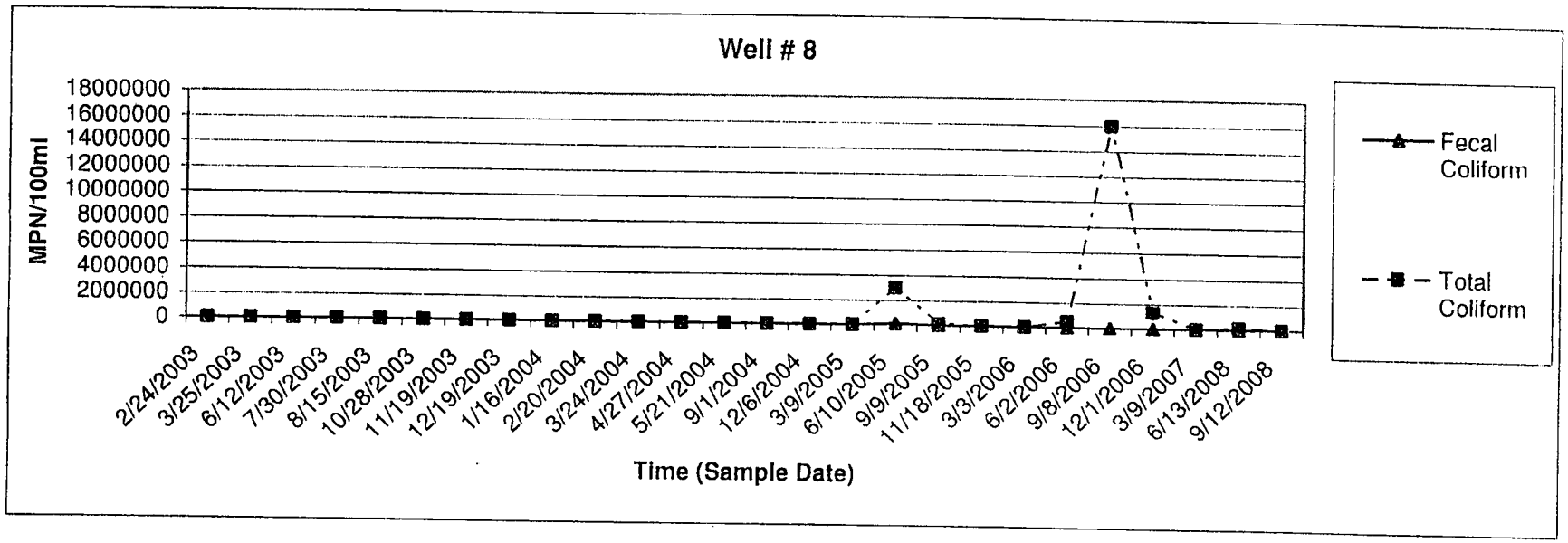
Malibu Administrative Center



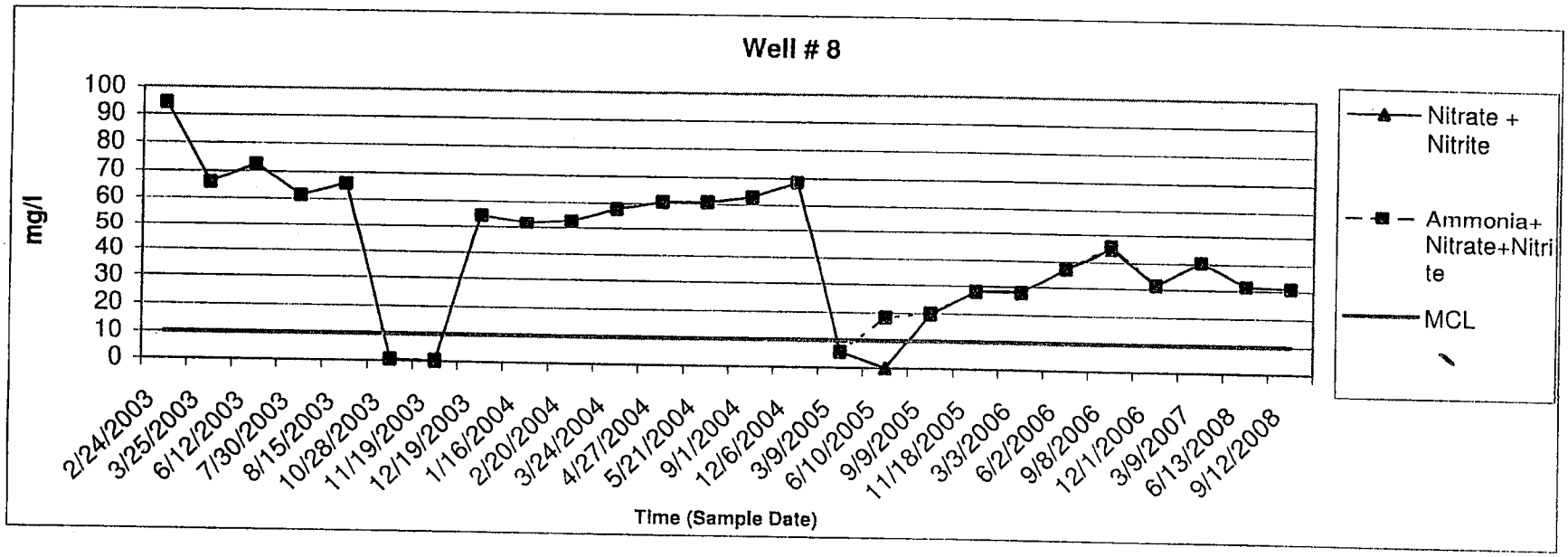


9 0 0 2 1 2 T C O T E A R D

Malibu Administrative Center

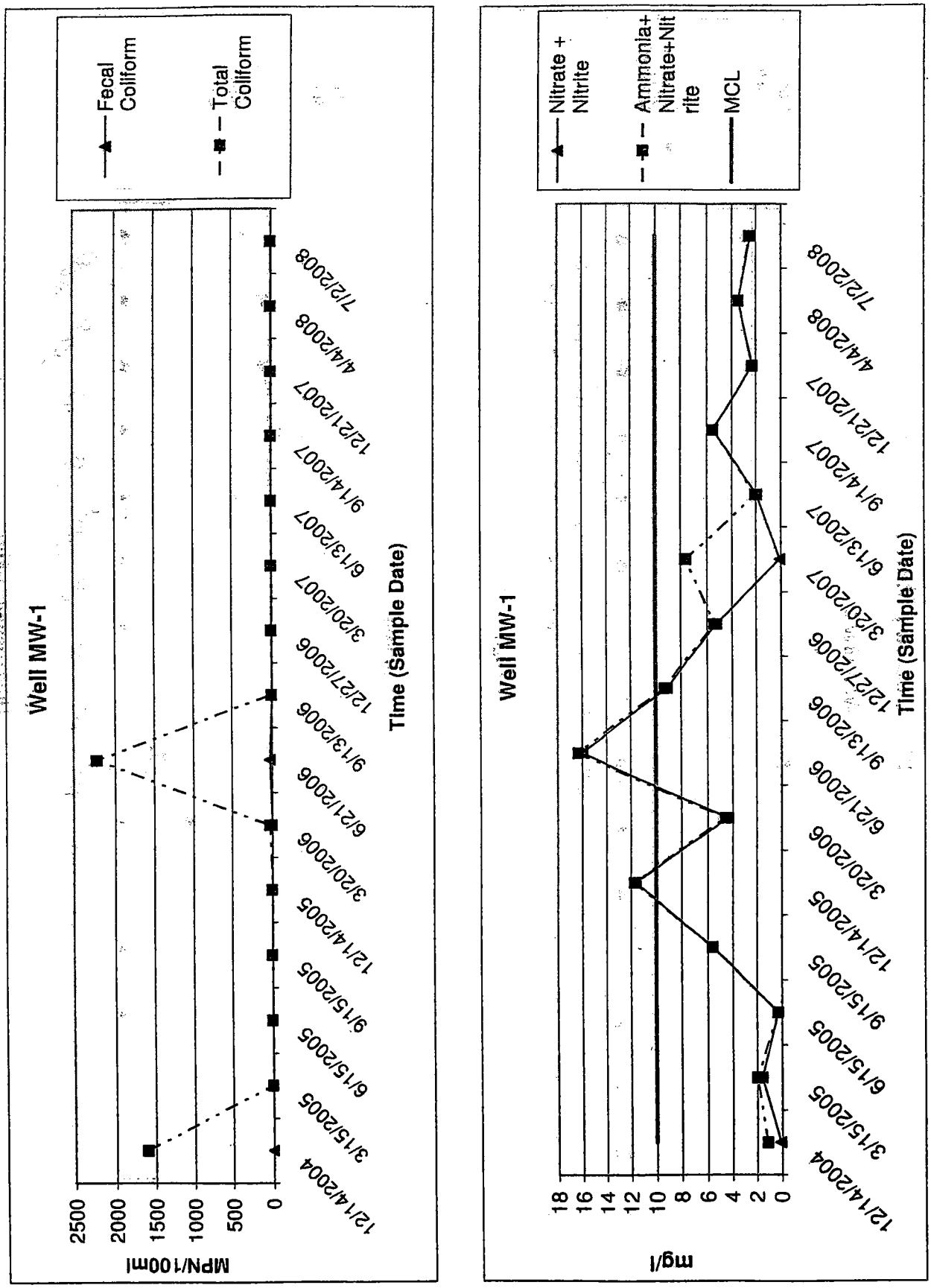


TM2-66



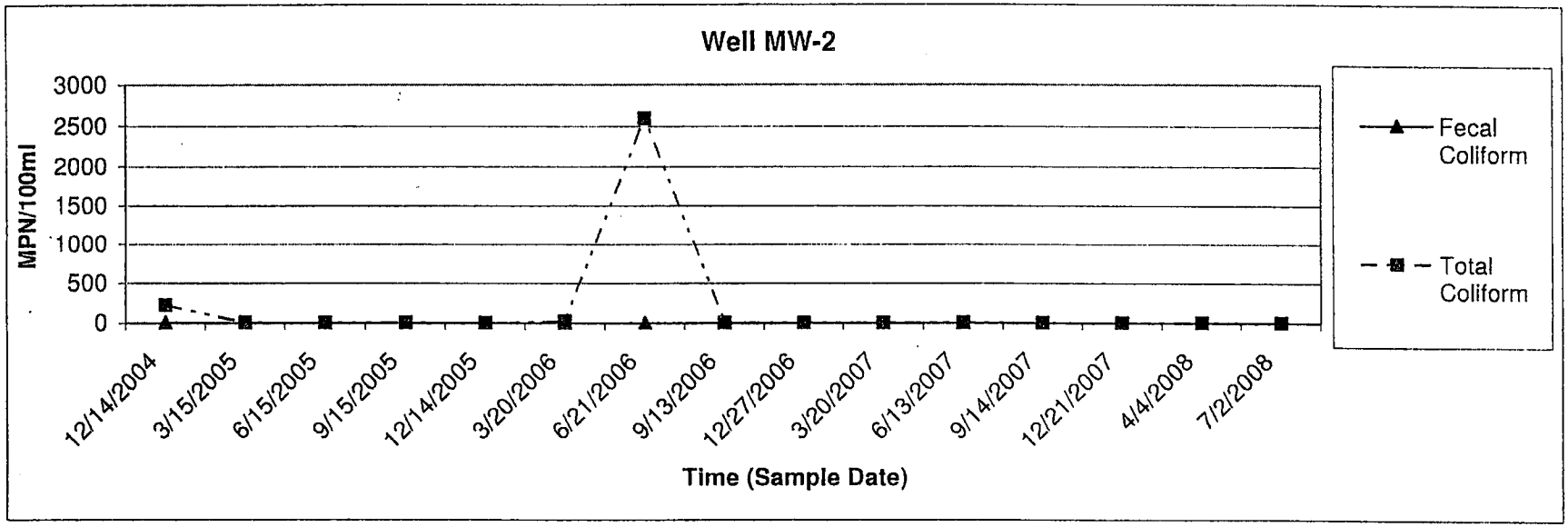
9 0 0 2 2 1 2 T C O E F A R D

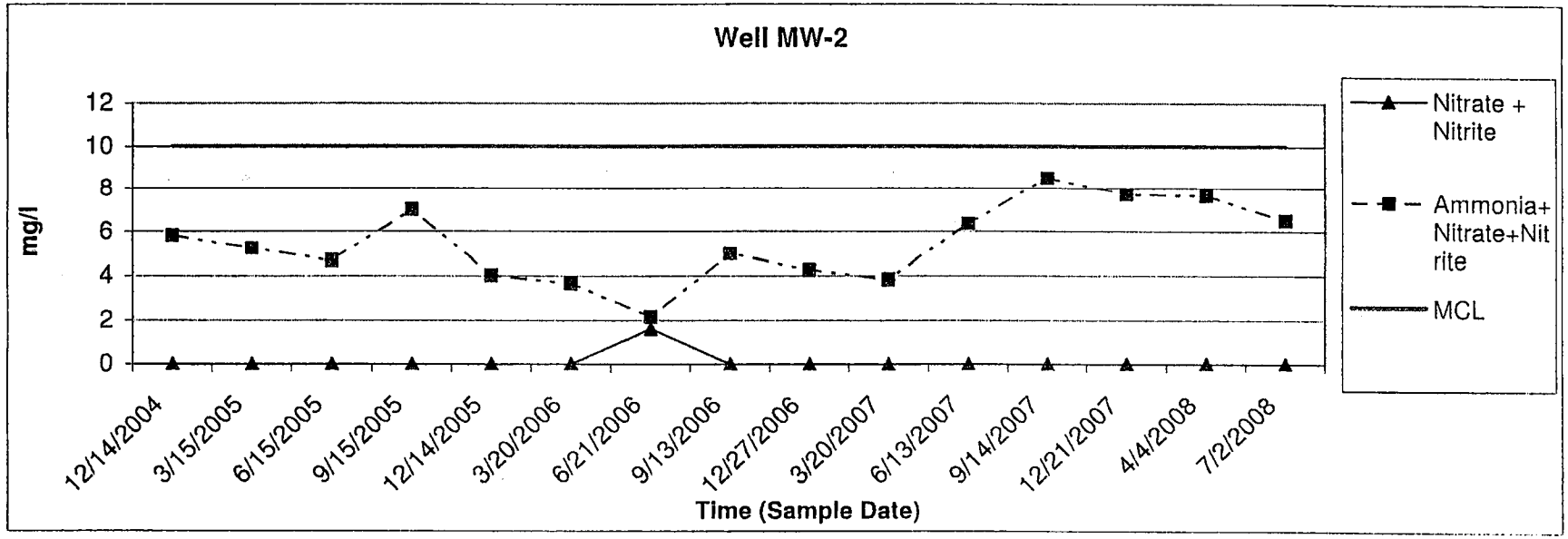
DRAFT OCT 21 2009



TM2-67

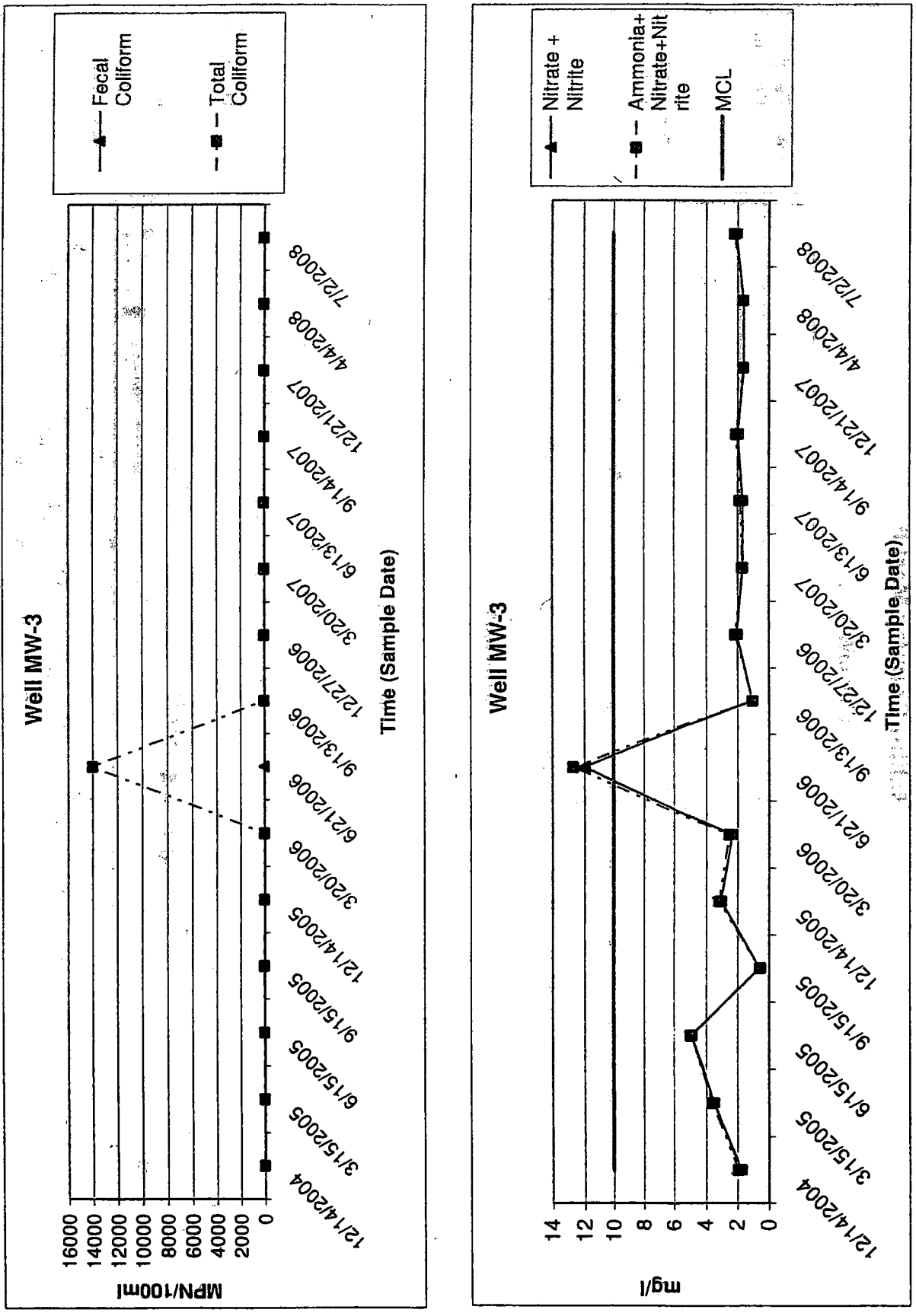
Malibu Country Mart I



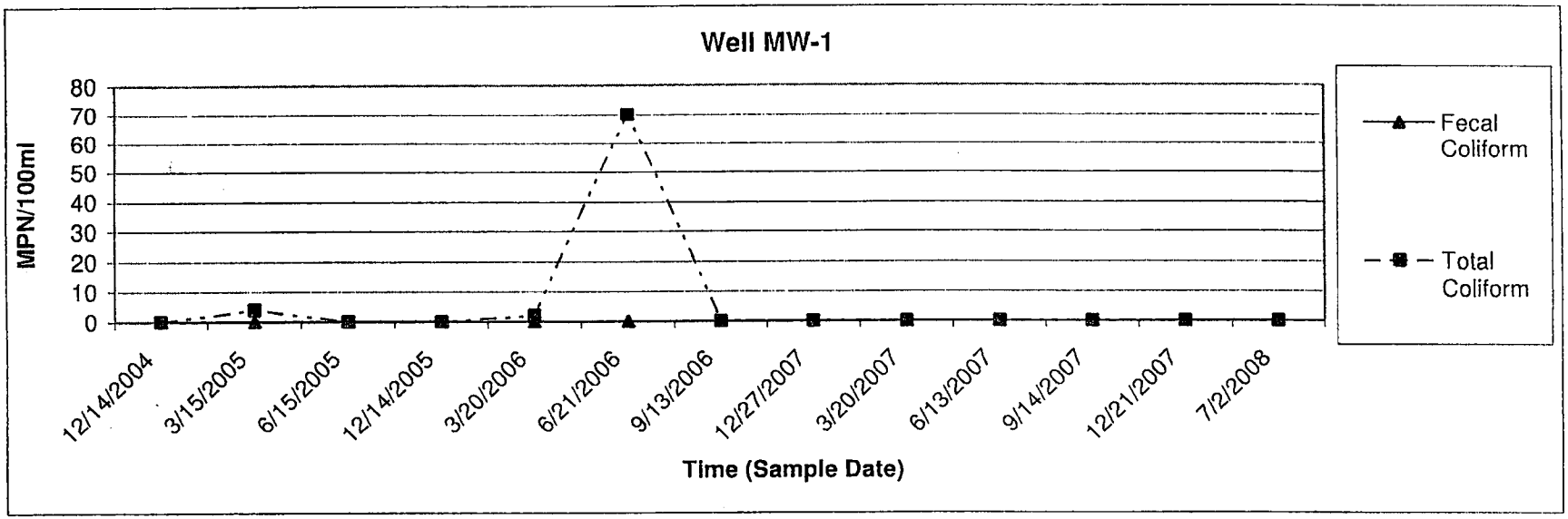


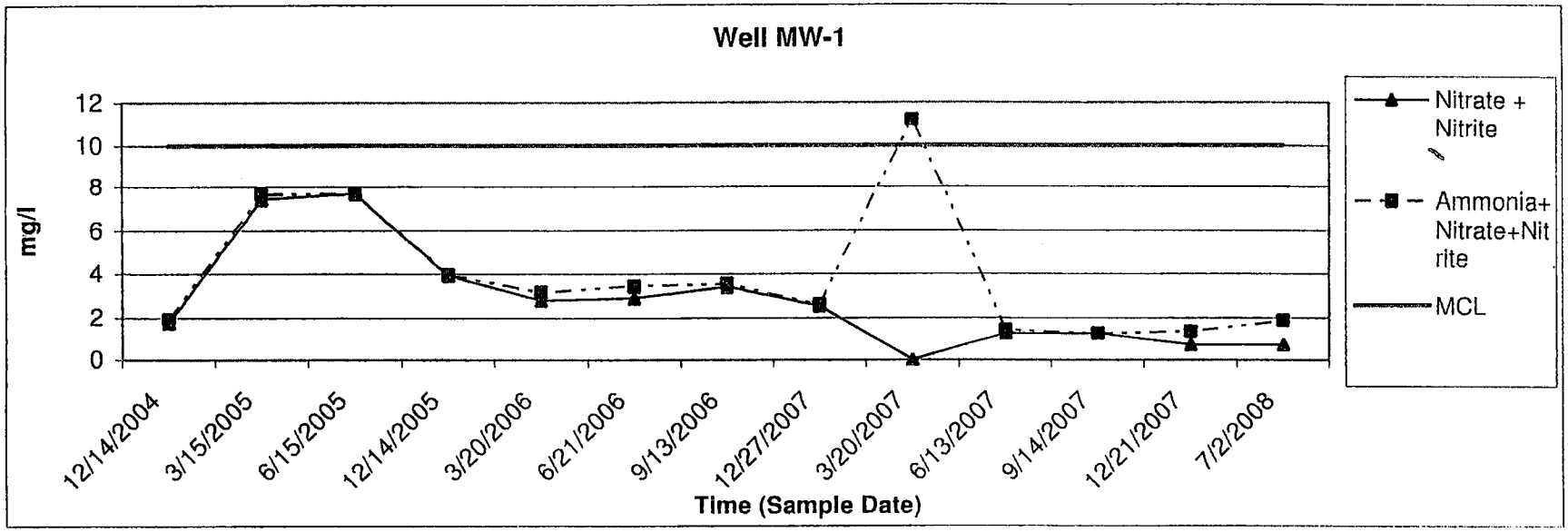
6 0 0 2 2 1 2 T C O T H E A R D

DRAFT OCT 21 2009



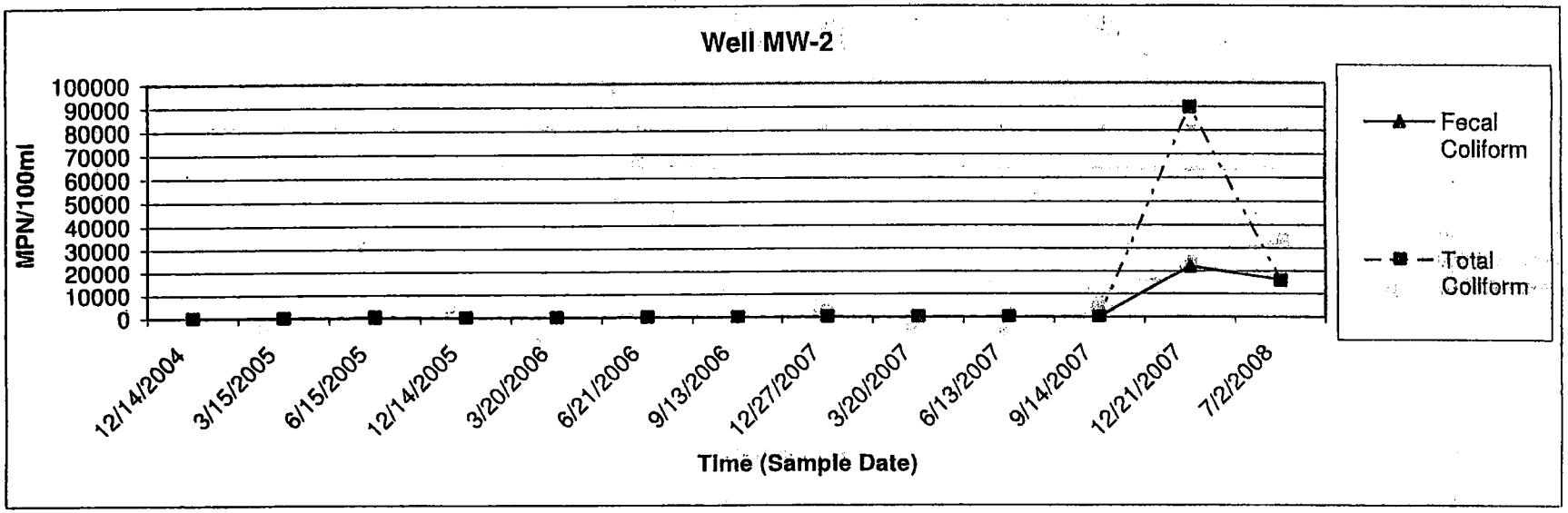
Malibu Country Mart II

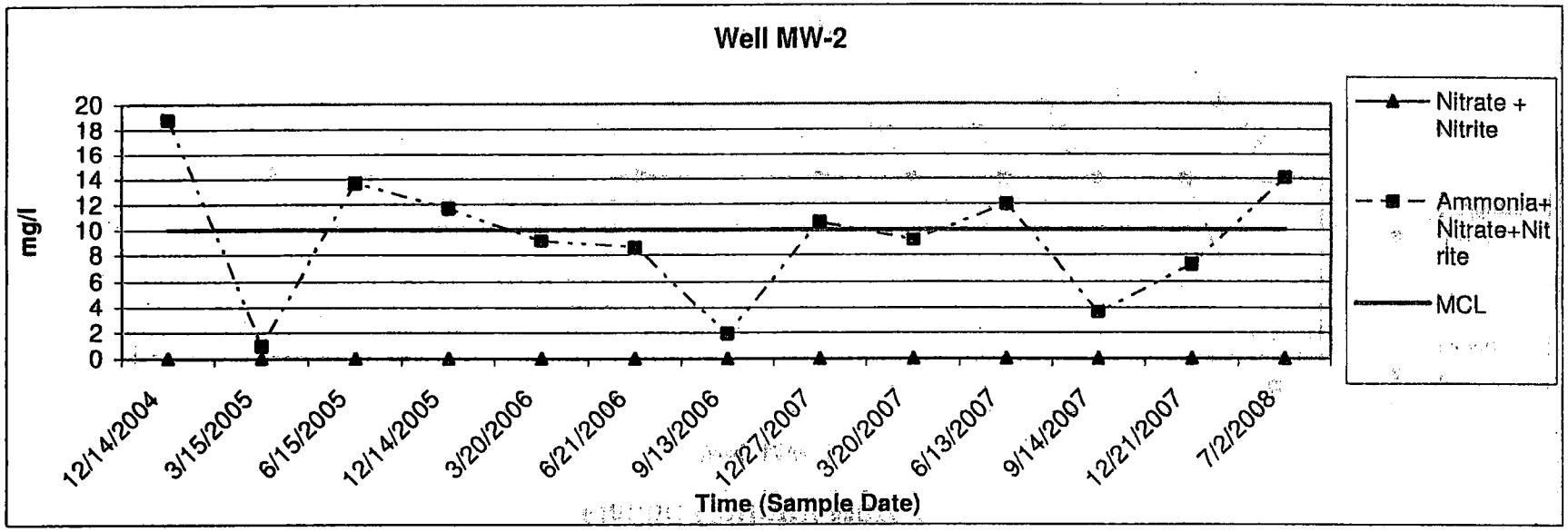




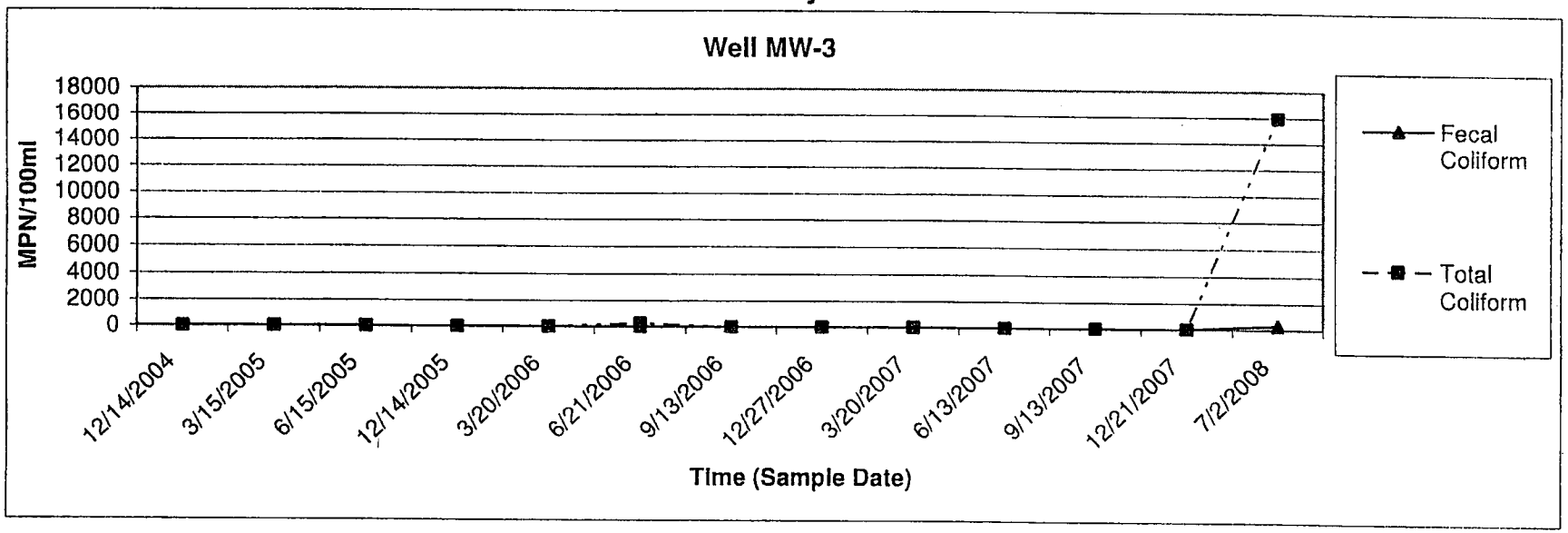
6 0 0 2 2 1 2 FEB 0 C T FEB 0 6 2

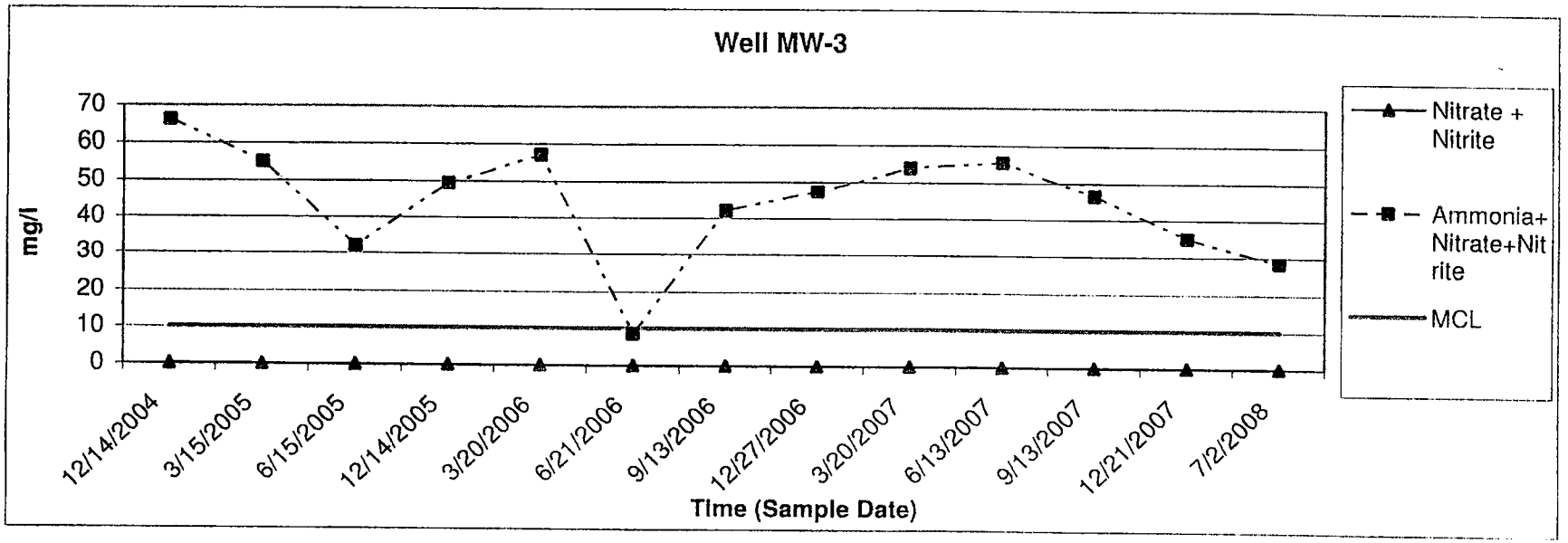
Malibu Country Mart II





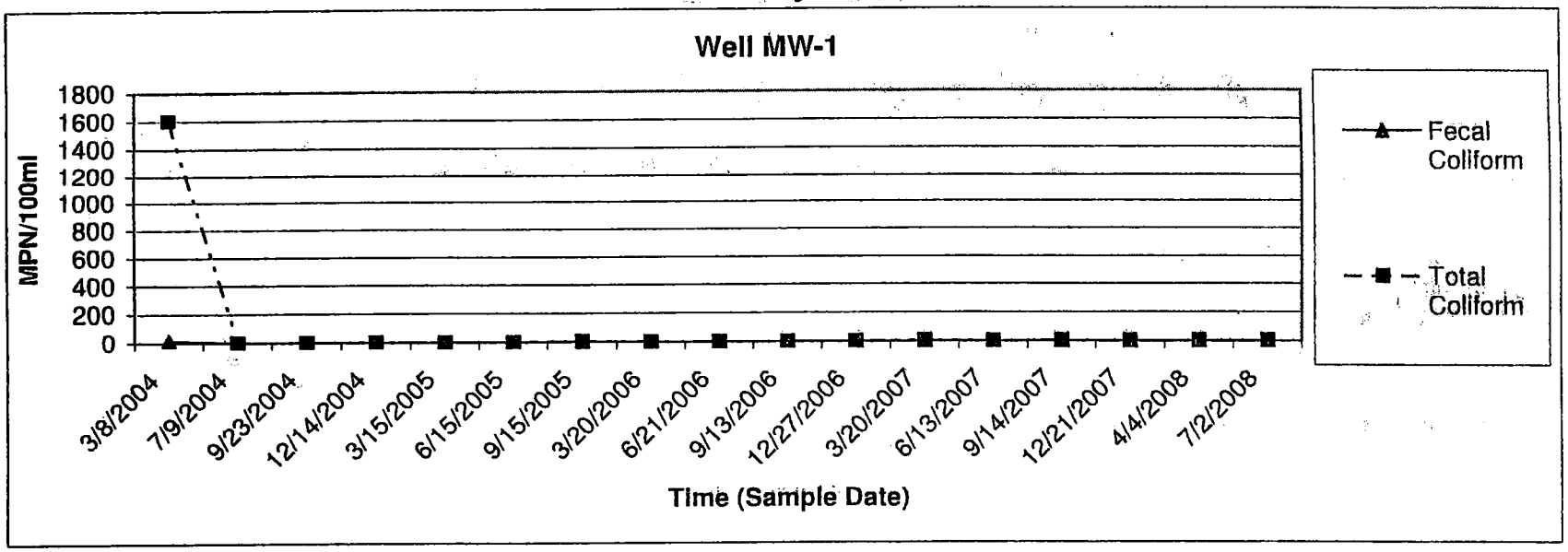
Malibu Country Mart II

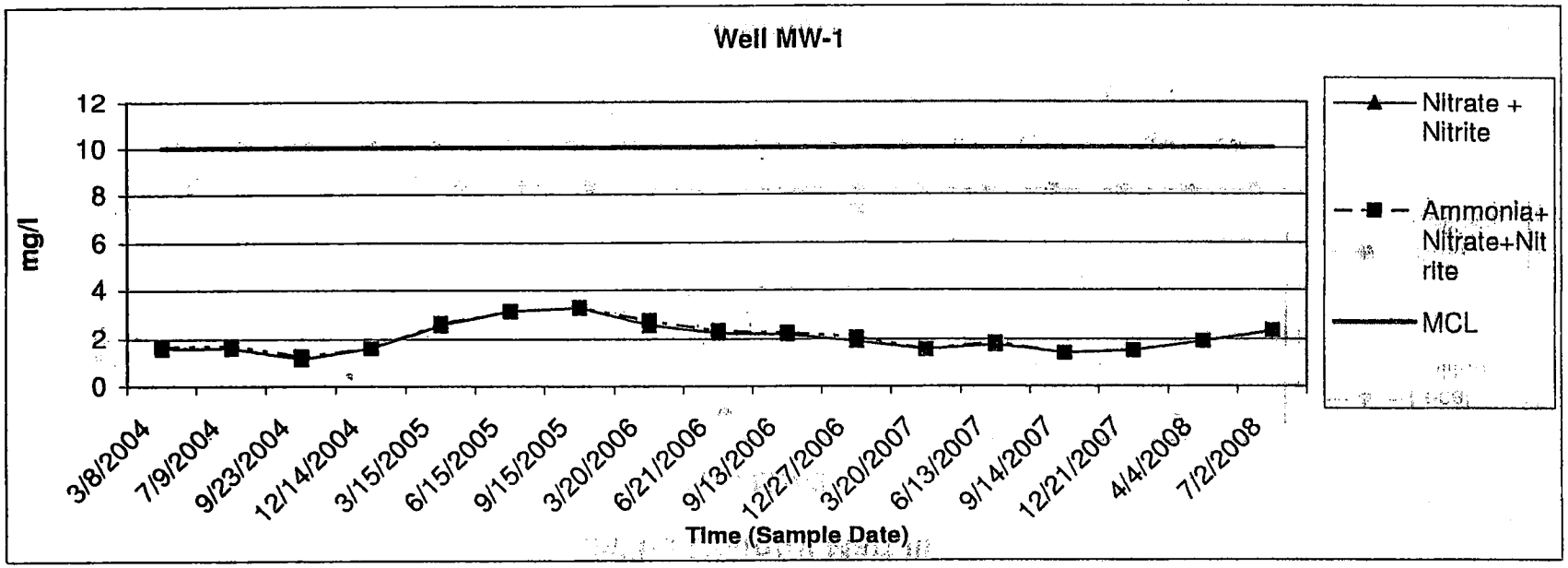




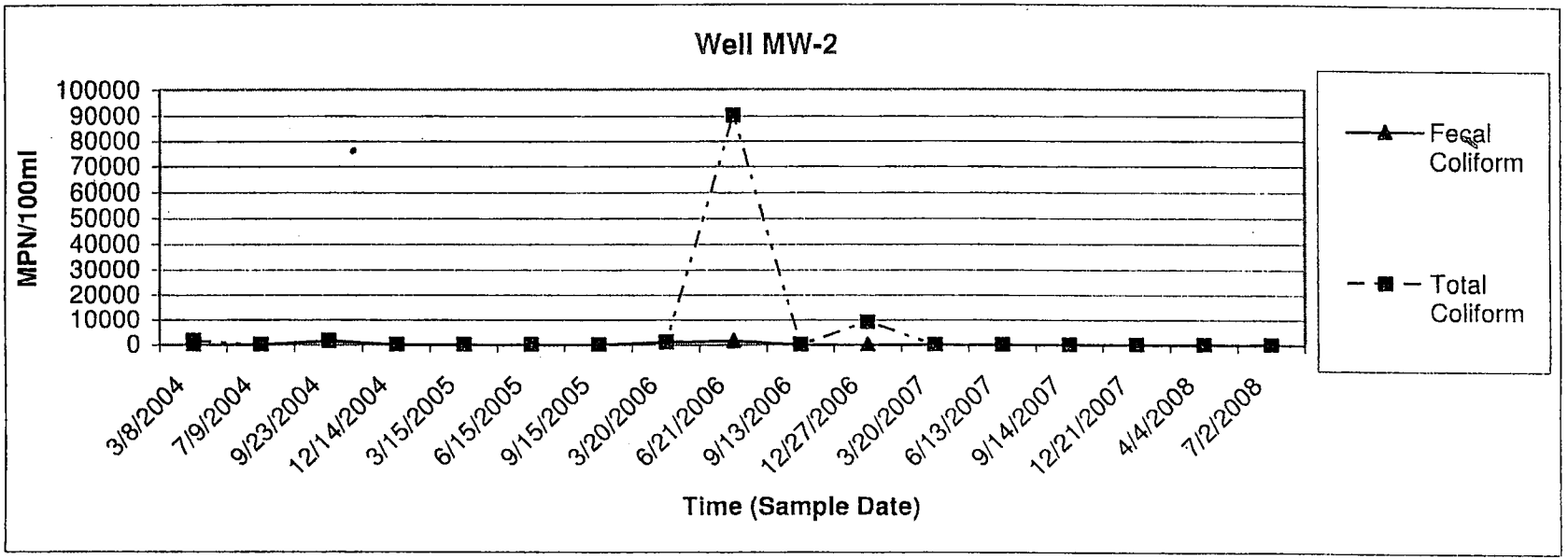
EDWARD TECO 12 2009

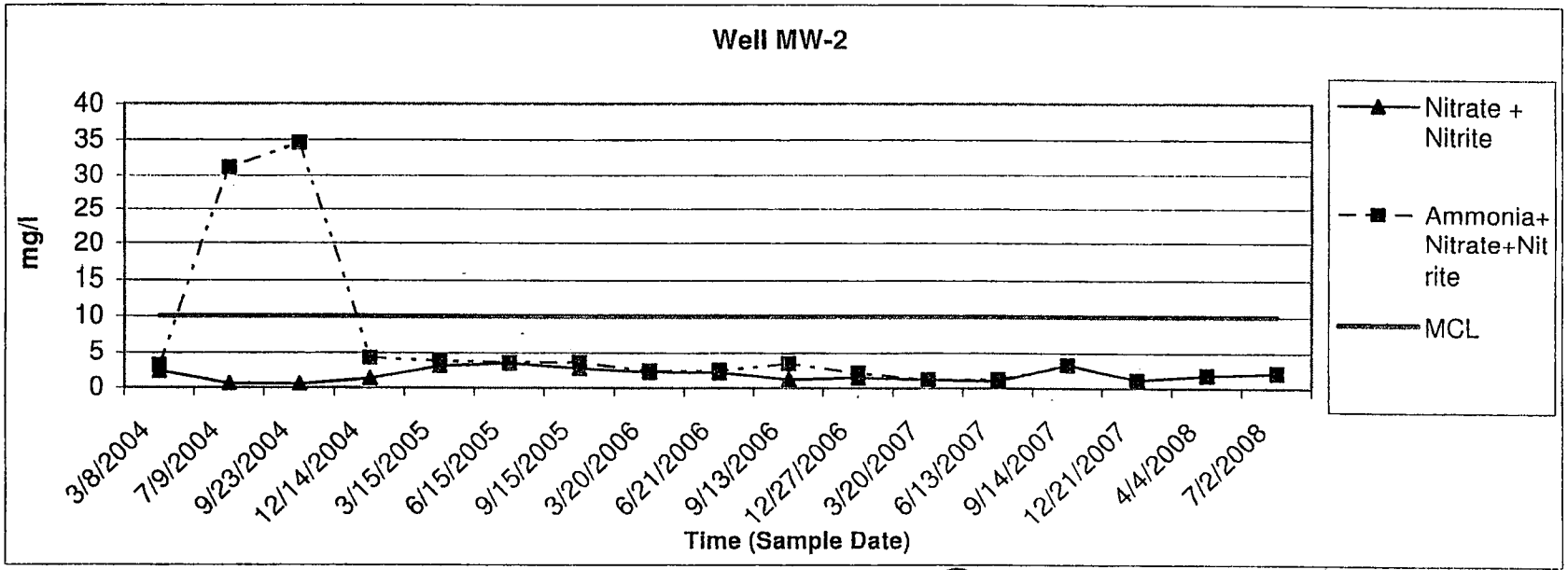
Malibu Country Mart III





Malibu Country Mart III



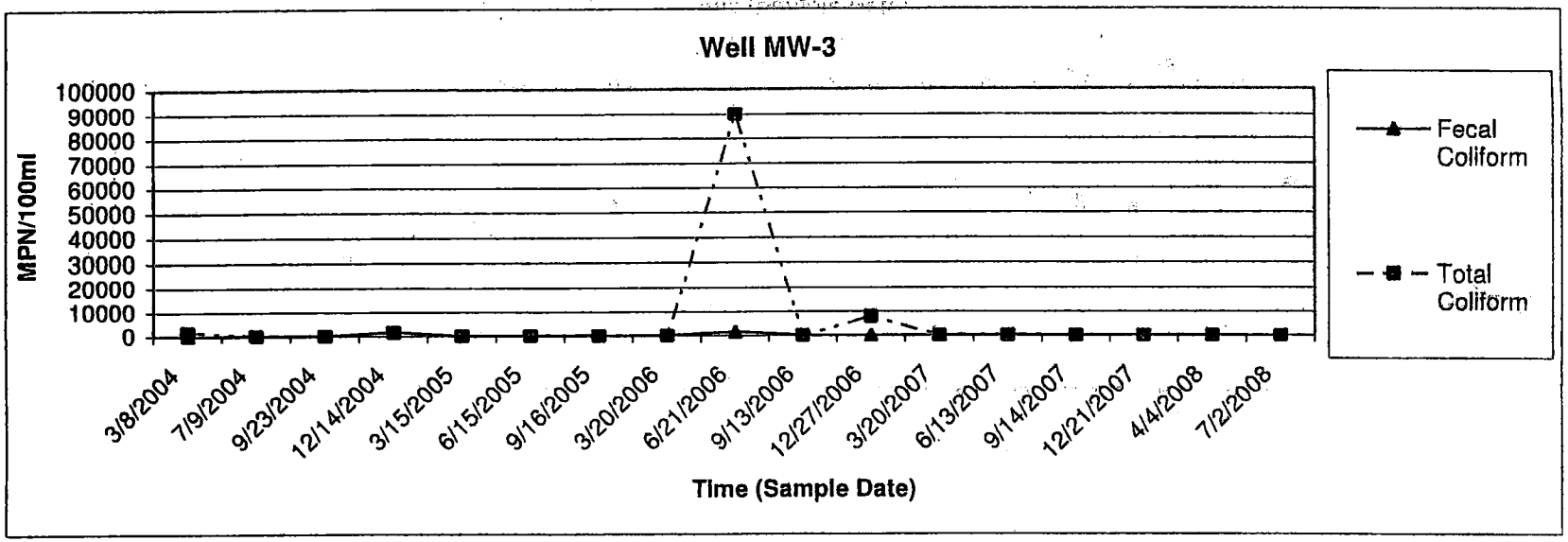


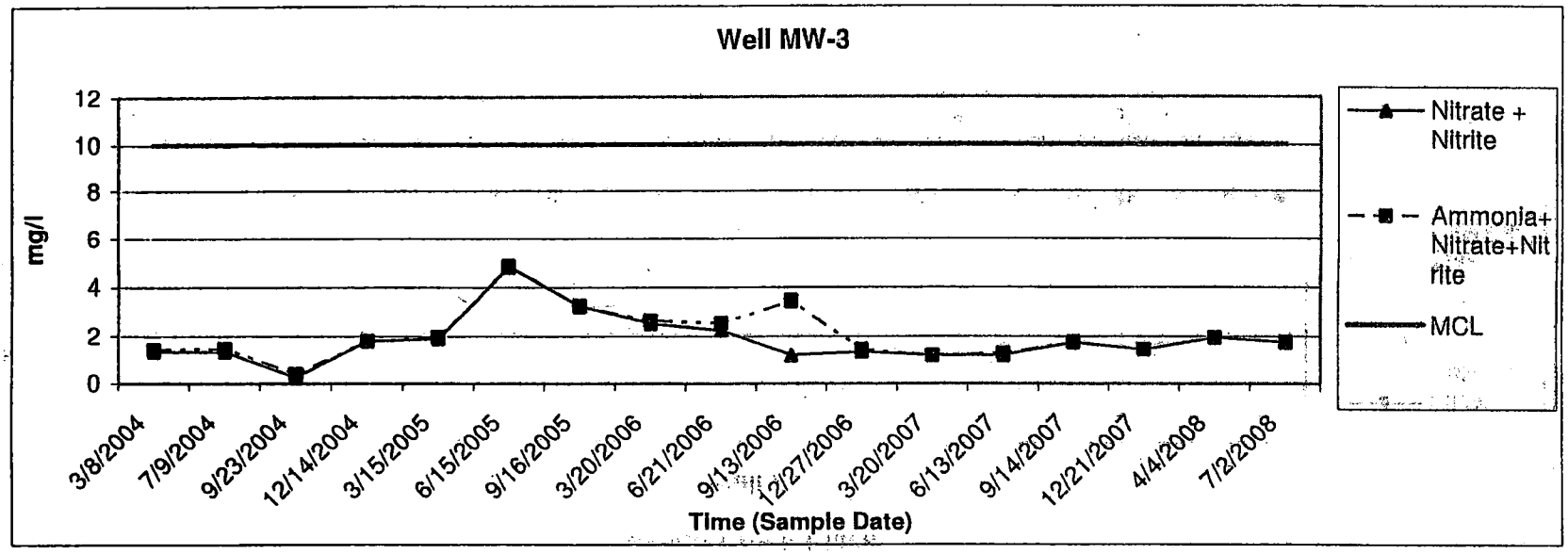
9 0 0 2 1 2 T C O T E A R D

3-819

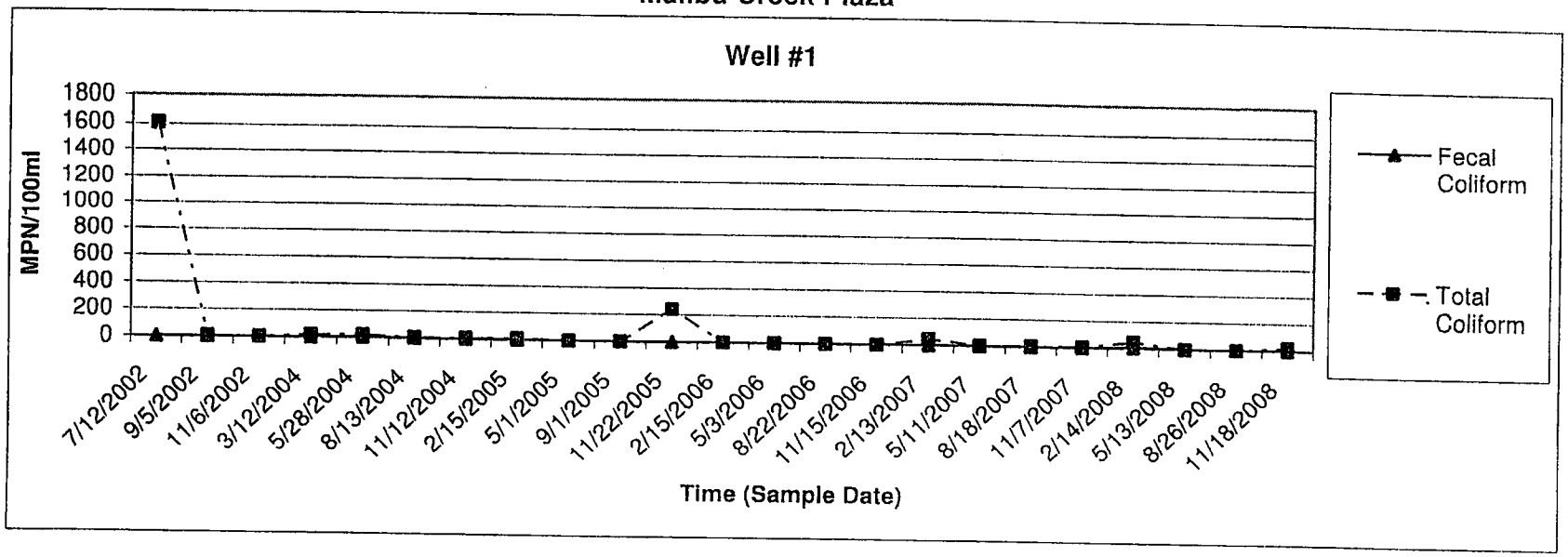
DEARTECO 12 2009

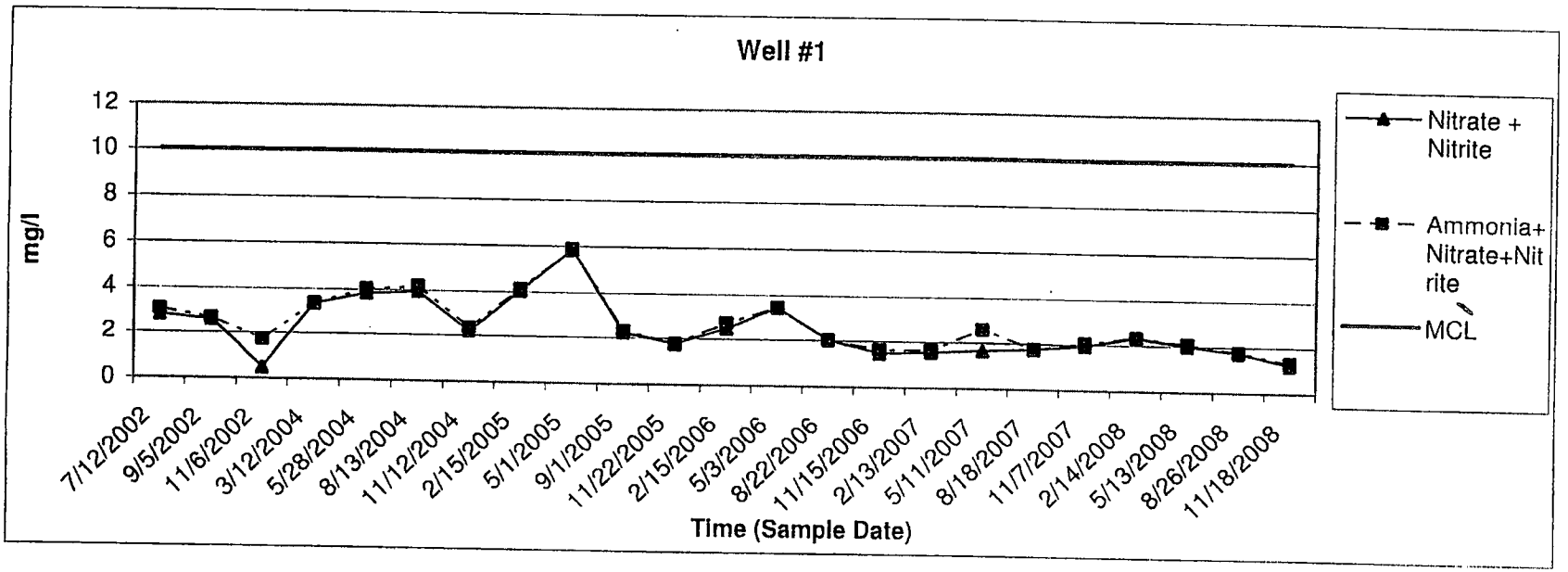
Malibu Country Mart III



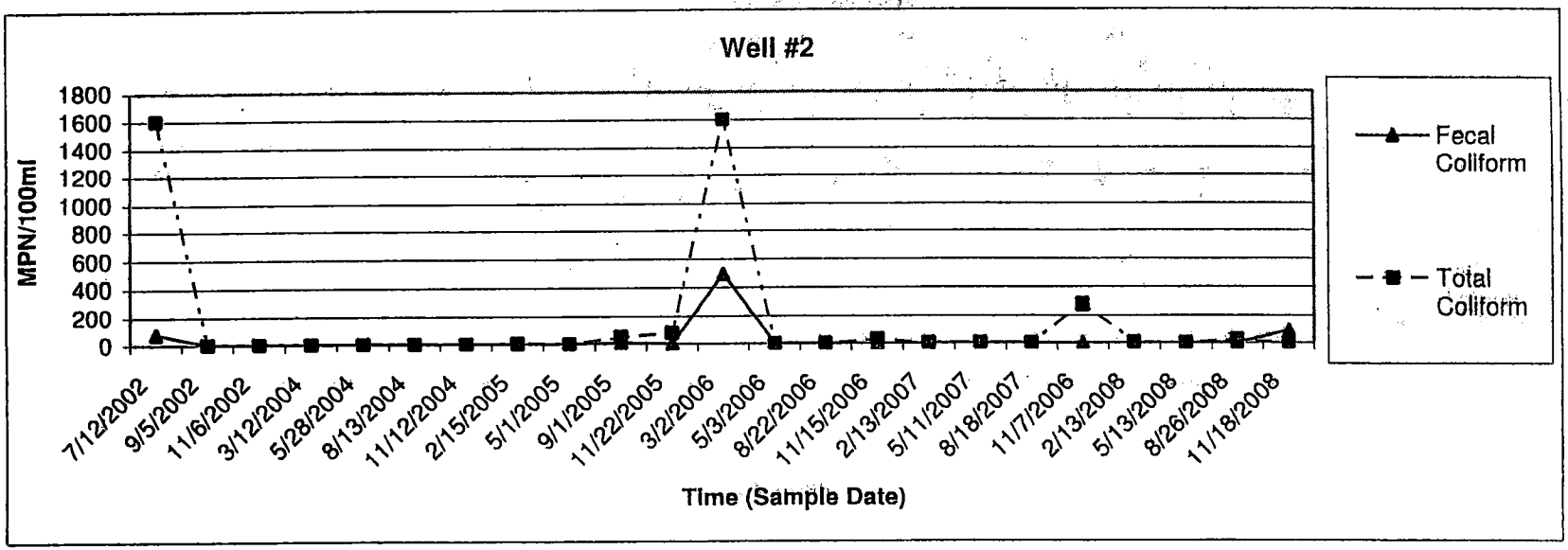


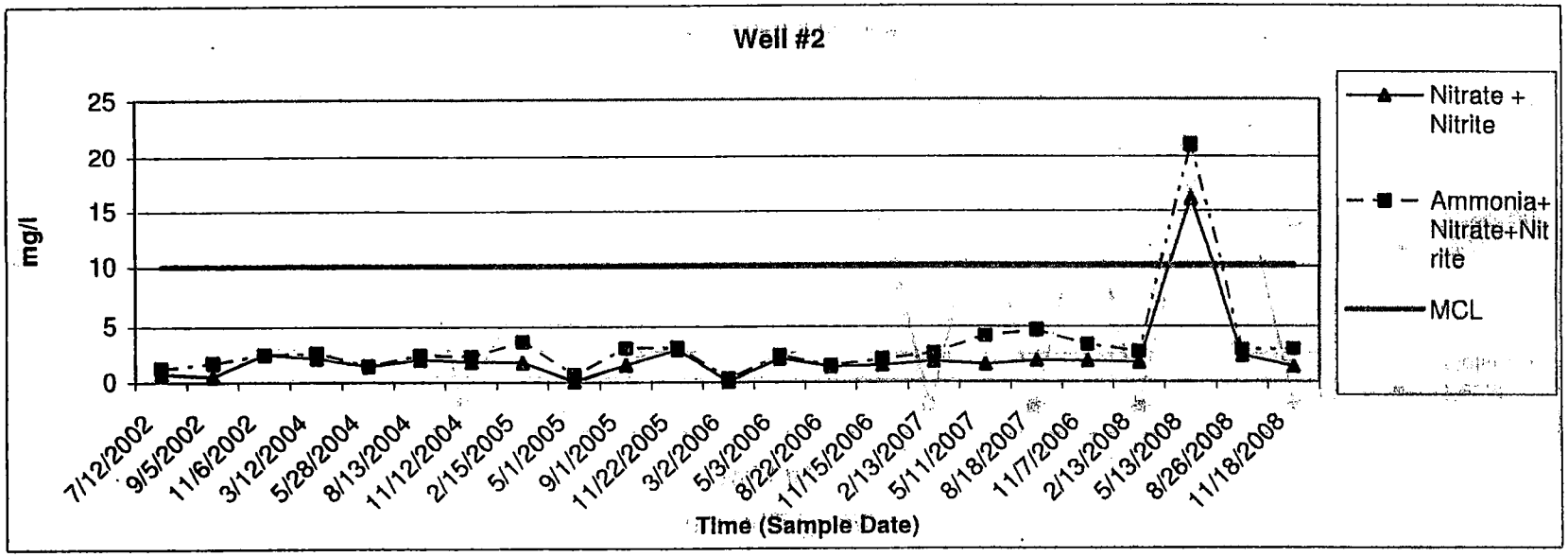
Malibu Creek Plaza





Malibu Creek Plaza

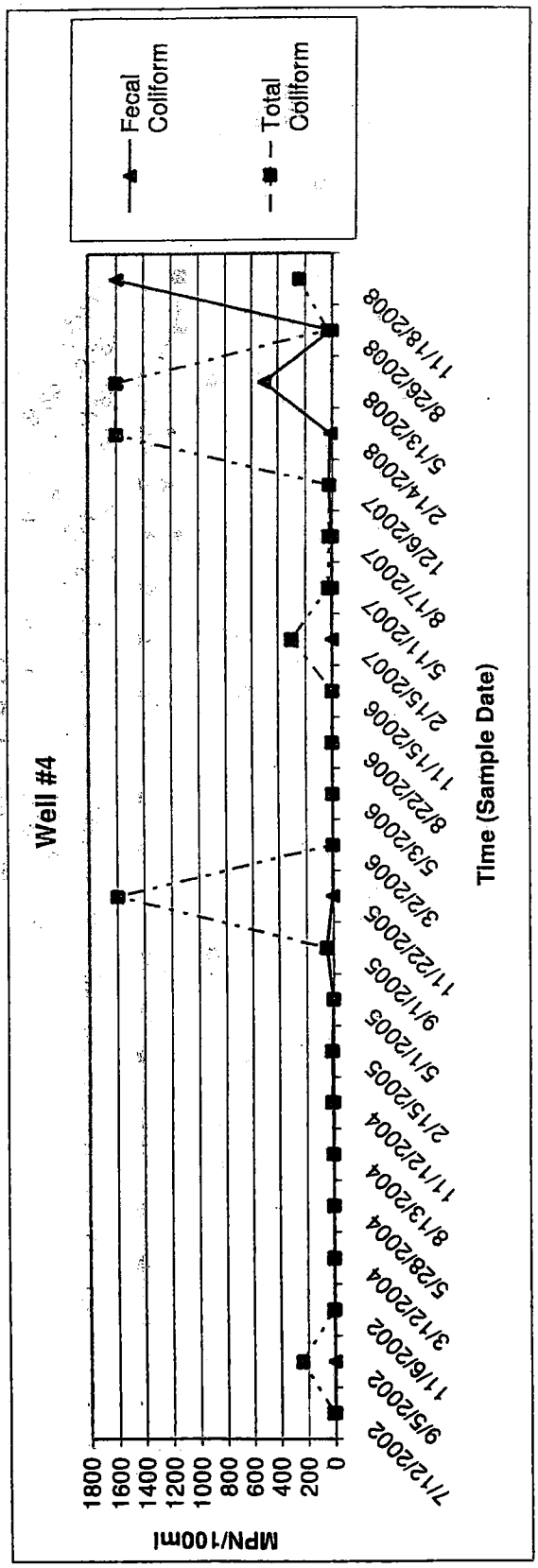


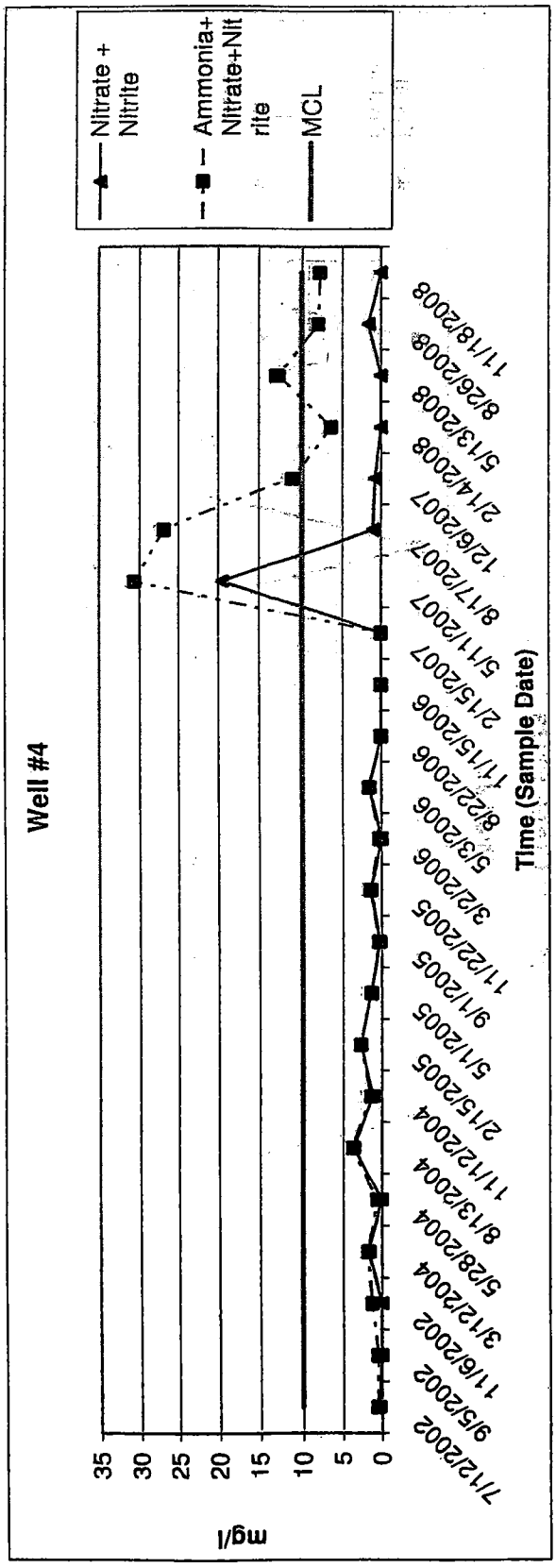


D R A F T 12 2009

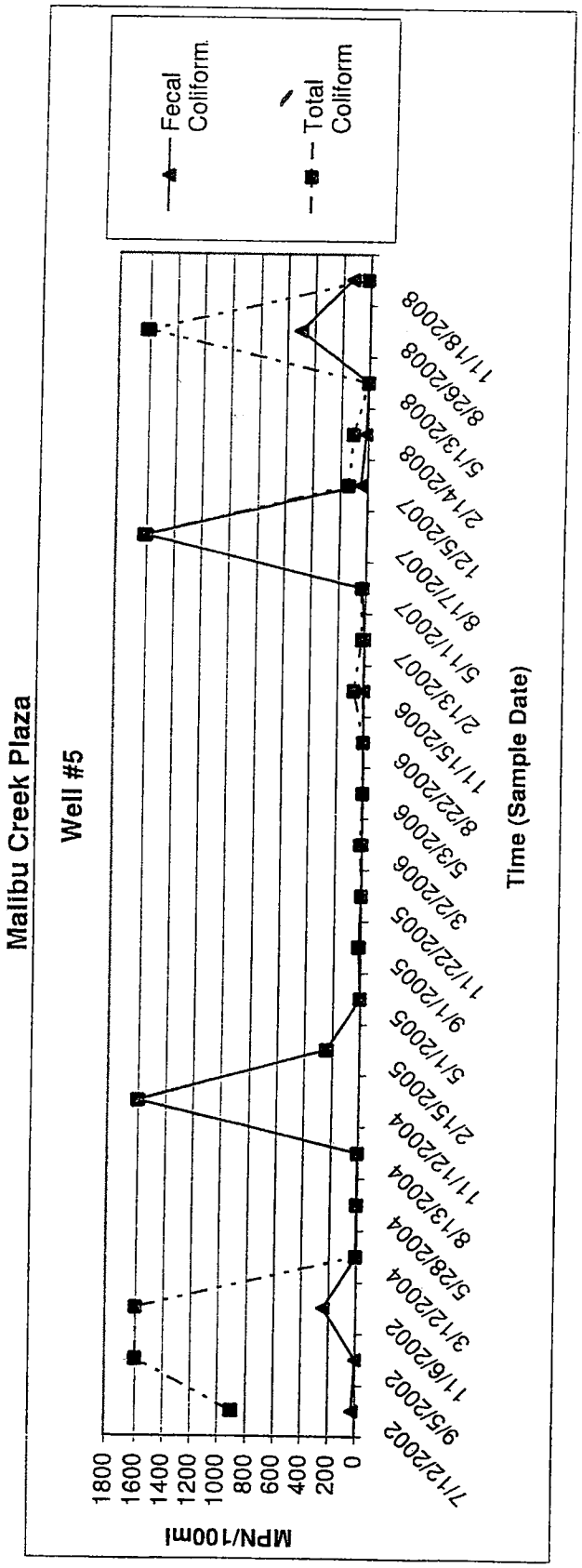
DRAFT OCT 2 1 2009

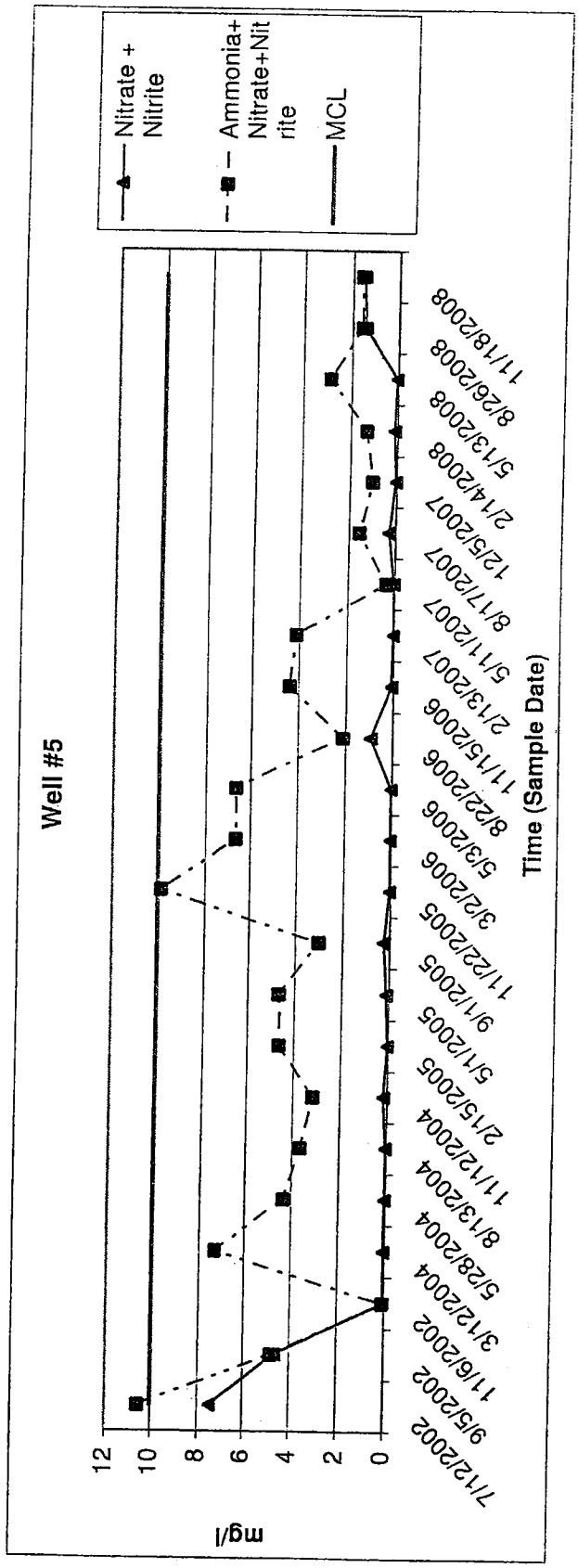
DRAFT OCT 21 2009



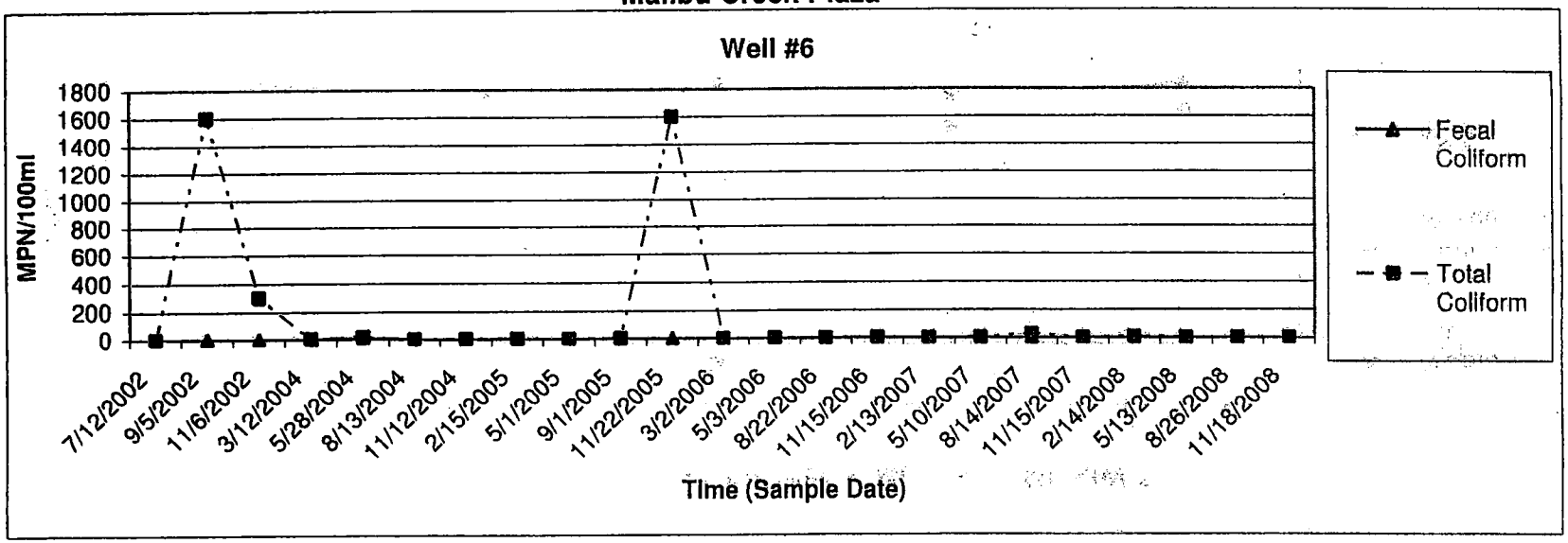


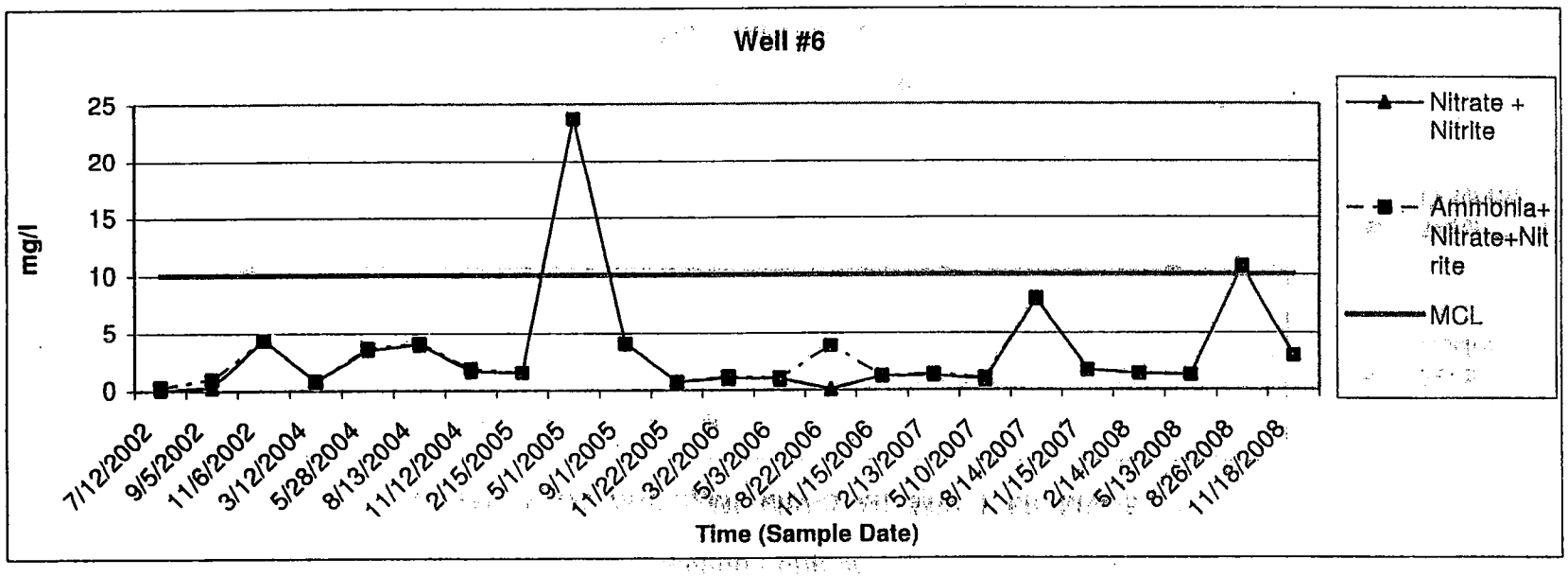
DRAFT OCT 21 2009





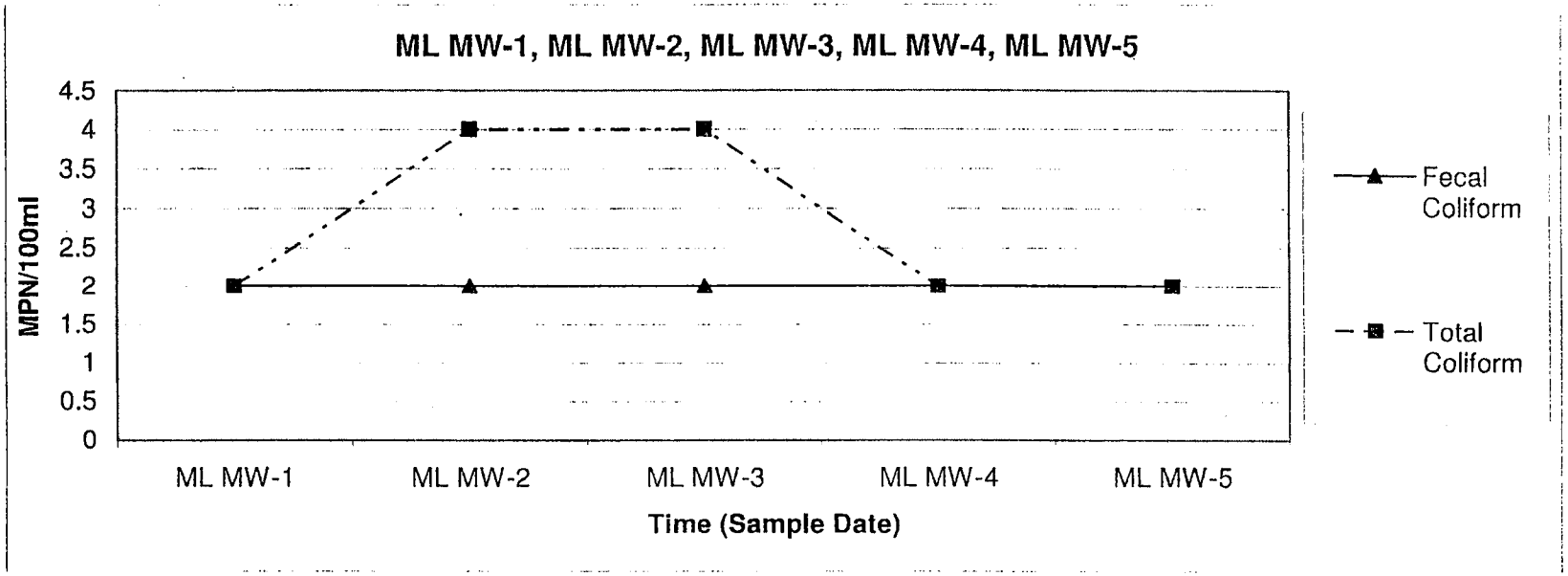
Malibu Creek Plaza

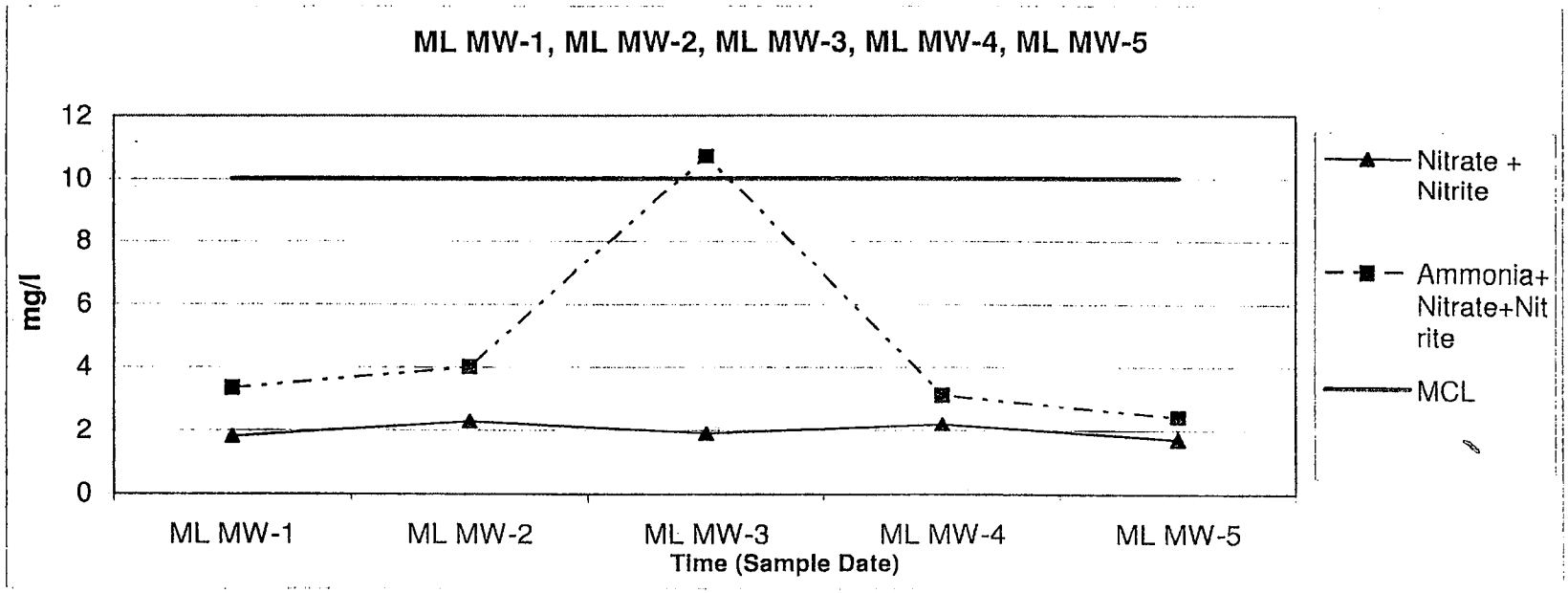




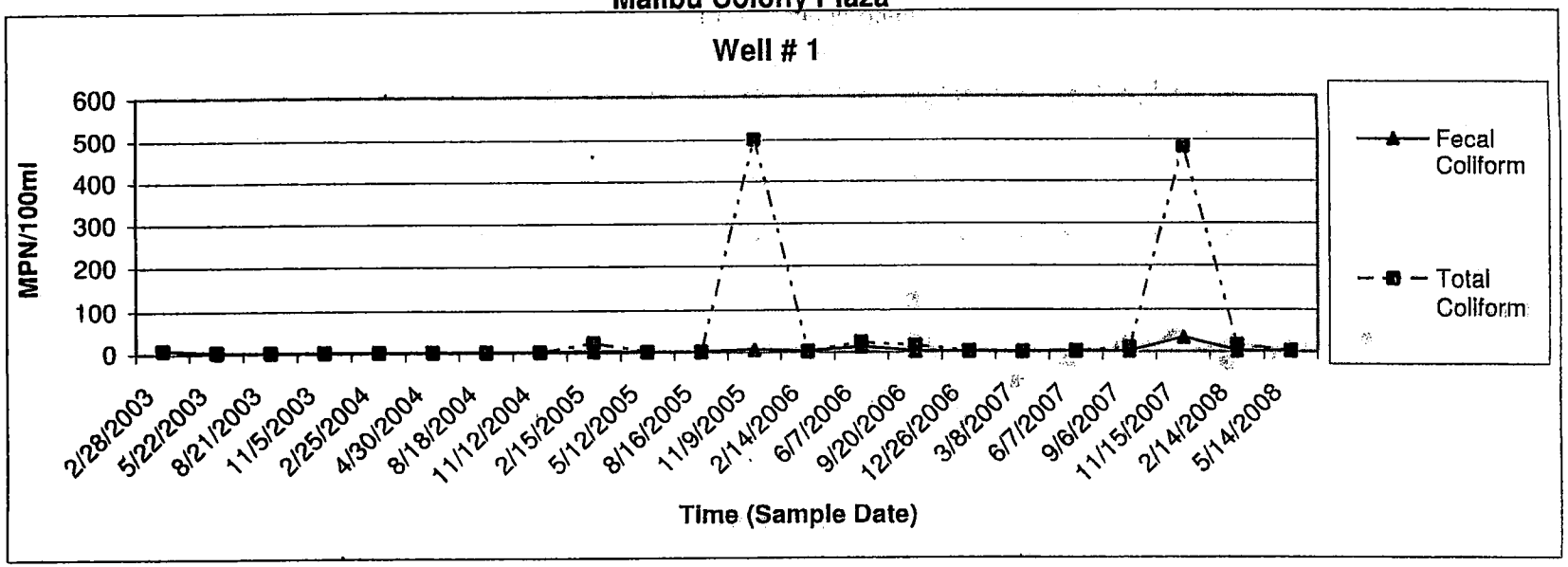
DEARTECO 12 2009

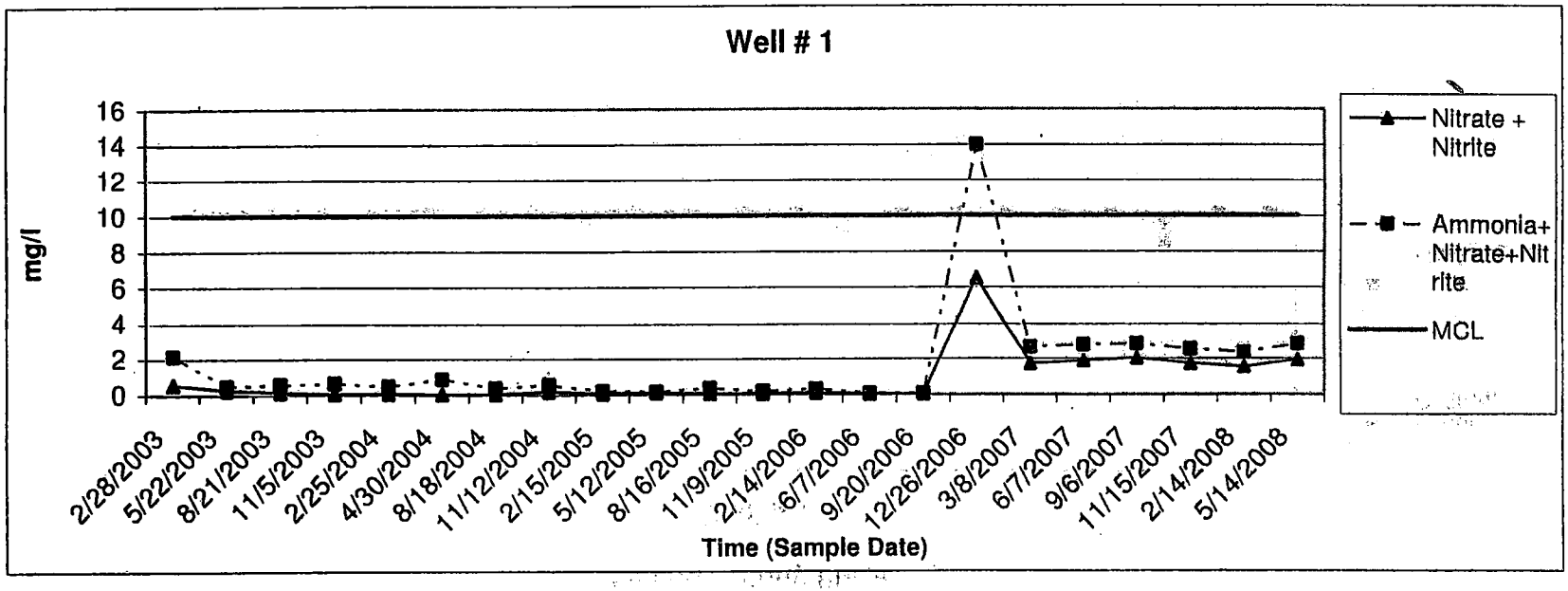
Malibu Lumber





Malibu Colony Plaza

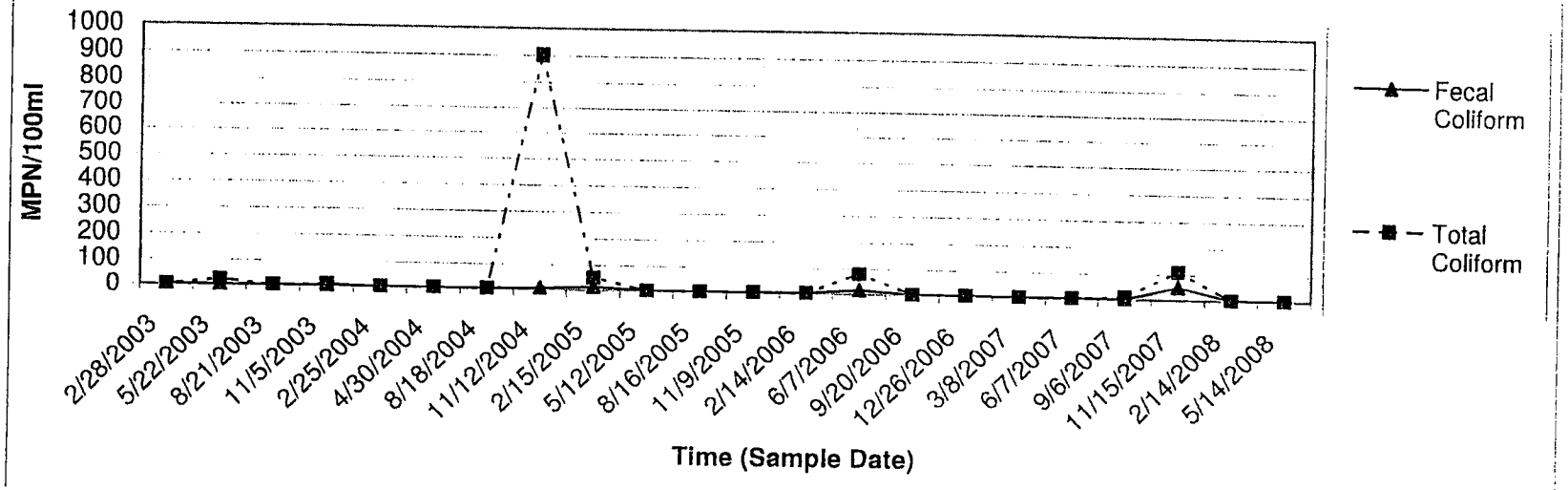




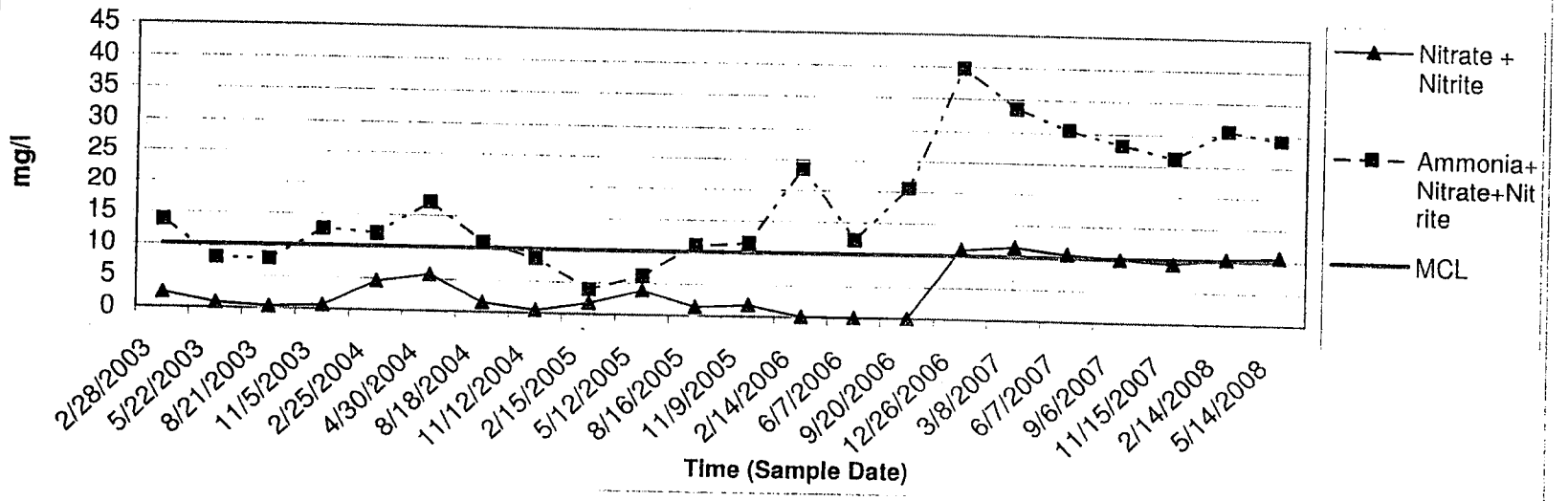
TM2-83

Malibu Colony Plaza

Well # 2

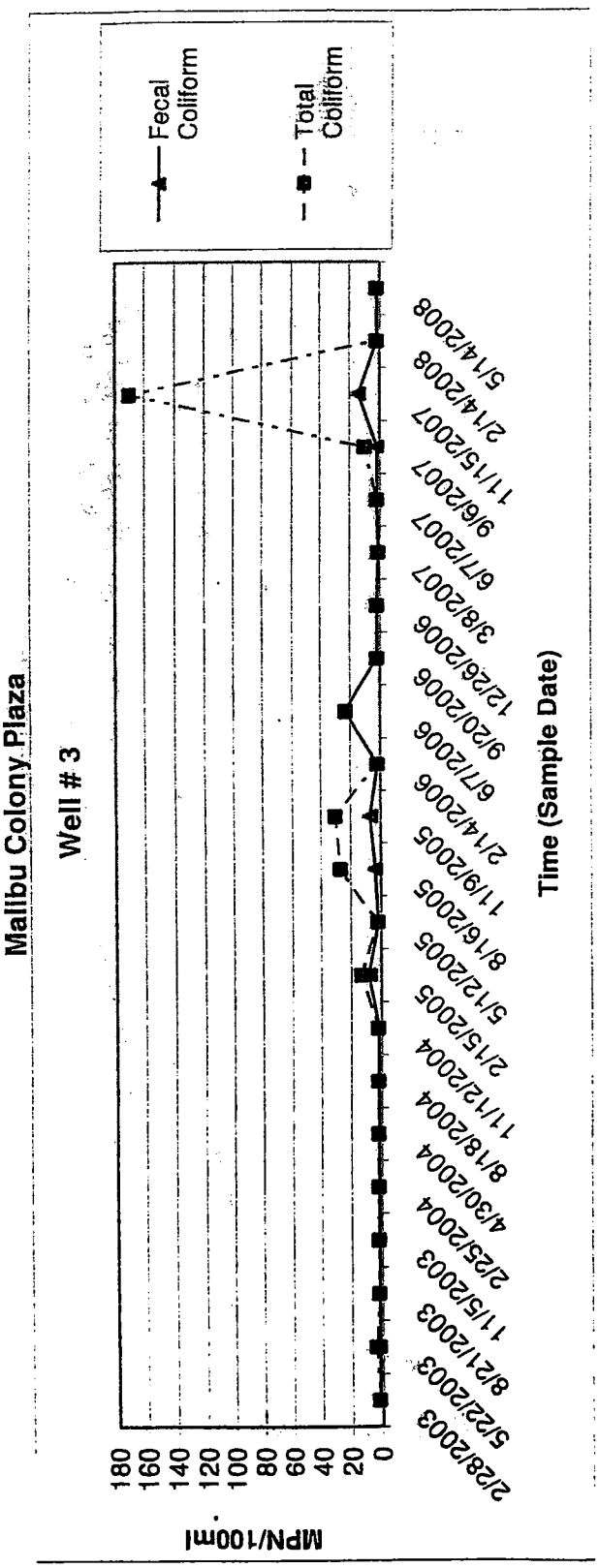


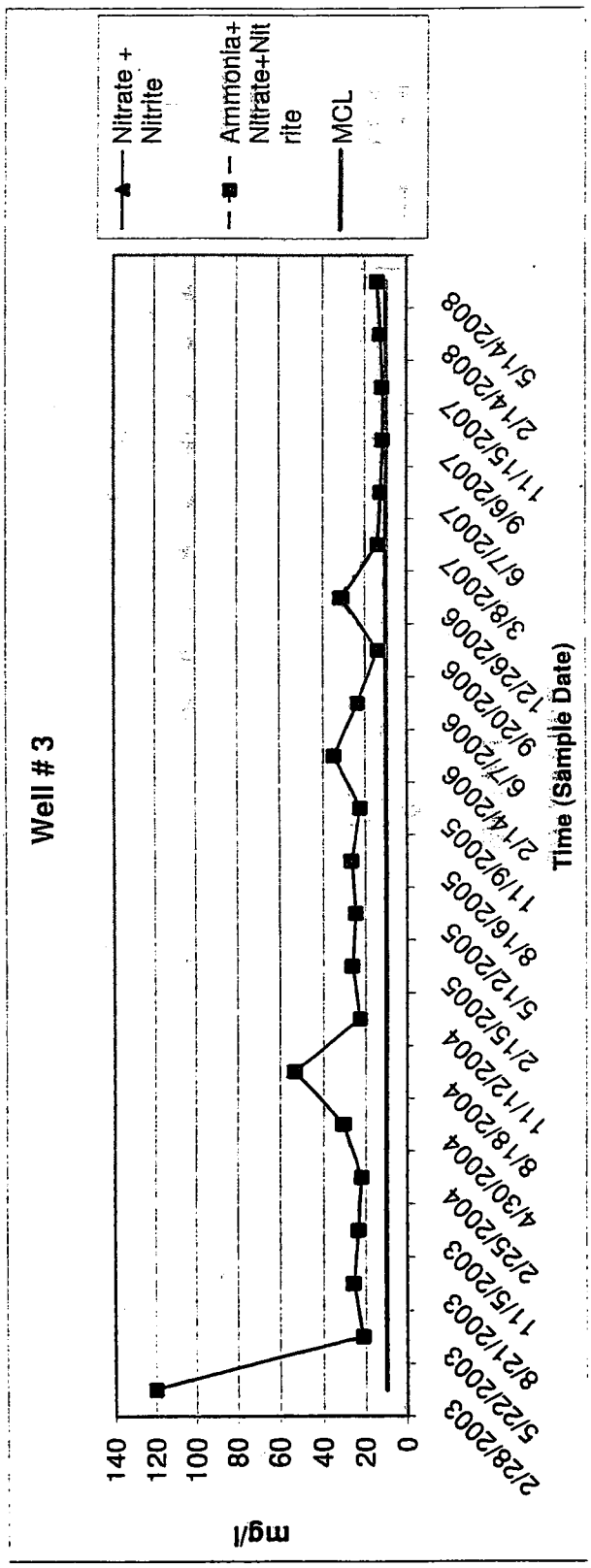
Well # 2



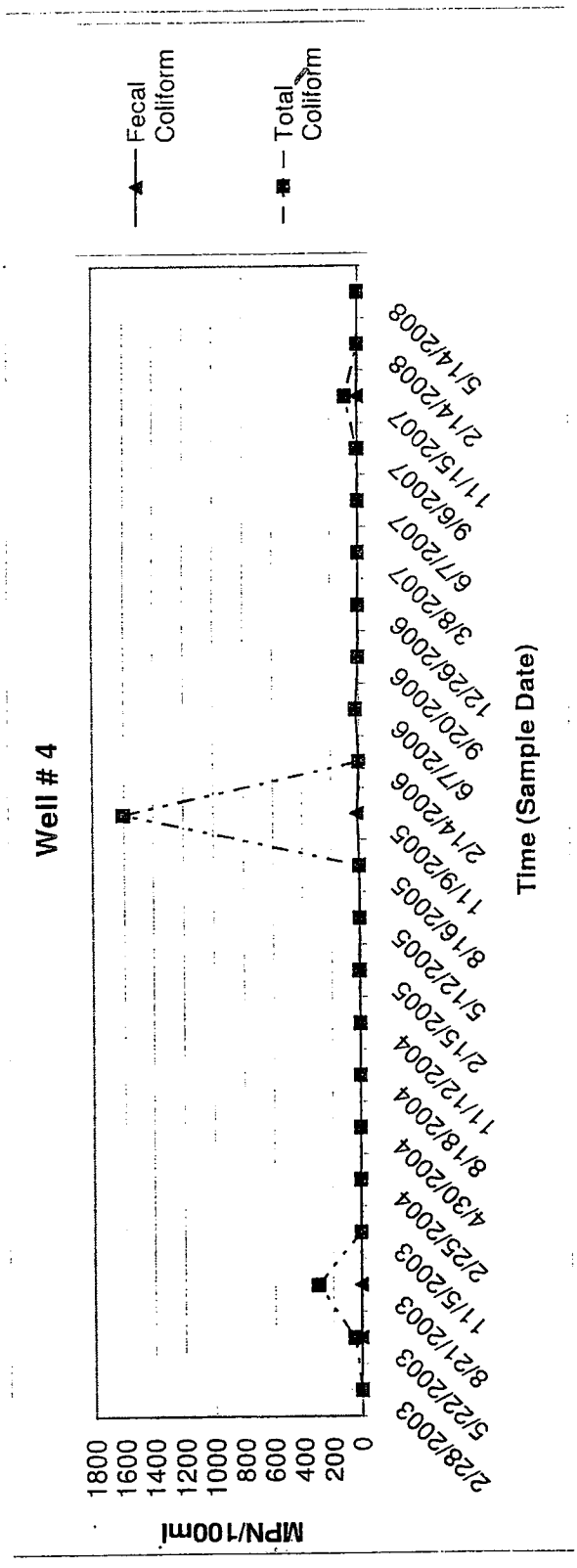
9 0 0 2 1 2 T C O T F A R D

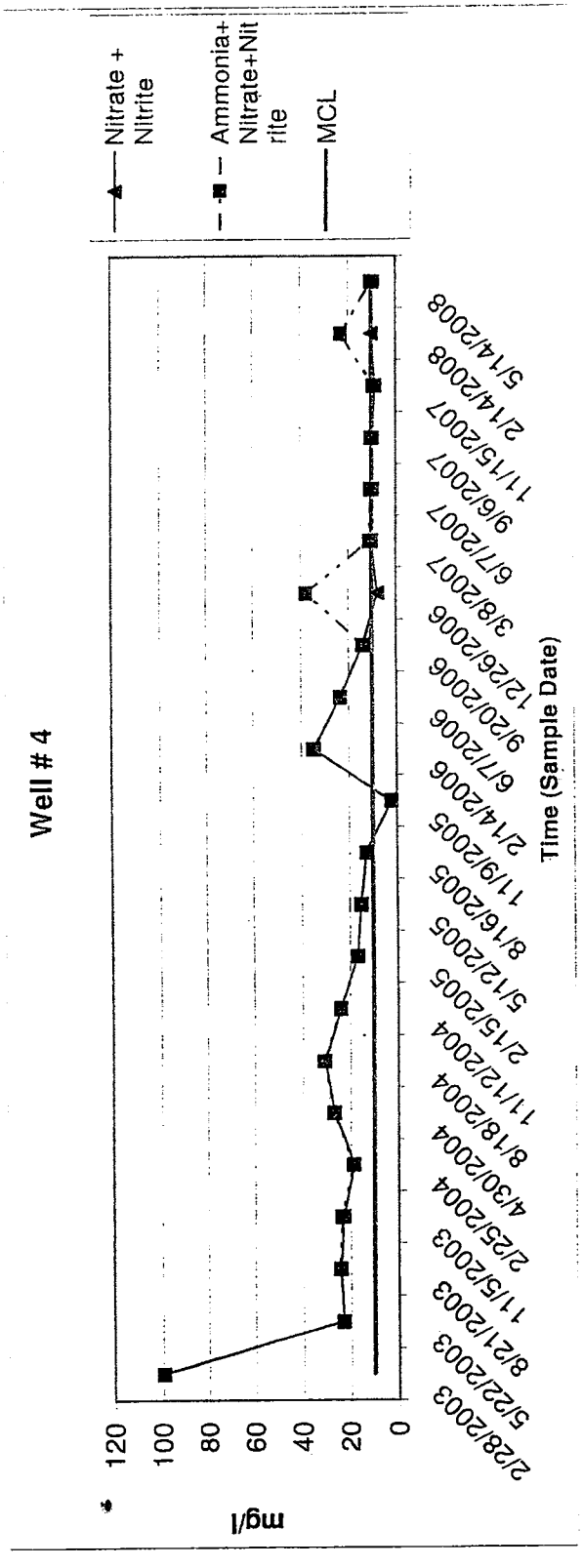
DRAFT OCT 2 1 2 0 0 9



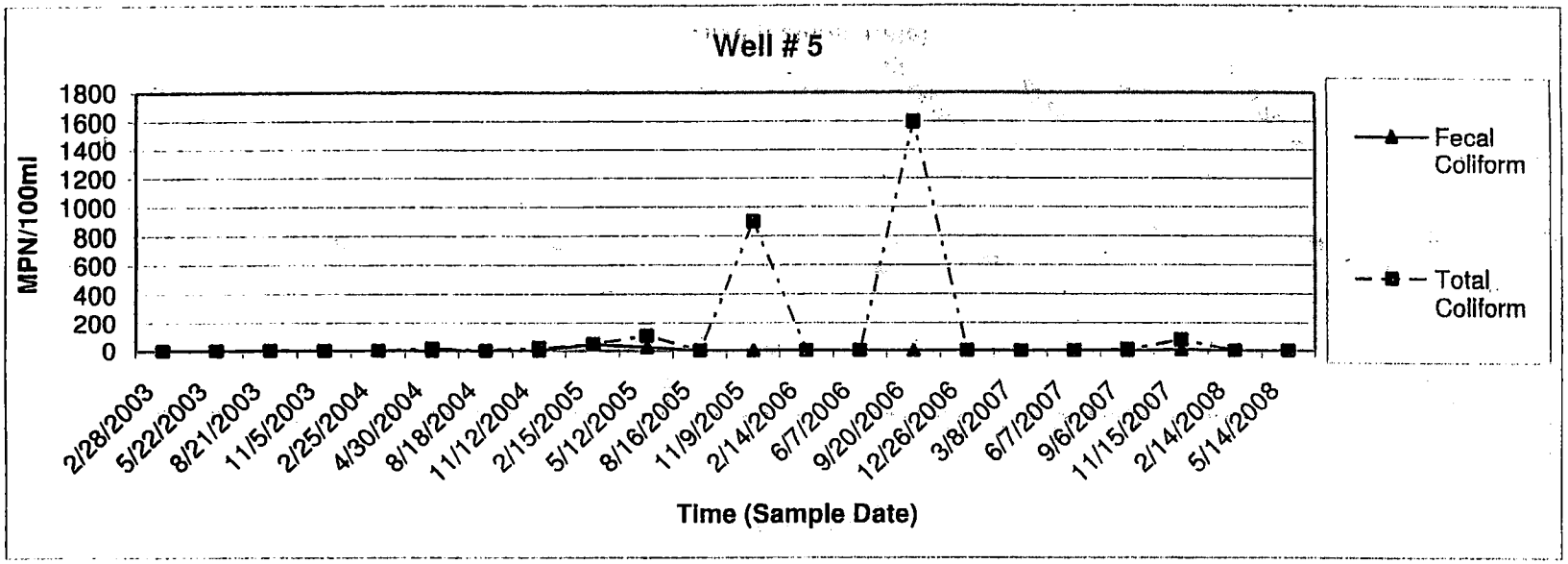


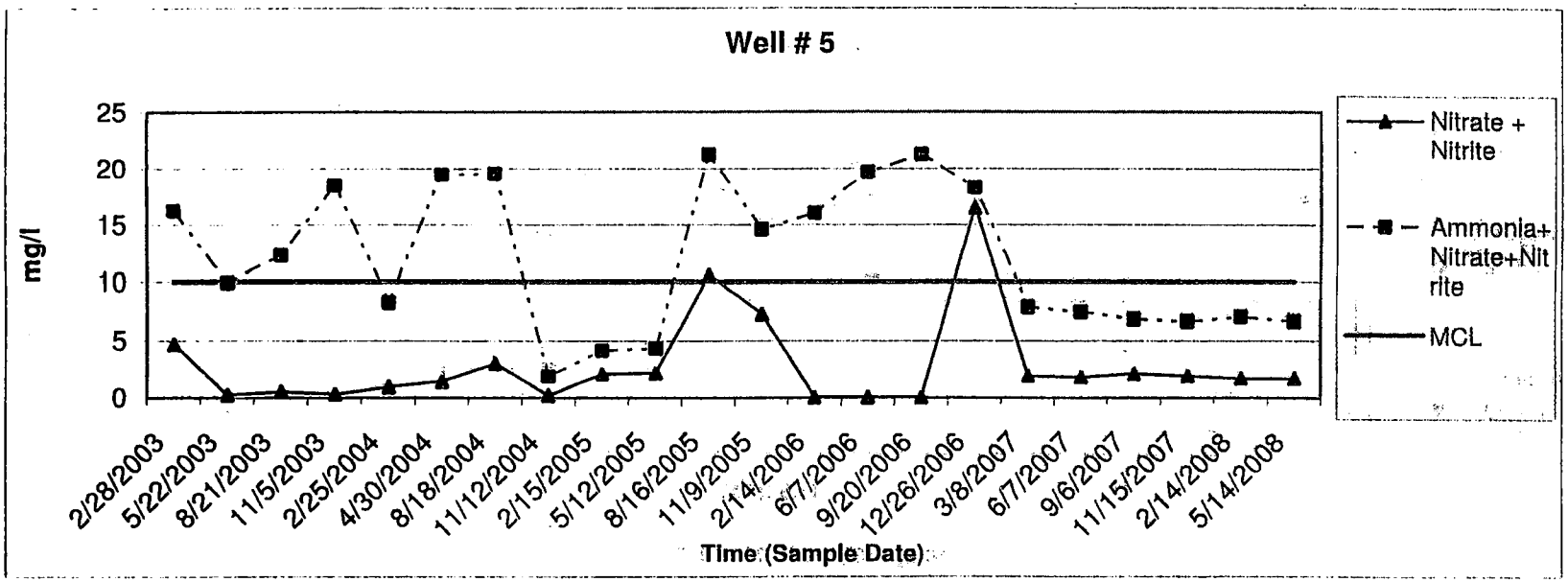
DRAFT OCT 2 1 2 0 0 9





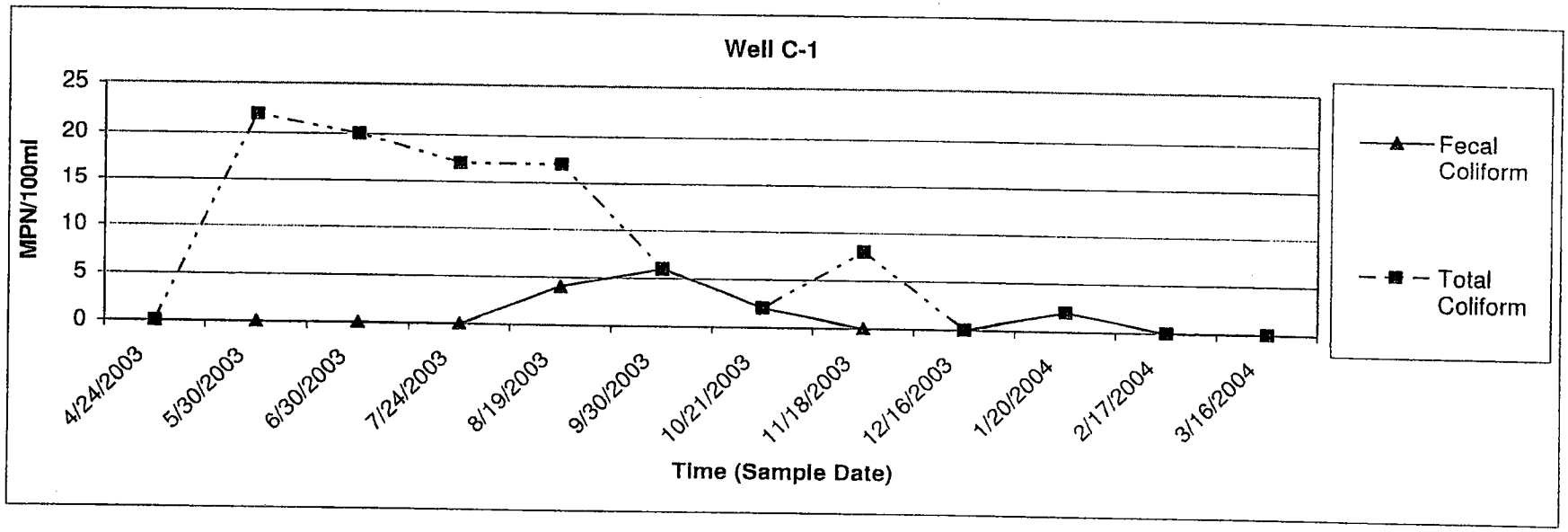
Malibu Colony Plaza

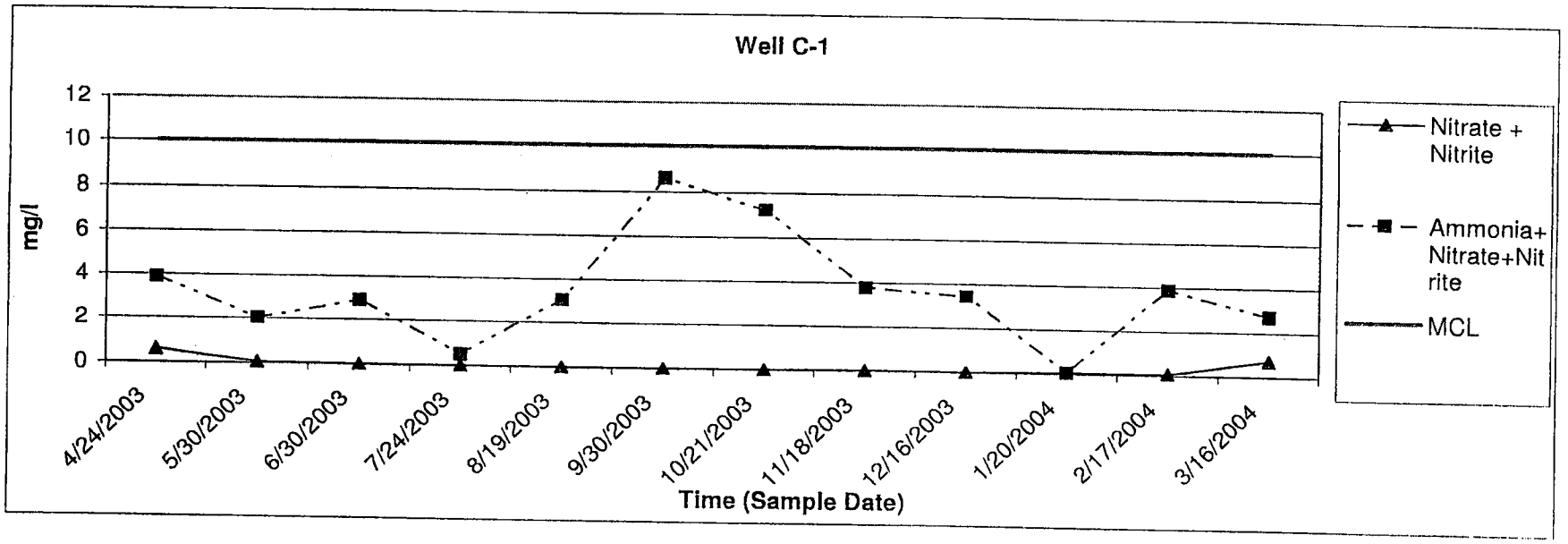




DEARTH 2012 9 0 0 2

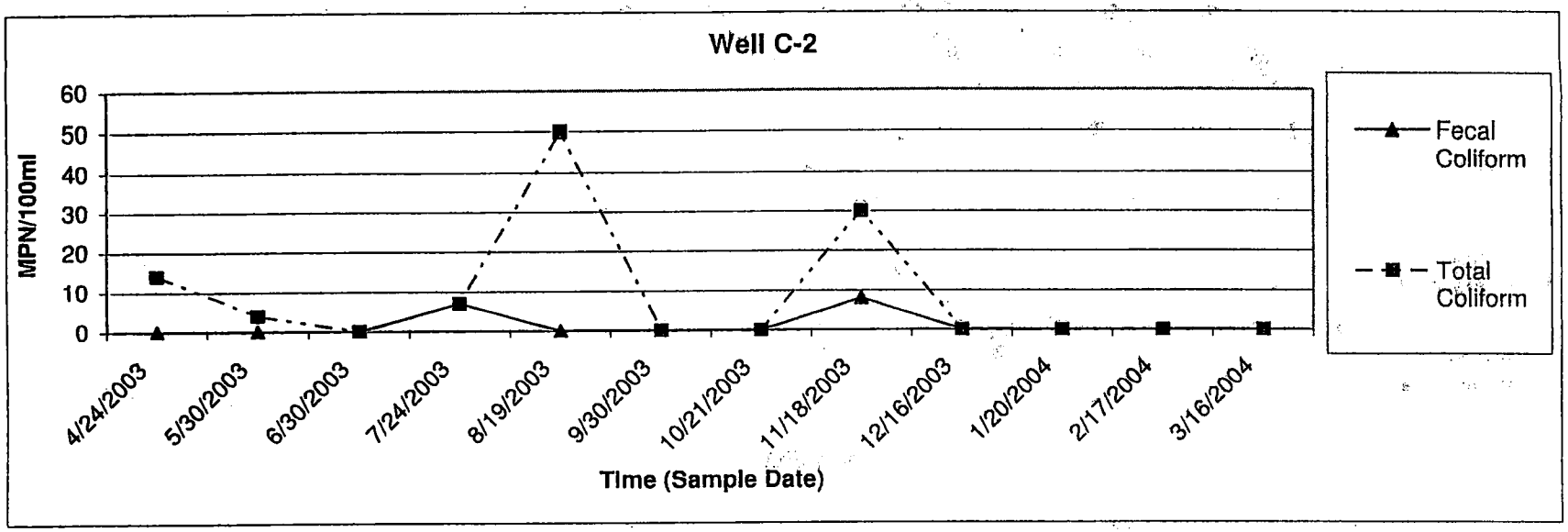
Malibu Civic Center Area

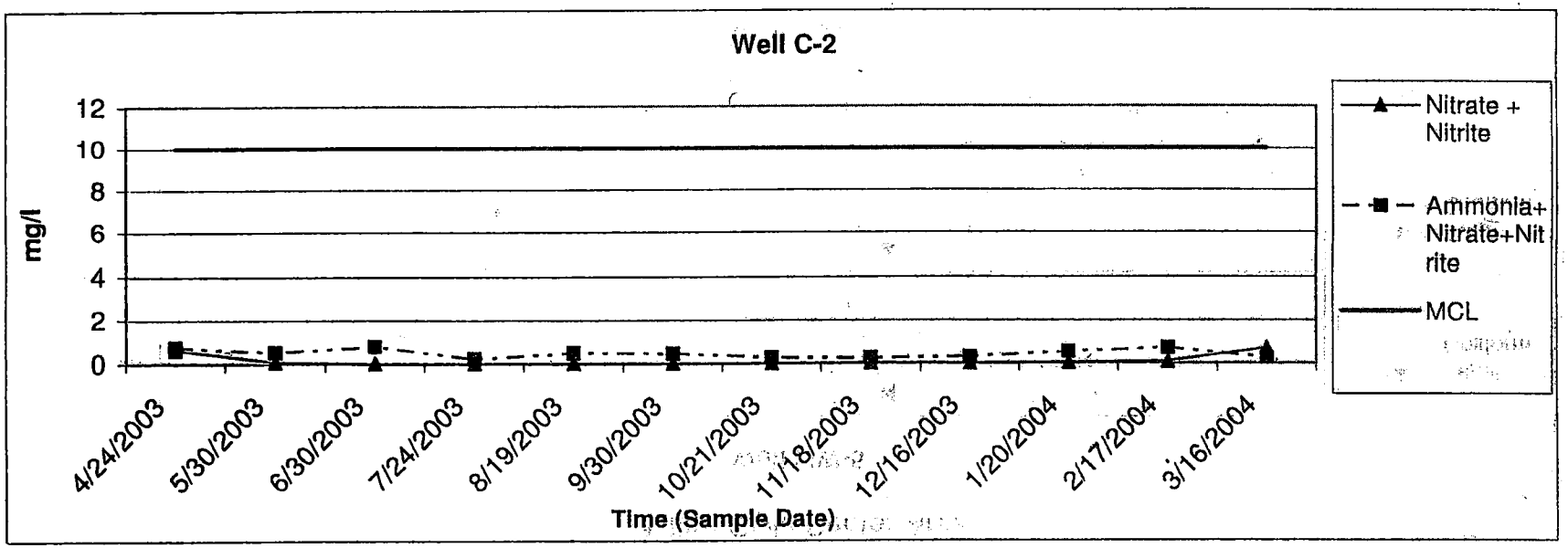




9 0 0 2 2 1 2 T C O E E A R D

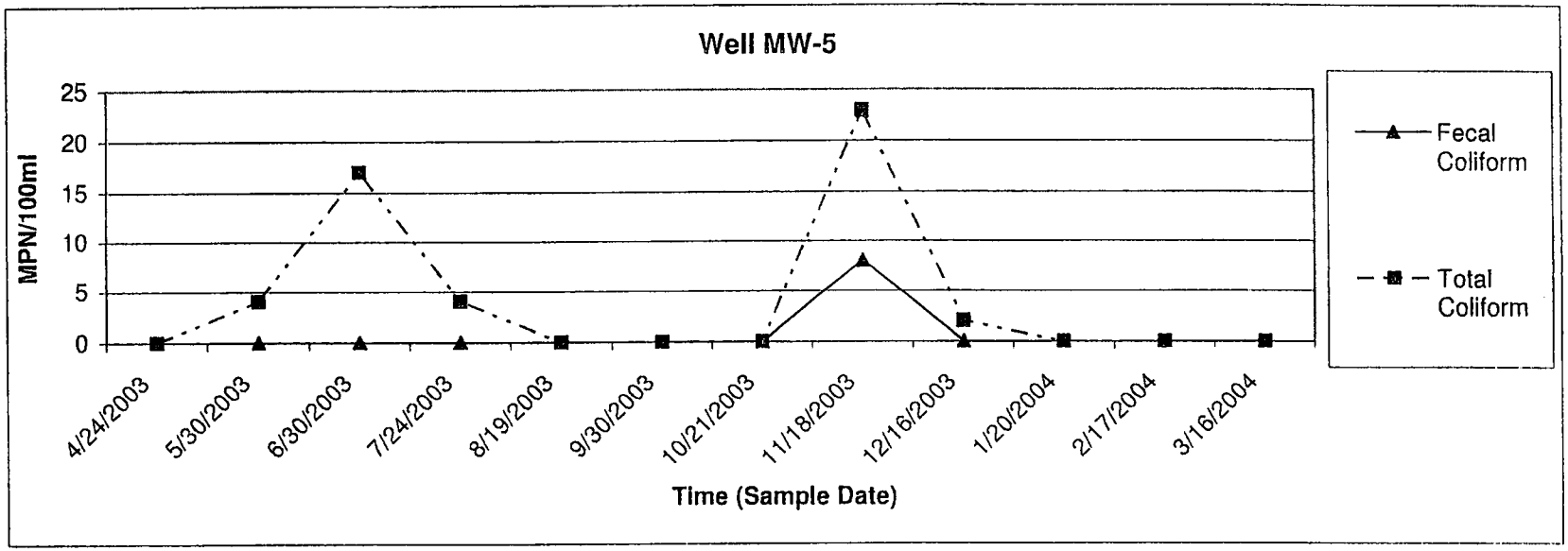
Malibu Civic Center Area

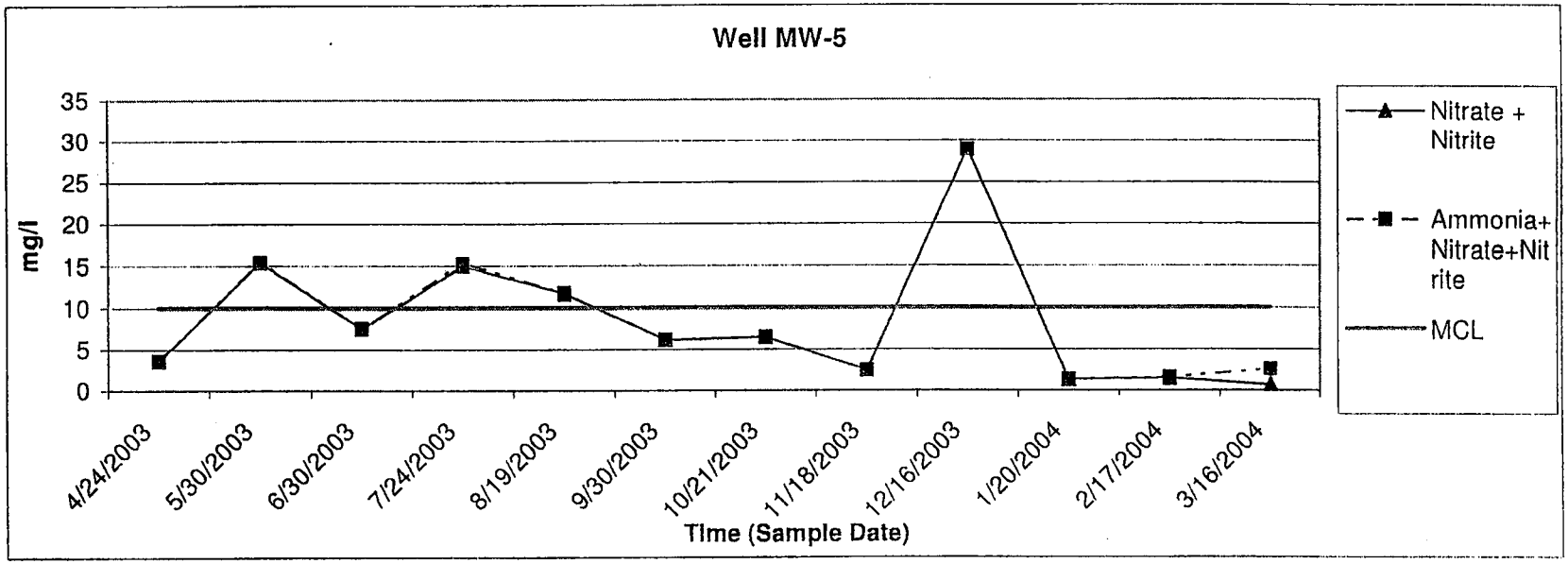




6 0 0 2 1 2 T C O T H E A R D

Malibu Civic Center Area

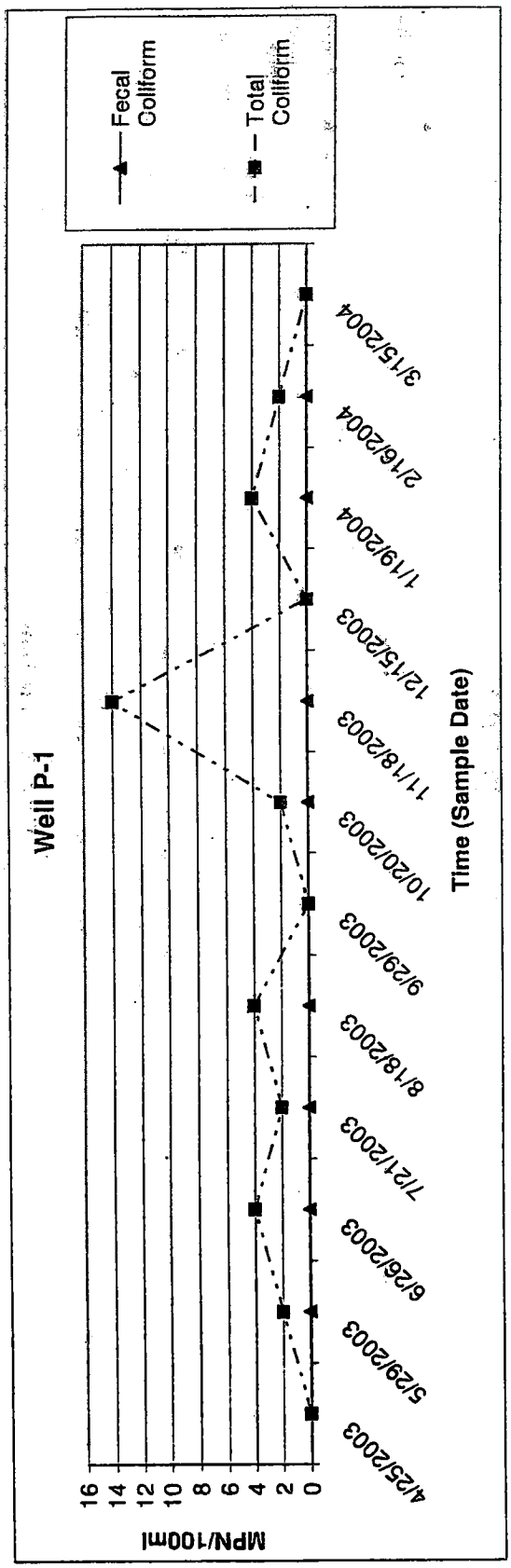


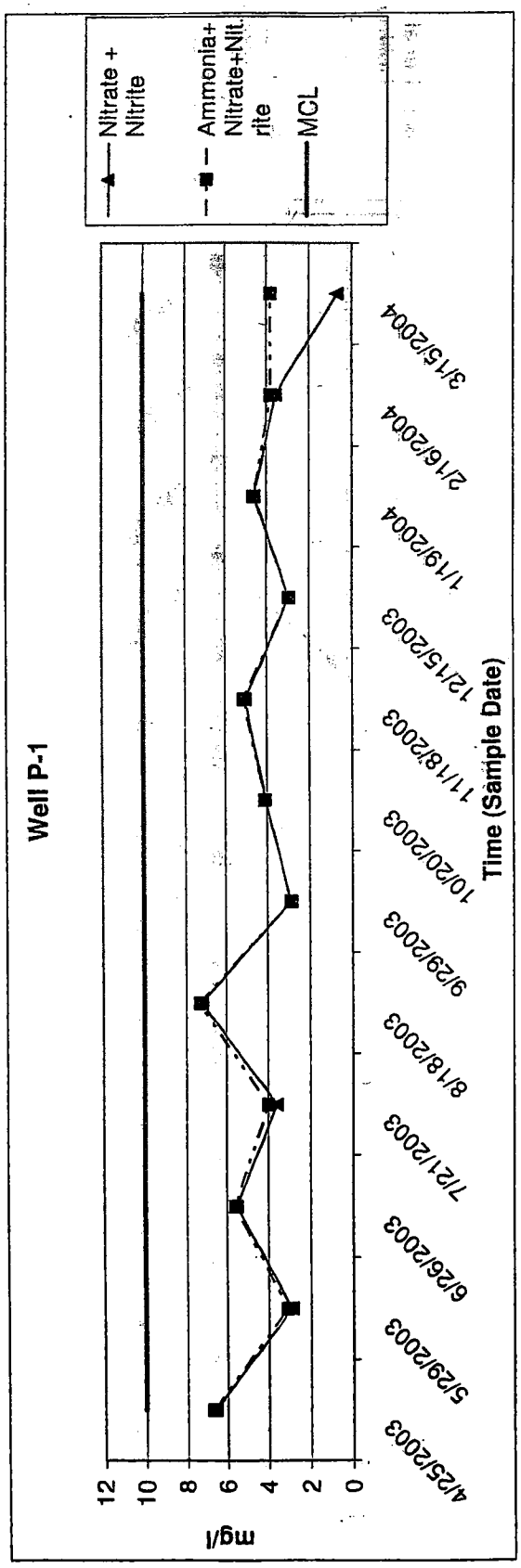


6 0 0 2 1 2 T C O F E A R D

DRAFT OCT 21 2009

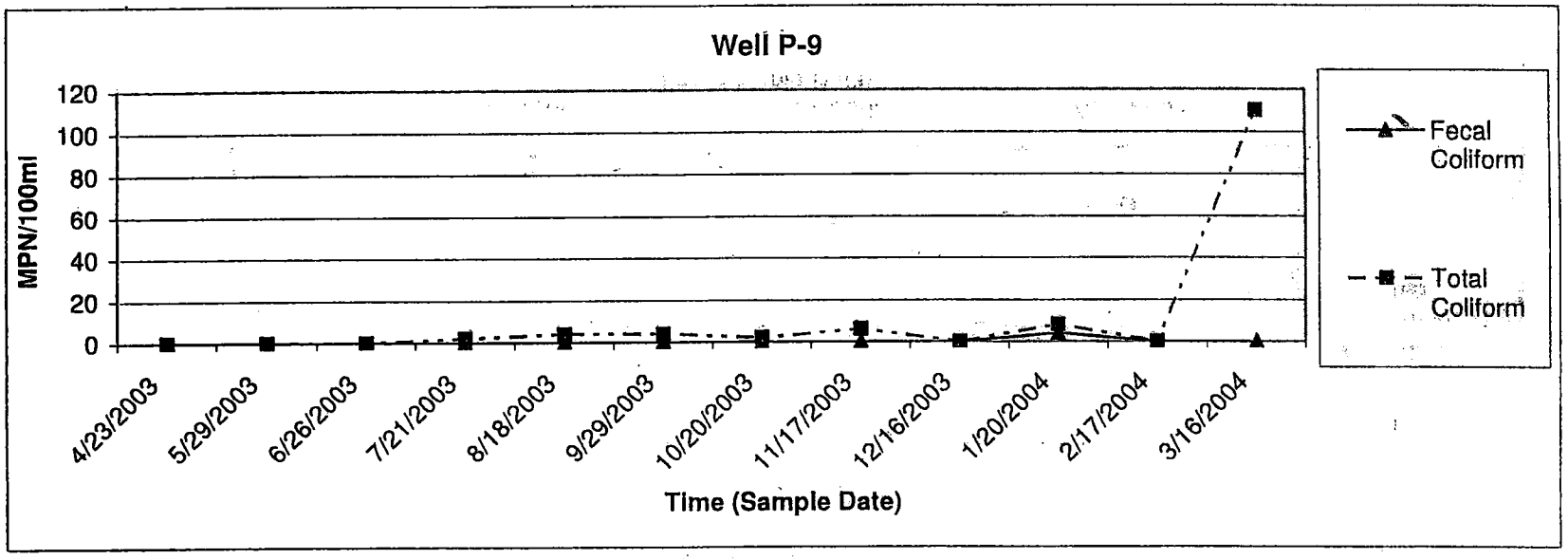
Malibu Civic Center Area

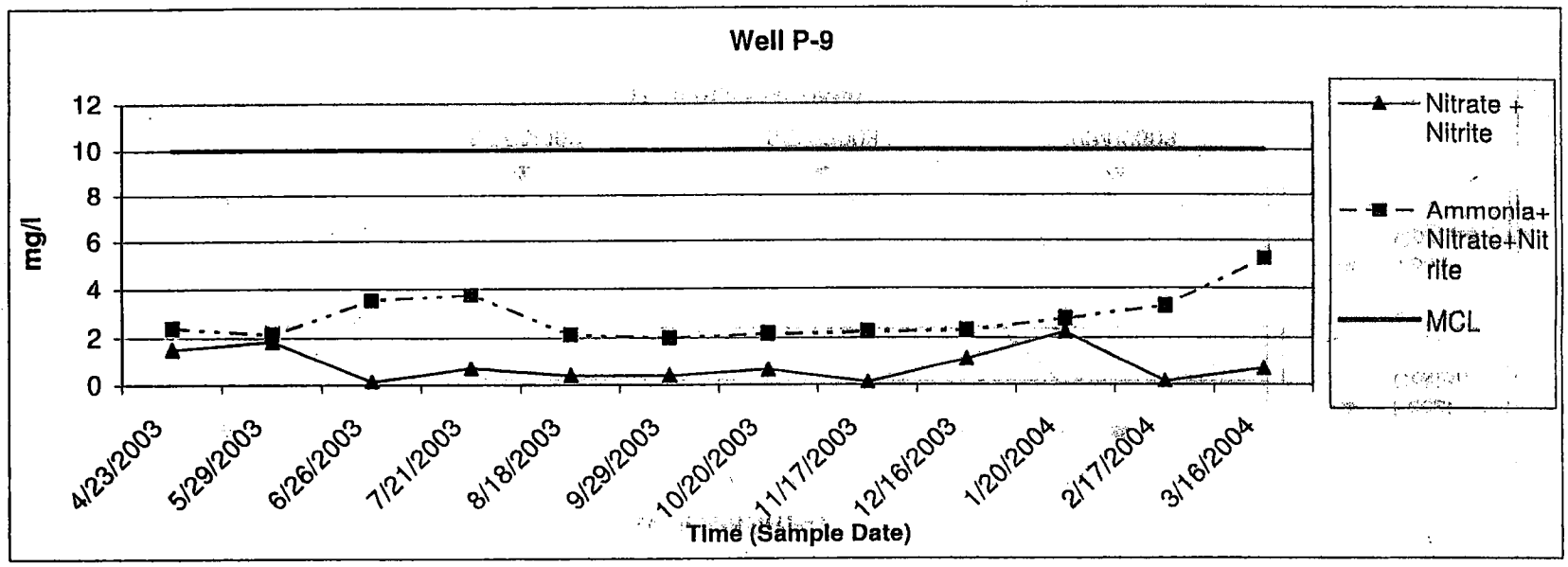




DRAFT OCT 2 1 2 0 0 9

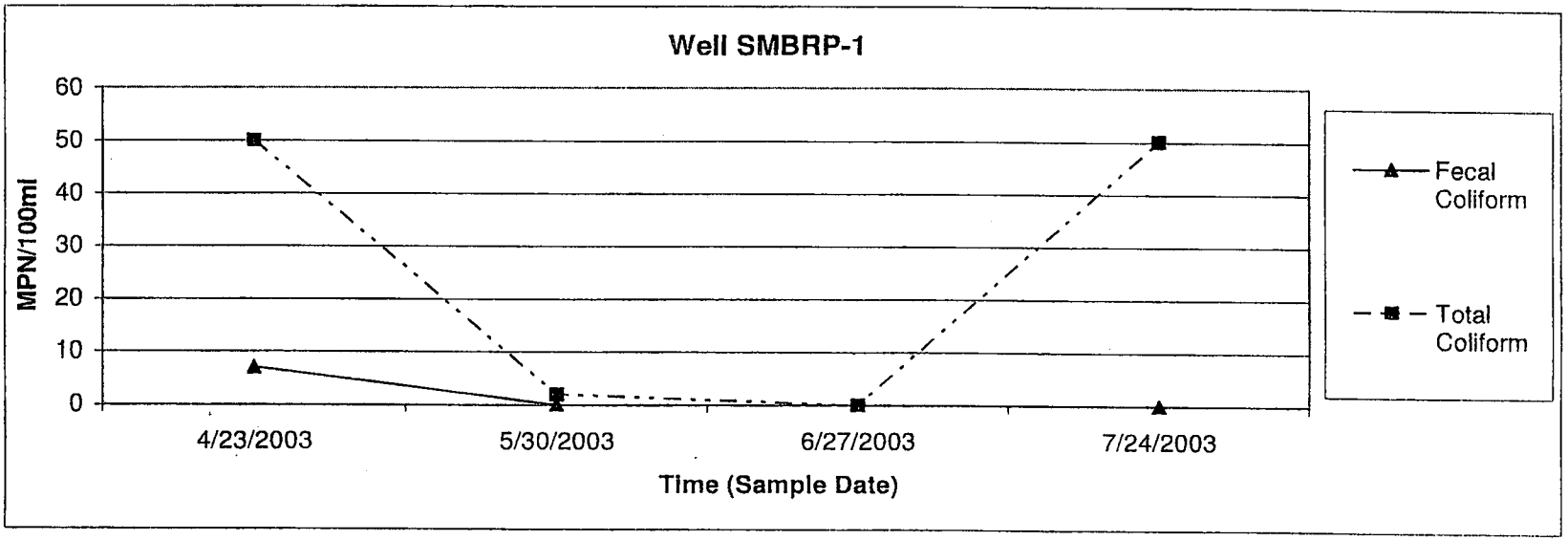
Malibu Civic Center Area

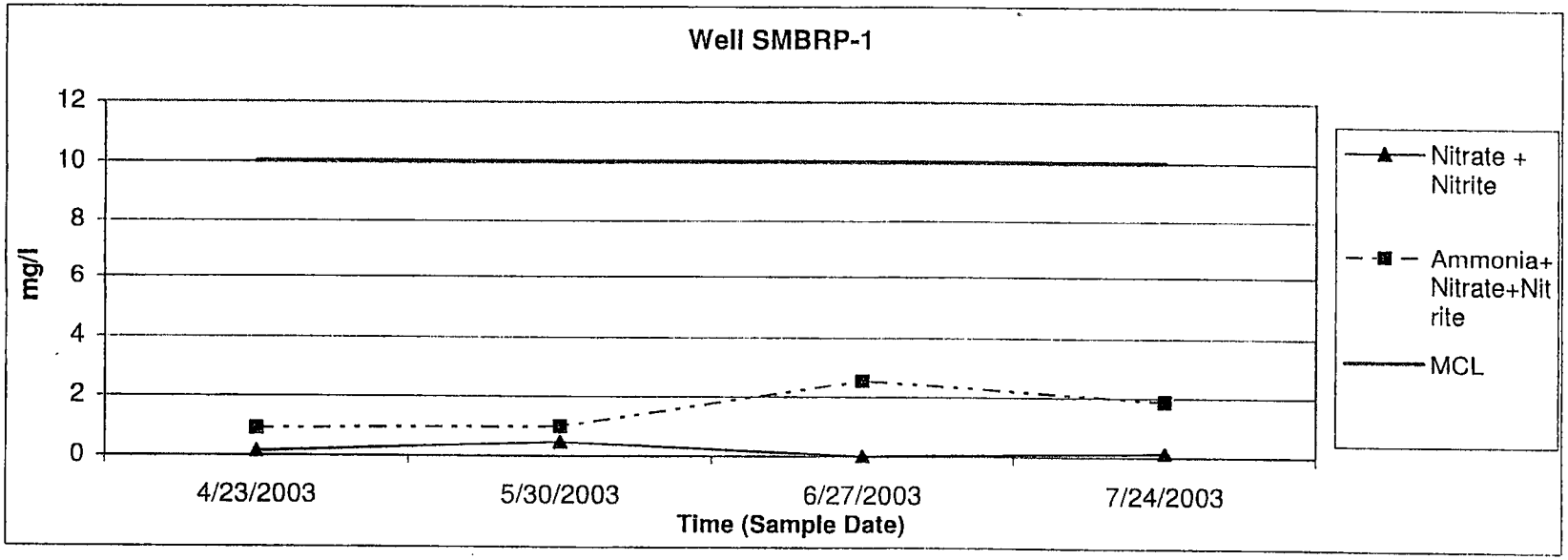




3-829
TM2-93
6 0 0 2 2 1 2 T C O T F A R D

Malibu Civic Center Area

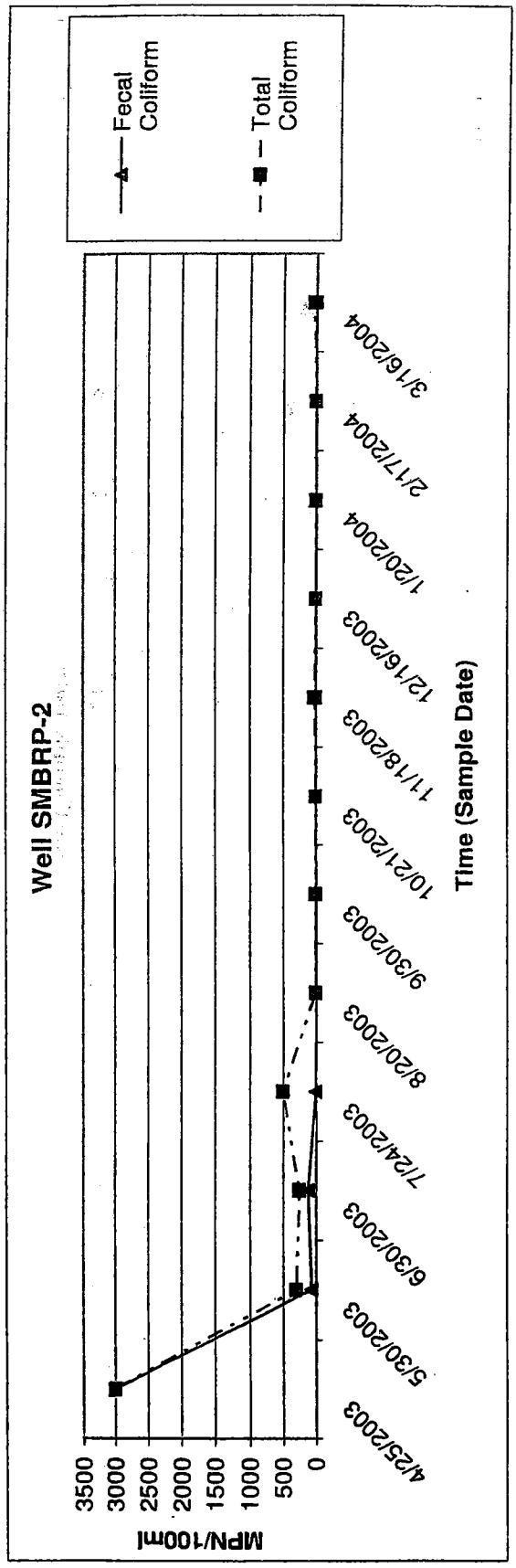


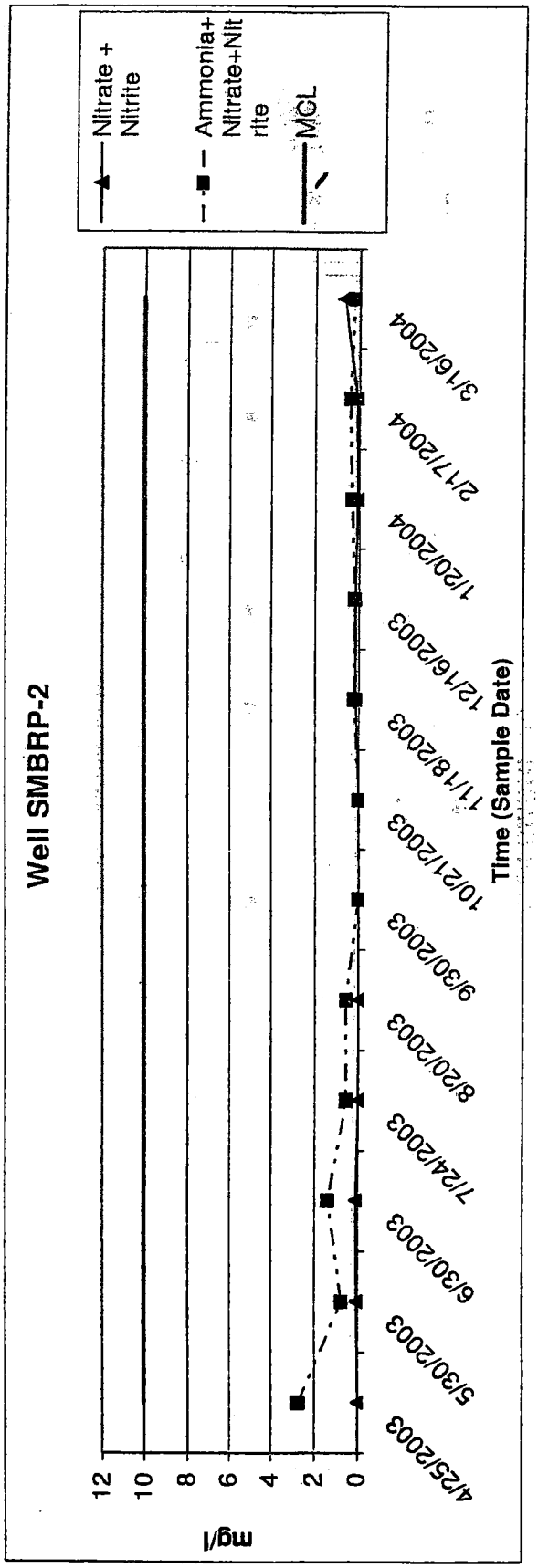


9 0 0 2 1 2 TCO TEARD

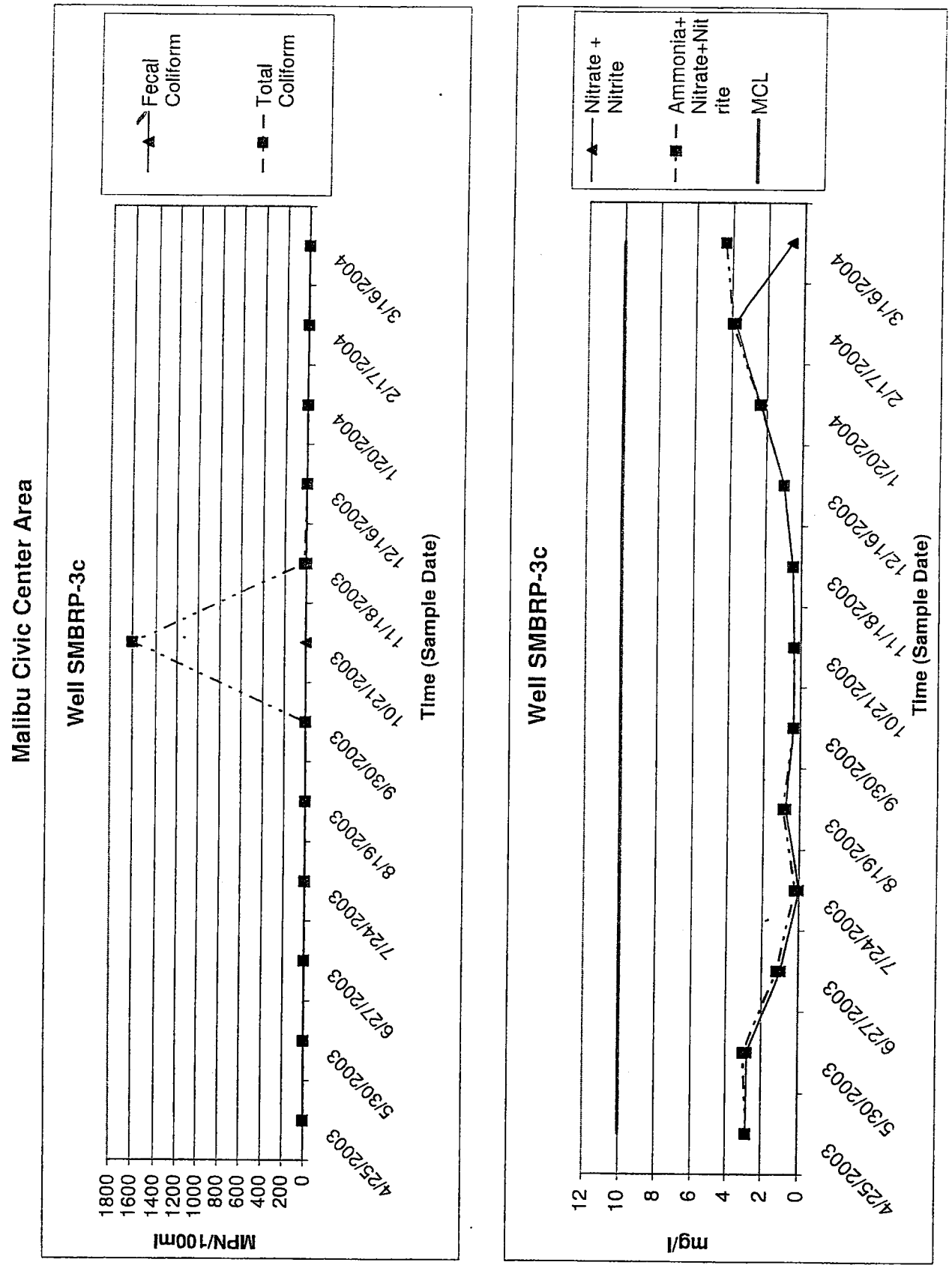
DRAFT OCT 21 2009

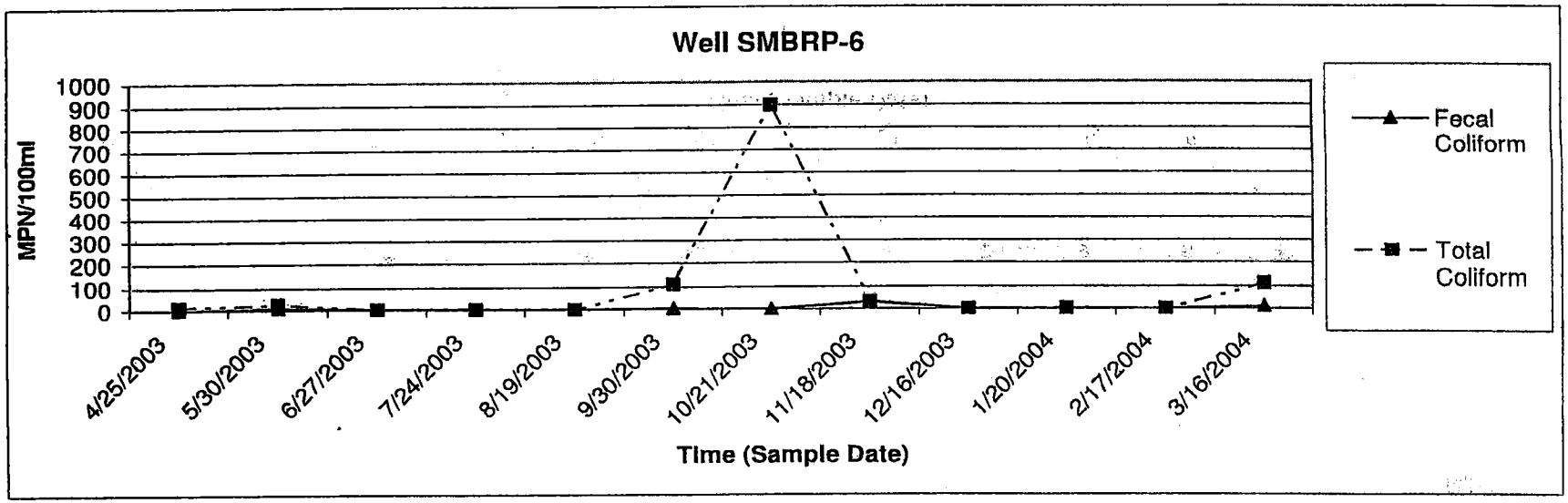
Malibu Civic Center Area

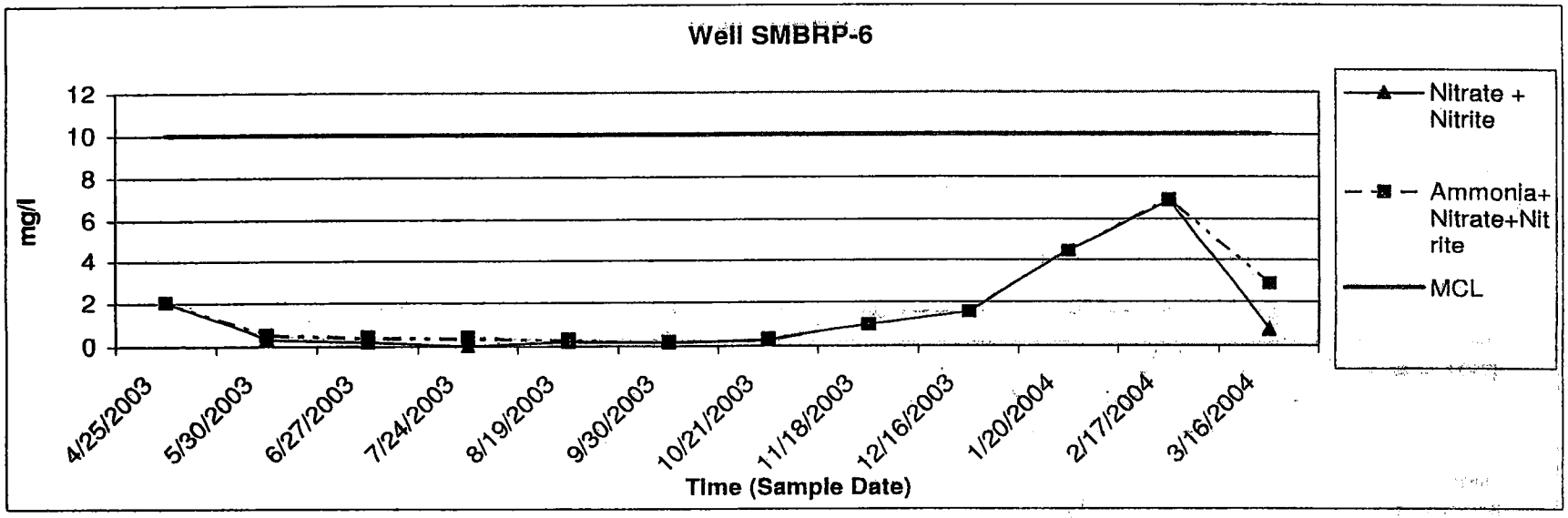




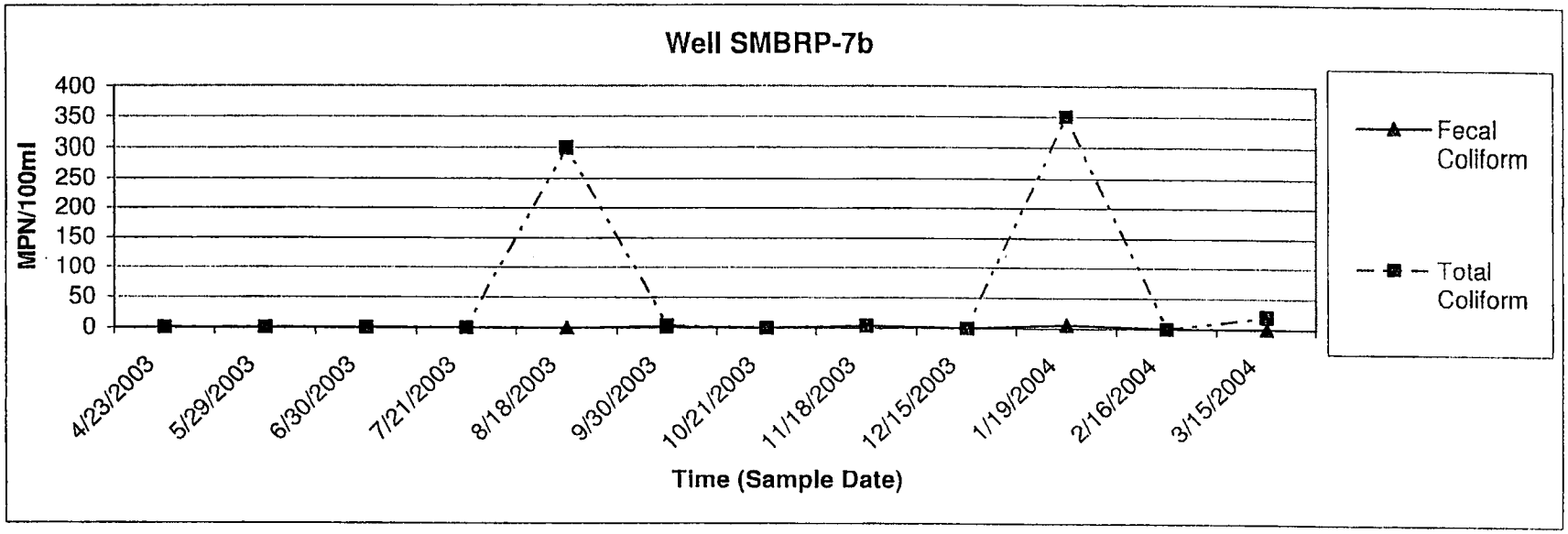
DRAFT OCT 21 2009

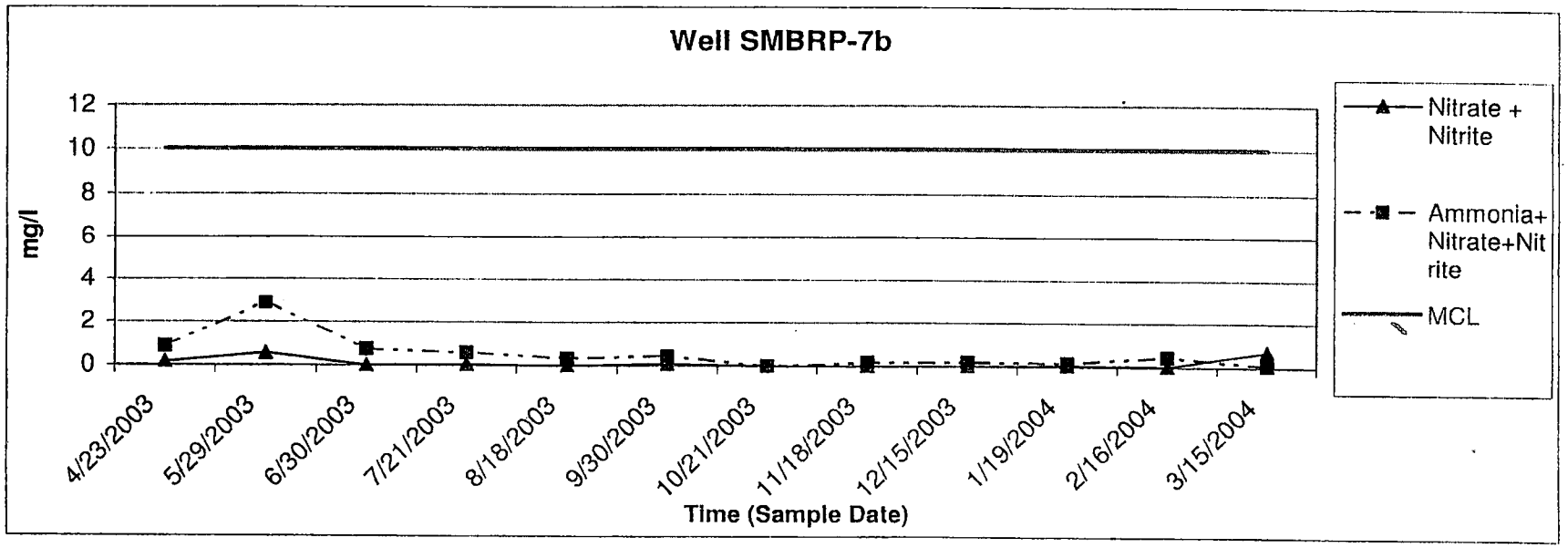



Well SMBRP-6
MPN/100ml
1000
900
800
700
600
500
400
300
200
100
0
4/25/2003
5/30/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)
Fecal Coliform
Total Coliform


Well SMBRP-6
mg/l
12
10
8
6
4
2
0
4/25/2003
5/30/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL

Malibu Civic Center Area

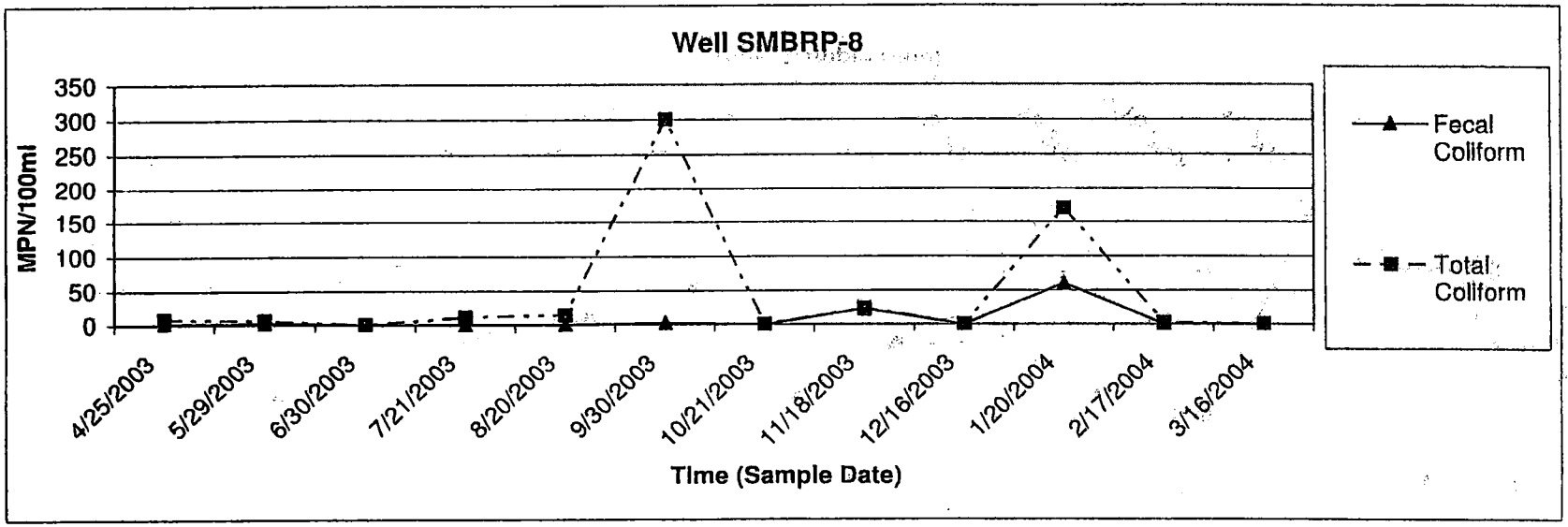


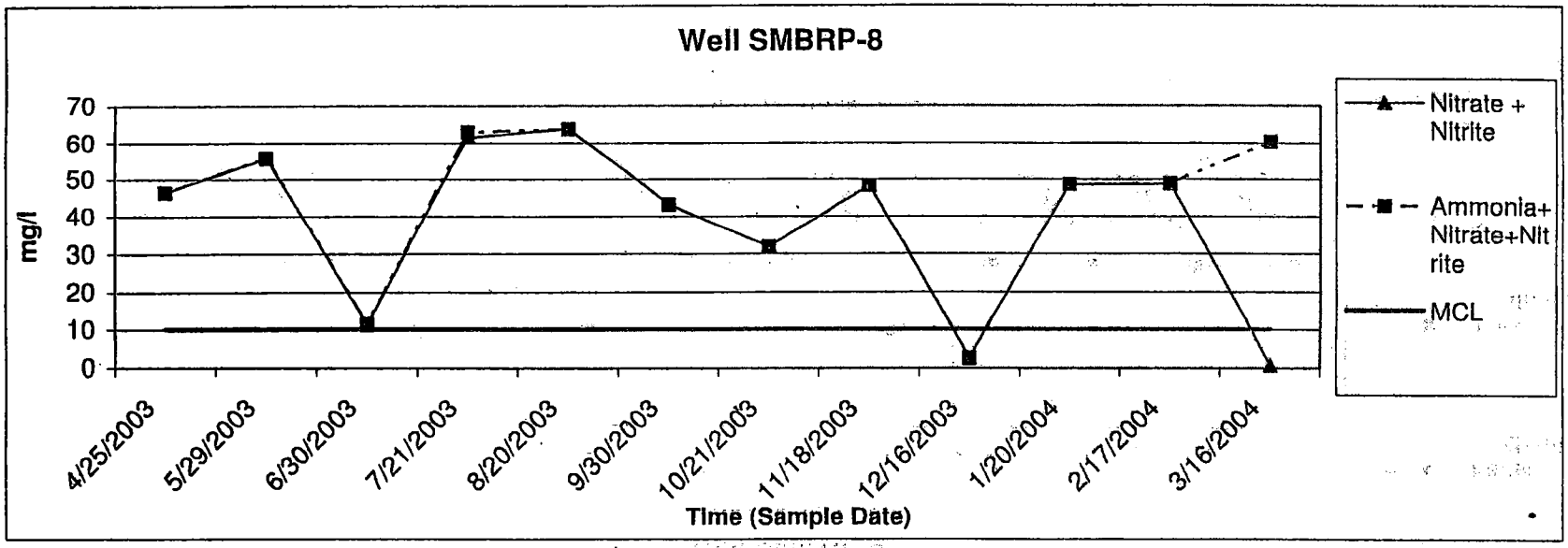


3-83h

TM2-98

9 0 0 2 1 2 TCO TEAR D





TM2-99

6 0 0 2 2 1 2 T C O T E A R D

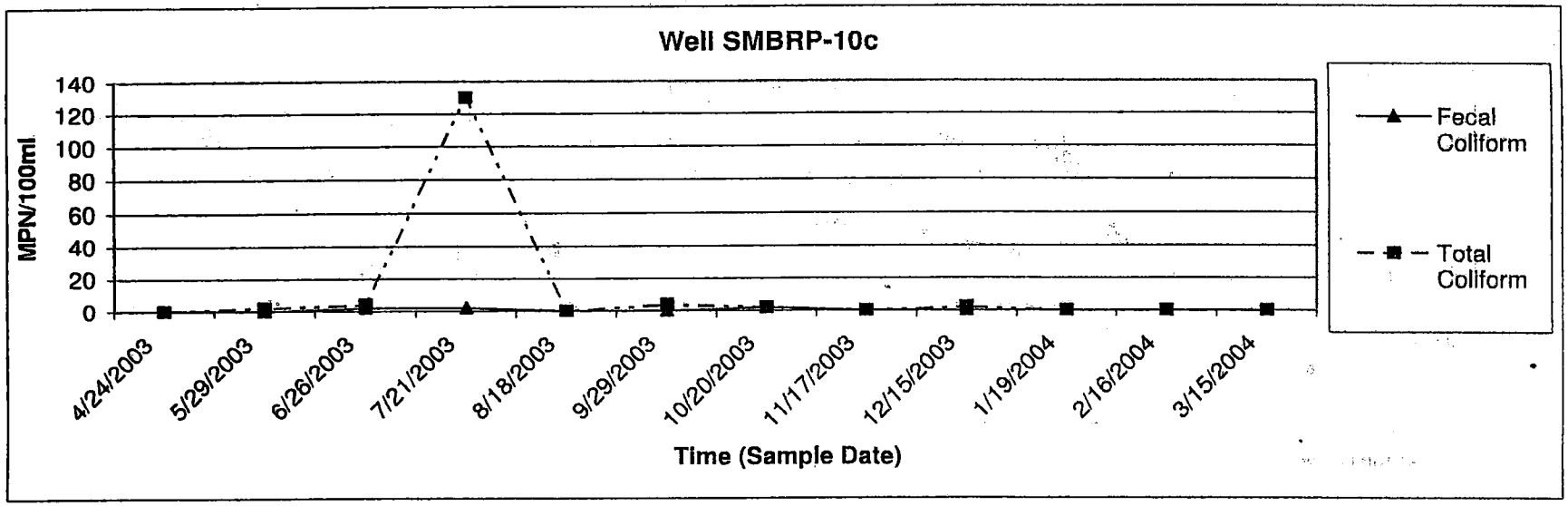
DRAFT OCT 21 2009

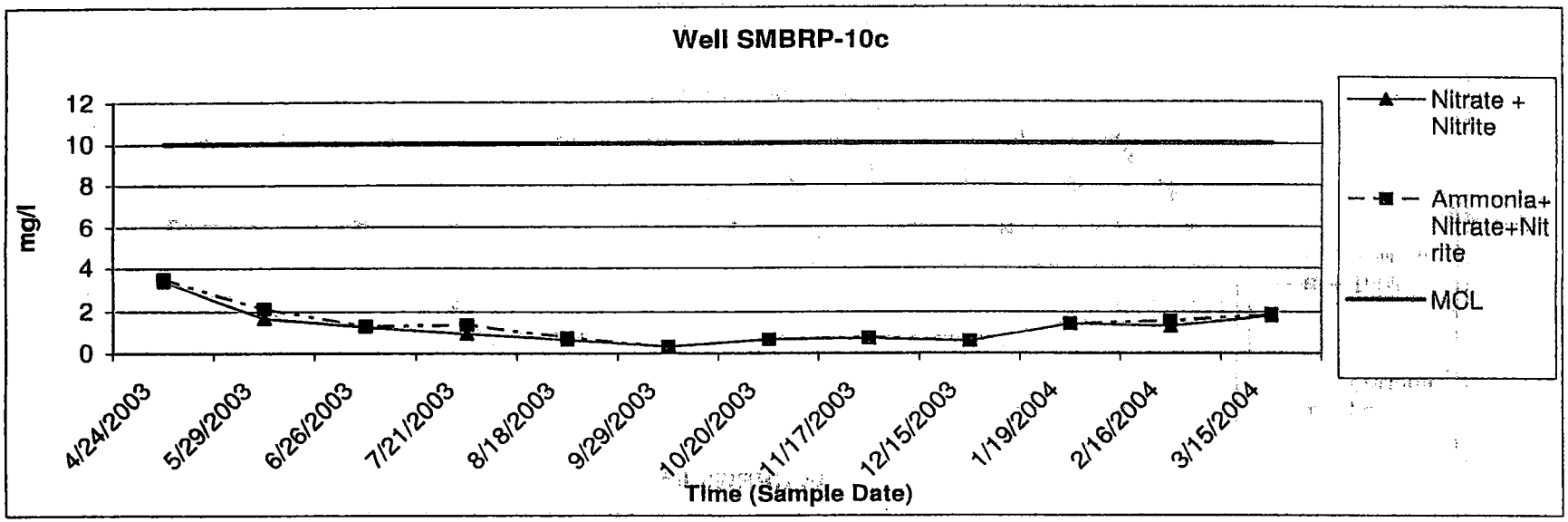
TM2-100

EXHIBIT 12
COASTAL COMMISSION
2009

TM2-101

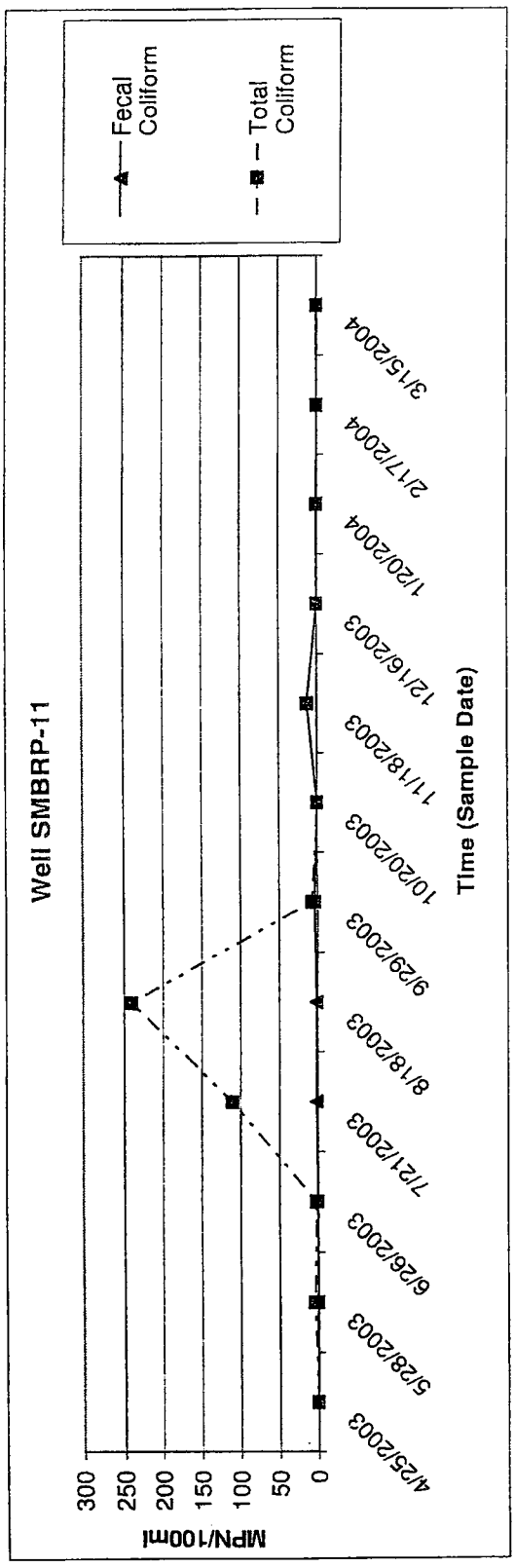
Malibu Civic Center Area

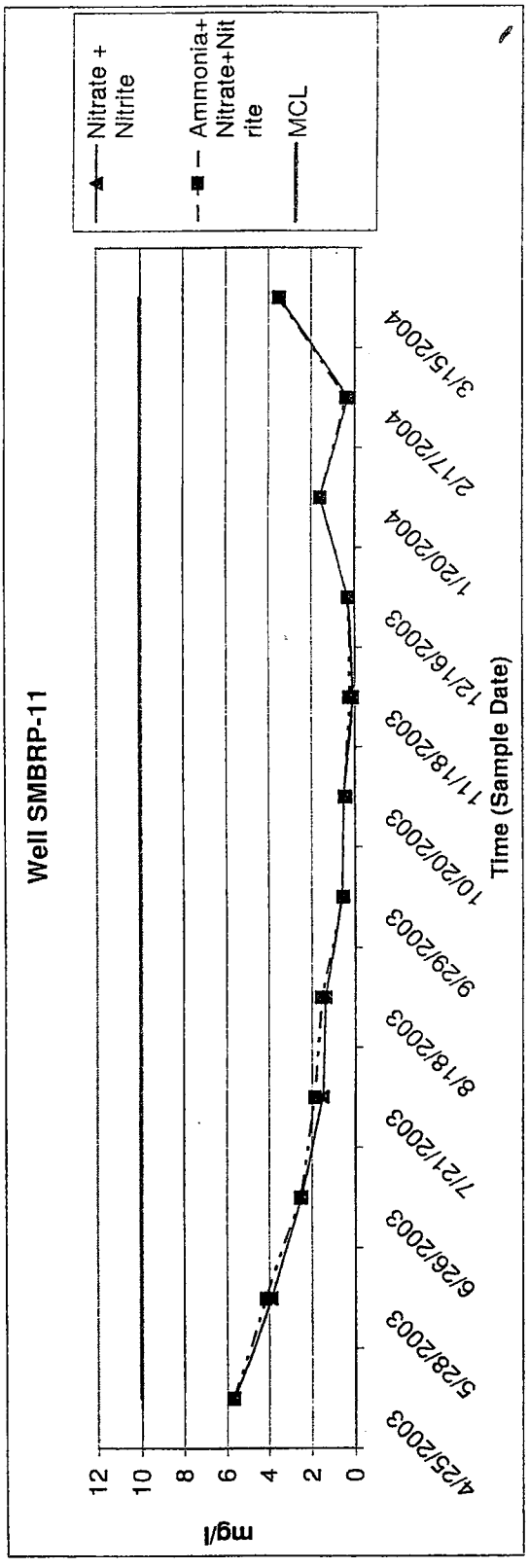




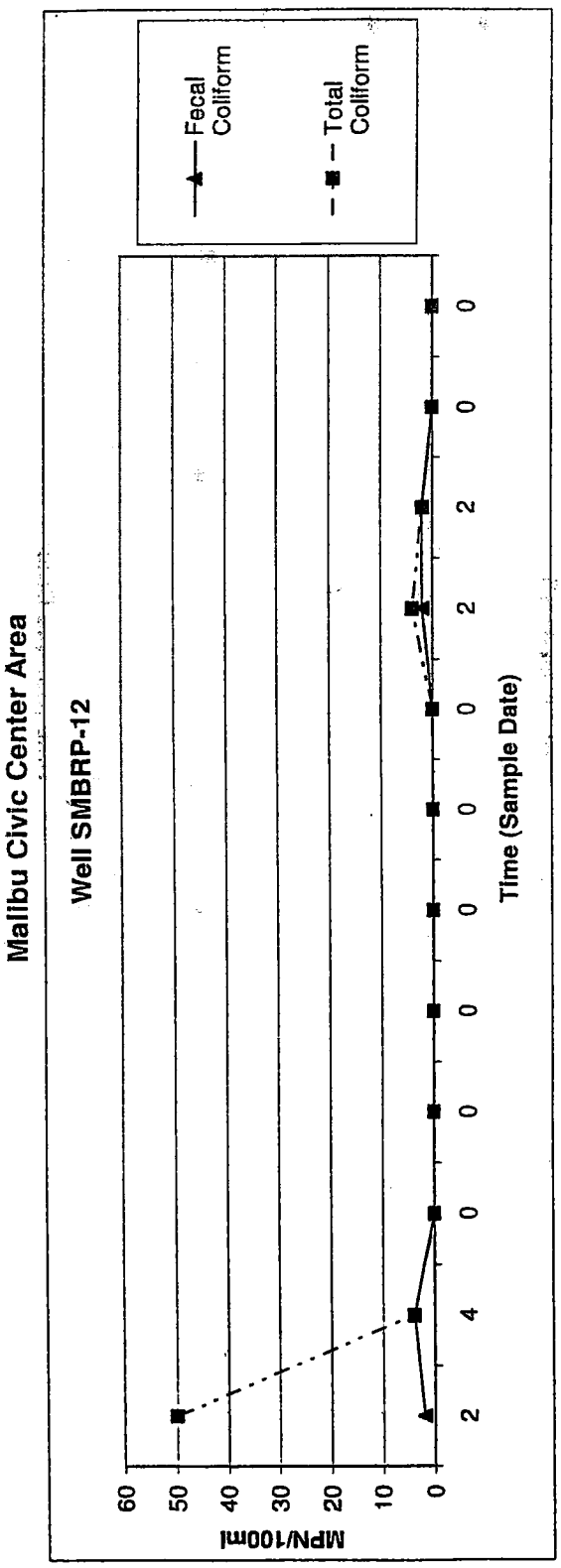
DRAFT OCT 21 2009

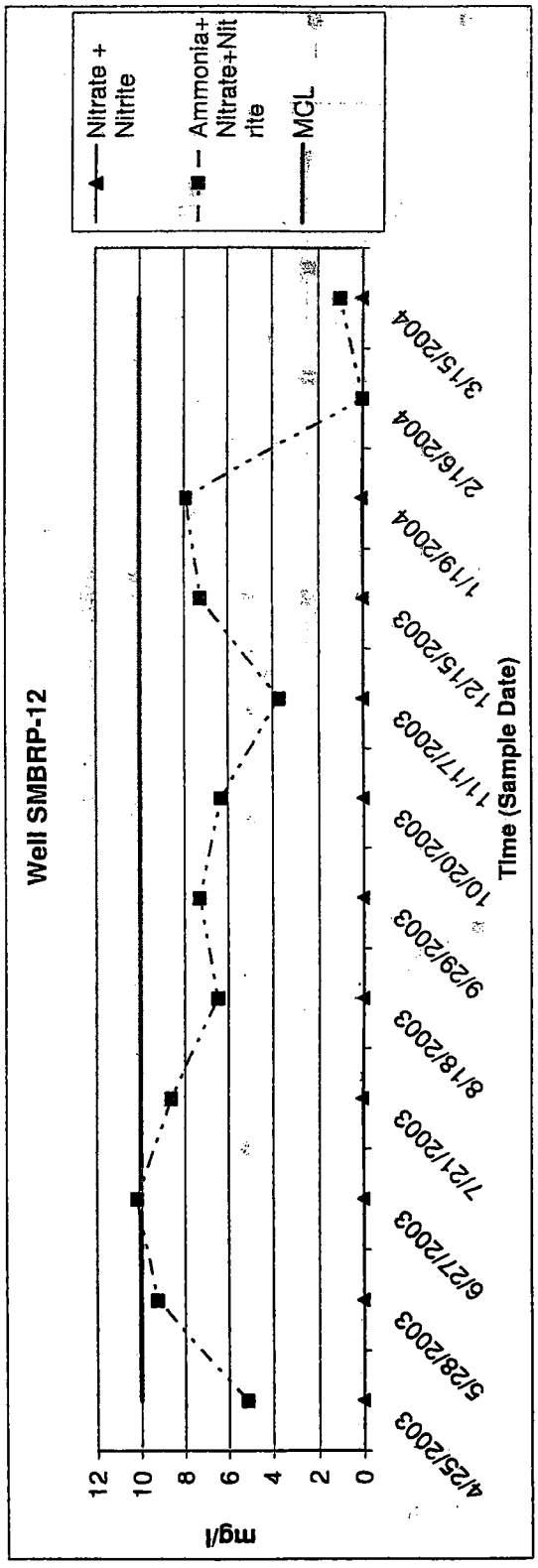
Malibu Civic Center Area



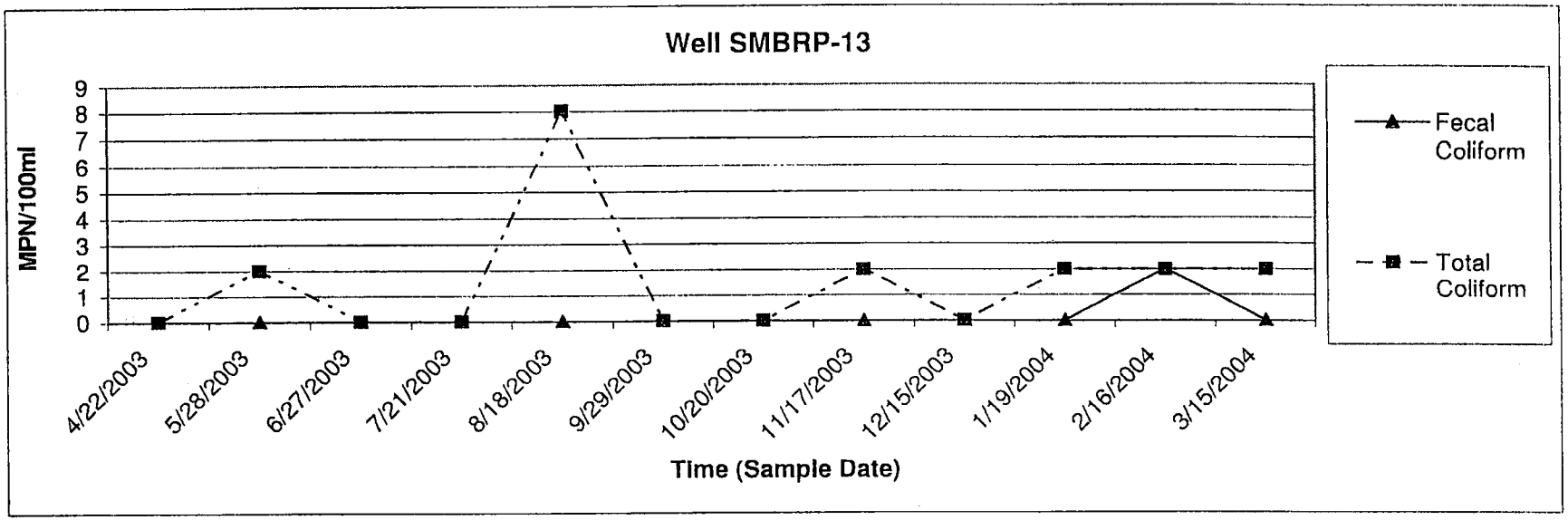


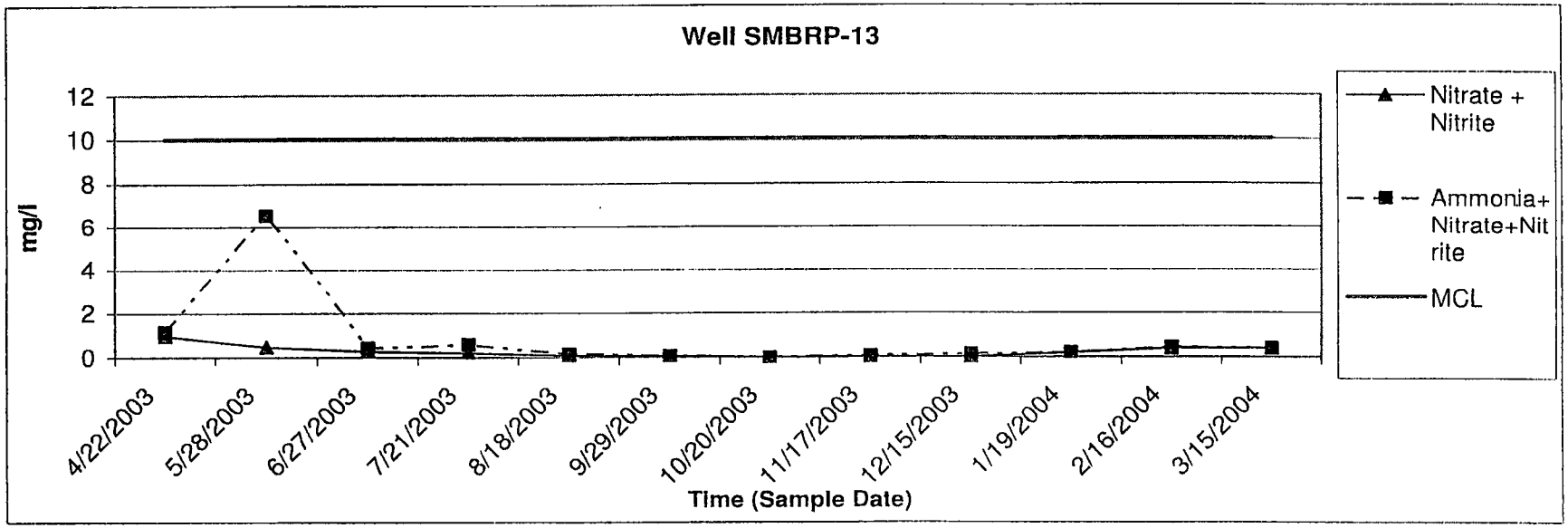
TM2-102


Malibu Civic Center Area
Well SMBRP-12
Fecal Coliform
Total Coliform
MPN/100ml
Time (Sample Date)


Well SMBRP-12
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL
mg/l
Time (Sample Date)

Malibu Civic Center Area





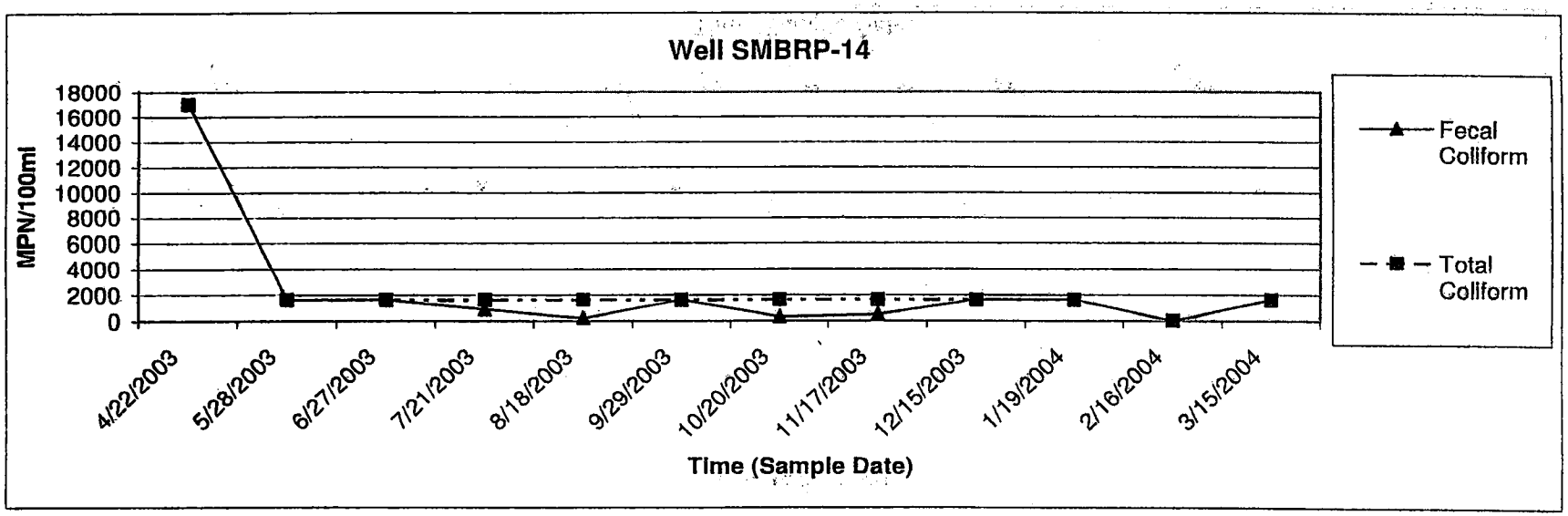
TM2-104

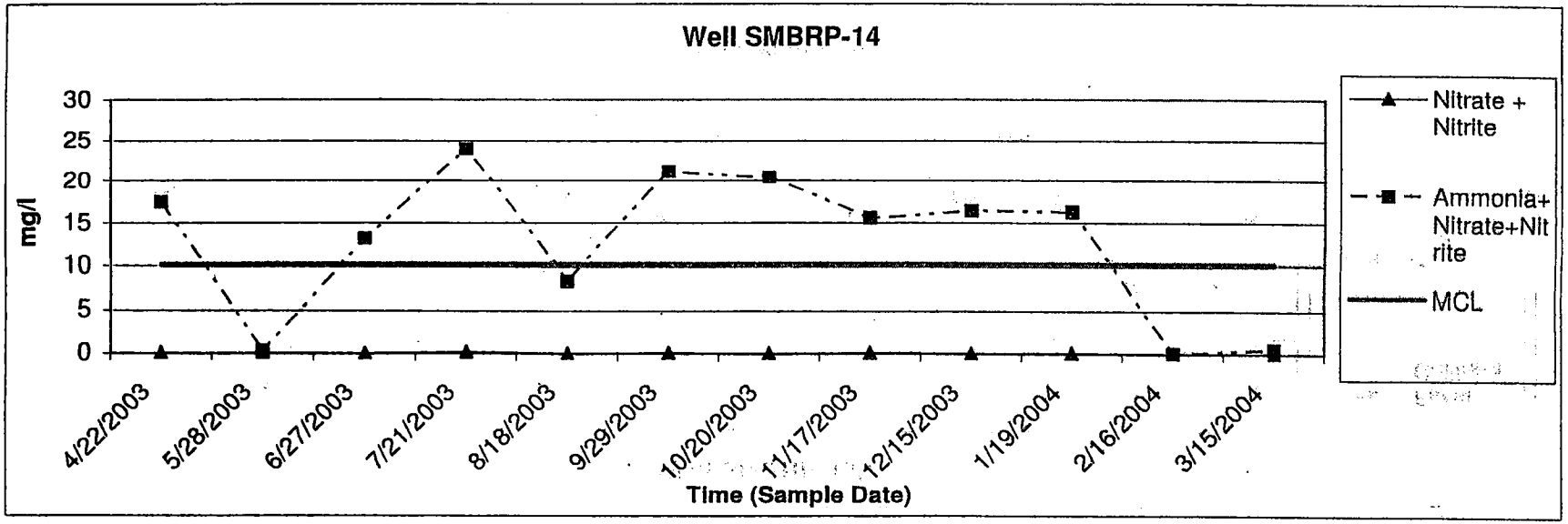
9 0 0 2 2 1 2 T C O T E A R D

3-841

TM2-105

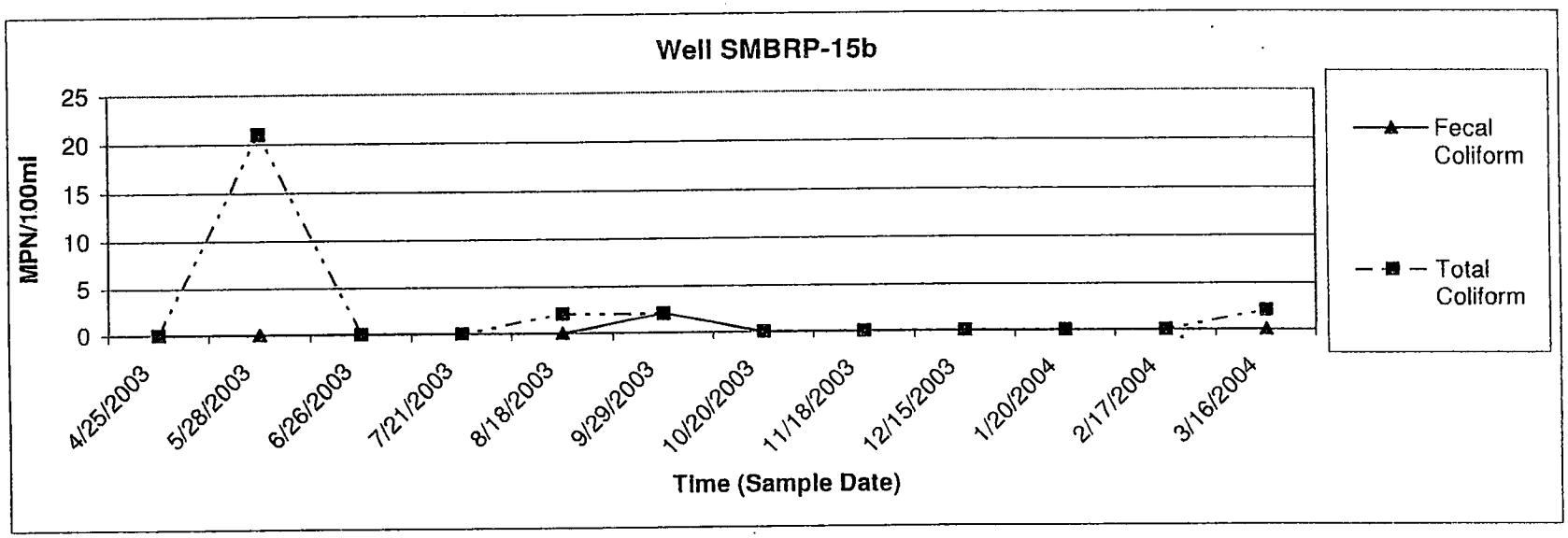
Malibu Civic Center Area

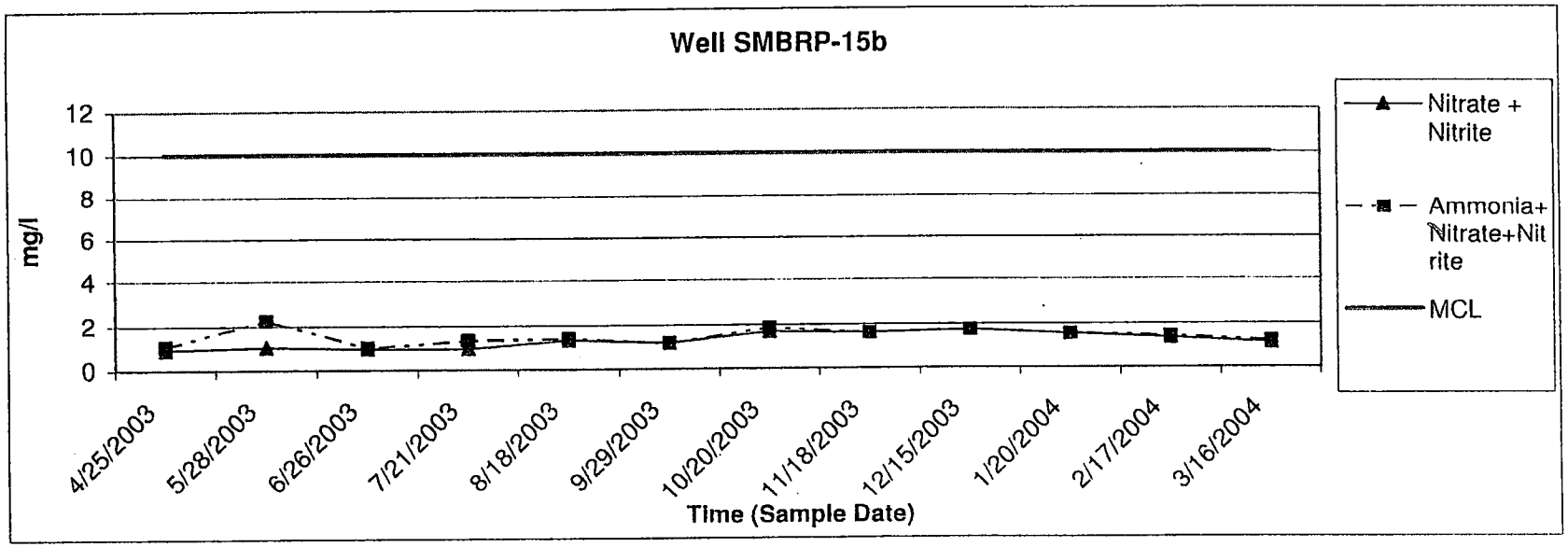




9 0 0 2 1 2 T C O T E A R D

Malibu Civic Center Area





3-812

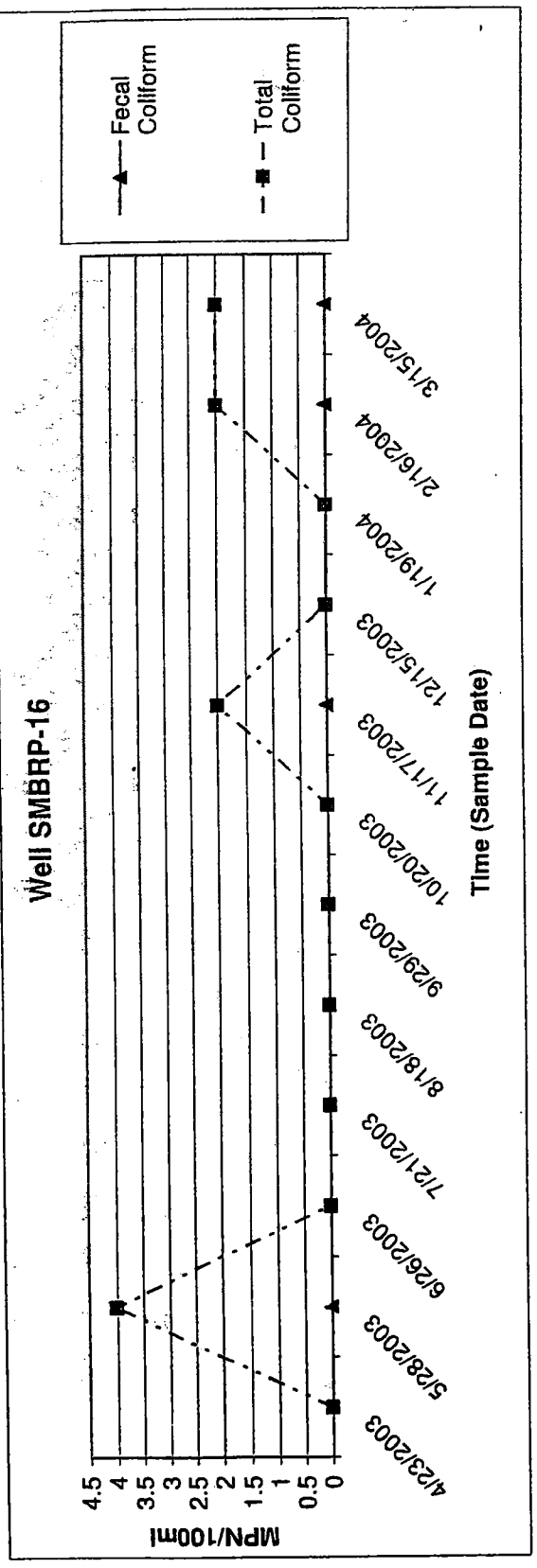
TM2-106

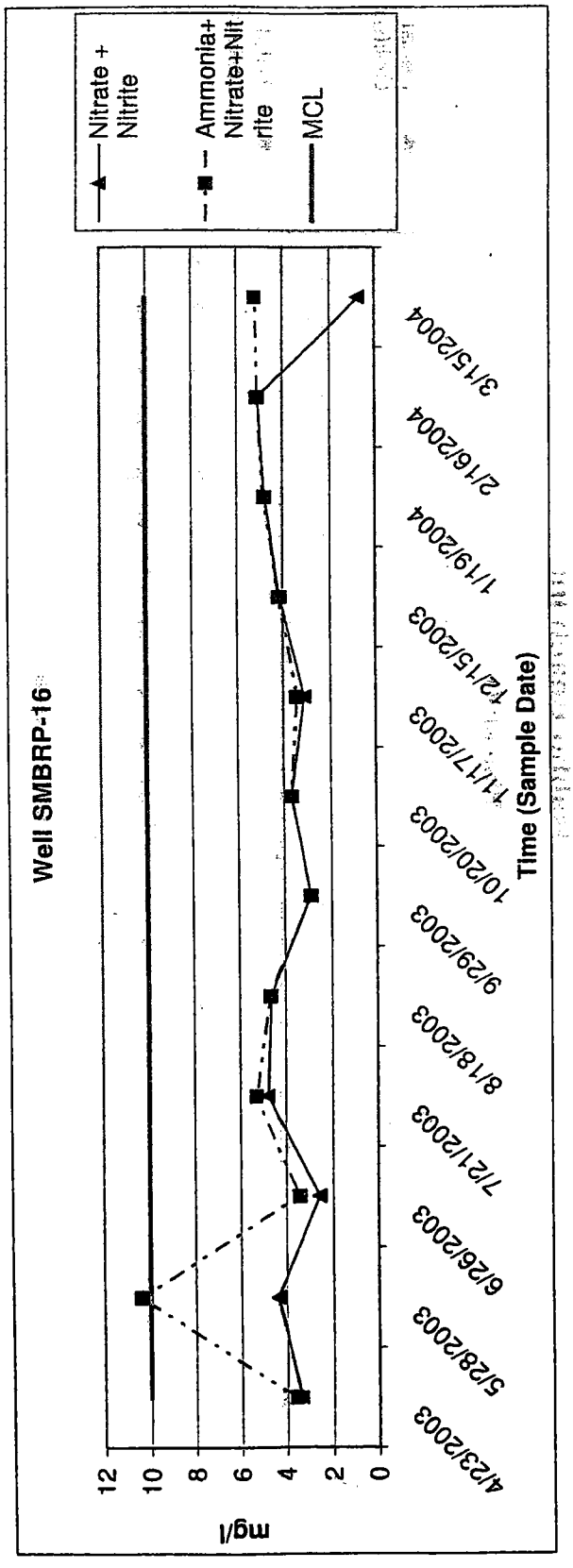
9 0 0 2 1 2 FEET

DRAFT

DRAFT OCT 21 2009

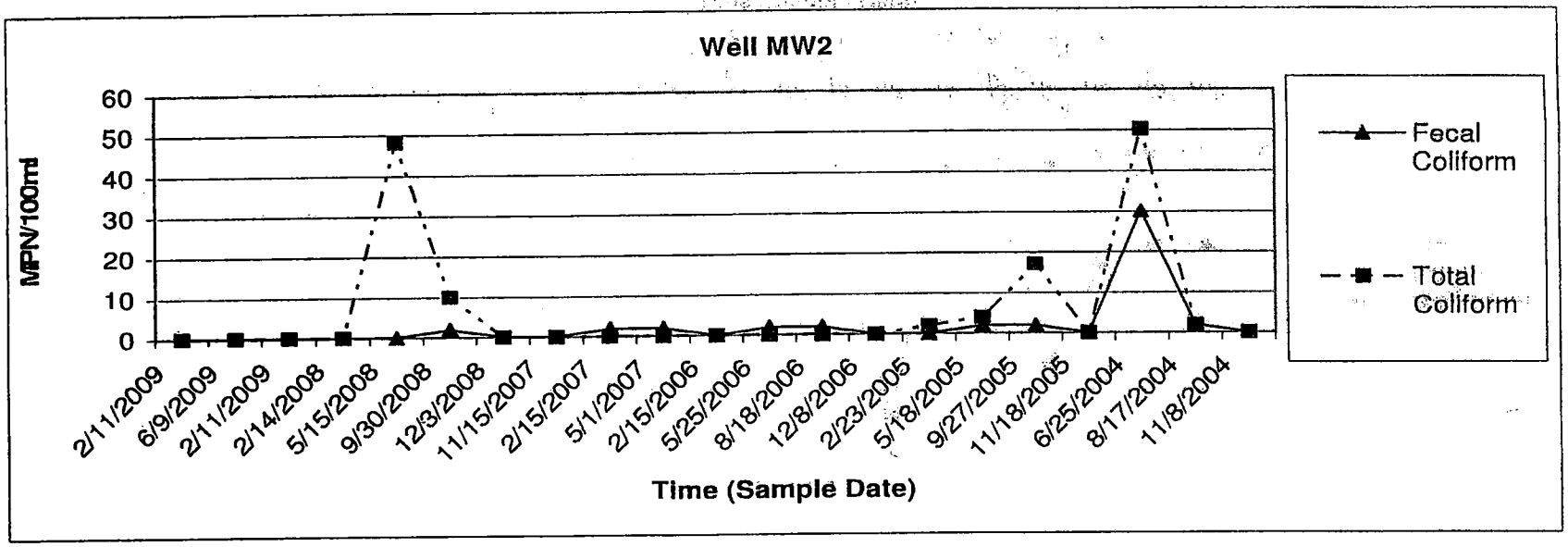
Malibu Civic Center Area

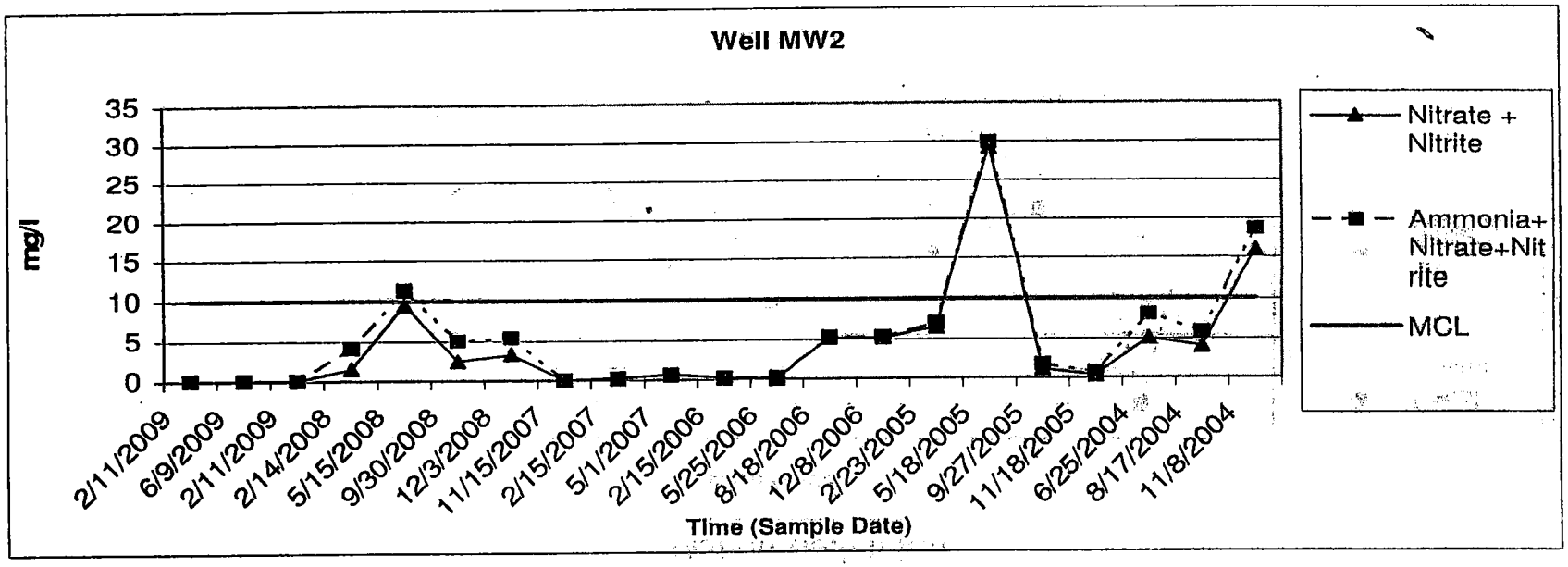




DRAFT OCT 2120 09

Malibu Beach Inn



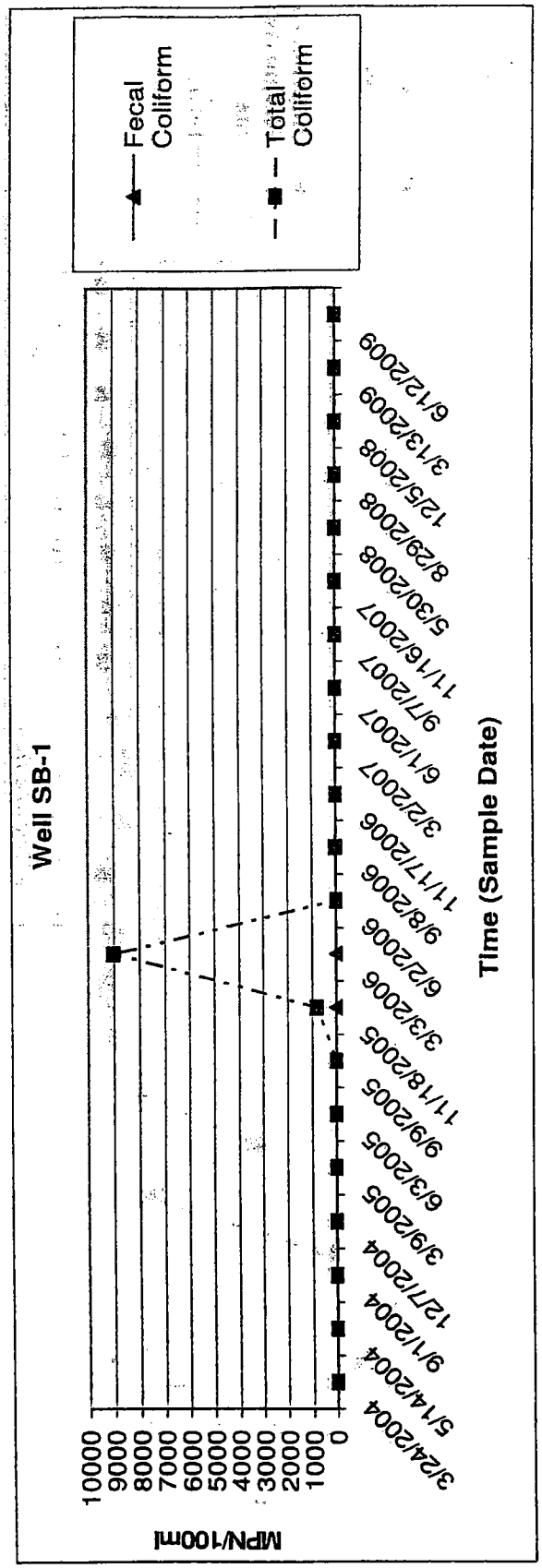


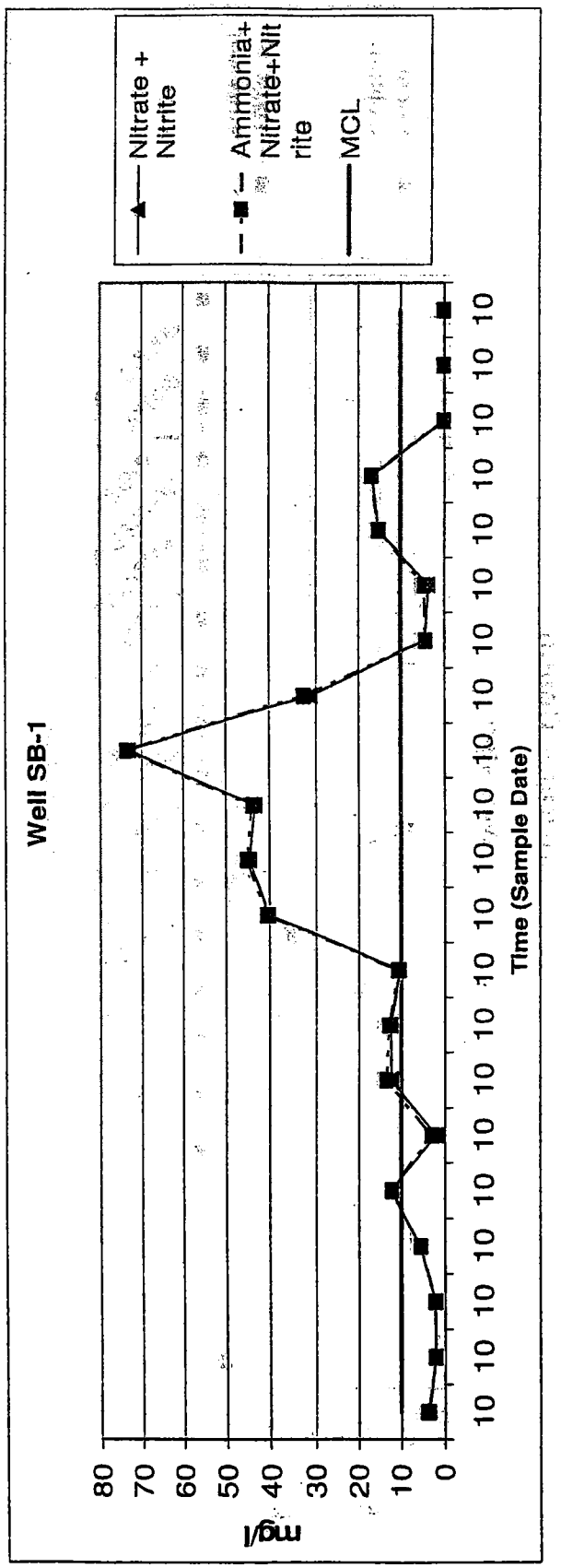
6 0 0 2 1 2 T C O T F A R D

DRAFT OCT 2 1 2009

TM2-110

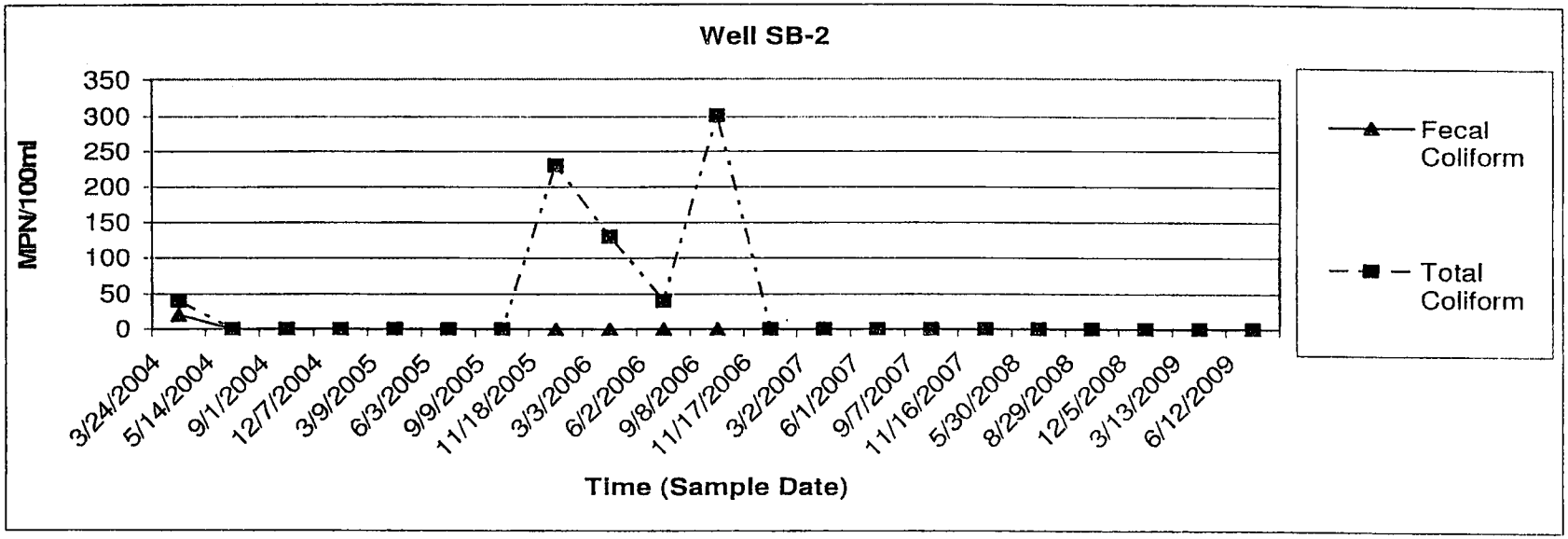
DRAFT OCT 21 2009

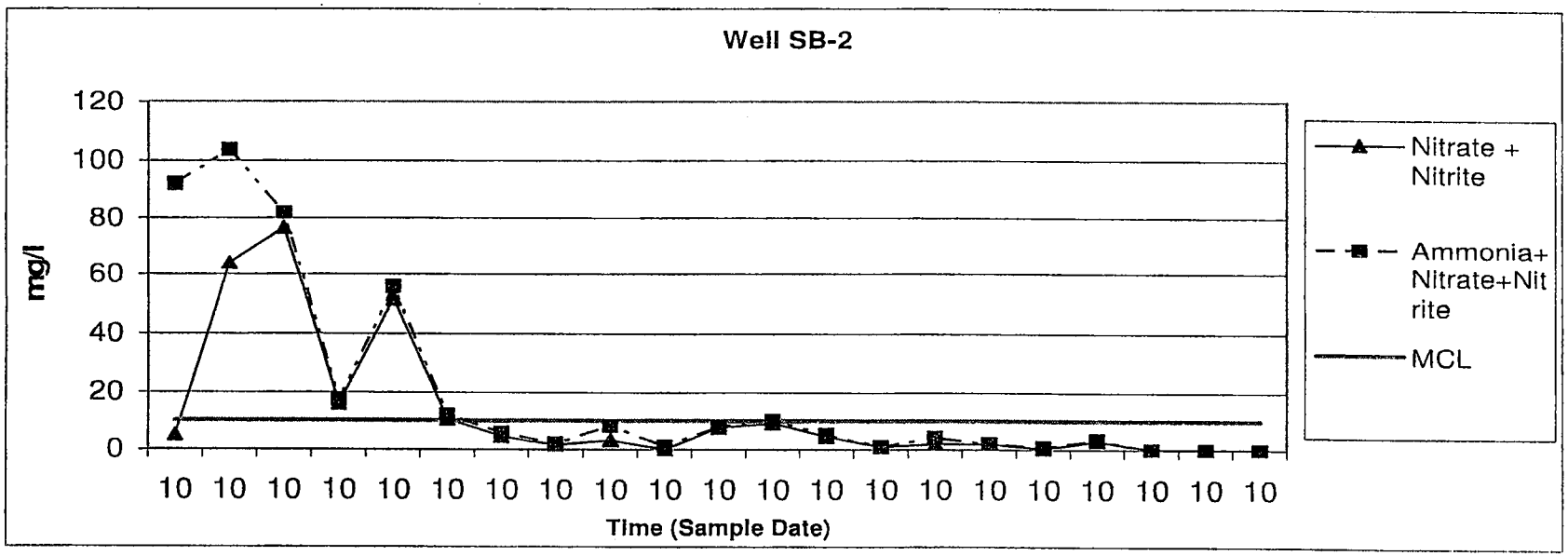




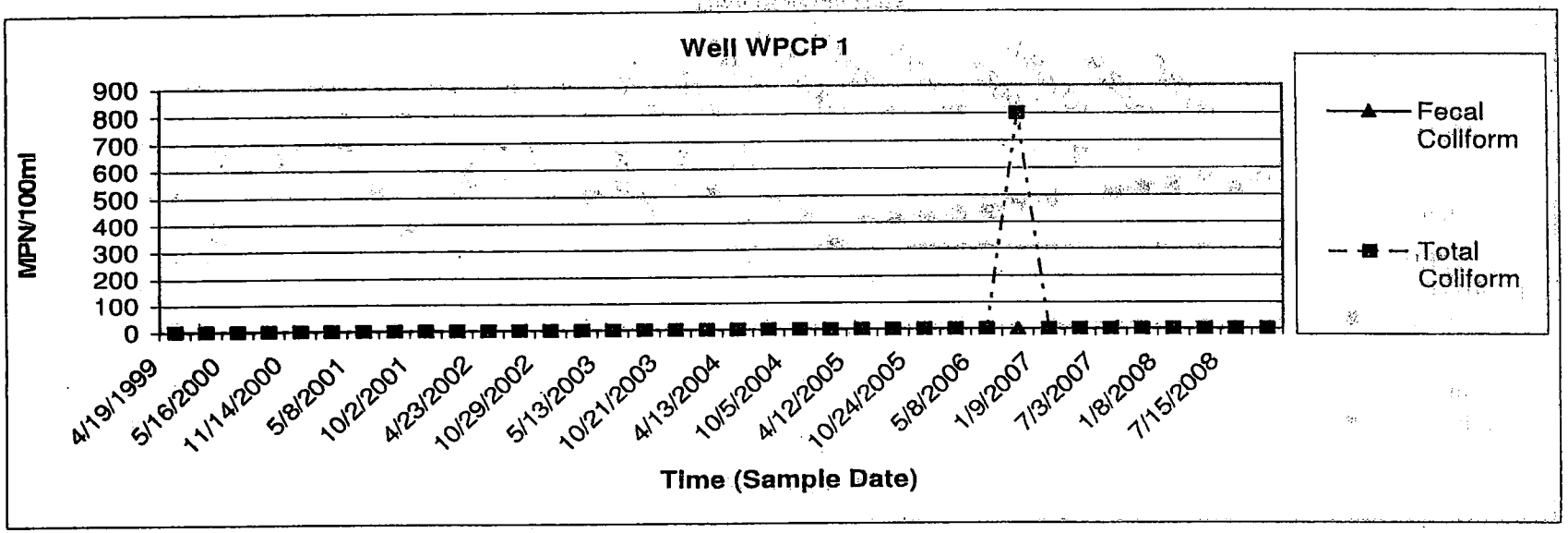
TM2-111

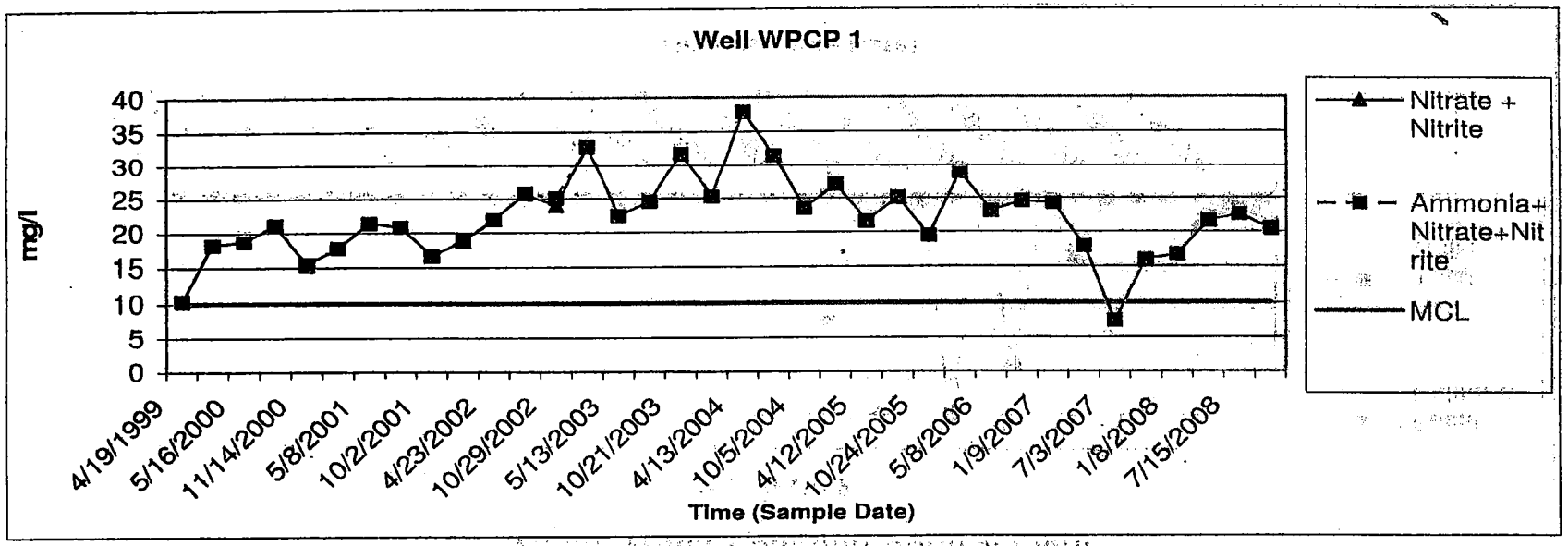
Surfrider Beach





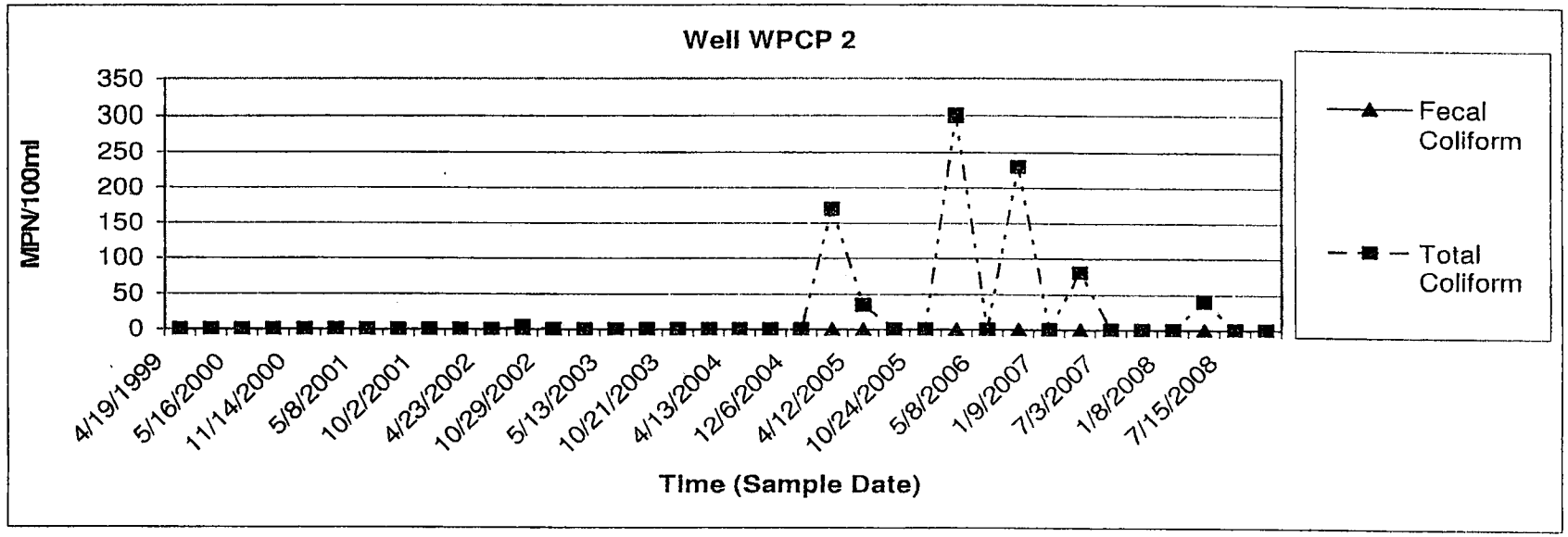
Malibu Water Pollution Control Plant

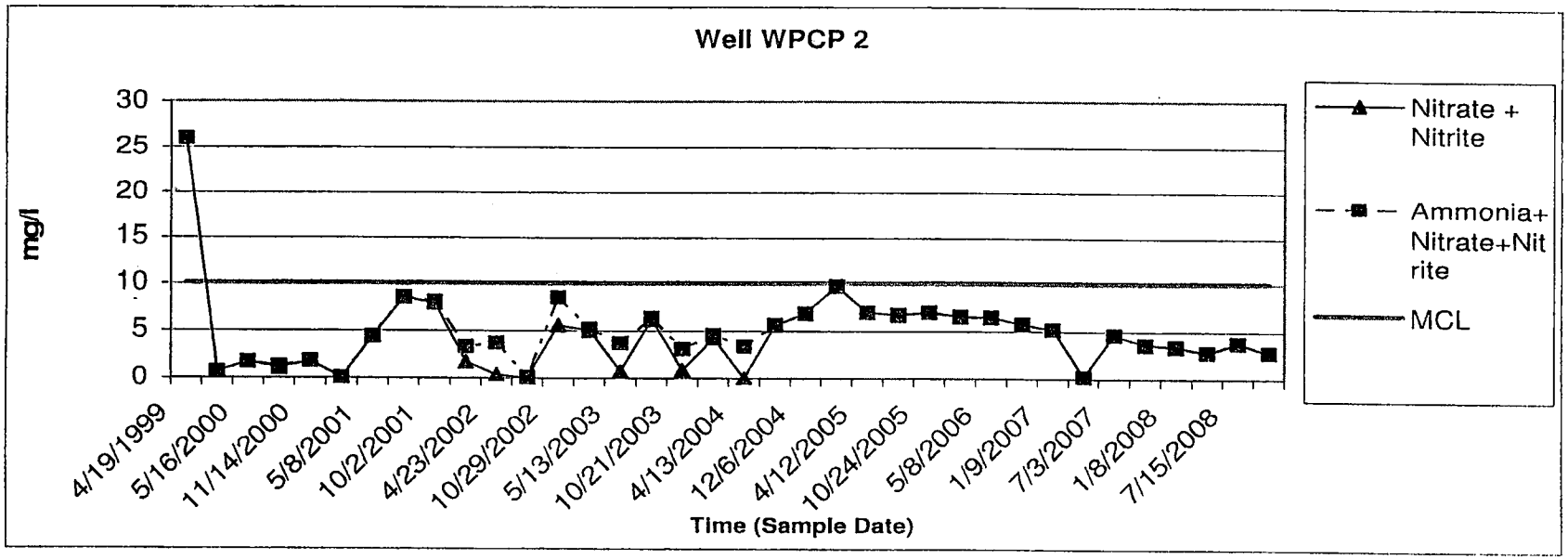




6 0 0 2 1 2 T C O T E A R D

Malibu Water Pollution Control Plant



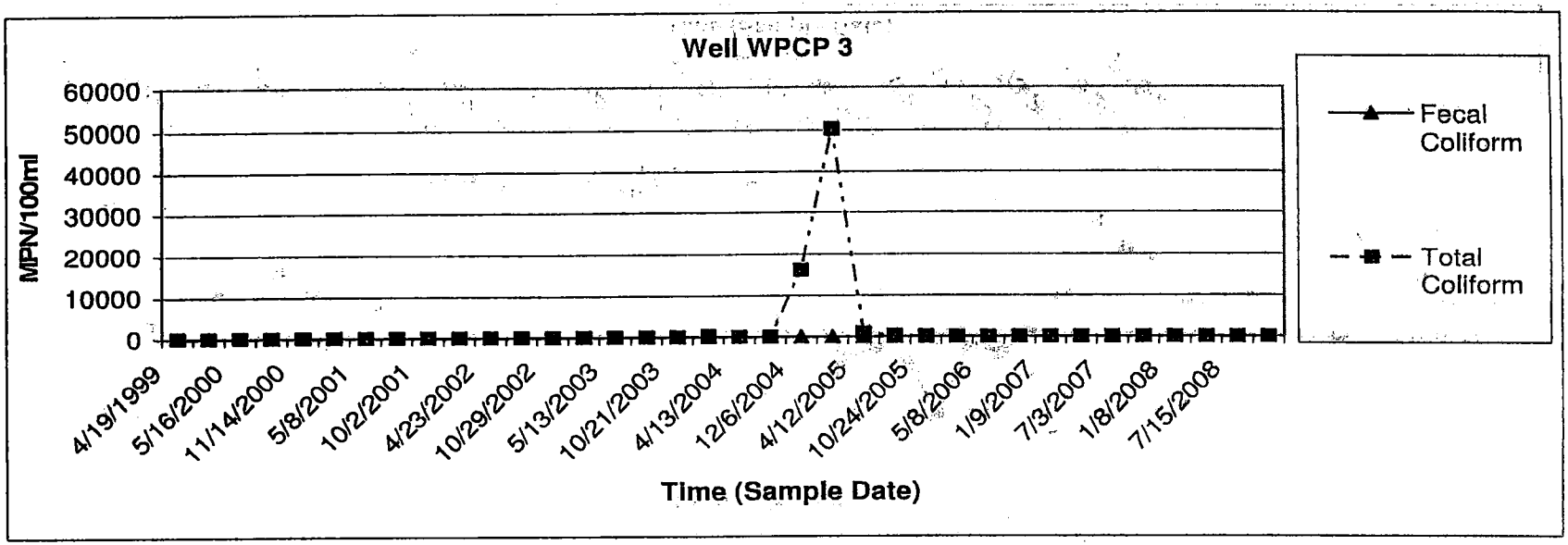


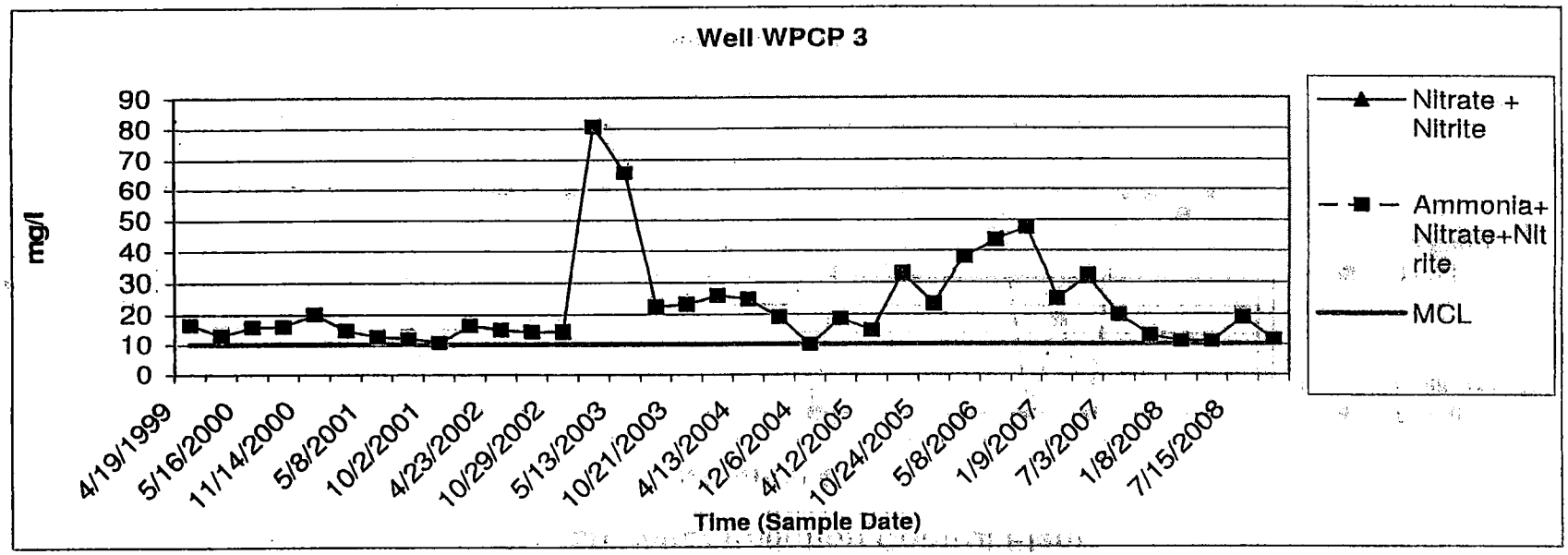
6 0 0 2 2 1 2 FEB 0 7 DATE

3-851

TM2-115

Malibu Water Pollution Control Plant



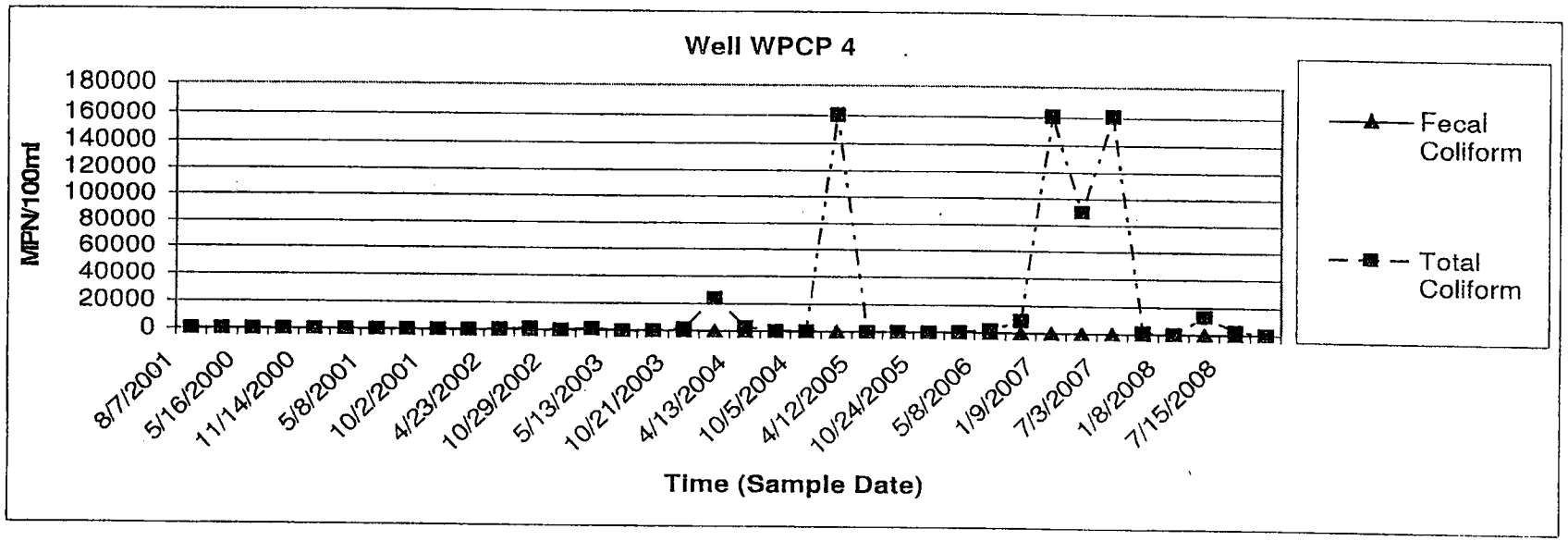


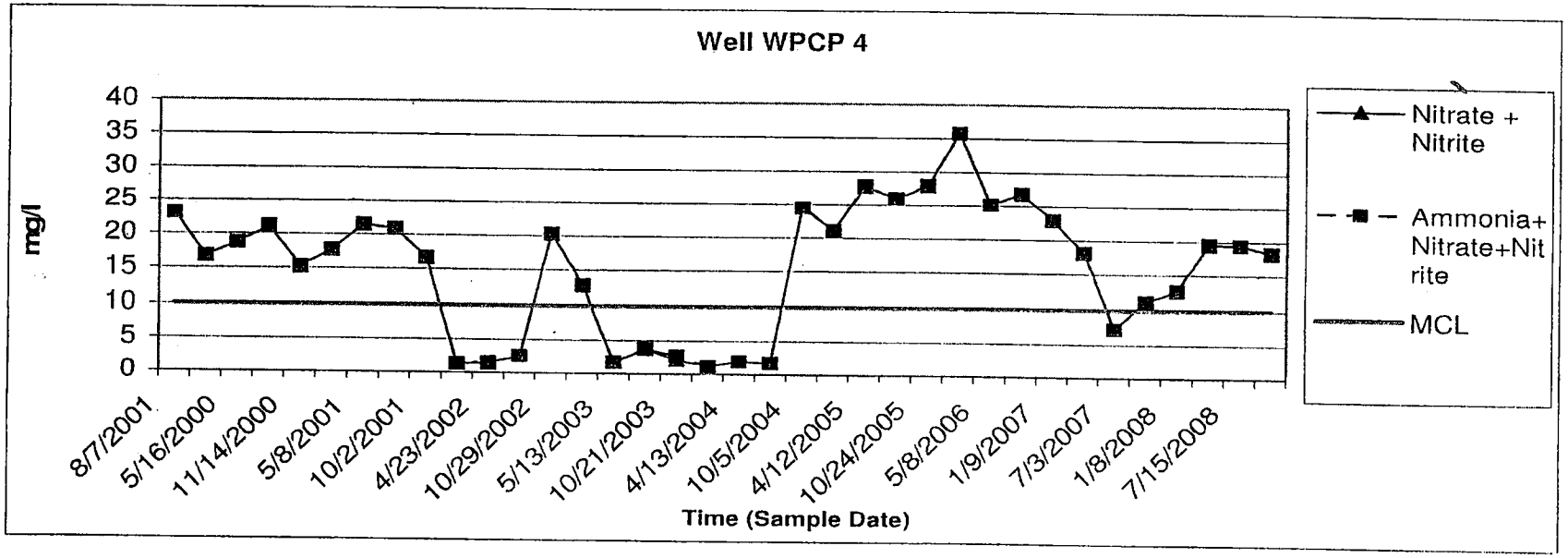
6 0 0 2 2 1 2 T C O T E A R D

3-852

TM2-116

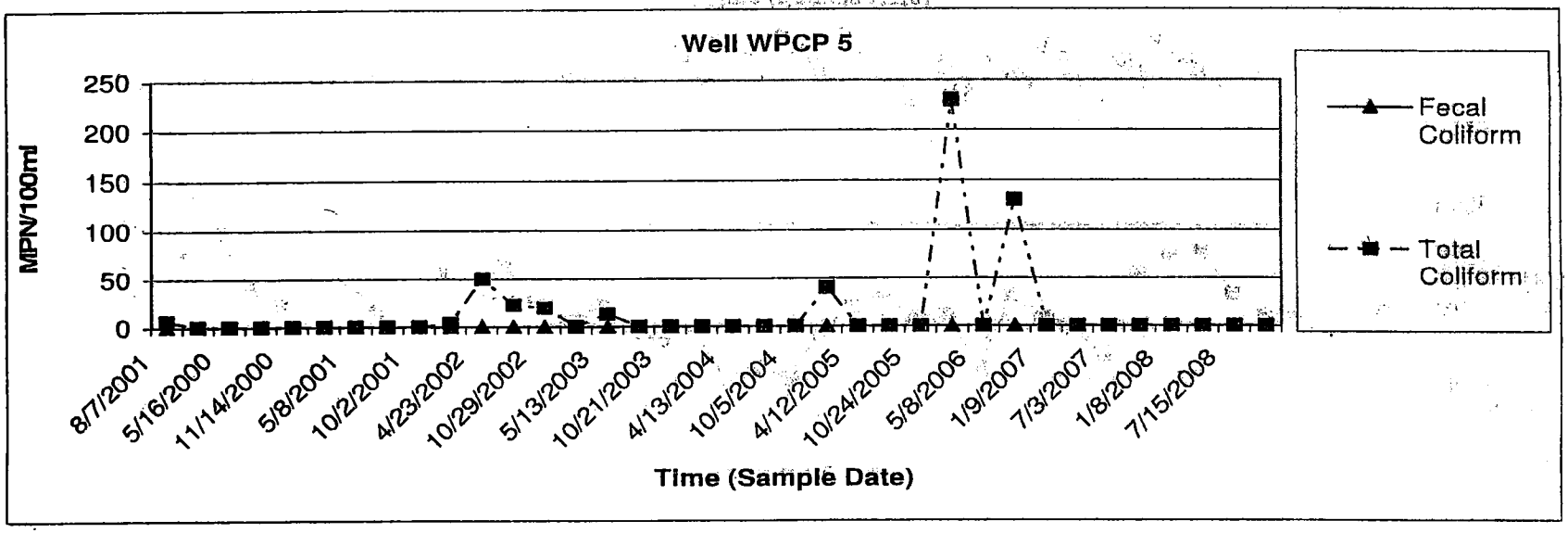
Malibu Water Pollution Control Plant

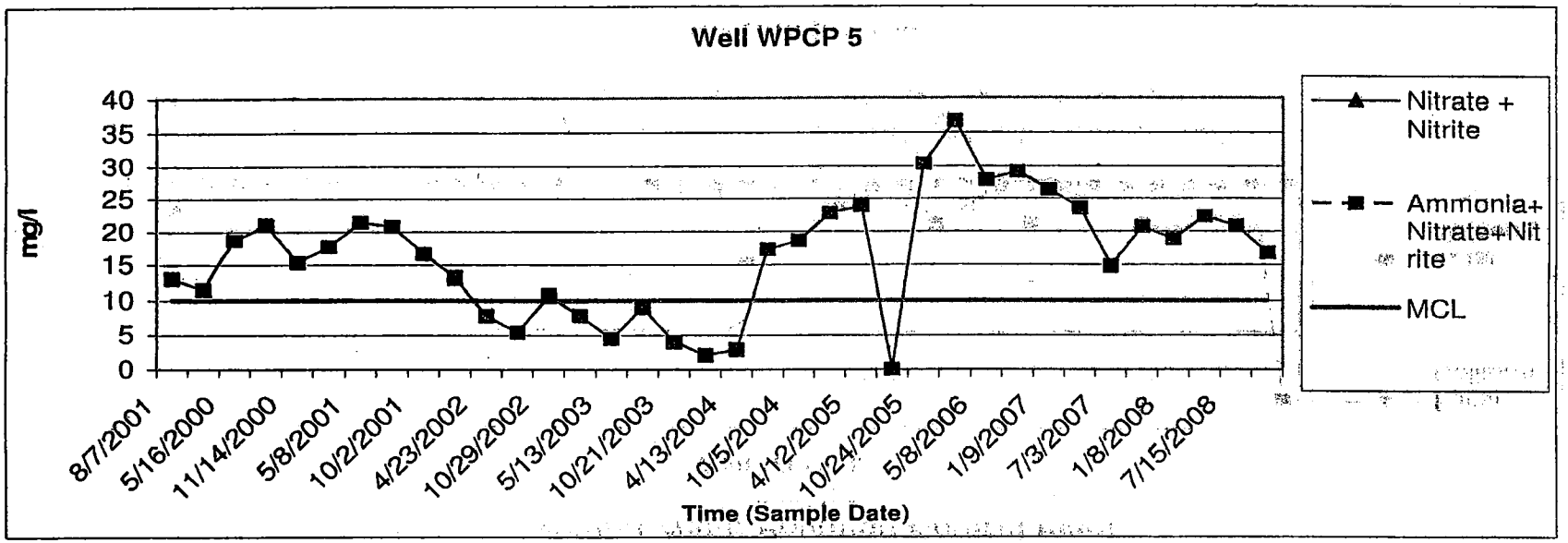




RECEIVED
2012
09

Malibu Water Pollution Control Plant

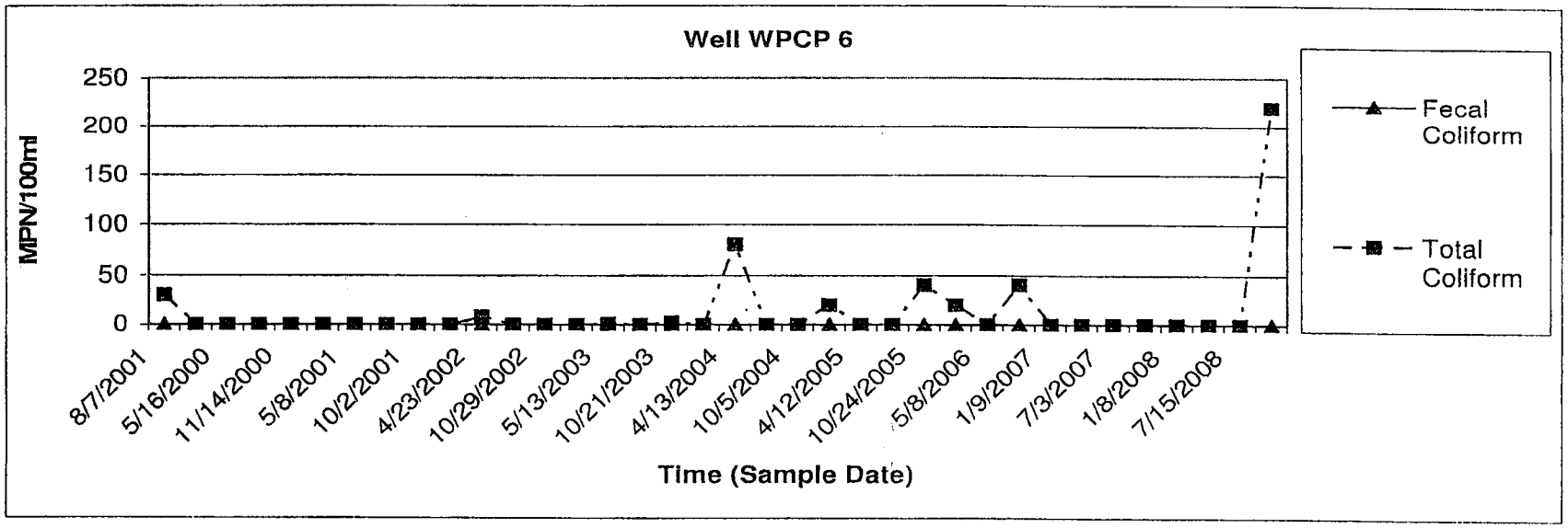


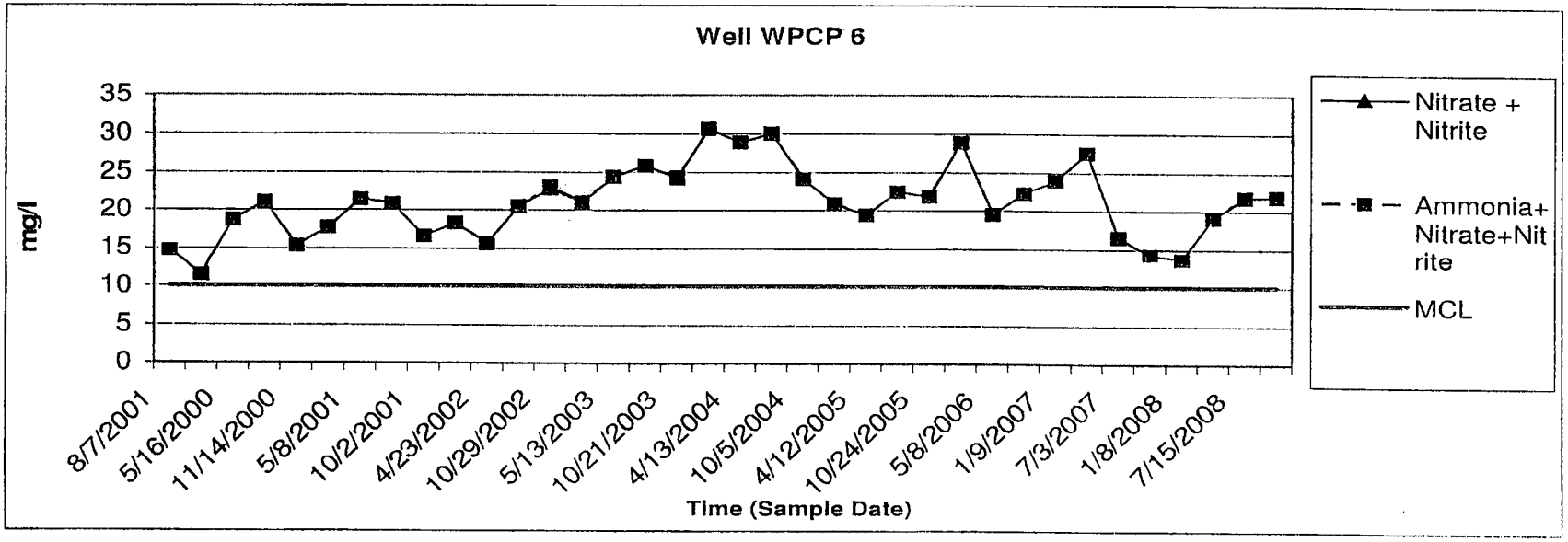


3-854

TM2-118

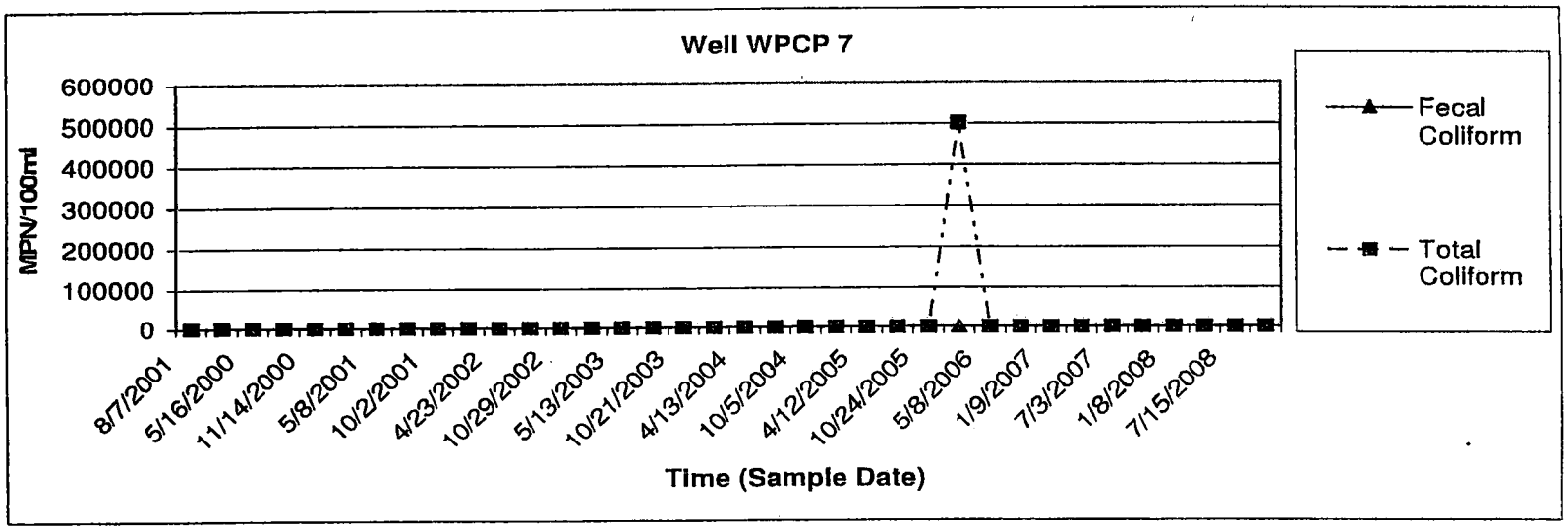
Malibu Water Pollution Control Plant

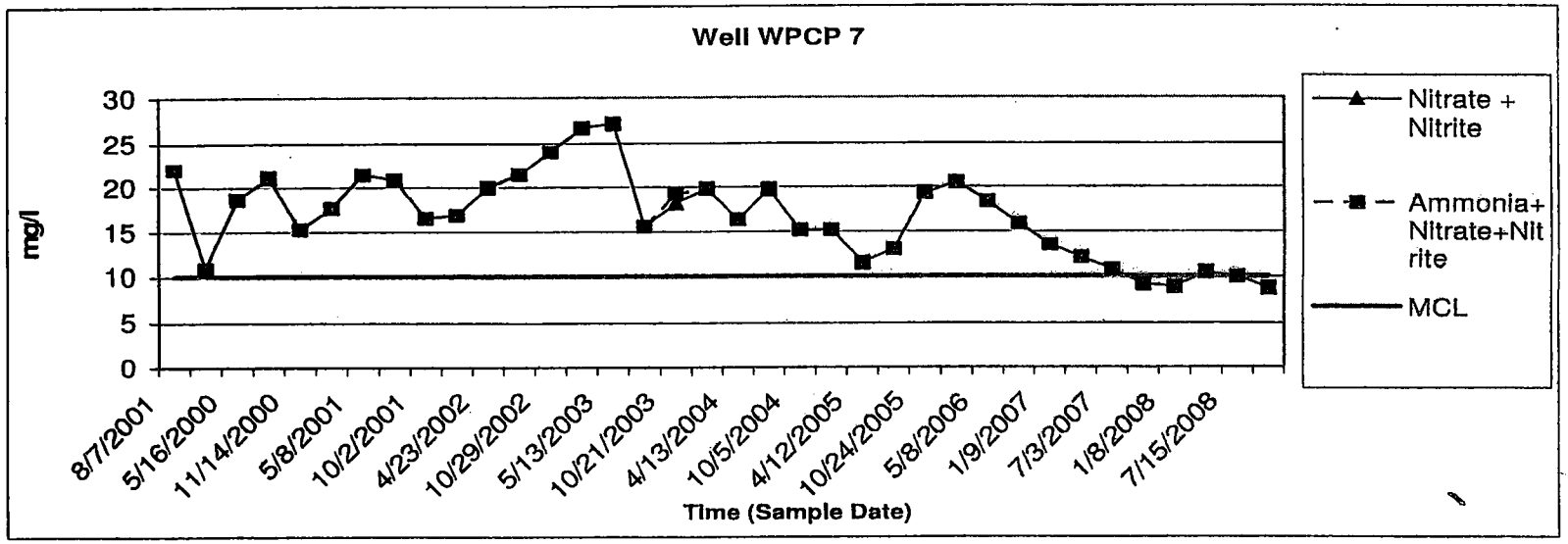




DEARTH COUNTY 2012 2009

Malibu Water Pollution Control Plant





RECEIVED 12 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #3: *Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation*

By
Elizabeth Erickson,* Professional Geologist
Groundwater Permitting Unit

* *The author would like to thank Regional Board staff, Joe Luera and interns Albert Chu, Shentong Lu, Shannon Liou, Justin Tang, Tessa Nielsen, Ben Leu, Holly MacGillivray, Thomas Palmieri, Ryan Thatcher and Yifei Tong for their assistance in preparing map, tables and graphs.*

REVISED OCT 21 2009

Technical Memorandum #3: ***Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation***[1]

By
Elizabeth Erickson, Professional Geologist
Groundwater Permitting Unit

REVISED OCT 21 2009

1. Purpose

The purpose of the memorandum is (a) to document the discharge of enterococcus, total coliform and fecal coliform, bacteria used to indicate risk of recreational waterborne illness, from on-site wastewater disposal systems (OWDS) in the Malibu Civic Center onto adjacent surface waters and beaches, and (b) to determine human health impacts on beach users from exposure to pathogens given observed levels of enterococcus in beach water.

2. Study Design and Data

The study sought to examine the distribution of bacteria in groundwater beneath the Malibu Civic Center area and surface water around Malibu Civic Center area. Fecal-indicator-bacteria are quantified in OWDS discharge, in leachfields/seepage pits, in groundwater, and in streams and beaches. OWDS performance data from permitted commercial facilities, groundwater monitoring data and beach monitoring data at the Malibu Civic Center are studied for the presence of enterococcus bacteria, which can originate in the human gut, have been used as indicators of pathogens, and are the basis of marine recreational criteria for the protection of human health.

Of the twenty permitted commercial facilities in the Malibu Civic Center under the Regional Water Quality Control Board's (Regional Board) oversight, four provided end-of-pipe measures and ten submitted groundwater monitoring results. End-of-pipe discharge reports from permitted systems document effluent quality as it enters the leachfield/seepage pit. Enterococcus densities were also examined in groundwater monitoring wells surrounding the leachfields.

The City of Malibu measures groundwater quality periodically throughout the Malibu Valley Basin which receives the effluent from the OWDS in the Malibu Civic Center area The groundwater monitoring of 20 such wells in the Malibu Civic Center area completed by the City of Malibu in 2004 and summarized by Stone Environmental, Inc. (Stone, 2004) are used for this study.

---

[1] The area subject to the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1). The area was defined using topographic features and drainage patterns, and encompasses the hydrologic areas of Malibu Valley (also referred to as the lower Malibu Creek watershed), Winter Canyon, and adjacent coastal strips including Amarillo Beach, Malibu Beach, Malibu Lagoon, and Malibu Lagoon Beach (aka Surfrider Beach, including First, Second, and Third Points at Surfrider). For more discussion on the prohibition boundaries defining the Malibu Civic Center area, refer to the Technical Staff Report Overview and the Environmental Staff Report.

Beach data collected as part of the Coordinated Shoreline Monitoring Plan for Santa Monica Bay beaches were used for this study. The "Santa Monica Bay Beaches Bacteria Total Maximum Daily Load Coordinated Shoreline Monitoring Plan, April 7, 2004" (CSMP) went into effect on April 28, 2004. The sites cover 44 beaches that were identified as impaired due to high fecal-indicator-bacteria and/or beach closures and therefore placed on the California Clean Water Act 2002 section 303(d) list. Detailed descriptions of standardized sampling and testing procedures can be found at http://ladpw.org/wmd/npdes/beachplan.cfm. Attachment 3-A contains a complete list of the beaches in the CSMP.

The study sought to determine if enterococcus bacteria were present continuously along likely hydrological transport paths, such as those documented for the Civic Center area or at other beaches described in the literature, from the OWDSs in the Civic Center area to the adjacent beaches. Beach enterococcus densities, and their frequency distributions, were compared to variables such as watershed size, urban acreage, beach visitor population, wave strength, setting such as lagoon or estuary, number of roofs seen on air photo (where indicative of a septic system), preceding winter weather as rainfall, and annual variation, to identify correlations with the highest Pearson's Correlation coefficients. Although the study design does not eliminate all possible alternative bacteria sources, it focused on bacteria delivered to the beach via groundwater by examining the beaches during the summer months (May to the end of October) when other bacteria sources, such stormwater and overland urban runoff, are known to be at a minimum. Further, examining bacteria during storm-free dry conditions minimizes other transport mechanisms, such as rainfall or heavy wave action, which could move bacteria onto the beach face.

Compilations of the data reviewed have been provided for public review. Over 8000 records collected for CSMP were compiled and released with a summary of the beach characteristics on August 24, 2009 on the Regional Water Quality Control Board Website www.waterboards.swrcb/los angeles. Among these records, the Civic Center beaches sampled by CSMP are Malibu Colony Beach labeled as MC-1, Malibu Surfrider Beach labeled as MC-2, and the beach near Malibu Pier Beach labeled as MC-3. Sweetwater Canyon at Carbon Beach, labeled as SMB 1-13, is the Civic Center beach which lies furthest to the southeast. Marie Canyon, labeled as SMB 1-12, is the beach which lies furthest to the northwest and just outside the Malibu Civic Center Prohibition area. Attachment 3-B contains an expanded reference list including those documents cited here. Attachment 3-C contains a list of selected correlation coefficients between the Civic Center Beaches.

Early Technical Review

An Early Technical Review (ETR) of this work was conducted between June 8, 2009, and the public release of this document. The ETR resulted in recommendations from the reviewers (a) to enhance the confidence of the conclusions using statistics, (b) to recommend additional studies to confirm and extend the results shown here, (c) to emphasize the complexity of the subsurface hydraulic and microbiological environment between OWDS discharge and the ocean, and (d) to verify the relationship between human illness from marine recreational activities and coastal OWDS use. In response to these comments, additional statistical results were generated and human health risks estimates were based on a site-specific study. The Early Technical Reviewers were Dr. Mark Gold (Heal the Bay), Mr. Steve Weisberg and Dr. John Griffith (Southern California Coastal Water Research Project or SCCWRP), Dr. Alexandria Boehm

REVISED OCT 2 1 2 0 0 9

(Stanford University) and Dr. John Izbicki (US Geological Survey). all of whom have completed research on microbial water quality at beaches.

Peer Review

Independent Peer Review was also conducted through a contract with the University of California at Berkeley and the State Water Resources Control Board, with the comments and response to comments released to the public and considered with this document by the Regional Board.

Integration with Ongoing Studies

An epidemiology study of Surfrider Beach by SCCWRP is ongoing with fieldwork conducted during the summer of 2009. Groundwater assessment was conducted during a ten-day period in July 2009 by Dr. John Izbicki of the USGS. The City of Malibu reports that Richard Ambrose and Jenny Jay of UCLA conducted a study of *Bacteroides* in Malibu Lagoon in 2009. General descriptions of the ongoing studies are available from the Regional Board.

3. Results

Hydrological Connection

The existence of a hydrological connection between the beaches and the groundwater underlying the Malibu Civic Center area has been well established in existing literature, by groundwater models (Stone, 2005; Questa, 2003), by surface water models (Malibu Creek and Lagoon nutrient TMDL 2003; Malibu Creek and Lagoon bacteria TMDL, 2004), and as described in the 2004 Memorandum of Understanding between the City of Malibu and the Regional Board. The City of Malibu's ongoing hydrology study, as expressed in the planning documents provided to Board staff in September, 2008, seeks to quantify and model the groundwaters of the Civic Center and their hydrological connection with the ocean.

Enterococcus is found all along hydrological transport paths from the Onsite Wastewater Disposal Systems in the Civic Center Area to the beaches.

Bacteria in Groundwater

End-of-pipe bacteria measurements are reported for four permitted commercial sites in the Malibu Civic Center. Disinfection has failed in each example except Malibu Beach Inn. The enterococcus values are considered to be typical for non-disinfection systems like most residential OWDSs. A more complete description of the extent of enterococcus in the groundwater basin is included as part of Technical Memo #2.

REVISED OCT 21 2009

Table 1: End-of-Pipe Effluent Bacteria Densities (MPN/100mL) reported for permitted Malibu Civic Center Commercial Facilities where Disinfection has failed.

Site	Total	Fecal	Enterococcus
Malibu Creek Preservation	1,600	350	46
	1,600	140	110
Malibu Beach Inn[2]	Not measured	2	2
	Not measured	2	2
Malibu Colony Plaza	105	2	2
	4,000	2	2
	1,600	1,600	2,419
	1,600	1,600	2,419
Fire Station 88	1,600	1,600	2,419
	9,000	Not available	90,000
	24,000	24,000	24,000
	30,000	2,400	50,000
	240,000	Not available	240,000
	300,000	50,000	1,600,000

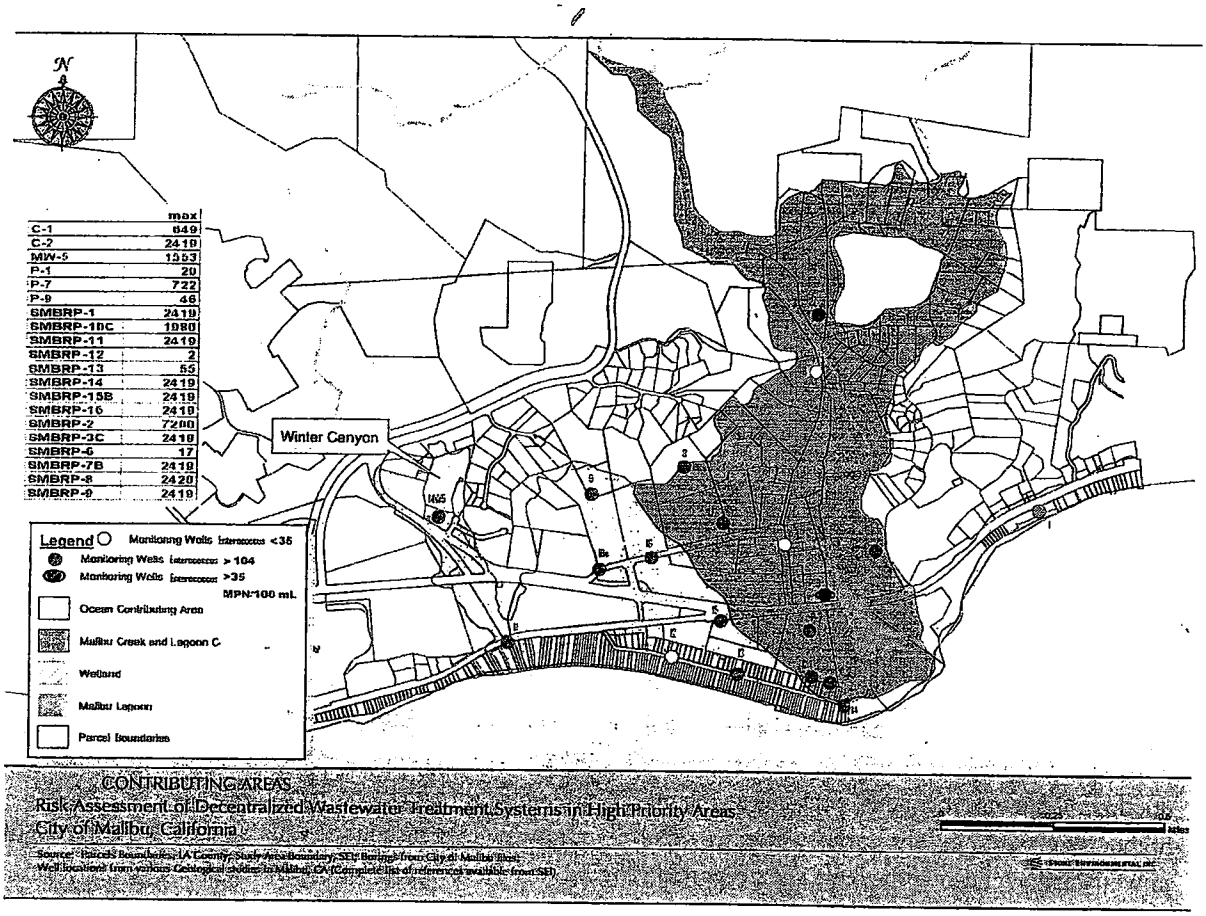
Shaded measures on the chart show where fecal-indicator-bacteria values are above the water quality objectives for protection of body contact recreation (REC-1)). The end-of-pipe data were provided to document that enterococcus is discharged from OWDSs into groundwater. Staff notes the values are higher than 'average' enterococcus ranges reported in raw sewage or natural waters. Enterococcus values in wells and at end-of-pipe have been reported ranging to 1 X 10^8, suggesting that high values are not computational, sampling or reporting errors.

Elevated bacteria levels were found throughout the Malibu Valley groundwater basin, which underlies the Malibu Civic Center area, and are also reported in 2004 by Stone Environmental's "Final Report-Risk Assessment of Decentralized Wastewater Disposal Systems in High Priority Areas in the City of Malibu, CA". Figure 1 shows the locations of monitoring wells in Stone's study. Elevated subsurface enterococcus densities are seen adjacent to the receiving waters. Fifteen out of 20 City wells, and 16 out of 27 permit monitoring wells, located at the edge of leachfields, contained a maximum enterococcus density exceeding the single sample maximum water quality objective of 104 MPN/100ml for protection of the beneficial use of REC-1, i.e., 31 out of the total 47 wells (76%) have an exceedance (Figure 2 and 3). Importantly, the occurrence of enterococcus in groundwater at these wells illustrates that enterococcus is present in the groundwater at the study site.

[2] Disinfection had not failed at Malibu Beach Inn, but end-of-pipe data were submitted.

REVISED OCT 21 2009

Figure 1. The maximum enterococcus measures in wells in the Civic Center area after Stone 2004.



REVISED OCT 21 2009

Figure 2: Chart of Maximum Enterococcus Density (MPN/100 mL) for 20 groundwater wells in the Civic Center area from Stone 2004 Study (well locations are shown in Figure 1).

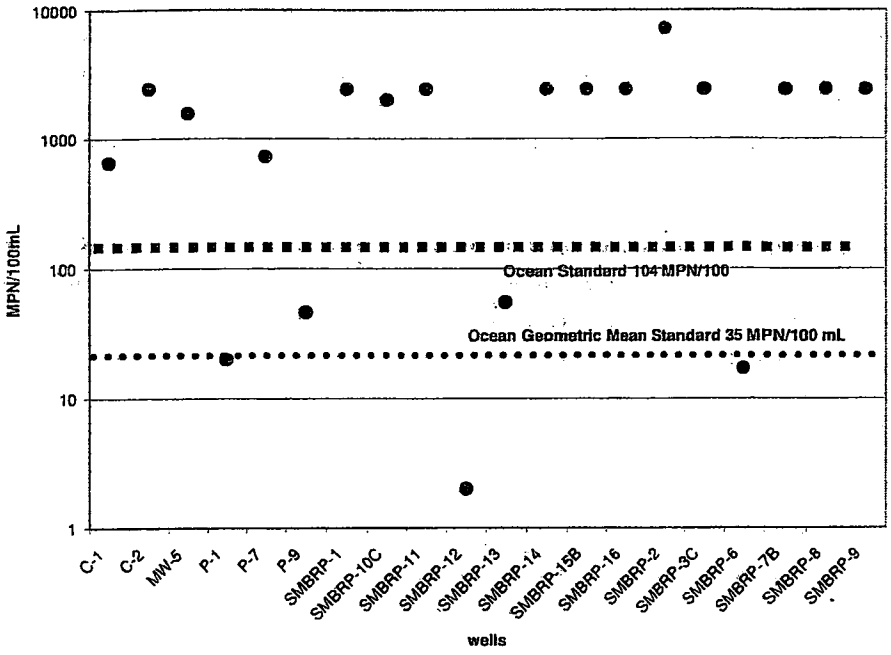
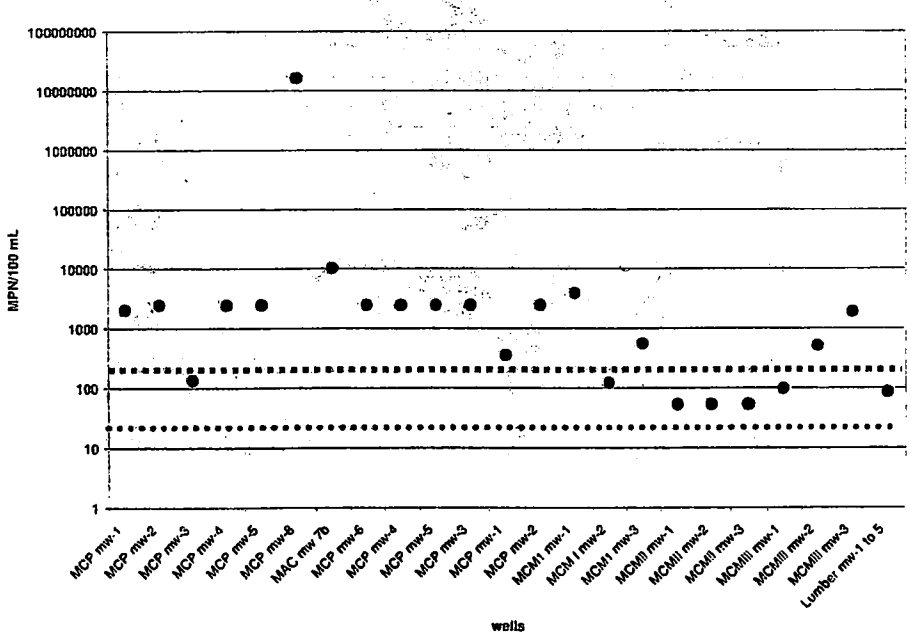


Figure 3: Chart of Maximum Enterococcus Density (MPN/100 mL) for 27 permit monitoring wells in the Civic Center area (well locations are shown in Technical Memorandum #2).



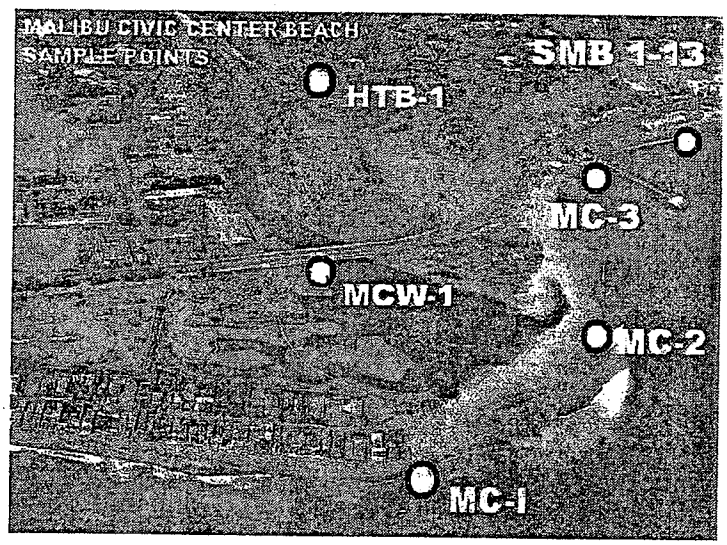
REVISED OCT 21 2009

Bacteria in Surface Water: Malibu Creek and Lagoon

Several public and not-for-profit agencies measure water quality on Malibu beaches, in Malibu Creek, in the lagoon and in the ocean. This data were not collected simultaneously, may not be sampled, transported or tested with consistent protocols, and is often not compiled. Recent data from 2 of many sample sites show that last summer's levels of enterococcus are lower in the water entering Malibu Lagoon from the Malibu Creek watershed (see HTB-1 in Figure 4), than downstream of the Malibu Civic Center area (MCW-1). The contrast can be seen at Lower Malibu Creek sampling station HTB-1 and Lagoon sampling station MCW-1.

Researchers have recently released data, but not interpretations, of water quality in the lagoon and creek that may ultimately lead to a better understanding of the temporal relationship between bacteria sources and transport mechanisms such as tides, creek flow volumes, groundwater discharge volumes, and rainfall. The recent data provided in Figure 5 demonstrate that periods have been observed when Malibu Creek is not the only source of bacteria in the lagoon. Given the elevated concentrations of enterococcus observed in the groundwater beneath the civic center, and Stone's (2004) conclusion that about half of groundwater is supplied by OWDSs and most of the groundwater makes it way to the ocean, the existence of Malibu Civic Center groundwater discharge is considered a possible source of increased levels of enterococcus in the Lagoon. Typically during the summer, bacteria from any source must travel via groundwater beneath the Surfrider Beach berm before discharging into the wave zone at MC-2, as seen in Figure 4, because the beach is not broken by overland flow.

Figure 4: Malibu Civic Center Surface Water and Beach Sampling Points.

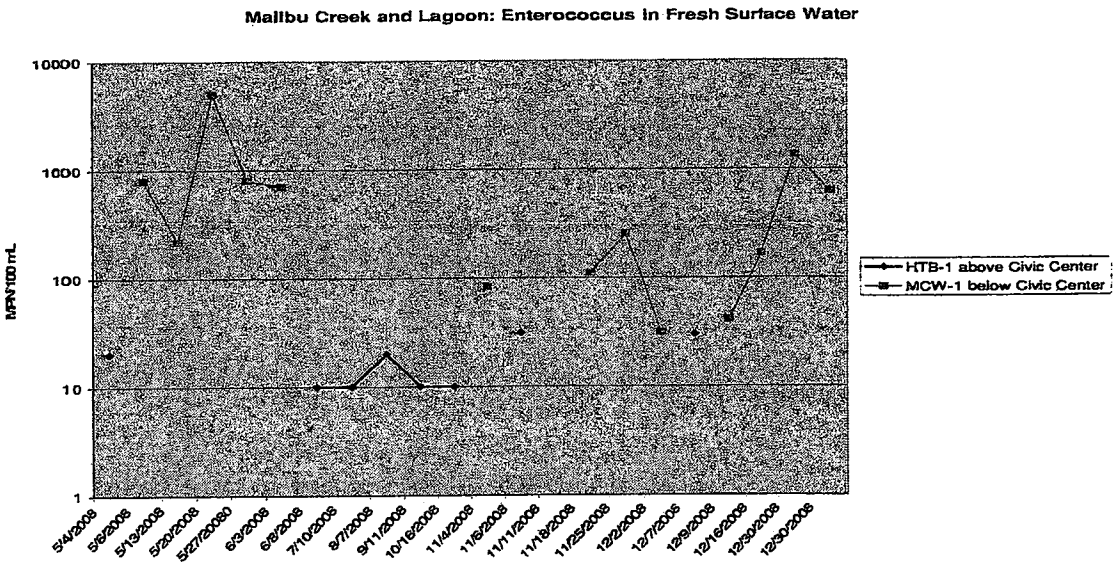


Sampling Point HTB-1 can be seen in Figure 4 where surface water from Malibu Creek watershed enters the Lagoon, MCW-1 where Malibu Creek enters Malibu Lagoon after receiving groundwater discharge from the Malibu Civic Center. The groundwater contains enterococcus which increases in concentration in the Lagoon, as shown in Figure 5. Also seen are beach sampling points MC-1 at the beach adjacent to

REVISED OCT 2 1 2 0 0 9

Malibu Colony, MC-2 at the breach point of Malibu Lagoon on Surfrider Beach, MC-3 at the beach adjacent to Malibu Pier and SMB-1-13 at Carbon Canyon Beach where Sweetwater Canyon discharges.

Figure 5: Summer 2008 Enterococcus above and below Malibu Civic Center in the Lagoon[3]



Bacteria in Surface Water: Beaches

The frequencies with which bacteria at Surfrider Beach, Malibu Colony Beach, adjacent to Malibu Pier and Sweetwater Canyon, and Marie Canyon Beach exceed the water quality objectives for enterococcus in the summers of 2005, 2006 and 2008 are listed here. A figure comparing these violations of the water quality standards for the protection of contact recreation beneficial use (REC-1) are displayed in Figure 6.

[3] Data have been collected at these locations for additional dates, but these data are the most recent and documents simultaneous measurements at upstream and downstream locations in the lagoon.

REVISED OCT 2 1 2009

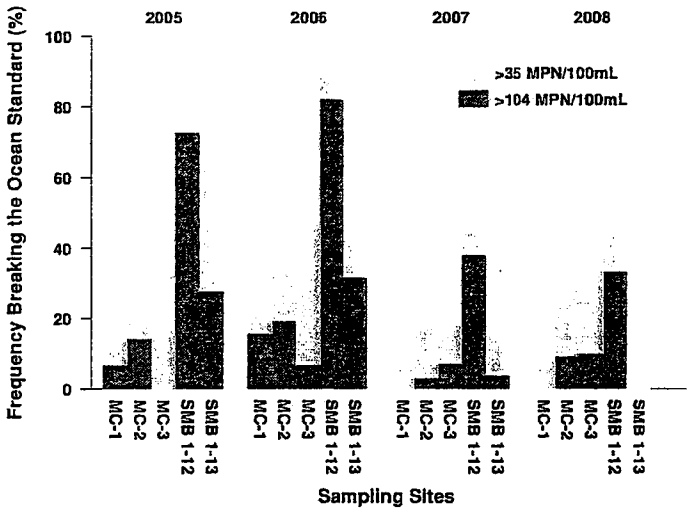
Table 2: Exceedences of single sample Enterococcus water quality standard[4].

Days/Frequencies with Enterococcus >104 MPN/100mL	2005	2006	2007	2008
Adjacent to Malibu Pier (MC 3)	0 (0)	2 (6.7%)	2 (7.1%)	0 (0)
Surfrider Beach (MC-2)	10 (14.3%)	25 (19.2%)	4 (3.1%)	12 (9.2%)
Malibu Colony (MC-1)	1 (6.7%)	5 (15.6%)	0 (0)	0 (0)
SMB 1-13 Sweetwater Canyon at Carbon Beach (southeast)	5 (27.8%)	12 (31.6%)	1 (3.7%)	0 (0)
SMB 1-12 Marie Canyon(northwest)	16 (72.7%)	55 (82.1%)	16 (38.1%)	13 (33.3%)

[4] The data summarized here were collected at each site four times a month from April through October

REVISED OCT 21 2009

Figure 6: Cumulative frequencies of enterococcus concentrations that failed to meet the ocean discharge standards in Malibu Civic Center beaches



On the beaches, bacteria are typically present at levels above water quality objectives at Malibu Colony (MC-1), Surfrider Beach (MC-2), and adjacent to Malibu Pier (MC-3). The pollution on beaches has been quantified in the 2002 303(d) list, Heal the Bay's beach report cards, and the Regional Board's Santa Monica Bay Beaches Bacteria TMDLs. Further, the Regional Board issued a Notice of Violation (NOV) for bacteria adjacent to the Malibu Civic Center beaches in March 2008. It identified violations of the waste discharge requirements established in Board Order No. 01-182, as amended by Order No. R4-2006-0074 and Order No. R4-2007-0042, pertaining to the Los Angeles MS-4 Permit controlling urban runoff and stormwater discharges. Tables 3, 4 and 5 show the water quality measures upon which the NOV was based for Malibu Civic Center Beaches.

REVISED OCT 21 2009

Table 3: Surfrider beach: Fecal-Indicator Bacteria Violations[5]

Surfrider Beach MC-2 Date of Violation(s)	Single Sample Result (MPN/100 ml)			
	Total Coliform	Fecal Coliform	Enterococcus	Total Coliform (Fecal:Total Coliform Ratio > 0.1)
Basin Plan Limit	**10,000**	**400**	**104**	**1,000**
9/14/2006		1,100		6,800
9/15/2006		1,100		7,900
9/16/2006				
9/17/2006				
9/18/2006				
9/19/2006				
9/20/2006				
9/21/2006				
9/22/2006				
9/23/2006				
9/24/2006				
9/25/2006				
9/26/2006				
9/27/2006				
9/28/2006		500		
9/29/2006		430		2,200
9/30/2006				1,400
10/1/2006				
10/2/2006				
10/3/2006	>13,000	6,300		>13,000
10/4/2006				
10/5/2006	13,000	7,300	1,400	13,000
10/6/2006				
10/7/2006		740		
10/8/2006				
10/9/2006				
10/10/2006		1,000	530	5,500
10/11/2006				
10/12/2006				
10/13/2006				
10/14/2006				
10/15/2006				
10/16/2006				

[5] Data listed here were gathered for enforcement purposes and does not represent all the information gathered in a particular year. The geometric mean calculations were incompletely documented in an 9/9/09 draft and have been deleted.

REVISED OCT 21 2009

10/17/2006		1,300		6,300
10/18/2006			110	1,100
10/19/2006				
10/20/2006		500		
10/21/2006				
10/22/2006				
10/23/2006				
10/24/2006				
10/25/2006		3,200	160	3,200
10/26/2006				
10/27/2006		430	110	3,400
10/28/2006				
10/29/2006				
10/30/2006				
10/31/2006				
4/6/2007		580		3,400
4/7/2007	>13,000	1,600		>13,000
4/24/2007	11,000	740		
4/25/2007	11,000	7,300		11,000
4/27/2007		430		1,600
5/18/2007		430	190	
5/19/2007		430		
6/2/2007			270	
6/16/2007		8,700	310	9,600
10/19/2007		500		1,300
10/20/2007	>13,000	830		
10/24/2007	11,000	500		
10/30/2007		580	120	
10/31/2007		910		5,900
Total Violations	**7**	**25**	**9**	**18**

REVISED OCT 21 2009

Table 4: Malibu Colony: Fecal-Indicator Bacteria Violations

MC-1 Malibu Colony Date of Violation(s)	Single Sample Result (MPN/100 ml)			
	Total Coliform	Fecal Coliform	Enterococcus	Total Coliform (Fecal:Total Coliform > 0.1)
Basin Plan Limit	10,000	400	104	1,000
9/14/2006				
9/15/2006				
9/16/2006				
9/17/2006				
9/18/2006				
9/19/2006				
9/20/2006				
9/21/2006				
9/22/2006				
9/23/2006				
9/24/2006				
9/25/2006				
9/26/2006				
6/4/2007		419		
Total Violations	0	1	0	0

Table 5: Adjacent to Malibu Pier: Fecal-Indicator Bacteria Violations

Malibu Pier MC-3 Date of Violation(s)	Single Sample Result (MPN/100 ml)			
	Total Coliform	Fecal Coliform	Enterococcus	Total Coliform (Fecal:Total Coliform > 0.1)
Basin Plan Limit	10,000	400	104	1,000
10/10/2006			422	
10/11/2006				
10/12/2006				
10/13/2006				
10/14/2006				
10/15/2006				
10/16/2006				
10/17/2006				
10/23/2006				
10/24/2006				
10/25/2006				

REVISED OCT 21 2009

10/26/2006				
10/27/2006				
10/28/2006				
10/29/2006				
10/30/2006				
10/31/2006				
6/4/2007			131	
10/29/2007			109	2,046
Total Violations	**0**	**0**	**3**	**1**

Correlations of Enterococcus with Beach Variables.

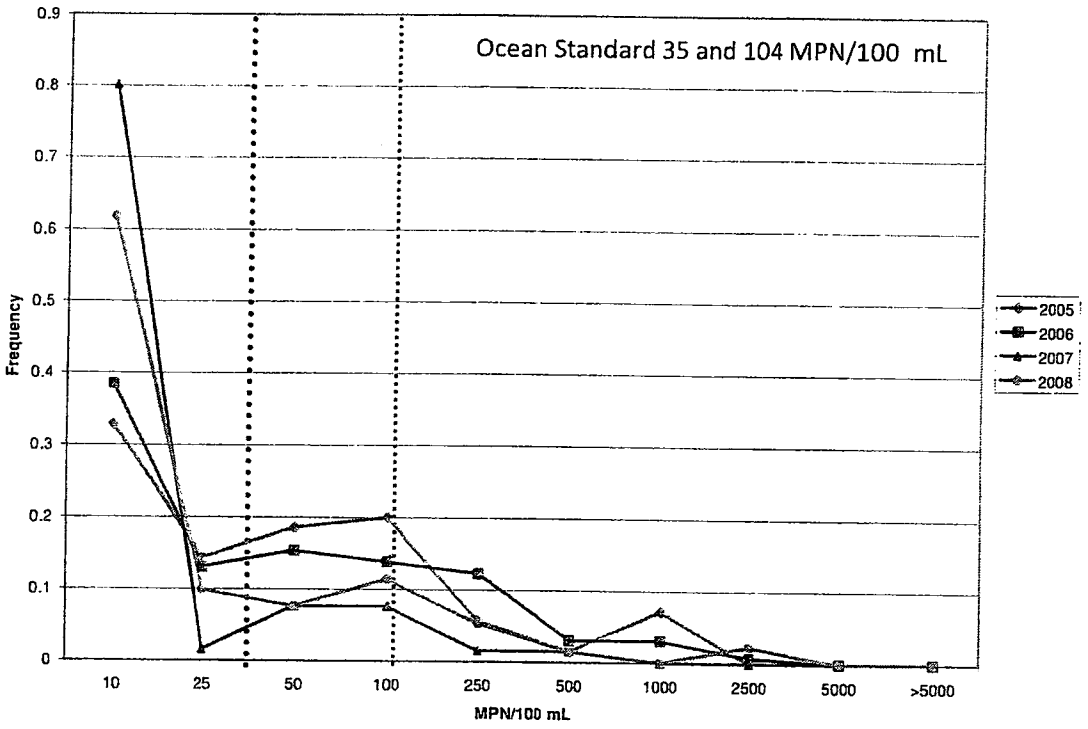
Staff did not include the results comparing beach enterococcus densities, and their frequency distributions, with other beach variables when no correlation was found. The variables examined include watershed size, urban acreage, beach visitor population, wave strength, setting such as lagoon or estuary, and number of roofs seen on air photo (where indicative of a septic system). The Pearson's Correlation Coefficient between enterococcus frequency distributions during four summers at a single beach defined statistically valid correlations (Appendix T3-C). More sophisticated statistical studies were applied, and Staff did find a statistically valid contrast between enterococcus frequency distributions from beaches adjacent to septic and sewered beaches and a statistically valid correlation between septic beaches and rainfall. These results are not included here, but included in the response to peer review.

Enterococcus on Malibu Civic Center Beaches

The enterococcus measures recorded on beaches adjacent to the Malibu Civic Center area over the summers 2005 to 2008 were sorted by interval frequency, plotted against the concentrations of enterococcus (MPN/100mL) and shown in Figures 7-9. The method was chosen to minimize the impact of varying sample sizes, to large variations in the measures and is a commonly used technique to analyze data.

REVISED OCT 21 2009

Figure 7: Surfrider Beach (site MC-2) Enterococcus Interval Frequency for May-October Summer Single Measures



REVISED OCT 21 2009

The enterococcus interval frequencies calculated for the beaches for the four summers were compared using the Pearson's correlation coefficient. The number of measures were counted in each of 8 intervals: values less than or equal to ten; more than ten but less than or equal to 25; more than 25 but less than or equal to 50; more than 50 but less than or equal to 100; more than 100 but less than or equal to 250; more than 250 but less than or equal to 500; more than 500 but less than or equal to 1000; and more than 1000. The intervals approximate a logarithmic distribution, but include more intervals between 25 and 100 and between 250 and 1000, ranges in which the beaches contrasted most sharply. Pearson's correlation coefficient was applied following the method used in EPA's *Ambient Water Quality Criteria for Bacteria, 1986* as described in the following quote:

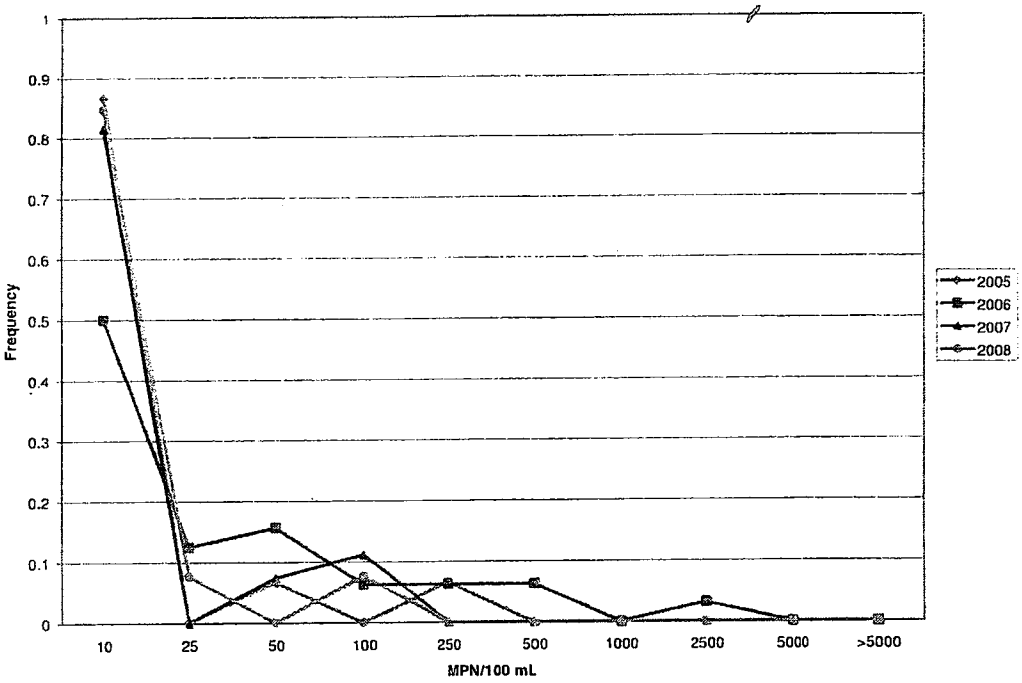
> "The examination of a number of potential indicators, including the ones most commonly used in the United States (total coliforms and fecal coliforms), was included in the study. Furthermore, the selection of the best indicator [enterococcus] was based on the strength of the relationship between the rate of gastroenteritis and the indicator density, *as measured with the Pearson's Correlation Coefficient. This coefficient varies between minus one and plus one. A value of one indicates a perfect relationship, that is, all of the paired points lie directly on the line which defines the relationship. A value of zero means that there is not linear relationship. A positive value indicates that the relationship is direct, one variable increases as the other increases. A negative value indicates the relationship is inverse, one variable decreases as the other increases.* The correlation coefficients for gastroenteritis rates are related to the various indicators of water quality from both marine and fresh bathing water as shown.... (page 5)"

Correlation coefficients between annual enterococcus frequency distributions for Surfrider Beach (MC-2) ranged from 0.78 to 0.98 suggesting little change in frequency distribution from year-to-year. Calculations of correlation coefficients for the Civic Center beaches with the best correlation, Surfrider, and the beach with the poorest correlation, next to Malibu Pier, are shown by year in Appendix T3-B:

Since enterococcus frequency distributions each year correlate well, this suggests that the distribution of bacteria frequencies is generally consistent at a beach, and not a function of random events such as swimmer shedding, the inappropriate disposal of a diaper or beach use by a homeless person.

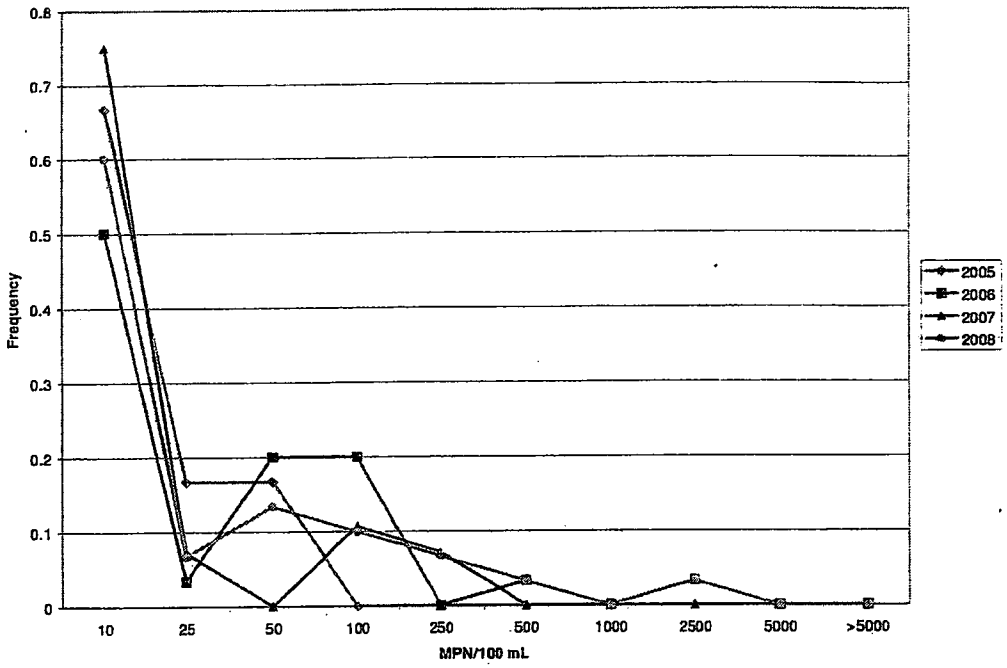
REVISED OCT 21 2009

Figure 8: Malibu Colony (site MC-1) Enterococcus Interval Frequency for May-October Summer Single Measures



REVISED OCT 21 2009

Figure 9: Adjacent to Malibu Pier (site MC-3) Enterococcus Interval Frequency for May-October Single Measures



4. Epidemiology Evidence of Human Health Impacts in the Malibu Civic Center.

Robert W. Haile and 13 co-authors (1996) completed an epidemiology study contrasting illness among immersed-head swimmers at Malibu's Surfrider Beach, Will Rogers Beach and Ashland Storm Drain. The results are summarized in Table 6. The first of its kind study on the health impacts of swimming at urban runoff contaminated ocean beaches was completed under the auspices of the USEPA's National Estuary Program's Santa Monica Bay Restoration Project (now a state commission). The study linked increased illness rates to fecal indicator bacteria densities at these beaches between June and September 1995.

Table 6: Epidemiology evidence of human impacts in Malibu

June 22 to September 17, 1995	Enterococcus Number > 104 MPN/100 mL	Percentage of days when exceeded 104 MPN/100 mL
Surfrider Beach	26	34.6
100 yards upcoast	4	5.1
100 yards downcoast	14	17.9

REVISED OCT 21 2009

Will Rogers Beach	32	45.2
100 yards upcoast	5	6.8
100 yards downcoast	7	9.6
Ashland Beach	5	6.3
100 yards upcoast	0	0
100 yards downcoast	1	1.3

Illness rates are given below for each of the days when enterococcus was above 104 MPN/100 mL at any beach. As a point of comparison, the EPA bathing water criteria for enterococcus (geometric mean of 35 MPN/100 ml and 104 MPN/ 100 ml for single samples) was determined by EPA to lead to a Highly Credible Gastrointestinal Illness (HCGI) rate of an additional 19 people with HCGI out of 1,000. The HCGI illness identified by EPA included a fever and correlates with Haile's HCGI 2 category.

Significant respiratory Disease (runny nose, coughing and fever) (SRD)	One of: vomiting, diarrhea and fever or stomach pain and fever. (HCGI 2)
45 per 1,000 swimmers	39 per 1,000 swimmers

The Santa Monica Bay bacteria and Malibu Creek and Lagoon TMDL used the term 'urban runoff' to identify surface dry weather flows not otherwise quantified and did not preclude surface flow originating as groundwater. The 1999 Haile study attributed decreasing illness in swimmers with increasing distance from the stormwater outlet point to the dilution of bacteria delivered at the stormwater outlet via 'urban runoff." However, Haile also measured illnesses at Surfrider Beach even when no surface flow crossed the 'storm drain' sampling point. Because Stone (2004) found that under average conditions the majority of the water in the Lagoon and entering the ocean comes from groundwater, the bacteria Haile measured could be associated with groundwater flows moving through the beach face at Surfrider as well as surface flows crossing the beach.

The Malibu beaches had more exceedances of the Ocean standard than the other two study areas in 2005, 2007 and 2008, after a low-flow diversion was installed on Will Rogers Beach to limit overland flow during the summer.

5. Discussion of Historic and Recent Studies

Historic Studies relating Malibu Civic Center Septic Systems to Human Health Risk and Beach Pathogens

REVISED OCT 21 2009

Existing technical studies (summarized in Table 7) link OWDS at the Malibu Civic Center area to beach bacteria and are discussed below:

On February 5, 1970, Los Angeles County Health provided a letter to the Regional Board stating that serious potential hazards to human health were expected to result from OWDS. LACH has repeatedly closed Surfrider Beach at the Malibu Civic Center due to high bacteria concentrations.

On July 8, 1987, Los Angles County Public Works held a public meeting to discuss a Draft Environmental Impact Report for a centralized waste water treatment plant and sewer for Malibu to address human health risk caused by OWDS system pathogens. The City of Malibu subsequently incorporated and a group of citizens brought a lawsuit to block the formation of assessment districts. The legal settlement required the new City of Malibu to provide sufficient oversight of on-site waste water treatment facilities such that they would meet Regional Board requirements.

The 1994 Ph.D. dissertation of Dr. Mark Gold "What are the health risks of swimming in the Santa Monica Bay?" identified human viruses in Malibu Lagoon and identified a potential source of the contamination as adjacent OWDS.

On January 24, 2002, the Regional Board adopted a Resolution amending the Santa Monica Beach Bacteria TMDL to the Basin Plan. The staff report found that bacteria loads from OWDS contribute to beach pathogens.

On August 30, 2004, the Stone report found that bacteria in the groundwater may enter receiving water where OWDS are found within 6-month groundwater travel time of the Ocean or Malibu Creek.

The September 17, 2004, Memorandum of Understanding between the City of Malibu and the Regional Board stated that "ordinances shall be drafted by staff, and recommended for adoption within the six-month-time-of-travel zone, as identified in the Risk Assessment Report (Stone), to provide advanced treatment and disinfection. The six-month time-of-travel zone shall include all areas contributing to Malibu Creek and Lagoon, and beaches between Sweetwater Canyon outfall and Winter Canyon outfall. OWTS located outside of the six-month-travel-time zone that cannot demonstrate compliance through inspection or that are identified as impacting groundwater by any other means shall provide adequate vertical separation and/or advanced treatment with disinfection." As of the date of this document, the City of Malibu has not provided documentation that systems within the six-month-time-of-travel zone have been upgraded to prevent bacteria discharge to the subsurface or include disinfection, nor has an ordinance to this effect been passed by the City of Malibu.

On Dec. 13, 2004, the Regional Board adopted a Resolution incorporating the Malibu Creek and Lagoon Bacteria TMDL into the Basin Plan. The staff report references a surface water model prepared by Tetra Tech which quantifies bacteria loads contributed by OWDS in the Malibu Civic Center.

Numerous studies have been completed to describe the ecosystem, hydrology, land use, possible mechanisms of waste water treatment, and costs to support policy decisions about bacteria and human health risk in the Malibu Civic Center (Ambrose et al. 2008; Bing Yen and Associates, 2001; Crawford Multari and Clark Associates, 1997, 2006, 2007; Ensitu Engineering, 2008; Gold, 1994; Jones and Stokes, 2008; Regional Board 1972, 1998, 1990, 2002, 2004b, 2008, 2008b; Lucero, 2008; Warshall,

R E V I S E D

O C T

2 1

2 0 0 9

1992: Questa, 2003; RMC. 2008; SMBRP, 1999, 2001; UCLA, 2000; URS Greiner, 1999; EPA, 2003: Stone, 2004a, 2004b, 2004c; Trim, 1994; Thorsen, 2008; and Van Beveren, 2008a, 2008b, 2008c).

Table 7: Historic Findings of Human Health Risk related to Malibu OWDS.

Date	Source	Summary
Feb 5, 1970	LA County Flood letter to Regional Board	Future OWDS will pollute groundwater in Malibu Creek with nutrients
Feb 5, 1970	LA County Health to Regional Board	Serious potential hazard to health from OWDS
Feb 11, 1970	CA DWR to Regional Board	Malibu Valley needs an area wide Water Quality plan
Apr. 8, 1970	Public Hearing SWRCB	Discontinue OWDSs, continue Regional Board surveillance
Jan. 21, 1971	CA DPH Status Ocean and streams in Malibu	Local ocean and freshwater bacteria exceed standards to protect shell fish collection in areas of development
Mar. 12, 1971	Regional Board EO to LA County Supervisors	Sewer for Malibu must be provided
May 31, 1972	Regional Board Resolution 72-4	Waste Discharge Requirements only allowed if a timetable is established to provide future connections to LA County sewer
Apr. 10, 1985	CA DPH to LA County Supervisors	Staff report and recommendation to authorize Sewer districts
July 8, 1987-Nov. 30 1988	LA Public Works Public Meeting and Malibu Citizens Committee public meetings	Draft Environmental Impact Report for Sewer, discussion of Malibu incorporating, discuss alternatives for centralized system with wetland treatment
Jan. 18, 1989	LA County Supervisors hearing	STEP WWTP system construction approved
1992	Warshall et al. report finalized	OWDS in Malibu described. Pathogen removal quantified. Author states that systems require extensive management and recommends centralized system in some areas like Civic center
1994	Mark Gold Dissertation	Three studies between 1990 and 1992 show high fecal-indicator-bacteria densities at ankle-depth wave wash and human viruses in runoff from three storm drains in Santa Monica Bay including Malibu Creek and Lagoon
May 7, 1996	Haile, et.al. 1996 epidemiology study	22,085 subjects in epidemiology study at Surfrider, Will Rogers and Santa Monica, with detailed study results for Malibu.
Dec. 14, 1998	Regional Board Resolution 98-023	Directs Report of Waste Discharge for all OWDSs and ACL to City of Malibu
Aug 12, 1999	Regional Board Resolution 99-13	El Rio septic staff report: Poorly maintained septic linked to nitrogen contamination in groundwater

REVISED OCT 21 2009

January 22, 1999	Haile, et al, 1999 epidemiology study	In Epidemiology July 1999, vol. 10, n. 4 22,085 subjects in epidemiology study at Surfrider, Will Rogers and Santa Monica showing increased risk to immersed-head swimmers for illness where fecal indicator bacteria are present.
1999	Dames and Moore study	Salt tracer, no pathogens found in wells within 200 feet, but tidal reversal confounds results
1999	URS Greiner study	Salt Tracer found at 20 feet in wells, but indicator bacteria not seen in short period test.
Dec. 12, 2002	Regional Board Resolution	Santa Monica Bay Bacteria Total Maximum Daily Load: beach pathogens attributed to loads from septic systems
March 21, 2003	EPA Malibu Creek Nutrient TMDL	Total Maximum Daily Load sets loads and numeric targets for total Nitrogen
2003	Questa study	Groundwater discharge to receiving water, quantified including volume from septic system discharge.
Aug 30, 2004	Stone study	Bacteria may enter receiving water where septic systems are found within 6-month travel time
Jan. 24, 2004	Regional Board Resolution	Malibu Creek and Lagoon bacteria TMDL: Tetra Tech surface water model sets loads for bacteria from septic systems
March 2006	Richard Viergutz, M.S. Thesis	Discharge of sewage-polluted groundwater into Malibu Creek and Lagoon resulting from groundwater surface interactions

Enterococcus as a Study Focus

Enterococcus is a bacteria indicative of the possible presence of etiological agents of human illness and a study focus for this analysis. Enterococcus was emphasized over fecal, total or Escherichia coli bacteria for the following reasons: (1) it is part of the flora of the human gut; (2) it is prevalent in discharge from septic systems into the leachfields in the Malibu Civic Center; (3) Annette Pruss' 1998 survey of epidemiology studies linking beach pathogens to human illness identified enterococcus as one of two bacteria correlating most strongly with highly credible gastrointestinal illness among swimmers; (4) The 58 sites sampled during the summers in Santa Monica Bay include data from the wet year of 2005 and the dry year of 2007; (5) it was correlated with increased human illness at Surfrider Beach, adjacent to the Civic Center, in the 1999 epidemiology study by Robert Haile and others; (6) the protocol for the sampling, transportation, and analysis of the most probable number of enterococcus colonies in 100 milli-Liters of water is well established in the refereed literature; and (7), the 1983 EPA marine recreational standard and its interpretation in the 2005 California Ocean Plan relate enterococcus density to both an acceptable illness threshold of 19 per 1000 swimmers and both a single sample and a geometric mean sample water quality objective.

Alternative indicators of human pathogens have been proposed, but the supporting research for candidates such as bacteroides or genetically defined species of enterococcus is insufficiently developed to support a new EPA criteria. In fact the 2005 study by Southern California Coastal Water Research Project or SCCWRP found bacteriodes in Ballona Creek, but not in Malibu Creek and Lagoon. Additional work is

REVISED OCT 21 2009

underway to determine if the density of bacteriodes retained after transport is sufficient for the species to serve as an indicator of human risk.

Species of enterococcus have also been identified in the feces of domestic animals, wild animals, birds, and in some plants. The genetic typing of enterococcus species in water along with the identification of other human-characteristic chemicals such as optical brighteners has been used to distinguish human from non-human enterococcus with some success in areas outside Malibu. The 1999 Haile epidemiology study results do not support dilution of enterococcus bacteria so as to preclude its value as an indicator of human illness. Specifically, the study found that for the same enterococcus densities, Surfrider Beach had a highly credible gastrointestinal illness with fever rate of 39 per 1,000 swimmers, which is higher than the 19 per 1,000 illnesses rate reported by EPA. The enterococcus concentration on the Malibu Civic Center beaches can be considered a conservative measure of the contribution of human fecal matter.

OWDS and Transport of Pathogens

Many studies have been completed within the last twenty years to characterize the transportation mechanisms of pathogens through the groundwater from the leachfield of septic systems or other OWDSs: Schaub and Sorber (1977) reported that viruses move by rapid infiltration and concluded that removal can be limited by low absorption rate of virus particles to soil. The authors used a mixed compound consisting of the tracer virus f2 and indicator bacteria in the tested septic tank and monitored the mitigation of indicators in well samples. It was found that enteric bacteria were quickly filtered by soil and concentrated on the soil surface; but the tracer viruses was not observed on the upper soil layers but was found in the down-gradient groundwater layers. Vaughn et al. (1983) also observed a preferential entrainment of bacteria, as opposed to viruses from septic discharge, in a shallow, sandy soil aquifer. These results illustrate that even when indicator bacteria are not present, viruses may still be present.

Goyal et al. (1979) further investigated the adsorption rates for different types or strains of viruses/bacteria to various types of soils. No specific viruses or bacteria were found to represent the general adsorptive behaviors of all viruses to soils, and no specific soil type can serve as a general model for all the soil types. Similarly, Chu et al. (2003) investigated the transportation rates of viruses passing through saturated and unsaturated soil columns. Strong correlations were found between virus adsorption and various factors, i.e. existence of metal oxides, water content, organic matter, pH, etc.

Bloch et al. (1990) presented a case study of a human virus infection (hepatitis A virus, HAV) due to groundwater contamination from on-site discharge system. The leachfield of the septic system in the studied site (a trailer park) was approximately 30 to 60 meters away from the drinking water well, and the author confirmed the direct association between septic discharge and virus infection. Fecal coliform was not significantly higher during the outbreaks period of hepatitis A.

These studies indicate the significant differences between viral and bacterial contaminants: viruses have the potential to penetrate the soil layers to a greater extent than bacteria. This highlights a limitation of using bacterial water quality indicators to predict viral groundwater contamination. However, it can be also implied that when higher densities of indicator bacteria occur, there is a higher risk that the soil layer can be contaminated by viruses. For example, Cuyk et al. (2004) reported a high correlation between virus concentrations and bacteria indicators in well-operated soil columns and field septic systems.

REVISED OCT 2 1 2009

Recent work also shows that the beach is a more complex hydrologic environment than the steady state condition previously modeled (Stone 2005 Malibu Risk Assessment). Episodic freshwater transport has recently been documented (Izbicki, 2009 in process). Bacteria densities have been tentatively linked to tidal and seasonal changes (Boehm et al., 2004; De Sieyes et al. , 2008, Izbicki, 2009 in press). Other researchers used sand column studies to show bacteria and virus retention and remobilization was related to the movement of organic material and bacteria and viruses have recently been shown to adhere and remain viable in beach material until remobilized (Yamahara et al., 2007; Azadpour-Keeley et al., 2003; Noble et al., 1996; Schaub et al., 1997, Schijven et al., 2002; Stramer et al., 1984).

In 2007, Nathalie Tifenkni provided a survey of particulate transport in the groundwater and noted that the existing models are deficient in successfully predicting the movement of organic particles. The survey specifically notes that work predicting the subsurface slowing of bacteria movement has not been paralleled by equally vigorous exploration of the subsurface enhancement of bacteria movement.

> "A substantial research effort has been aimed at elucidating the role of various physical, chemical and biological factors on microbial transport and removal in natural subsurface environments. The major motivation of such studies is an enhanced mechanistic understanding of the these processes for development of improved mathematical models of microbial transport and fate. In this review, traditional modeling approaches are systematically evaluated. A number of these methods have inherent weaknesses or inconsistencies (page 1455)....For instance, calculations based on Tufenkji and Elimelech (TE) equation indicate that particles in the size range of [about] 2μm (e.g. many bacteria) are nearly twice as mobile in porous media than previously believed (page 1461)....The release (detachment) of microorganisms from sediment grain surfaces can be of considerable importance in natural subsurface environments and engineered water treatment systems...an improved understanding of.. factors controlling microbial release are required before practical incorporation of this process into mathematic transport models (page 1646)... Future areas for fundamental research in this area have been identified and include (i) inactivation kinetics of microorganisms in soils, (ii) role of protozoan grazing in removal of bacteria, (iii) mechanisms of microbial detachment from sediment grain surfaces,)iv) interactions between cell/cyst surface biomolecules and mineral surfaces, and (v) the influence of physical and geochemical aquifer heterogeneity on microbial transport (page 1468)."

Other possible mechanisms that may result in the preservation of enterococcus include elevated nitrogen and/or oxygen levels (Azadpour-Keeley et al., 2003; Yates, 1985, 1986) in the subsurface or on the beach face. In addition, septic plumes are now known to stay intact during subsurface movement (Groundwater Monitoring and Assessment Program: Baxter. Minnesota, 1999) limiting the impact of subsurface dilution of discharged enterococcus densities.

REVISED OCT 2 1 2 0 0 9

Studies relating OWDS to Beach Pathogens[6]

Research completed over the last ten years has expanded the understanding of beach bacteria sources . For example, it has been demonstrated that the fecal-indicator-bacteria enterococcus are present at many California beaches. In 2003(b), Borchardt et al. reported that the density of septic systems correlated with increased rates of infectious diarrhea in children in central Wisconsin. The authors found that viral diarrhea increased by 8% for every additional holding tank in 640 acres and bacterial diarrhea increase by 22% for every additional holding tank in 40 acres. While household wells were sampled for bacterial, risks were attributed to surface contact with pathogens near septic systems.

In 2004, Boehm et al. reported that groundwater discharge of microbial pollution moved from a shallow beach aquifer on to the beach face at Huntington Beach. While fecal indicator bacteria were found in only one groundwater sample, column studies show that the transport of enterococcus is not inhibited by sand collected in the field. In addition, radium isotopes characteristic of groundwater linked 38% of the enterococcus variation to groundwater discharge.

In 2007, Yamahara et al. reported in Environmental Science and Technology, Vol. 41, No. 12, that 91% of sampled California coastal beaches had enterococcus present in sand. The presence of a putative pollution source such as a river, wave shelter and surrounding anthropogenic land use correlated with higher enterococcus concentrations in the sands.

In 2008, De Sieyes et al. reported that fresh nutrient-rich groundwater discharges in fortnightly pulses into the ocean across a beach from adjacent septic systems and leachfields. While fecal indicator bacteria and human enterococcus genes were found in monitoring wells and attributed to pollution from adjacent septic systems, the concentrations of these pathogens did not increase with nutrients in the surf zone.

In 2009, the American Association for the Advancement of Science summarized studies identifying Methicillin Resistant Staphylococcus Aureus Bacteria (MSRA) in ocean water and on beaches in Florida.. Citizens have claimed an MSRA infection was contracted at Malibu beaches. The infections, which are resistant to antibiotics and are more commonly found in hospitals, are now known to be transmitted to beach water through contact with infected individuals and, according to one report, through municipal effluent. The ability of the bacteria to travel via sewage has not been quantified.

Enterococcus has been grown in the laboratory setting in unseeded beach sand (Yamahara et al., 2009) and found in a freshwater environment free from human impact (Tiefenthaler et al., 2008 Enterococcus has also been shown to persist in the beach sand and occur in higher concentrations in organic beach

[6] Early Technical Reviewers recommended enhancements of staff's summary of studies on beach pathogens completed since 2004. While it is beyond the scope of this document to present a complete literature study on the topic, the summary emphasizes the scope of ongoing technical investigations in the field. The authors of the papers cited, some of whom were Early Technical Reviewers, wished staff to emphasize that additional study is necessary to characterize the physical, chemical and biological processes which allow bacteria and viruses to move through the groundwater for surface discharge. The authors should be contacted for the most up-to-date information on their research and the interpretation of the work already completed.

3-881

REVISED OCT 2 1 2 0 0 9

debris where it may later be transported to near shore waters (Pednekar et.al, 2007; Yamahara et al., 2007).

These studies and others show that the beach is a more complex microbiological environment than was previously understood.

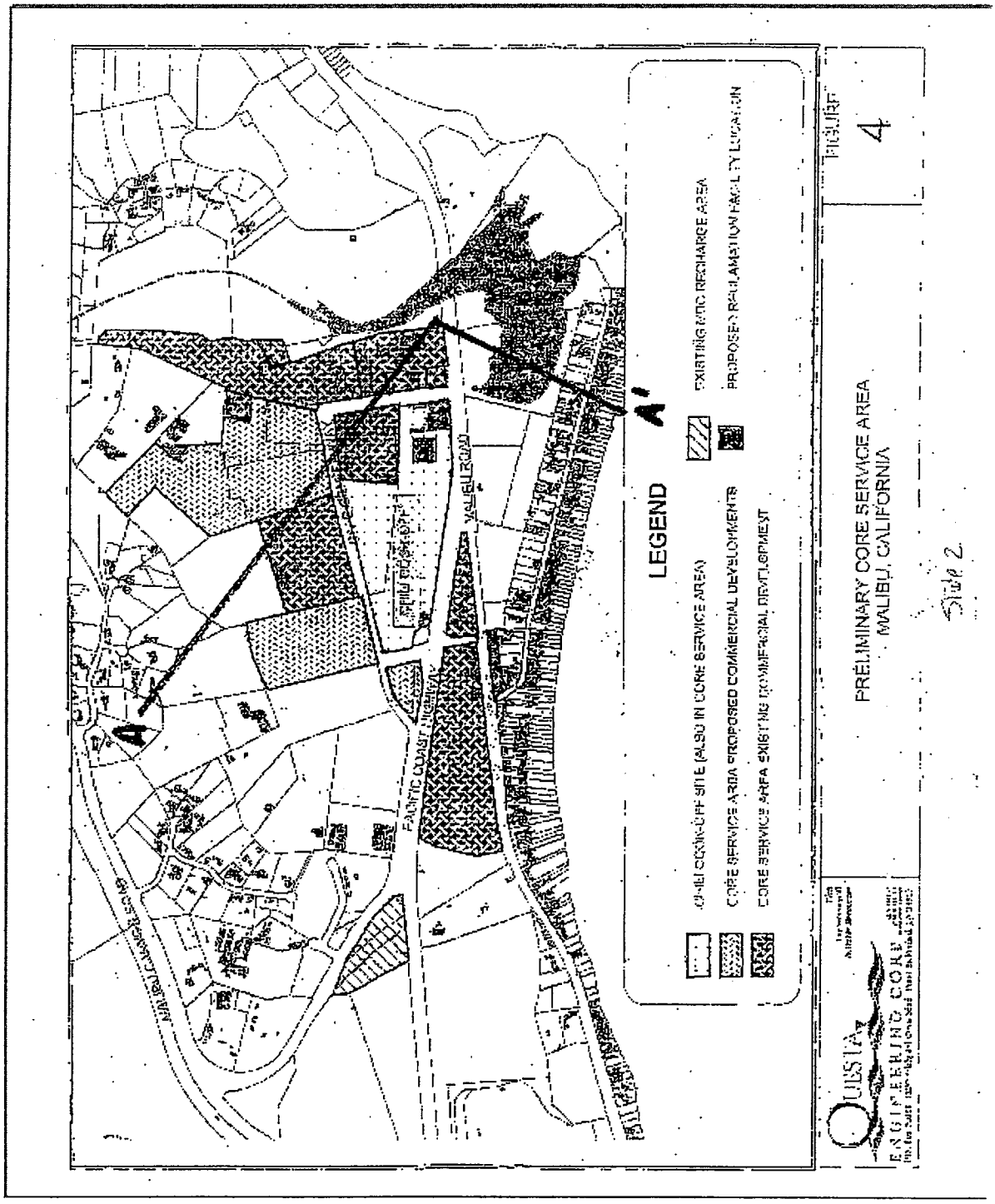
Potential Scenarios for Sources and Transport Mechanisms for Bacteria in the Malibu Civic Center.

Figure 10 shows the Malibu Civic Center with planned development (Questa, 2003), and the line of the cross section shown in Figure 11. The cross section shows possible paths of transport for the bacteria discharged into OWDS leachfields/seepage pits to Malibu Creek, Malibu Lagoon and the ocean. Note in the cross section that bacteria leaving OWDS in Malibu Colony or adjacent to Legacy Park have the shortest travel times and fewest opportunities for subsurface physical detention, chemical attack or biological predation.

The movement of septic system bacteria from the Civic Center area north of Pacific Coast Highway via subsurface transport to Surfrider Beach under summer conditions would require movement through the beach barrier into marine water (see Figure 11 [cross section]). Enterococcus from septics must survive physical, chemical and biological destruction in the subsurface before ocean discharge. Enterococcus from higher elevations within the watershed must travel further on the surface and both light and distance are known to cause de-activation of both viruses and bacteria (Azadpour-Keeley, 2003; Yates, 1985, 1986).

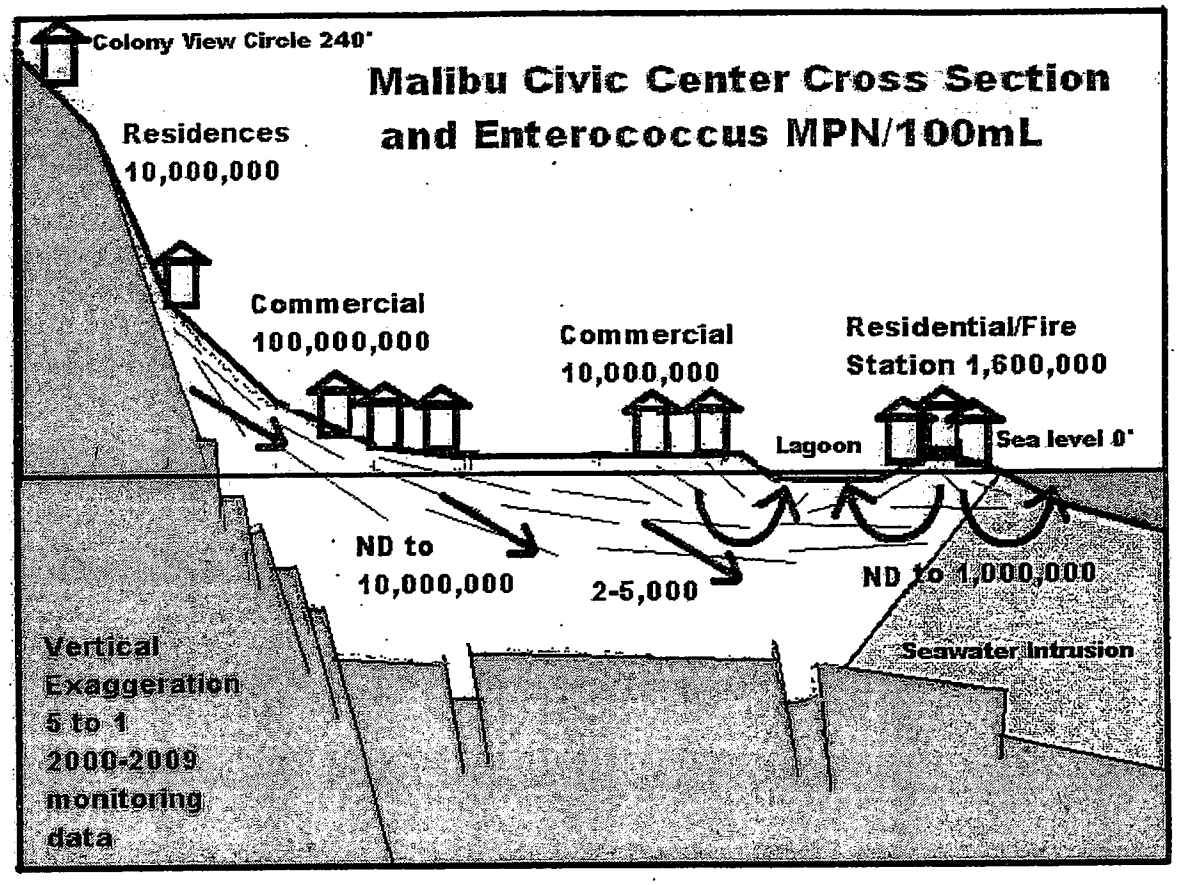
REVISED OCT 2 1 2 0 0 9

Figure 10. Planned development in the Malibu Civic Center from Questa 2003 and cross section line



REVISED OCT 21 2009

Figure 11. Cross Section A to A' showing facility and groundwater bacteria and flow paths



6. Conclusion

Malibu Creek, Lagoon, and nearby beaches are popular within the local community and as a destination for well over 1 million visitors per year. In the Basin Plan, the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards, using the best available science, at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, and consistently have failed to meet State health and water quality standards set to protect swimmers and surfers in contact with the water. Repeated failures to meet standards set to protect public health have resulted in a poor water quality reputation for Surfrider Beach.

To examine the hydraulic connection of discharges from Onsite Wastewater Disposal Systems (OWDSs) through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater

REVISED OCT 21 2009

effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters are likely migrate to surface waters and that, consistent with data supporting the designations of impairments, threaten human health. This conclusion is based on our analysis of the indicator bacteria enterococcus. The levels of this bacteria do not meet standards protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center based on work by Haile et. al. 1999.

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to the beneficial use of water contact recreation.

REVISED OCT 21 2009

ATTACHMENT 3-A: Monitored Santa Monica Bay Beaches[7]

No	CSMP	Location	Linked Watershed	Treat-ment Type	Strom drain/ Freshwater	Total Acres
1	SMB 1-01	Arroyo Sequit Creek, Leo Carrillo State Beach	Arroyo Sequit	Septic	Y	7,549
2	SMB 1-02	El Pescador State Beach	Los Alisos	Septic	N	2,396
3	SMB 1-03	El Matador State Beach	Encinal	Septic	N	1,794
4	SMB 1-04	Trancas Creek	Trancas	Septic	Y	6,514
5	SMB 1-05	Zuma Break at Zuma Beach	Zuma	Septic	Y	6,339
6	SMB 1-06	Walnut Creek	Ramirez	Septic	Y	3,334
7	SMB 1-07	Ramirez Canyon at Paradise Cove Pier	Ramirez	Septic	Y	3,334
8	SMB 1-08	Escondido Creek	Escondido	Septic	Y	2,295
9	SMB 1-09	Latigo Canyon	Latigo	Septic	Y	813
10	SMB 1-10	Solstice Creek at Dan Blocker County Beach	Solstice	Septic	Y	2,841
11	SMB 1-11		Corral	Septic	Y	4,280
12	SMB 1-12	Marie Canyon Strom Drain on Puerco Beach	Corral	Septic	Y	4,280
13	SMB 1-13[8]	Sweetwater Canyon on Carbon Beach	Carbon	Septic	Y	2,320
14	SMB 1-14	Las Flores Creek on Las Flores State Beach	Las Flores	Septic	Y	2,897

[7] Data as reported in Santa Monica Bay beaches Bacteria TMDLs and SMB beaches Bacteria TMDL Coordinated Shoreline Monitoring Plan

REVISED OCT 2 1 2009

15	SMB 1-15	Big Rock Beach	Piedra Gorda	Septic	Y	664	
16	SMB 1-16	Pena Creek on Las Tunas County Beach	Pena	Septic	Y	608	
17	SMB 1-17	Tuna Canyon	Tuna	Septic	N	1,013	
18	SMB 1-18	Topanga Canyon on Topanga State Beach	Topanga	Septic	Y	12,575	
19	SMB 2-01	Castlerock storm drain aka Parker Mesa Storm Drain	Castlerock	Sewer	Y	4,976	
20	SMB 2-02	Santa Ynez Storm Drain	Santa Ynez	Sewer	Y	1,203	
21	SMB 2-03	Will Rodgers State Beach 1/4 mile east of Gladstones	Santa Ynez	Sewer	N	1,203	
23	SMB 2-04	Pulga Storm Drain on Will Rodgers State Beach	Santa Ynez	Sewer	N	1,203	
24	SMB 2-05	Bay Club Storm Drain on Will Rodgers State Beach	Santa Ynez	Sewer	N	1,203	
25	SMB 2-07	Santa Monica Canyon	Santa Monica Canyon	Sewer	Y	10,088	
26	SMB 2-08	Venice Beach Pier	Venice Beach	Sewer	N	5,241	
27	SMB 2-09	Topsail Street, Venice Beach	Venice Beach	Sewer	N	5,241	
28	SMB 2-10	Culver Storm Drain	Dockweiler	Sewer	Y	6,573	
29	SMB 2-11	North Westchester Storm Drain	Dockweiler	Sewer	Y	6,573	
30	SMB 2-12	Dockweiler Beach	Dockweiler	Sewer	N	6,573	
31	SMB 2-13	Imperial Highway Storm Drain	Dockweiler	Sewer	Y	6,573	
32	SMB 2-14	Hyperion Plant, Dockweiler Beach	Dockweiler	Sewer	N	6,573	
33	SMB 2-15	Grand Ave, Dockweiler Beach	Dockweiler	Sewer	Y	6,573	
34	SMB 3-01	Montana Ave, Santa Monica Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	

REVISED OCT 2 1 2009

35	SMB 3-02	Wilshire Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	
36	SMB 3-03	Santa Monica Pier Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	
37	SMB 3-04	Pico-Kenter Storm Drain	Santa Monica	Sewer	Y	8,850	
38	SMB 3-05	Ashland Storm Drain	Santa Monica	Sewer	Y	8,850	
39	SMB 3-06	Rose Ave Storm Drain, Venice Beach	Santa Monica	Sewer	Y	8,850	
40	SMB 3-07	Brooks Ave Storm Drain, Venice Beach	Santa Monica	Sewer	Y	8,850	
41	SMB 3-08	Venice Pavillion	Santa Monica	Sewer	Y	8,850	
42	SMB 3-09	Strand Street, Santa Monica State Beach	Santa Monica	Sewer	N	8,850	
43	SMB 4-01	San Nicholas Canyon	Nicholas	Septic	Y	1,235	
44	SMB 5-01	40th Street, Manhattan Beach	Hermosa	Sewer	N	2,624	
45	SMB 5-02	28th Street Drain, Manhattan Beach	Hermosa	Sewer	Y	2,624	
46	SMB 5-03	Manhattan Beach Pier	Hermosa	Sewer	Y	2,624	
47	SMB 5-04	26th Street, Hermosa Beach	Hermosa	Sewer	N	2,624	
48	SMB 5-05	Hermosa Beach Pier	Hermosa	Sewer	N	2,624	
49	SMB 6-01	Herondo Storm Drain	Redondo	Sewer	Y	3,544	
50	SMB 6-02	Redondo Beach Pier	Redondo	Sewer	Y	3,544	
51	SMB 6-03	Sapphire Street	Redondo	Sewer	N	3,544	
52	SMB 6-04	Topaz Groin	Redondo	Sewer	N	3,544	
53	SMB 6-05	Avenue I	Redondo	Sewer	Y	3,544	
54	SMB 6-06	Malaga Cove	Redondo	Sewer	N	3,544	
55	SMB 01	BC- Ballona Creek	Ballona Creek	Sewer	Y	81,980	

REVISED OCT 2 1 2009

56	SMB 01	MC-	Malibu Point on Malibu State beach	Malibu Creek	Septic	Y	70.410
57	SMB 02	MC-	Breach Point of Malibu Lagoon on Malibu State Beach	Malibu Creek	Septic	Y	70,410
58	SMB 03	MC-	Malibu Pier on Carbon Beach near Malibu Creek	Malibu Creek	Septic	Y	70,410
59	SMB 7-01		300 Paseo Del Mar, Palos Verdes Estates	Palos Verdes Peninsula	Sewer		10,023
60	SMB 7-02		Bluff Cove, Palos Verdes Estates	Palos Verdes Peninsula	Sewer		10,023
61	SMB 7-03		Long Point, 7200 Palos Verdes Drive South, Rancho Palos Verdes	Palos Verdes Peninsula	Sewer		10,023
62	SMB 7-04		6000 Palos Verdes Drive South, Rancho Palos Verdes	Palos Verdes Peninsula	Sewer		10,023
63	SMB 7-05		Portuguese Bend Club, Rancho Palos Verdes	Palos Verdes Peninsula	Sewer		10,023
64	SMB 7-06		White's Point/Royal Palms County Beach, San Pedro	Palos Verdes Peninsula	Sewer		10,023
65	SMB 7-07		Midway between White Point County Beach and Wilder Annex	Palos Verdes Peninsula	Sewer		10,023
66	SMB 7-08		Point Fermin/Wilder Annex, San Pedro	Palos Verdes Peninsula	Sewer		10,023
67	SMB 7-09		Cabrillo Beach, San Pedro	Palos Verdes Peninsula	Sewer		10,023

REVISED OCT 21 2009

ATTACHEMENT 3-B: REFERENCES

Ambrose, Richard. May 14, 2008. Ecological Goals. Malibu Legacy Park Project prepared in association with RMC Water and Environment.

Allen, L.A., Brooks, E., Williams, & I.L., 1949. Effect of Treatment at the Sewage Works on the Numbers and Types of Bacteria in Sewage. *The Journal of Hygiene*, **47**(3):303-319.

Azadpour-Keeley, A., Faulkner, B.R., & Chen, J.S. April 2003. Movement and Longevity of Viruses in the Subsurface. United States Environment Protection Agency.

Bales, R.C., Gerba, C.P., Grondin, G.H., & Jensen, S.L. 1989. Bacteriophage Transport in Sandy Soil and Fractured Tuff. *Applied and Environmental Microbiology*, **55**(8): 2061–2067.

Bing Yen & Associates, Inc. January 5, 2001. Report of Malibu Civic Center Groundwater Evaluation. City of Malibu, Camarillo CA.

Bloch, A.B., Stramer, S.L., Smith, D., Margolis, H.S., Fields, H.A., McKinley, T.W. Gerba, C.P., Maynard, J.E., & Sikes, R.K. April 1990. Recovery of Hepatitis A Virus from Water Supply Responsible for a Common Source Outbreak of Hepatitis A. *American Journal of Public Health.*, **80**(4): 428-430.

Boehm, A.B., Shellenbarger, G.G., & Paytan, A. 2004. Groundwater Discharge: Potential Association with Fecal Indicator Bacteria in the Surf Zone. *Environmental Science & Technology*, **38**(13):3558-66.

Borchardt, M.A., Bertz, P.D., Spencer, S.K.,& Battigelli, D.A. 2003a. Incidence of Enteric Viruses in Groundwater from Household Wells in Wisconsin. *Applied and Environmental Microbiology*, **69**(2):1172-1180.

Borchardt, M.A., Chyou, P.H., DeVries, E.O., & Belongia, E.A. 2003b. Septic System Density and Infectious Diarrhea in a Defined Population of Children. *Environmental Health Perspectives*, 111(5):742-748.

Cabelli, V.J. August 1983. Health Effects Criteria for Marine Recreational Waters. Health Effect Research Laboratory Office of Research and Development.

CDM. August 10, 2006. Technical Memorandum Task 10, TMDL Implementation Analysis.

CDM., Irvine CA, February 27, 2007. Integrated Total Maximum Daily Load Implementation Plan for the Malibu Creek Watershed. Los Angeles County Department of Public Works.

City of Malibu. November 5, 2002. Ordinance No. 242. City Council of the City of Malibu.

City of Marco Island. City of Marco Island Position Paper Septic Tank Replacement Program. City of Malibu.

REVISED OCT 2 1 2 0 0 9

Crawford, Multari & Clark Associates. July 1997. Draft, City of Malibu. Civic Center Specific Plan. Prepared for City of Malibu by Crawford, Multari & Clark Associates, San Luis Obispo CA.

Cuyk, S.V., Siergrist, R.L., Lowe, K., & Harvey, R.W. 2004. Evaluating Microbial Purification during Soil Treatment of Wastewater with Multicomponent Tracer and Surrogate Tests, Vadose Zone Processes and Chemical Transport. *Journal of Environmental Quality*. 33: 316-329.

De Sieyes, N.R., Yamahara, K.M., Layton, B.A., Joyce, E.H., & Boehm, A.B. 2008. Submarine Discharge of Nutrient-Enriched Fresh Groundwater at Stinson Beach, California is enhanced during Neap Tides. *Limnol Oceanography*, 53: 1434-1455.

Ensitu Engineering Inc. June 30, 2008. Advanced On-site Wastewater Treatment System Design, California Department of Health Services Engineering Report. Malibu Lumber, Morro Bay CA.

Ensitu Engineering Inc. August 13, 2008. Malibu Lumber Wastewater Flow Calculations Commercial Development without Restaurant Use. Letter addressed to Brett Thornton, prepared by Ensitu Engineering, Morro Bay CA.

Ensitu Engineering Inc. 2008. Advanced On-site Wastewater Treatment System Design, City of Malibu Engineering Report. Prepared for Malibu Lumber by Ensitu Engineering Inc., Morro Bay CA.

Gold, M.A. 1994. What are the health risks of swimming in the Santa Monica Bay?: An examination of the issues surrounding the public health debate. Prepared for University of California, Los Angeles.

Gronewold, A.D.,& Wolpert, R.L. April 7, 2008. Modeling the Relationship between Most Probable Number (MPN) and Colony – Forming Unit (CFU) Estimates of Fecal Coliform Concentration. Elsevier.

Ground Water Monitoring and Assessment Program. May 1999. Effect of Septic Systems on Ground Water Quality – Baxter, Minnesota.

Haile, Robert W., Witte, John S., Gold, Mark, et. al. July 1999. "The Health Effect of Swimming in Oceaen Water Contaminated by Storm Drain Runoff" in Epidemiology, vol. 10, n. 4, page 355-363.

Haile, Robert W., et. al. 1996"An epidemiological study of possible adverse health effects of swimming in Santa Monica Bay", unpublished but peer reviewed, Heal the Bay document, May 7, 1996.

James, Kirsten. November 19, 2008. Comments on Tentative Waste Discharge Requirements, Water Reclamation Requirements and Monitoring and Reporting Program for Malibu Lumber. Heal The Bay, Santa Monica CA.

Jones & Stokes. 2008. Malibu Legacy Park Project, Draft Environmental Impact Report. Prepared for City of Malibu by Jones & Stokes, Los Angeles CA.

Regional Board. 1972. Resolution No. 72-4, Policy Statement Relative to Sewage Disposal in the Malibu Area. California Regional Water Quality Control Board, Los Angeles Region.

LARWCB. December 14, 1998. Resolution No. 98-023 Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

REVISED OCT 2 1 2009

Regional Board. 1990. Regional Water Quality Control Board's Interim Policy on the Use of Septic Tanks. California Regional Water Quality Control Board, Los Angeles Region.

Regional Board. 2002. Santa Monica Bay Beaches Wet Weather Bacteria TMDL, Item #5 Regional Board Workshop, June 27, 2002. California Regional Water Quality Control Board, Los Angeles Region.

Regional Board. 2004b. Total Maximum Daily Loads for Bacteria, Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

Regional Board. 2008. 520th Regular Board Meeting, Item 16, Consideration of Termination of Memorandum of Understanding for On-site Wastewater Treatment Systems for the City of Malibu. California Water Quality Control Board, Los Angeles Region.

Regional Board. 2008b. 521st Regular Board Meeting, Item 18, Revised Order, Waste Discharge Requirements/Water Reclamation Requirements and Monitoring and Reporting Program for City of Malibu's Malibu Lumber at City of Santa Monica's Legacy Park. California Regional Water Quality Control Board, Los Angeles Region.

Lucero, Gene. 2008. Submittal of Comments to Tentative Waste Discharge Requirements and Water Reclamation Requirements for Malibu Lumber LLC. Latham & Watkins, LLP.

National Center for Environment Research. 2003. Final Report: Fate for Pathogens in Storm Water Runoff; prepared for National Center for Environment.

Office of Water. October 2006. Occurrence and Monitoring Document for the Final Ground Water Rule. Prepared for Office of Water by the Office of Water.

Peter Warshall & Associates and Philip Williams & Associates. 1992. Malibu Wastewater Management Study, A Human Ecology of the New City. Prepared for City of Malibu by Philip Williams and Associates, San Francisco CA and Peter Warshall & Associates, Tucson AZ.

Pednekar, A.M., Grant, S.B., Candelaria, L, 2007. Assessing the Seasonal Impact of Storm Drains on Water Quality in Western Newport Bat, Southern California, report to the SWRCB.

Pradhan, S., Hoover, M.T., Clark, G.H., Gumpertz, M., Wollum, A.G., Cobb, C., & Strock, J. February 2008. Septic Tank Additive Impacts on Microbial Populations. *Journal of Environmental Health.*

Pruss, A, 1998, *Review of Epidemiological Studies on Health Effects from Exposure to Recreational Water.* International Epidemiological Association Vol. 17 pages 1-9.

Questa Engineering Corporation. July 7, 2003. Preliminary Conceptual Plan for Wastewater Reclamation in the Civic Center Area, Malibu, California. Prepared for City of Malibu by Questa Engineering, Santa Barbara CA.

RMC Water and Environment. August 15, 2008. Irrigation of Legacy Park with Treated Effluent from Lumber Yard Development. Technical Memorandum prepared by RMC Water and Environment.

REVISED OCT 2109

RMC Water and Environment. May 14, 2008. Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon. Prepared by RMC Water and Environment for City of Malibu. Legacy Park.

Rong, Y. November 3, 1997. Pitfalls in Statistics for Environmental Sampling Evaluation. *Environmental Geosciences*.

Santa Monica Bay Restoration Project. 1999. Malibu Creek Watershed Restoration Activities Draft. Malibu Creek Watershed Executive Advisory Council.

Santa Monica Bay Restoration Project. January 2001. Improving Septic System Management in the Santa Monica Bay Watershed. Santa Monica Bay Restoration Project, Septic System Task Force.

Schaub, S.A., & Sorber, C.A. May 1977. Virus and Bacteria Removal from Wastewater by Rapid Infiltration Through Soil. *Applied and Environmental Microbiology*, **33**(3):609-619.

Stone Environmental, Inc. 2004. Final Report- Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu CA. Prepared for Santa Monica Bay Restoration Commission by Stone Environmental, Montpelier VT.

Stone Environmental, Inc. April 9, 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates, Inc by Stone Environmental, Montpelier VT.

Stone Environmental, Inc. May 6, 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates, Inc by Stone Environmental, Montpelier VT.

Stramer, S.L., & Cliver, D.O. 1984. Septage Treatments to Reduce the Numbers of Bacteria and Polioviruses. *Applied and Environmental Microbiology*, **48**(3): 566-572.

Tiefenthaler, L.L, Stein, E.D., & Lyon, G.S. January 2008. Fecal Indicator Bacteria Levels During Dry Weather form Southern California Reference Streams. Prepared for Southern California Coastal Water Research Project.

Tifenkji, N. 2007, *Modeling Microbial transport in porous media: Traditional approaches and recent developments.* Advances in Water Resources, Vol. 30, pages 1455-1469.

Tim, Heather. November 1994. Review of Monitoring and Response Protocol for the Malibu Creek Watershed. Santa Monica Bay Restoration Project.

Thorsen, Jim. 2008. Letter in Response to the Los Angeles Regional Water Quality Control Board's Letter Regarding Notification of Incomplete Application for Waste Discharge Requirements for Malibu Lumber. City of Malibu, CA.

United States Environmental Protection Agency. January 2001. Linkage between Water Quality Targets and Pollutant Sources.

United States Environmental Protection Agency. August 2002. Predicting Attenuation of Viruses During Percolation in Soils.

REVISED OCT 2 1 2009

University of California, Los Angeles. May 200. Lower Malibu Creek and Lagoon Resource Enhancement and Management. Final Report to the California State Coastal Conservancy by UCLA.

URS Greiner Woodward Clyde. 1999. Final Report, Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems. Prepared for City of Malibu by URS Greiner Woodward Clyde, Santa Ana CA.

US Environmental Protection Agency. January 10, 2003. Total Maximum Daily Loads for Nutrient, Malibu Creek Watershed, Public Review Draft. US Environmental Protection Agency, Region 9.

Van Beveren & Butelo Inc. 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared for Malibu Lumber, LLC by Van Beveren & Butelo Inc.

Van Beveren & Butelo Inc. February 20, 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. June 27, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. August 11, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. October 13, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Vaughn, J.M., Landry, E.F., & Thomas, M.Z., 1983. Entrainment of Viruses from Septic Tank Leach Fields Through a Shallow, Sandy Soil Aquifer. *Applied and Environmental Microbiology*, 45(5): 1474–1480.

Viergutz, Richard, 2006, Discharge of Sewage-Polluted Groundwater into Malibu Creek and Lagoon Resulting from Groundwater Surface Interactions: MS Thesis, California State University, Los Angeles.

Yates, M.V., Gerba, C.P., & Kelley, L.M. April 1985. Virus Persistence in Groundwater. *Applied and Environmental Microbiology*, **49**(4): 778–781.

Yates, M.V., Yates, S.R., Warrick, A.W., & Gerba C.P. September 1986. Use of Geostatistics to Predict Virus Decay Rates for Determination of Septic Tank Setback Distances. *Applied and Environmental Microbiology*, 52(3): 479–483.

Yamahara, K.M., Layton, B.A., Santoro, A.E., & Boehm, A.B. 2007. Beach Sands along the California Coast are Diffuse Sources of Fecal Bacteria to Coastal Waters. *Environmental Sciences & Technology*, 41(13):4515-4521.

Yamahara, K.M., Walters, S.P., & Boehm, A.B., 2009. Growth of Enterococci in Unaltered, Unseeded Beach Sands Subjected to Tidal Wetting. *Applied and Environmental Microbiology*, 75(6): 1517-1524

REVISED OCT 2 1 2009

Appendix T3-C[9]										
Enterococcus Frequency distributions for Civic Center Beaches and Selected Correlation Coefficients										
Malibu Pier						**Surfrider Beach**				
MPN/100mL	2005	2006	2007	2008		MPN/100mL	2005	2006	2007	2008
<10	0.417	0.067	0.464	0.233		<10	0.21	0.262	0.58	0.435
10	0.25	0.433	0.286	0.367		10	0.11	0.123	0.221	0.183
25	0.167	0.033	0.071	0.067		25	0.14	0.131	0.015	0.099
50	0.167	0.2	0	0.133		50	0.19	0.154	0.076	0.076
100	0	0.2	0.107	0.1		100	0.2	0.138	0.076	0.115
250	0	0	0.071	0.067		250	0.06	0.123	0.015	0.053
500	0	0.033	0	0.033		500	0.01	0.031	0.015	0.015
1000	0	0	0	0		1000	0.07	0.031	0	0
2500	0	0.033	0	0.033		2500	0	0.008	0	0.023
5000	0	0	0	0		5000	0	0	0	0
>5000	0	0	0	0		>5000	0	0	0	0
sum of frequencies	1	1	1	1.033			1	1	1	1
Correlation Coefficients			**2005-2006**	**2006-2008**		**Correlation Coefficients**			**2005-2006**	**2006-2008**
2007-2008	**2006-2007**		0.437	0.847		**2007-2008**	**2006-2007**		0.904	0.871
0.8075	0.427					0.98	0.78			

[7] Shaded boxes indicate corrections of clerical errors since 9/09/2009 Draft

REVISED OCT 21 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review – Staff Memorandum

Technical Memorandum #3:
Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

By

Elizabeth Erickson, Professional Geologist
Groundwater Permitting Unit

TM-40

California Regional Water Quality Control Board
Los Angeles Region

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Cal/EPA Secretary

Arnold Schwarzenegger
Governor

To: Wendy Phillips, C.E.G., C.H.G.,
Chief of Groundwater Permitting and Landfills Section
Rebecca Chou, Ph.D. P.E., Chief of Groundwater Permitting Unit

From Elizabeth Erickson, P.G. Groundwater Permitting Unit

Date: October 21, 2009

Subject: Peer Review Response to Comments - Technical Memo #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

Attachments:

1. Comments dated October 5, 2009 from Dr. Robert Arnold, Arizona State University
2. Comments dated October 7, 2009 from Dr. Jörg Drewes, Colorado School of Mines
3. Comments dated September 10, 2009 from Dr. JoAnn Silverstein, University of Colorado at Boulder

To ensure that the proposed amendment to the *Basin Plan*[1] is based on sound science and engineering principles, the scientific elements of Technical Memorandum #3: "Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation" dated September 9, 2009, was peer reviewed. This peer review was conducted in accordance with requirements and guidelines from the Cal/EPA Scientific Peer Review Program, Office of Research, Planning and Performance.

Summary

Dr. Robert Arnold of Arizona State University, Dr. Jörge Drewes of Colorado School of Mines, and Dr. JoAnn Silverstein of the University of Colorado at Boulder agreed that the approach and methods used in Tech Memo #3 incorporate sound scientific and engineering principles. Although some suggestions were made to improve staff's discussion, none of the comments materially altered the conclusion of Tech Memo #3. That is: OWDSs in the Malibu Civic Center area cumulatively release bacteria to Malibu Beaches, where the enterococcus densities exceed the water quality criteria for the protection of human health.

[1] Proposed amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to prohibit on-site subsurface disposal systems (OWDSs) in the Malibu Civic Center area.

New Material Added

Dr. Bob Arnold asked for additional material to be added. Statistical support for the findings were added on page T3-17 and summarized in Appendix 1.

Dr. Arnold: "The contention here is that the correlations among annual frequency distribution provides evidence of annual similarities at each beach for which data were provided and thus an indication that fluctuation in enterococcus numbers is probably the result of some regular pattern of events as opposed to random odd events like direct communication with bathers, etc. I am unable to provide a convincing statistical analysis as part of this review..." (page 3).

Response: The enterococcus interval frequencies calculated for the beaches for four summers were compared using the Pearson's correlation coefficient. The number of measures were counted in each of eight intervals: (1) values less than or equal to ten; (2) more than ten but less than or equal to 25; (3) more than 25 but less than or equal to 50; (4) more than 50 but less than or equal to 100; (5) more than 100 but less than or equal to 250; (6) more than 250 but less than or equal to 500; (7) more than 500 but less than or equal to 1,000; and (8) more than 1,000. The intervals approximate a logarithmic distribution, but include more intervals between 25 and 100 and between 250 and 1,000, ranges in which the beaches contrasted most sharply. Pearson's correlation coefficient was applied following EPA's "Ambient Water Quality Criteria for Bacteria, 1986" as described in the following quote:

> "The examination of a number of potential indicators, including the ones most commonly used in the United States (total coliforms and fecal coliforms), was included in the study. Furthermore, the selection of the best indicator [enterococcus] was based on the strength of the relationship between the rate of gastroenteritis and the indicator density, *as measured with the Pearson's Correlation Coefficient. This coefficient varies between minus one and plus one. A value of one indicates a perfect relationship, that is, all of the paired points lie directly on the line which defines the relationship. A value of zero means that there is not linear relationship. A positive value indicates that the relationship is direct, one variable increases as the other increases. A negative value indicates the relationship is inverse, one variable decreases as the other increases.* The correlation coefficients for gastroenteritis rates are related to the various indicators of water quality from both marine and fresh bathing water as shown in Table 2" (page 5).

Staff also conducted an additional study to determine if evidence for groundwater contributions to beach bacteria could be statistically linked to existing water quality and hydrology data. Early technical reviewers commented that the approach had not been used before and asked for additional time to evaluate the study. The analysis is provided in Attachment #1.

Requests for Clarification

Dr. Arnold, Dr. Jorge Drewes and Dr. JoAnn Silverstein asked for clarification on three topics. Dr. Arnold requested clarification on how the scientific process was used. Dr. Drewes' inquiry on non-

human sources for enterococcus and Dr. Silverstein's query about bacteria transport in groundwater have been resolved with clarifying language in the memo.

Dr. Arnold: "I feel that this is a weak argument, primarily because the statement does not seem to rest on statistically valid hypothesis testing. That is, do the calculated correlation coefficients in fact justify the conclusion that the distribution of values observed is derived from the same population of actual values each year - that the distribution of MPNs does not change from year to year. Even if that distribution of concentrations is time invariant (as suggested) it seems that the population of enterococcus concentrations in the waters tested may take on a distribution of this sort for any number of reasons, including a somewhat randomly generated source of contamination due to bathing and so forth. It seems difficult to justify the elimination of such an explanation based on the data provided."

Response: Material has been added on pages T3-2 and T3-25 to clarify the hypothesis testing process which led to the results.

Dr. Drewes: "The author neglects to state that there are also non-human sources for enterococcus, which could potentially contribute to the concentrations observed in beach samples, although the likelihood for non-human contributions is small in the given settings (page 1)."

Response: Enterococcus has been attributed by some researchers to feces from warm-blooded animals such as raccoons, a source which may be present at the Malibu beaches. See the additional clarifying material included on page T3-23 and in Attachment 2.

Dr. Silverstein: "..the Haile et. al. epidemiology study was based on illness resulting from swimming at or near storm drain outfalls. The 1983 EPA document, Health Effects Criteria for Marine Recreational Waters, was based on studies of illness linked with treated wastewater outfalls. These are both point sources at beaches. The mechanism for transport of septic tanks and subsurface infiltration such as those in Malibu is thorough porous media, which may lessen the risk of these discharges. One source of difference resulting from subsurface discharge is the removal of particulate matter and attached bacteria. The 1983 EPA Health Effects document noted that removal of suspended solids during wastewater treatment reduced the density of Salmonella."

Response: Both the Haile and EPA epidemiology studies measured illnesses associated with enterococcus from point and non-point sources. Additional clarifying discussion was added at T3-24 and in Attachment 3.

Recommendations Not Incorporated

Staff appreciated comments from Dr. Drewes and Dr. Silverstein and provides further explanation, but did not incorporate two recommendations. Dr. Drewes requested that more surface water information should be provided in the memo. Staff chose to rely on existing surface water documents. Dr. Silverstein commented that the end-of-pipe enterococcus measures were not consistent with average raw sewage densities. Staff agrees, but inserted additional discussion describing why a change was not made.

Dr. Drewes: "Data presented in this Technical Memorandum provide support that beach water quality in the vicinity of the Malibu Creek watershed repeatedly fails to meet water quality objectives. The data presented would not support that the water quality "persistently" fails to meet the water quality objectives since only a limited data set is presented. For some tables, information is missing regarding the size of the data set considered. For example, regarding Table 2, what is the total number of samples collected? Exceedances reported for the Surfrider Beach (2006 and 2007) in Table 2 seems to be based on data collected during six weeks in 2006 only, whereas the 2007 data set represents data collected over a four-month period. Are results presented in Tables 3-5 all data that is available for these sampling locations? At a minimum, a clarification should be provided in the Memorandum" (page 3).

Response: Sufficient evidence of a persistent problem has already been made available to the public in EPA's 2002 303(d) list, Santa Monica Bay Bacteria, Malibu Creek and Lagoon bacteria and Malibu Creek and Lagoon nutrient TMDLs and the 2008 NOV on stormwater exceedances in Malibu, but additional discussion was provided on page T3-7.

Dr. Silverstein: "Some of the data in Table 1 (page T3-3) seem questionable. For the Malibu Colony Plaza, the numbers of total and fecal coliform are identical, and typically fecal coliform are a log unit less than total. Also the number of Enterococci is higher than either total or fecal coliform, which is atypical in general, and not consistent with the other samples. For Fire Station 8, the data are more puzzling. In all samples, the MPN for enterococcus is equal to or greater than either total or fecal MPNs. .....these data should be questioned by anyone familiar with typical trends for these three indicators reported in the literature and therefore some explanation of the differences should be offered."

Response: The end-of-pipe data were provided to document that enterococcus can be discharged from OWDSs into groundwater. The bacteria densities and proportions are not consistent with sewage or non-sewage related waters. Inconsistencies within these samples is attributed to the wide range of data reported for OWDS effluent where disinfection has failed and different detection methods are used on serial grab samples of samples of partially treated sewage. See discussion added on page T3-4.

Dr. Silverstein: "The scientific basis for Figure 11 is weak..."

Response: The end-of-pipe values included in this figure show the wide variation in enterococcus densities entering the groundwater at the location indicated and discussed above. Staff questions if 'average' range of enterococcus in raw sewage concentrations from homogenized municipal waste is an appropriate criteria for well testing or septic tank outlet to a seepage pit. Numerous reported enterococcus values in the Malibu Civic Center wells and at end-of-pipe range up to 1×10^8 MPN/100 mL, suggesting that any one high value is not a computational, sampling or reporting error.

Comments in Support

Dr. Arnold: "Considering the entire argument presented and supporting information provided, the staff has made an adequate case for improving the microbial quality (indicators of fecal contamination) in Malibu ground water in order to improve the water quality in the near shore marine area off the Malibu coastline in order to reduce associated threats to human health (page 4)."

Dr. Arnold: "There are somewhat speculative, but increasingly accepted, mechanisms for the transport of bacteria and viruses from proximate ground waters, through the near-surface beach sand and into the surf zone. Observations regarding transport through the beach front were derived from studies outside the Malibu area, but in southern California, from multiple lines of experimentation. These have been described in peer-reviewed archival journals, adding to their credibility (page 4)."

Dr. Drewes: "The reviewer concurs with the interpretation of the key literature considering in this Technical Memorandum indentifying factors that increase the levels of pathogen indicators and risk to human health. The reviewer also concurs with the selection of enterococcus bacteria, since it is more persistent in water and sediments as compared to coliforms, as a recreational water quality indicator illustrating the presence of human waste at the sites studied "(page 1).

Dr. Drewes: "The reviewer agrees with staff's determination of impairment through pathogenic organisms and the conclusion that groundwater in this area is a source of impairment to lagoon and beaches (page 3)."

Dr. Drewes: "Plotting enterococcus occurrence data as frequency graphs is appropriate to illustrate distribution changes over several years for May-October summer time periods. (page 3)"

Dr. Drewes: "Correlation coefficients between annual enterococcus frequency distributions are reported for the Surfrider Beach (MC-2) data set only and they demonstrate that the variability of the distribution is small from year to year (page 3)."

Dr. Silverstein: "Overall, the movement of groundwater from the area served by OWDSs is well documented in other reports (Tech Memo 4). Literature cited confirms that pathogens, especially viruses, are transported in the subsurface from OWDSs, and would therefore reach the ocean water, especially in a sandy aquifer with short travel time. The presence of enterococcus in septic tank effluent, nearby groundwater, and the beaches is credible support for the contribution of OWDSs to contamination of the Malibu beaches by bacteria."

Dr. Silverstein: "a particular source of pathogen risk is associated with the fact that OWDSs serve a small number of people. This was discussed in the EPA Health Effects Criteria for Marin Recreational Waters (1983, page 49). That document notes that when the number of individuals who are sources of fecal waste becomes smaller, the ratio of pathogen-to-indicator density will vary highly from numbers based on aggregate wastes from a large population. If one or a small number of individuals in these small systems have an infectious disease, the ratio could approach 1, making the risk a significantly higher than that addressed by the water quality standard. The EPA document advises in that case, which may include OWDSs : " The solution is administrative action prohibiting such discharges into recreational waters."

Dr. Silverstein: "Taken as a whole, the conclusions of Technical Memos #3 and #4 are based on sound scientific principles and reasoning. Epidemiologic studies cited provide a strong basis for increased health risks to swimmers and the presence of indicator bacteria measured at the beaches, especially enterococcus, at concentrations higher than marine recreational water quality standards. There are some relatively minor concerns about interpretations of literature and some of the reported data as discussed above and in previous comments on Tech Memo #4. Addressing these will acknowledge real uncertainties that always exist with environmental studies, but will not weaken the conclusions."

Other Revisions

Dr. Arnold: "I feel that the case is well made for construction of sewerage in the Malibu area, but I was convinced in part by information from the supporting documents that might be included directly in the technical memorandum. The epidemiological case in particular requires supporting information. In my opinion, further studies are not required to justify Board action, so that recommendations specific to such studies are unnecessary. The complexity of the hydrology conditions, microbiological transport mechanisms and so forth are sufficiently plain (page 4)."

Response: The supporting documents have been included as part of the administrative record and posted on the website for the use of the public in considering Technical Memo #3. Specifically, we included Haile et. al, "An epidemiological study of possible adverse health effects of swimming in Santa Monica Bay", 1996; Haile et. al. "The health effects of swimming in ocean water contaminated by storm drain runoff", 1999; Gold, M.A. "What are the health risks of swimming in Santa Monica bay", 1994; and EPA "Health Effects Criteria for Marine recreational waters", 1983.

Dr. Silverstein: "Caution should be used in associated the bacteria indicator with human waste."

Response: Corrections in the text are made as per your recommendations emphasizing that enterococcus can also be associated with non-human waste.

Editorial and grammatical suggestions have been followed as appropriate, but are not specifically listed here. Staff wishes to express appreciation for the contributions of the peer reviewers.

Attachment #1

Comparison of Santa Monica Bay Beaches Adjacent to OWDS and to Sewers with Winter Rainfall using Gehan Statistical Test.

Dr. Arnold asked for additional statistical support for staff's findings.

Data

Beach data were collected as part of the "Santa Monica Bay Beaches Bacteria Total Maximum Daily Load Coordinated Site Monitoring Plan, April 7, 2004" (CSMP) and can be found at http://ladpw.org/wmd/npdes/beachplan.cfm.

Sampling procedures are standardized, including morning sampling in ankle-deep water at fixed points with testing in State certified laboratories. The study focused on records for June through August in 2005, May through October in 2006, April through October in 2007, and May through October in 2008, on a total of 58 beaches, 36 of which receive freshwater drainage (with MS-4 stormwater permits) and 22 of which do not. The beaches stretch from El Pescador Beach in the northwest to Redondo Beach in the southeast.

The sample sites were sorted according to characteristics, such as watershed size, land-use, fecal-indicator-bacteria concentrations, septic system presence, wave strength and beach visitor population. A full array of site characteristics were found to be represented: sewage or septic system waste treatments, adjacent groundwater levels of enterococcus levels above 1 MPN/100mL, watershed sizes ranging from 813 acres to 81,980 acres, urban acres ranging from 128 acres to 68,700 acres, and wave action identified from surf web-sites ranging from none to persistent. Some beaches had adjacent lagoons, tidally influenced pools, stormwater containments and low flow diversions.

Results

Enterococcus on Malibu Civic Center Beaches and all Santa Monica Bay Beaches

The enterococcus measures recorded on CSMP beaches over the summers 2005 to 2008 were sorted by interval frequency and plotted against the concentrations of Enterococcus (MPN/100mL). The method was chosen to minimize the impact of varying sample sizes and simplify large variations in the measures.

The beaches were found to have the most measures at 10 MPN/100 mL and some additional measures above 1,000 MPN/100 mL Figures A to D and Tables A to D of all Santa Monica Bay beaches for 2005 through 2008 show that these general characteristics are present for all the studied beaches.

Figure A. 40 Santa Monica Bay Beaches 2005 (All MS-4 beaches) Enterococcus Interval Frequency for June-August Single Measures[2]

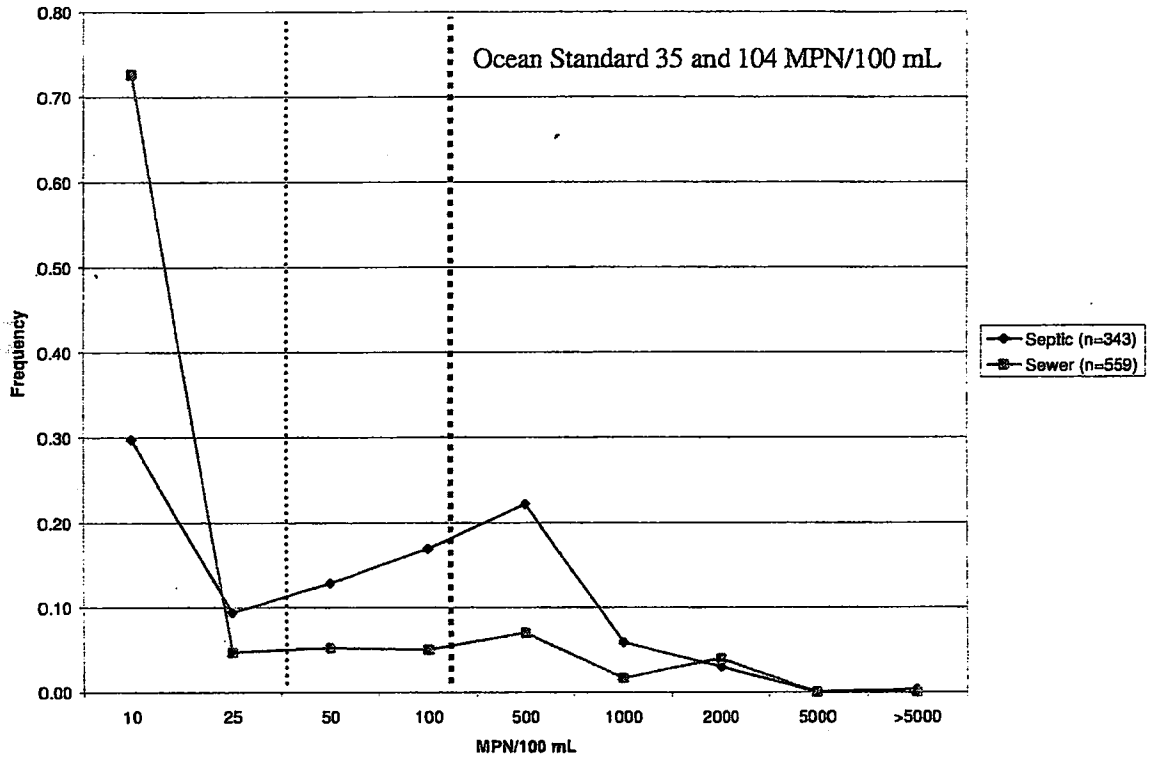


Table A: Relative Number of Exceedances for 57 Septic and Sewered Beaches in 2005.

In MPN/100mL	all beaches in 2005			
Enterococcus	Septic (n=466)	% total days reported at septic sites	Sewer (n=859)	% total days reported at sewer sites
Days above 35	206	44%	207	24%
Days above 104	108	23%	126	15%

[2] For the purposes of this study, the following site definitions were made: MS-4 Septic (19) 1-01, 1-03, 1-04, 1-05, 1-06, 1-07, 1-08, 1-09, 1-10, 1-11, 1-12, 1-13, 1-14,1-16,1-18, 4-01, MC-01, MC-02, MC-03; MS-4 Sewer (21) 2-01, 2-02, 2-06, 2-07, 2-10, 2-11, 2-13, 2-15, 3-01, 3-02, 3-03,3-04, 3-05, 3-06, 3-07, 3-08, 5-02, 5-03,6-01,6-05, BC-01; Non MS-4 Septic (3)1-02,1-15,1-17;
Non MS-4 Sewer (15) 2-03,2-04,2-05,2-08,2-09,2-12,2-14,3-09,5-01,5-04,5-05,6-02,6-03,6-04,6-06

Figure B. 40 Santa Monica Bay Beaches 2006 (All MS-4 beaches) Interococcus Interval Frequency for May-October Single Measures

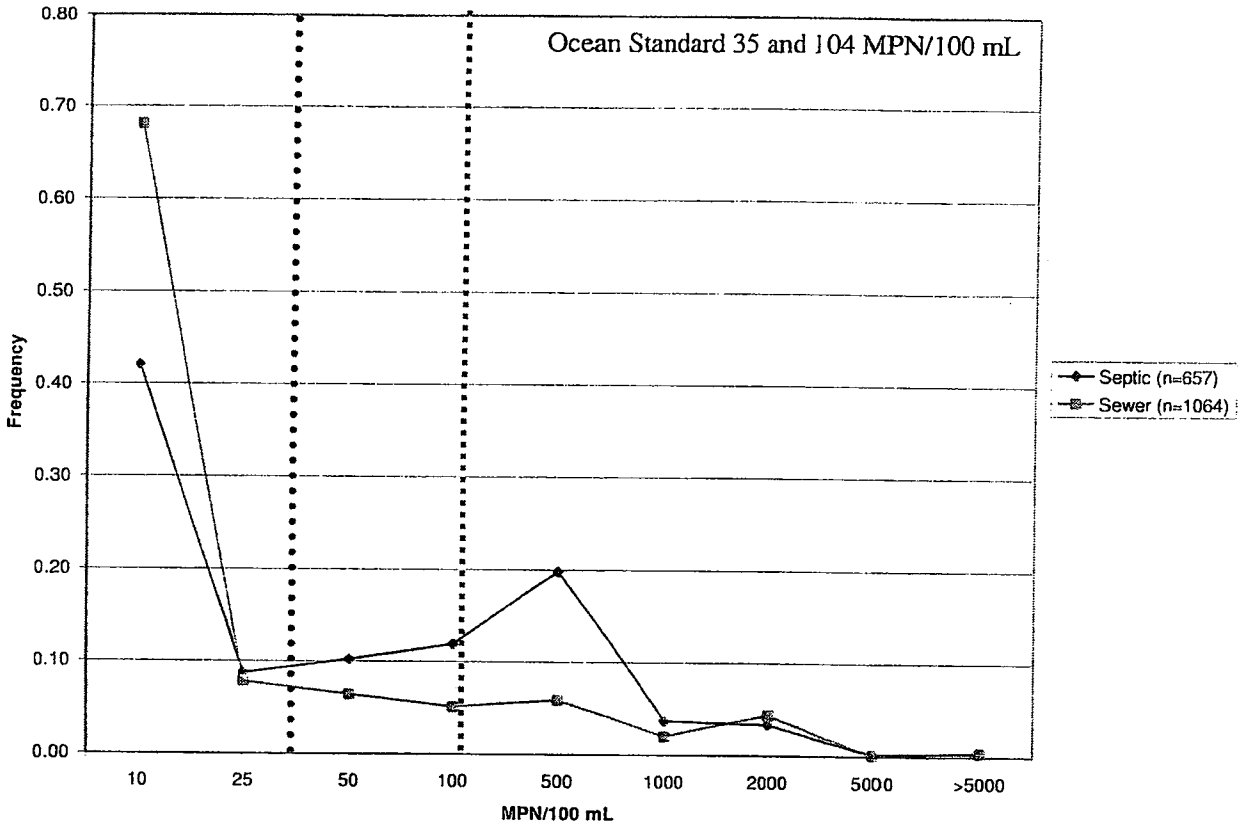


Table B: Relative Number of Exceedances for 57 Septic and Sewered Beaches in 2006. Sewered beaches were tested about one and a half times as often, in this year, as septic beaches, yet more days were recorded when enterococcus densities on septic beaches were higher than the Ocean single sample and geometric mean objectives.

In MPN/100mL	all beaches in 2006			
Enterococcus	Septic (n=903)	% total days reported at septic sites	Sewer (n=1669)	% total days reported at sewer sites
Days above 35	326	36%	295	18%
Days above 104	183	20%	156	9%

Figure C. 40 Santa Monica Bay Beaches 2007 (All MS-4 beaches) Enterococcus Interval Frequency for May-October Single Measures

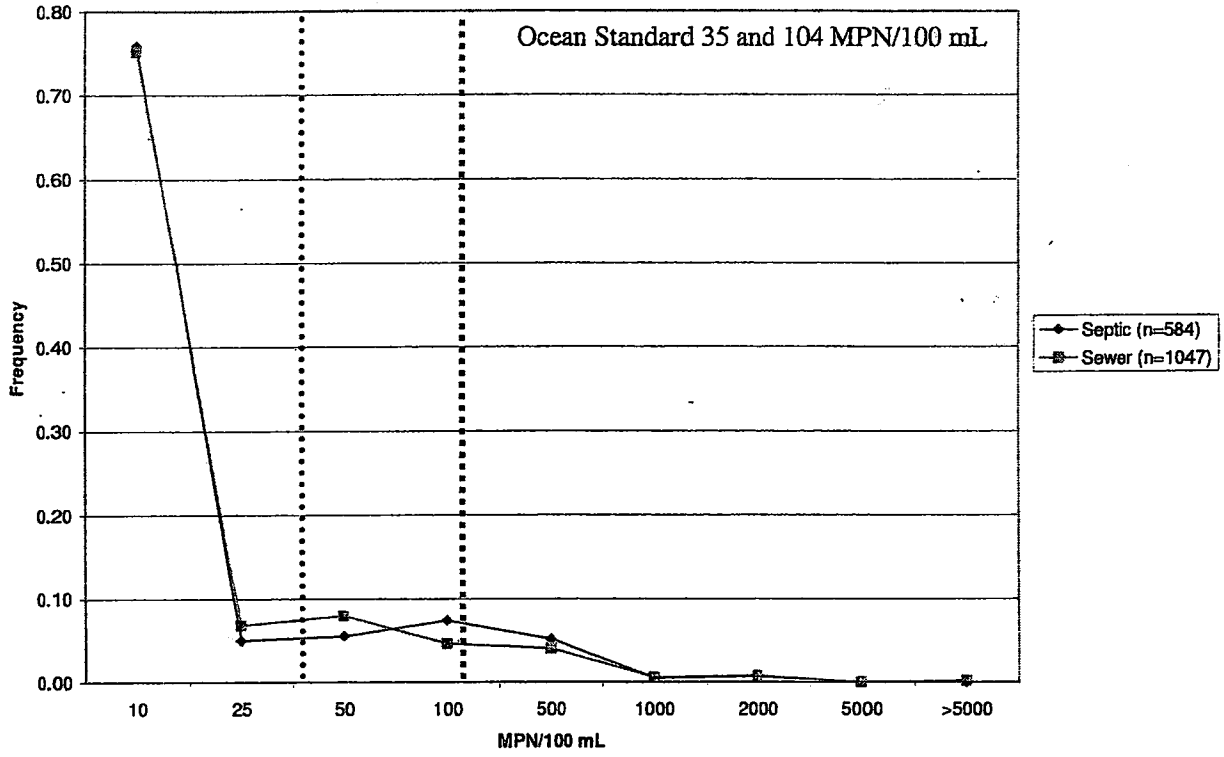


Table C: Relative Number of Exceedances for 57 Septic and Sewered Beaches in 2007. Sewered beaches were tested about twice as often, in this year, as septic beaches, and both had the same frequency of exceedances.

In MPN/100mL	all beaches in 2007			
Enterococcus	Septic (n=816)	% total days reported at septic sites	Sewer (n=1705)	% total days reported at sewer sites
Days above 35	106	13%	215	13%
Days above 104	38	5%	79	5%

Figure D. 40 Santa Monica Bay Beaches 2008 (All MS-4 beaches) Enterococcus Interval Frequency for May-October Single Measures

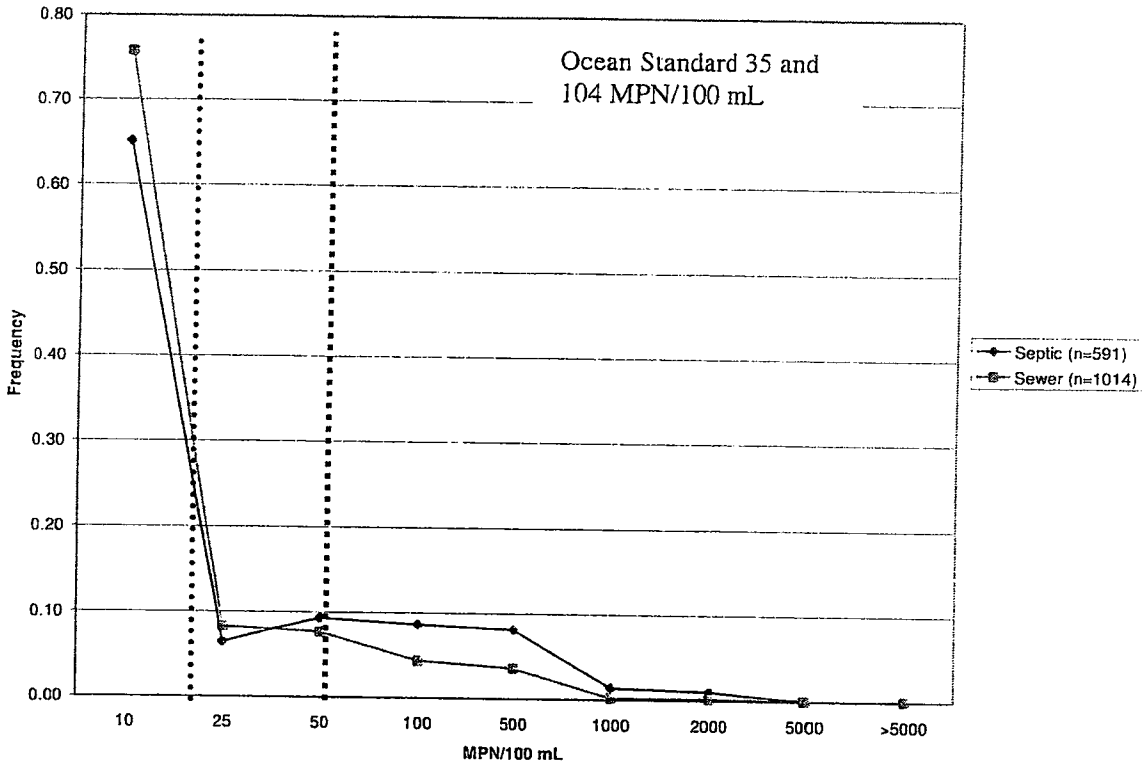


Table D: Relative Number of Exceedances for 57 Septic and Sewered Beaches in 2008.

In MPN/100mL	all beaches in 2008			
Enterococcus	Septic (n=813)	% total days reported at septic sites	Sewer (n=1644)	% total days reported at sewer sites
Days above 35	145	18%	176	11%
Days above 104	59	7%	54	3%

This annual comparison of all Santa Monica Bay beaches is consistent with the hypothesis that the mechanism(s) supplying enterococcus bacteria to beaches during the summer months does not operate uniformly every year. Further, the mechanism which supplies enterococcus bacteria to the beaches at levels of 10 MPN/100 mL, and to a lesser extent at levels above 1,000 MPN, must operate on all beaches regardless of the year or the method of waste treatment in the adjacent area.

The difference between the septic and sewered data sets for 2005, 2006 and 2008 is statistically significant.

Statistic analysis was performed for the same data sets of 2005-2008 using a t-test, and a Chi-square test. The use of these tools to measure the significance of enterococcus distributions was found to produce variable results depending on the size of the population and any truncation of the population. This observation is attributed to the non-normal and non-Chi-square shape of the distributions with a predominance of very low values and wide variations in the number and size of the largest values.

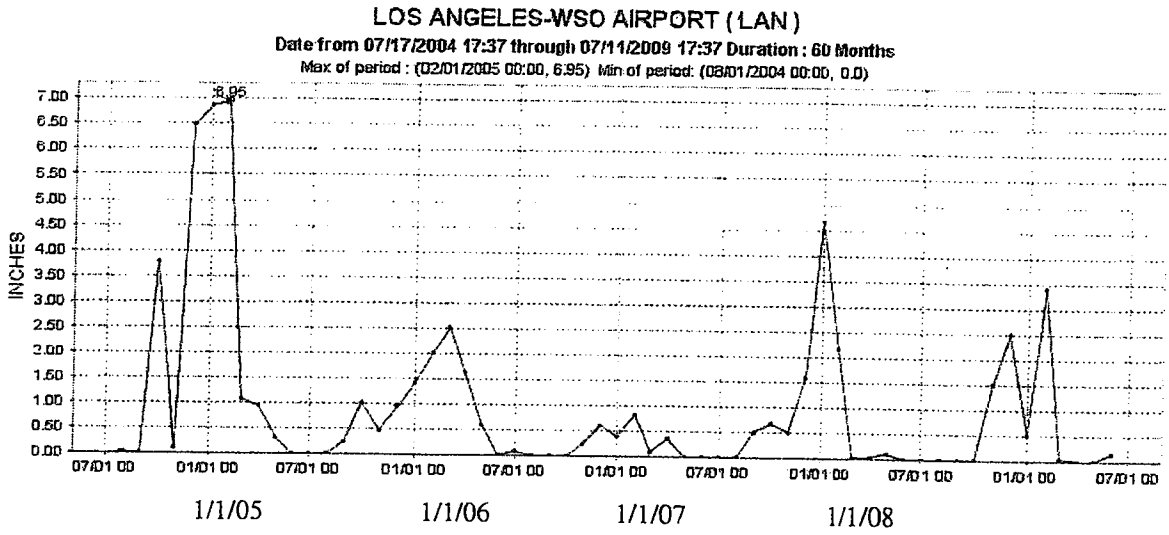
Consistent statistical results were obtained for the entire population of over 8,000 measures using the Gehan Test (a non-parametric Statistical Program) from USEPA ProUCL Statistical Program in conjunction with the Wilcoxsin and Quartile tests. All results confirmed hypothesis that enterococcus concentrations at septic beaches are greater than sewered beaches with 95% confidence level except for 2007 data. Gehan Test results and a discussion of the discarded methods are provided below.

This examination of all Santa Monica Bay beaches over four years provides evidence that bacteria may be transported by groundwater to the beach face as other mechanisms such as stormwater flow, overland urban flow, storm surge are minimal in the summer and the only other major source present only at septic beaches in groundwater discharge. Because bacteria must be transported by the groundwater between the septic systems and surface receiving waters and groundwater gradients increase after rain, a correlation between the number of enterococcus measures per site and the rainfall is expected at beaches where groundwater movement of the bacteria takes place.

Rainfall and Enterococcus

The highest monthly volume of rain fell in 2005 (wet year), among the years evaluated here, when 6.95 inches were recorded. The lowest was reported in 2007 (dry year) when less than one inch was recorded. However, the average annual rain fall in this area is 12 inches per year, significantly larger than the rain received in this study's "wet" year of 2005. Rain gauge reports from Los Angeles International Airport reported by the Department of Water Resources confirm annual variations in precipitation by year and are shown in Figure E.

Figure E. Rain gauge information for Los Angeles International Airport



Septic beaches are more distinct from sewered beaches in summers preceeded by rainy winters. The relative frequency of bacteria densities above 35 MPN/100mL on the beaches during the summer are seen to decrease between 2005 and 2007 in Tables A through D. The rainfall also decreases during this period as shown in Figure E.

Non parametric statistical tools were applied to the enterococcus beach data sets using Gehan Test from EPA's ProUCL statistical program. Using Form 1 Test, the Null Hypothesis is "Septic Beach Mean/Median Less Than or Equal to Sewer Beach Mean/Median;" and the Alternative Hypothesis is "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median". The result of the Gehan Test for 2005, 2006 and 2008 shows that the Null Hypothesis is rejected by a low P-value with an alpha value of 0.05 (a confidence level of 95%) , which rejects the Null Hypothesis and supports the Alternative Hypothesis "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median".

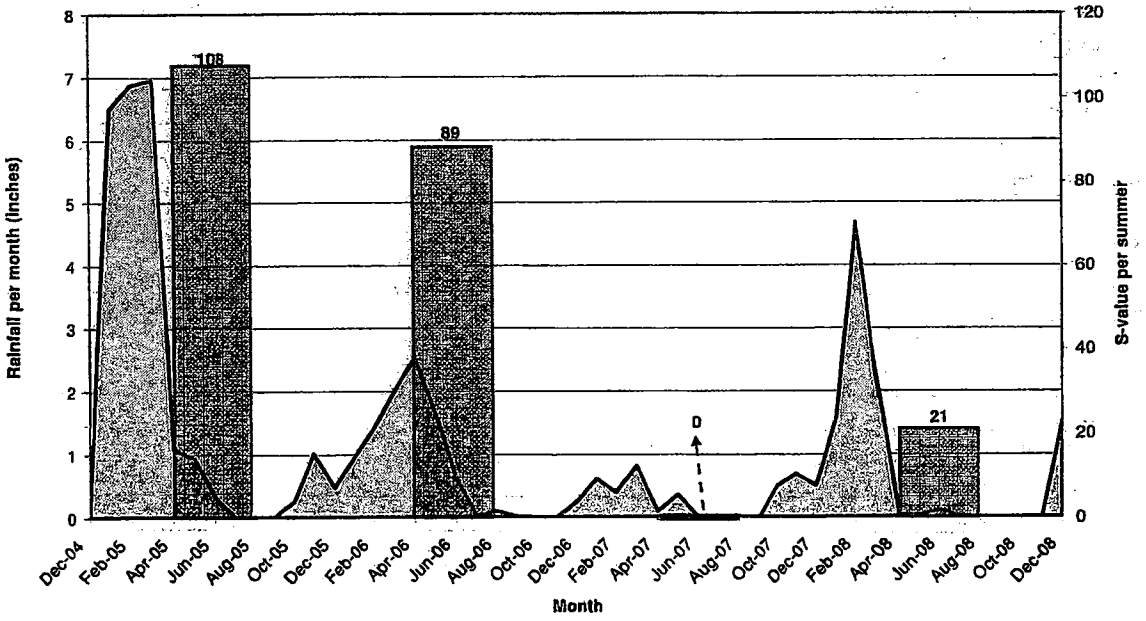
The statistical assessments of the 2007 enterococcus data are not consistent with the statistical results for 2005, 2006, and 2008. The same results were also obtained with an alpha value of 0.01 (a confidence level of 99%); enterococcus concentrations at septic beaches are higher than concentrations at sewered beaches statistically. Form 2 Test is also performed using the Gehan Test to verify the above conclusions.

The "Substantial Difference" (S) is used to estimate the difference in enterococcus concentration between septic and sewered beaches and is shown in Figure F. The rainfall was low in 2007, as is the S value. The S increases as the winter rains increase in 2008.

Because septic or sewered beach have little stormwater discharge for June to September, these observations document a supply and transport mechansim. Ground water discharge with elevated enterococcocus densities after wet winters is affecting septic beaches to a greater extent than is occuring on sewered beaches. In the summer of 2008, the frequency of enterococcus densities above 35 MPN/100mL does not increase to the 2006 summer levels, despite increasing rainfall in the winter of 2007-2008, nor does the S value increase to 2006 levels. This observation is attributed to short term rain events in February 2008 when discharge was via stormwater and not groundwater recharge.

Figure F.

Santa Monica Bay: Los Angeles International Airport Monthly Rainfall and Dimensionless Measure of Significance for the Contrast between Summer-Month Septic and Sewered Beach Enterococcus-Interval-Frequency-Distributions vs. Months



Septic Density

Septic Density did not show a strong correlation with enterococcus measures or interval frequencies.

The number of septic systems at a beach within 1000 feet of the CSMP monitoring location was estimated by counting roofs on air photos dating after 2004 and available for coastal areas on Google for the area northwest of Castlerock Mesa, where no sewer hook up is available. The counts are as follows:

Table E.

Beach with Lower Septic System Density	Sampling Point	Number of roofs within 1000 feet
Zuma Beach	1-05	3
Malibu Pier	MC-3	4
Leo Carrilo	1-01	5
San Nicholas Canyon	4-01	10
Solstice Creek an Dan Blocker Beach	1-10	10

Table F.

Beach with Higher Septic System Density	Sampling Point	Number of roofs within 1000 feet
Latigo Canyon	1-09	20
Surfrider Beach	MC-2	21
Trancas Creek	1-04	22
Walnut Creek	1-06	29
Sweetwater Canyon on Carbon Beach	1-13	32
Corral Canyon	1-11	34
Escondido Creek	1-08	34
Pena Creek on Las Tunas County Beach	1-16	36
Topanga Beach	1-18	41
Marie Canyon	1-12	43
Malibu Colony	MC-1	45
Las Flores Creek	1-14	58
Tuna Canyon	1-17	93
Ramirez Creek	1-07	120

Six beaches with no sewer connections and less than 20 roofs within 1000 feet of the CSMP monitoring point were compared with 14 beaches with no sewer connections and more than 20 roofs, as shown in Tables E and F and Figures G, H, J, and K. The plots below demonstrate that significant differences, as measured by the less reliable student t-test, were found on beaches in 2005 and 2006, when some rain fell. The following two years, a significant difference was not found. A weather related summer month difference, when direct discharge across the beaches is limited, is most likely attributed to groundwater flows.

Figure G.

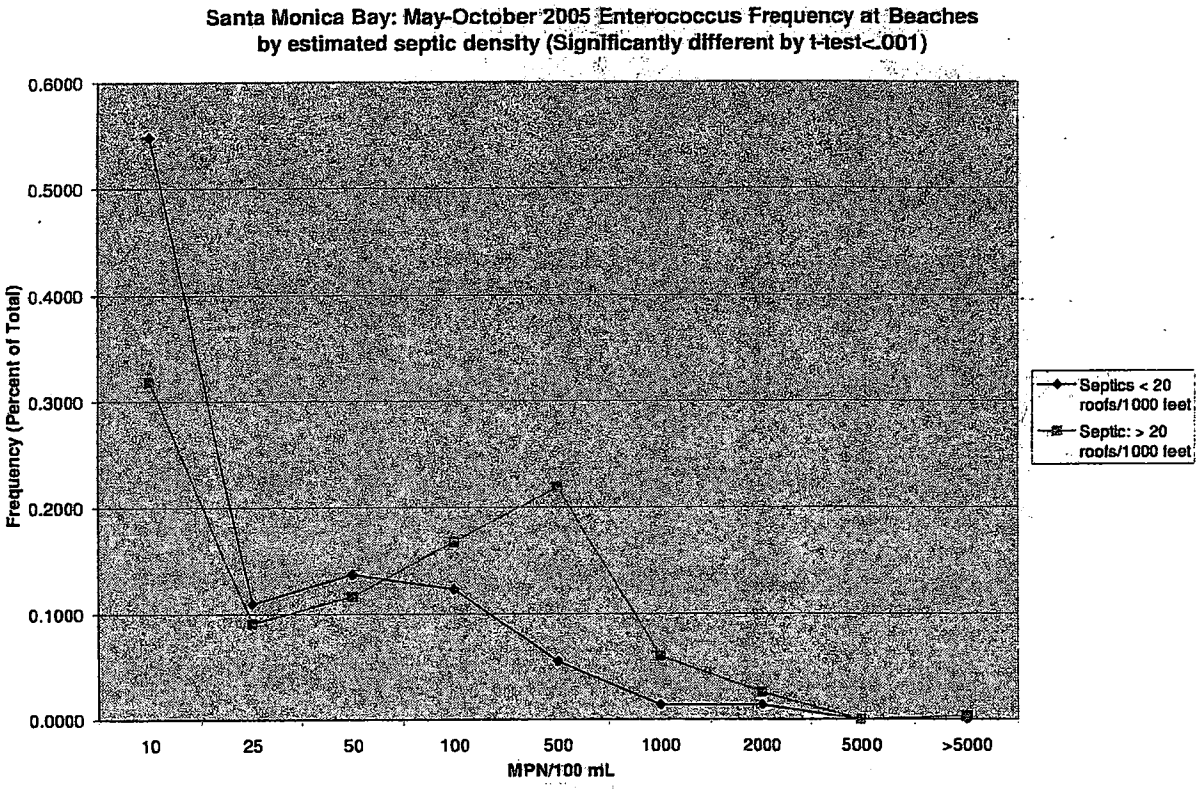

Santa Monica Bay: May-October 2005 Enterococcus Frequency at Beaches
by estimated septic density (Significantly different by t-test<.001)
Frequency (Percent of Total)
0.6000
0.5000
0.4000
0.3000
0.2000
0.1000
0.0000
10
25
50
100
500
1000
2000
5000
>5000
MPN/100 mL
Septics < 20 roofs/1000 feet
Septic: > 20 roofs/1000 feet

Figure H.

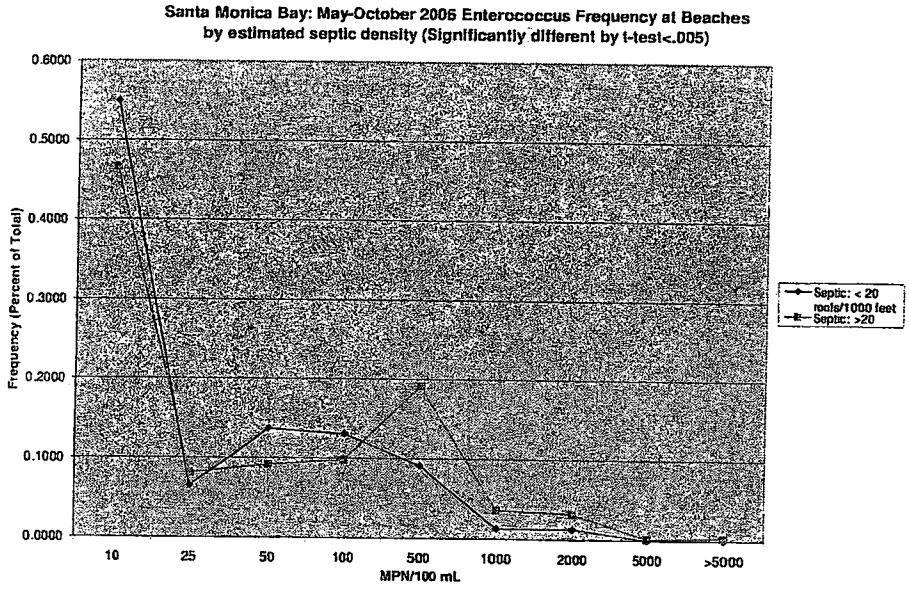


Figure J.

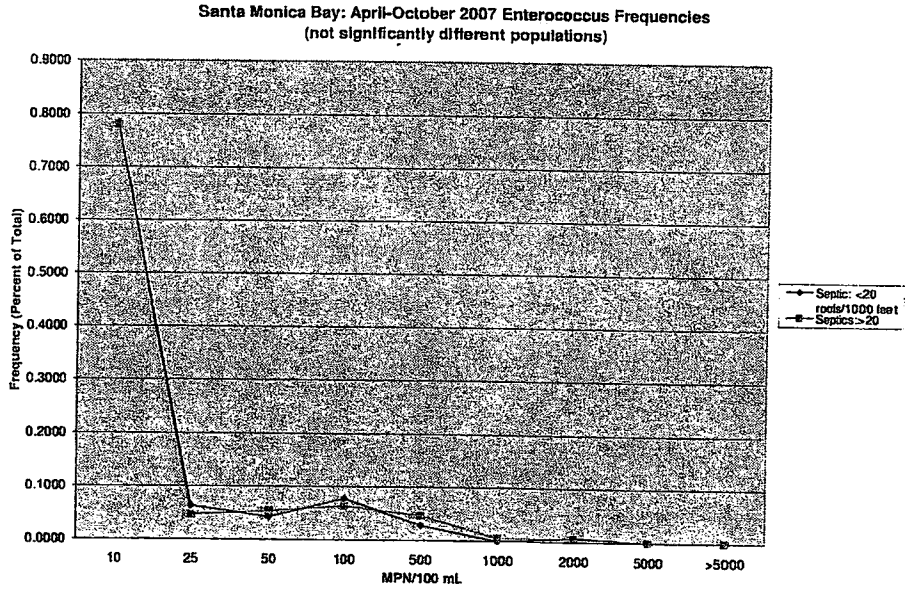
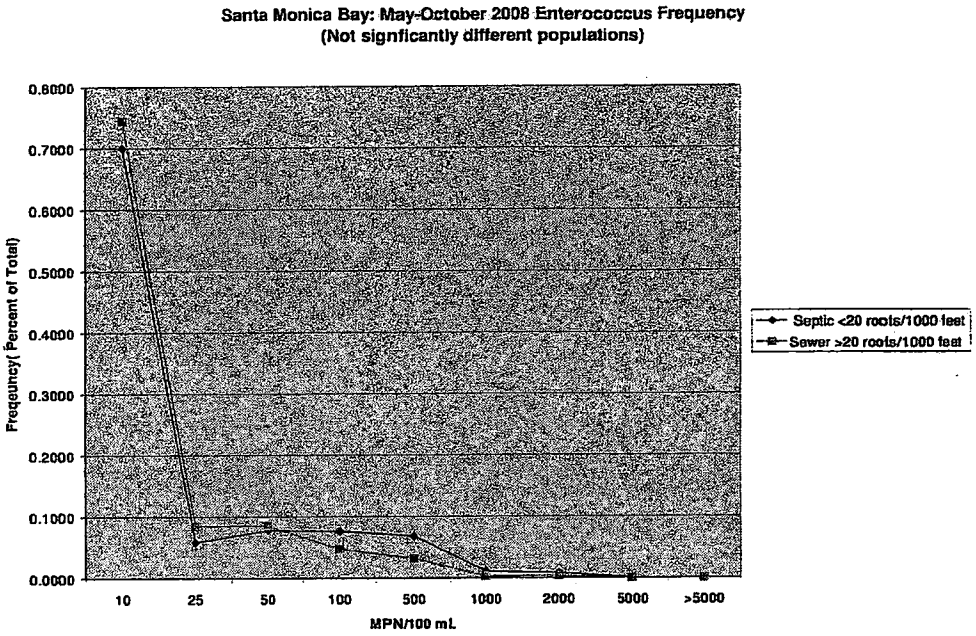


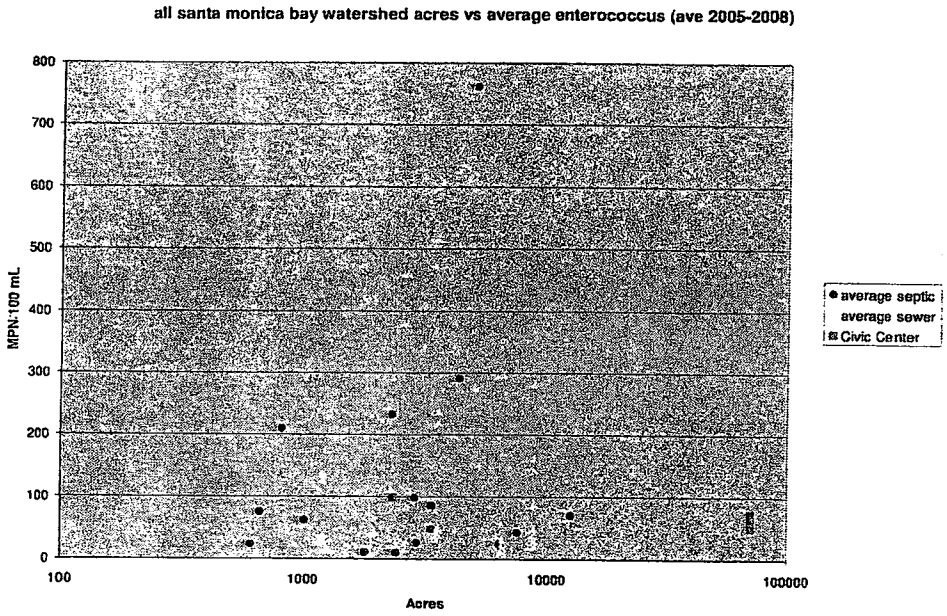
Figure K.



Watershed Area, Urban development and Beach populations

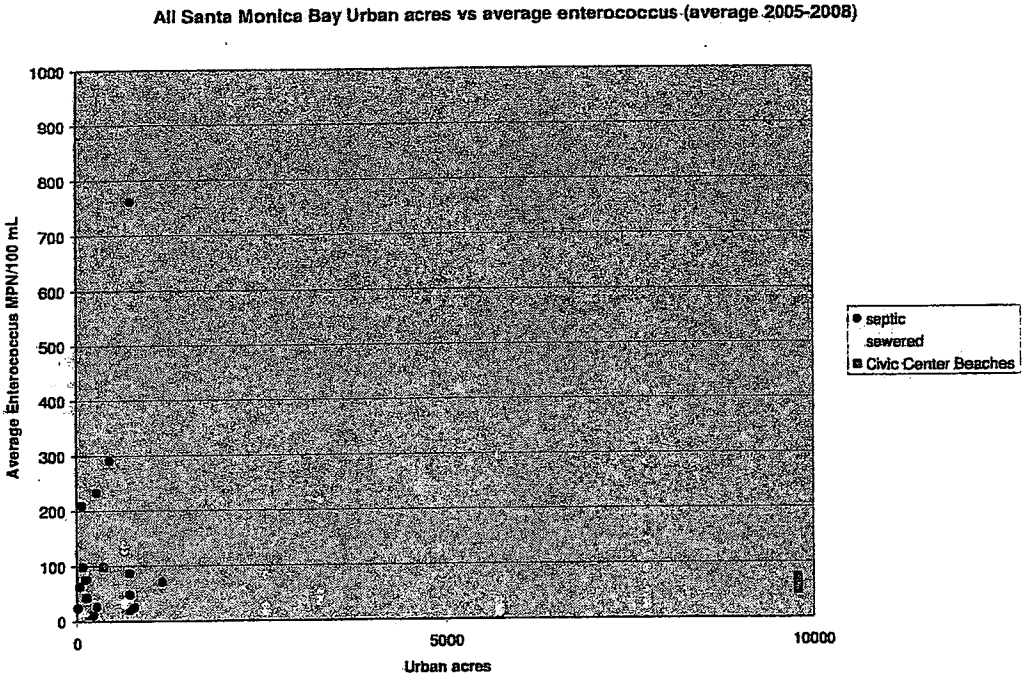
Watershed area, urban acreage and beach populations were not found to correlate with variations in enterococcus density distributions in Figure K. The following charts were prepared to show that the average enterococcus density on beaches with or without adjacent sewers is not seen to vary with these potentially confounding factors.

Figure L.



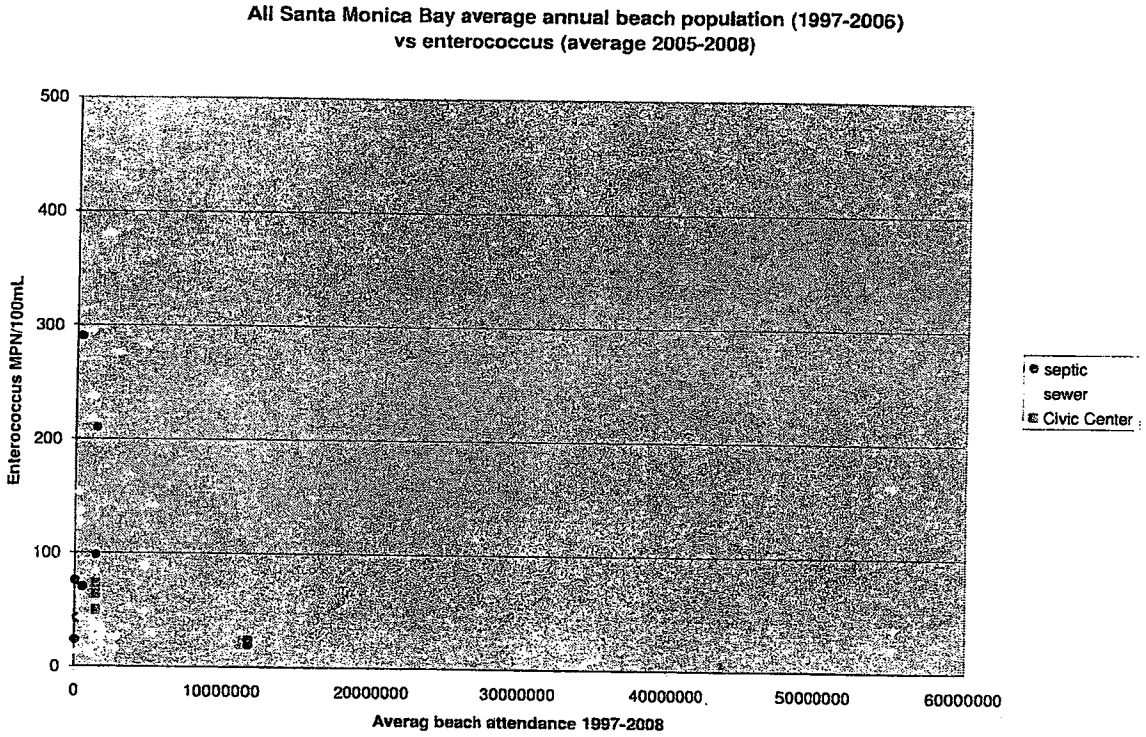
The Surfrider, Malibu Colony and Malibu Pier septic beaches appear on the right side of Figure L (greater than 10,000 acres) and a nearby beach, Sweetwater Canyon at Carbon beach, appears in the center (less than 5,000 acres). The acreage values come from the Santa Monica Bay bacteria Total Maximum Daily Load documents, and staff notes that three Civic Center beaches share the same high value for acreage. This may incorrectly suggest that the watershed size for is much greater than other beaches. Further evidence that watershed size does not correlate with enterococcus average comes from the two largest watersheds: Santa Monica Canyon with an average of 117.42 MPN/100 mL and acreage of 10,088; and, Ballona Creek with an average of 47.42b MPN/100 mL and acreage of 81,980.

Figure M.



No strong correlation is seen in Figure M above between urban acreage and average enterococcus densities for beaches with or without sewers. The Surfrider, Malibu Colony and Malibu Pier septic beaches appear on the right side of the chart (at 10,000 acres) and Sweetwater Canyon at Carbon beach appears on the left (at less than 1,000 acres). The acreage values come from the Santa Monica Bay bacteria Total Maximum Daily Load documents.

Figure N.



No strong correlation is seen in Figure N between acreage beach attendance and average enterococcus densities for beaches with or without sewers. The Surfrider, Malibu Colony, and Malibu Pier beaches appear on the left (at less than 1,000,000 people).

Statistical Significance

The application of statistical tools to the beach bacteria data sets revealed that standard tests have a high potential to produce misleading results. Additional statistical tests were used to confirm a significant difference between enterococcus interval frequency distributions for septic and sewered beaches in 2005, 2006 and 2007 for non-MS-4 beaches not including beaches with direct discharge to beach wave wash. The examination of enterococcus on beaches requires the manipulation of very large data sets. As an example, 7,081 measures were collected from beaches receiving MS-4 discharge in the summers of 2005 through 2008. The measures were not all normally distributed and were dominated by densities at or below 10 Most Probable Number (MPN)/100 mL (considered to be non-detect), with the presence of occasional measures above 24,000 MPN/100mL. The majority of the bacteria measures in the beach data sets had low and high enterococcus densities which together constitute a log normal distribution, but with interval frequencies between 50 and 1,000 MPN/100 mL which were not consistent with a log normal distribution.

Statistics which rely on normal distributions may produce false positive measures of significance for the beach bacteria populations. Many single beach samples assembled through weekly sampling over 4

summers did not have sufficiently large populations to allow statistical assessment with such tests. For example, an attempt to compare Surfrider and Manhattan (40th Street) beaches during the summer of 2007 was not successful because of the distribution of the measures for Manhattan Beach (9 measures below 10 MPN/100 mL, one of 24,000 MPN/100mL and 5 of 10 MPN/100mL). The resulting sample distribution was not normally distributed nor was the natural log of the sample distribution normally distributed. A comparison of the data with the larger sample at Surfrider Beach varied with the interval to which the statistical test was applied.

Where data sets are large, normal distributions can be created through repeated sampling. However, the largest data sets also had a few very large measurements and many small measurements, suggesting that population distribution is not improved with sampling. As an example, annual populations for all sewered and septic beaches had high correlation coefficients for large and small intervals, but not for the interval between 50 and 1,000 MPN/100 mL.

If normality was assumed and Student's t-tests and Correlation Coefficient were applied to the entire population, the results were repeatedly inconsistent. T-tests and t-tests of normal log values would show sewer and septic populations were distinct in a given year, but fail to provide this result if the data were truncated to remove high values or low values. The statistic package Minitab was used to apply the Chi-square test. When the chi square correlation was made on truncated populations of all beaches with some values below 10 MPN/100 ML removed, the results ($p<.05$) indicated that septic and sewered beaches did not belong to the same population. However, the removal of about half of the population was of concern.

Non parametric statistical tools were applied to the same data sets. When all septic and sewered beaches for the year 2005 - 2008 were contrasted using the non-parametric Quartile Hypothesis Test, the Wilcoxon-Mann-Whitney (WMW) Test and Gehan Test from EPA's ProUCL statistical program, the Quartile Test results recommend using the WMW Test. However, the WMW Test is only applicable for data set with less than 40% non-detect level of 10 MPN/100mL. Therefore, the Gehan Test is the most appropriate Test for this study. The Gehan test looks at all intervals and emphasizes the mean/median interval. The results are summarized in Tables 1 through 4.

The Null Hypothesis is termed "Septic Beach Mean/Median Less Than or Equal to Sewer Beach Mean/Median;" and the Alternative Hypothesis is "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median" using Gehan Form 1 Test.

The result of the Gehan Test for 2005, 2006 and 2008 shows that the Null Hypothesis is rejected by a low P-value with an alpha value of 0.05 (a confidence level of 95%) , which rejects the Null Hypothesis and supports the Alternative Hypothesis "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median". The 2007 data are not consistent with the results of 2005, 2006, and 2008 due to low groundwater discharge to beaches after dry winter. The same results were also obtained with an alpha value of 0.01 (a confidence level of 99%) that enterococcus concentration at septic beaches is higher than concentration at sewered beaches statistically.

Table 1 - 2005 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	358	754
Number of Non-Detect Data	113	482
Number of Detect Data	245	272
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	31.56%	63.93%
Minimum Detected	20	20
Maximum Detected	9208	4200
Mean of Detected Data	261.7	368.9
Median of Detected Data	87	99
SD of Detected Data	661.3	591.3

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	9.461
Critical z (0.95)	1.645
P-Value	1.52E-21

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

Table 2 - 2006 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	685	1377
Number of Non-Detect Data	293	921
Number of Detect Data	392	456
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	42.77%	66.88%
Minimum Detected	20	20
Maximum Detected	24192	48010
Mean of Detected Data	324.9	532.3
Median of Detected Data	86.5	42
SD of Detected Data	1320	2701

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	11.74
Critical z (0.95)	1.645
P-Value	4.17E-32

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

Table 3 - 2007 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic

Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	731	1364
Number of Non-Detect Data	574	1023
Number of Detect Data	157	341
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	78.52%	75.00%
Minimum Detected	10	20
Maximum Detected	2000	24192
Mean of Detected Data	127.5	260
Median of Detected Data	52	41
SD of Detected Data	281	1713

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	-1.226
Critical z (0.95)	1.645
P-Value	0.89

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Site <= Background

P-Value >= alpha (0.05)

Table 4 - 2008 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	734	1315
Number of Non-Detect Data	514	979
Number of Detect Data	220	336
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	70.03%	74.45%
Minimum Detected	20	20
Maximum Detected	2000	2000
Mean of Detected Data	146.8	90.55
Median of Detected Data	53	31
SD of Detected Data	290.3	226.3

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	3.45
Critical z (0.95)	1.645
P-Value	2.81E-04

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

An additional measurement of significance using the Gehan test can be achieved by adding an investigation value (i.e. enterococcus concentration) to the mean/median before assessing the Null hypothesis to demonstrate the magnitude of difference using Gehan Form 2 Test. The larger this value, called substantial difference, S, the greater the difference between the populations, i.e., the greater an S, the greater an enterococcus concentration for septic beaches versus sewered beaches. Definitions from EPA's ProUCl program are detailed follow.

> Δ (delta): The true difference between the mean concentration of X in one sample and the mean of X in a second sample. Delta is an unknown parameter which describes the true state of nature. Hypotheses about its value are evaluated using statistical hypothesis tests. In principle, we can select any specific value for Δ and then test if the observed difference is as large as Δ or not with a given confidence and power.

> S (substantial difference): A difference in mean concentrations that is sufficiently large to warrant additional interest based on health or ecological information. S is the investigation level. If Δ exceeds S, the difference in concentrations is judged to be sufficiently large to be of concern, for the purpose of the analysis. A hypothesis test uses measurements from the site and from background to determine if Δ exceeds S.

In the study cases, the S value was calculated to determine the significance of the contrast between sewered and septic beaches for the summers of 2005, 2006, 2007 and 2008. The resulting S values show that septic beaches were most distinct from sewered beaches in 2005 after wet winter and not distinct in 2007 after dry winter. A substantial difference exists between septic and sewered beaches for every year except 2007.

Year	2005	2006	2007	2008
S value MPN/100 mL	108	89	0	21

The Gehan calculation with S factor calculation for the 2005 - 2008 are shown in Tables 5 - 9.

Table 5 – 2005 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	108
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	358	754
Number of Non-Detect Data	113	482
Number of Detect Data	245	272
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	31.56%	63.93%
Minimum Detected	20	20
Maximum Detected	9208	4200
Mean of Detected Data	261.7	368.9
Median of Detected Data	87	99
SD of Detected Data	661.3	591.3

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 108

Gehan z Test Value	-1.631
Critical z (0.95)	-1.645
P-Value	0.0514

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Site >= Background + 108.00

P-Value >= alpha (0.05)

Table 6 – 2006 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	89
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	685	1377
Number of Non-Detect Data	293	921
Number of Detect Data	392	456
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	42.77%	66.88%
Minimum Detected	20	20
Maximum Detected	24192	48010
Mean of Detected Data	324.9	532.3
Median of Detected Data	86.5	42
SD of Detected Data	1320	2701

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 89

Gehan z Test Value	-1.353
Critical z (0.95)	-1.645
P-Value	0.088

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Site >= Background + 89.00

P-Value >= alpha (0.05)

Table 7 – 2007 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	731	1364
Number of Non-Detect Data	574	1023
Number of Detect Data	157	341
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	78.52%	75.00%
Minimum Detected	10	20
Maximum Detected	2000	24192
Mean of Detected Data	127.5	260
Median of Detected Data	52	41
SD of Detected Data	281	1713

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 0

Gehan z Test Value	-1.226
Critical z (0.95)	-1.645
P-Value	0.11

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Site >= Background + 0.00

P-Value >= alpha (0.05)

Table 8 – 2008 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	21
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	734	1315
Number of Non-Detect Data	514	979
Number of Detect Data	220	336
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	70.03%	74.45%
Minimum Detected	20	20
Maximum Detected	2000	2000
Mean of Detected Data	146.8	90.55
Median of Detected Data	53	31
SD of Detected Data	290.3	226.3

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 21

Gehan z Test Value	-0.305
Critical z (0.95)	-1.645
P-Value	0.38

Conclusion with Alpha = 0.05

Do Not Reject H0, Conclude Site >= Background + 21.00

P-Value >= alpha (0.05)

Attachment #2

Non-Human Sources for Enterococcus

Dr. Drewes asked Staff to include additional discussion on non-human sources for enterococcus

Staff finds that enterococcus densities exceeding the water quality objective are a sufficiently reliable indicator of human health risk despite research documenting non-human sources for the bacteria.

Enterococcus, a genus of bacterium, has been found in feces from humans and warm-blooded animals including marine birds. State and federal standards establish a water quality objective of 35 MPN/1000 mL enterococcus for any marine human-contact recreation, yet genetic typing of the enterococcus has been used to preferentially close beaches when human enterococcus was identified. The Vermont case, described below, resulted in fewer beach closures using this more sophisticated method when combined with a reduction of the human-sourced bacteria identified, a process which has not proved successful in Malibu.

> "The Vermont staff deployed Microbial Source Tracking (MST) to classify isolates of enterococcus as being from humans, birds, dogs, or wildlife sources, and flurometery (detection of optical brighteners in detergents from sewers and septic drain fields) was added as a chemical method to differentiate between human and non-human sources of pollution. Based on 2004 results that human sources of pollution were present at several beaches, investigations by officials from Hampton, Newport News and Hampton Road Sanitation Districts identified probable sources of the pollution and took steps to eliminate the problems. Sampling in 2005 and 2006 confirmed the success of these efforts (reduction in the level of pollution from human sources) and demonstrated improved water quality conditions at beaches....Hilton, King-Lincoln and Anderson Beaches all had advisories in 2004 and 2005, but none in 2006. This demonstrated the success of using MST to identify sources of fecal pollution in 2004, performing remediation to remove the origins of the pollution in 2005, and then follow-up with MST in 2006 to prove that the sources found in 2004 and 2005 were no longer present in 2006. This is the first report where MST results indicated pollution from a particular source was present (human-origin sewage), the origin of the pollution was then located, steps taken to eliminate the pollution, and subsequent MST results indicated the success of those remediation efforts. (Hagedorn, C., 2006, *Final Project Report: Microbial Source Tracking and Virginia Beach Monitoring Program.* Virginia Polytechnic Institutes and State University and Virginia Department of Health)"

Anti-biotic resistant enterococcus has been identified in bird waste and the proportion of antibiotic resistant species used to conclude that non-human sources generated entercoccus in densities exceeding water quality standards. In the Huntington Beach studies, garbage and an offshore sewage outfall were also identified the sources for anti-biotic resistant enterococcus to enter the food chain. The United States Fish and Wildlife provided the alternative explanation that the bird population, alone, was insufficient to explain the bacteria densities.

> "The Huntington Beach studies showed that the levels of bacteria generated within the marsh contributed to the bacteria population, but were not sufficient, in and of themselves, to account for the problem itself. Specifically, the studies showed that bacteria generated by birds in the Talbert Marsh could cause bacteria concentrations in the surf line near the marsh to briefly exceed criteria on outgoing nighttime or early morning tides. The study further concluded that fecal material deposited by western gulls is a significant source of indicator bacteria in the water flowing out of Talbert Marsh and that indicator bacteria growing on vegetation in the marsh and in marsh sediment may also contribute to the near shore loading of these microorganisms. The study additionally concluded that the levels of bacteria recorded along the beach were higher than could possibly have been generated by Talbert Marsh alone and that there has to be another source (page 47).....data show that beaches near tidal wetlands do not have chronic beach postings. Postings on beaches near tidal wetlands had an average of about 2 postings for 12 days in 1999 while beaches not near wetlands had an average of about 3 posting for 32 days(page 49)." (US Fish and Wildlife Service, 2001 Staff Report and Recommendation on Consistency Determination: Bolsa Chica Lowlands, Orange County, California Coastal Commission Determination CD-061-01.)

Further, literature on non-human enterococcus sources does not include an epidemiology study linking decreased illness rates among swimmers exposed only to enterococcus species generated outside the human body. In fact, the 1983 Cabelli epidemiology study, upon which the 1983 EPA enterococcus criteria is based, states that the beaches studied did not all have an identifiable point source of human sewage. In addition, the 1999 Haile study looked at fecal, total, e. coli, and enterococcus and related human illness to the densities of each of these bacteria on the beach, even though both fecal and total bacteria are known to include bacteria species not related to human feces.

The literature on non-human sources of enterococcus reviewed by staff also fails to interpret a change to the enterococcus water quality objective, except to say in the most general way that the criteria may 'require revision.' Instead, Pruse's review in 1998 found that enterococcus was among the most reliable indicators of illness.

> "The indicator organism which correlate best with health outcome were enterococcus/fecal streptococci for both marine and freshwater (pg 3)." (Pruse, A, 1998, *Review of Epidemiological Studies on Health Effects from Exposure to Recreational Water*. International Epidemiological Association vol. 17, pages 1-9)

Future research is desirable to resolve these apparent contradictions in the application of the enterococcus standard. Staff offers the possible explanation that bacteria densities correlate with human illness because bacteria and virus densities are highest in microbiological and hydrological environments where bacteria are successfully transported and protected. The proximity and volume of a human fecal source would be the secondary variable controlling the infectious natural of the enterococcus observed. The 1998 Pruse summary confirms a correlation between illness and indicator bacteria in 19 of 22 studies.

Staff's explanation allows agreement with research showing enterococcus can exceed the water quality objective where no human fecal sources are present, without negating its use in protecting beaches where

a proximal human fecal source is present. In the Malibu Civic Center, the three sources of human feces are stormwater, urban runoff and groundwater containing septic discharge. Further, concerns about an over-stringent application of the enterococcus standard are settled by the site specific epidemiology study linking illness rates at the Civic Center beach called Surfrider to bacteria density at approximately the published criteria rate for gastrointestinal symptoms which include a fever (HCGI 2). Staff notes that the enterococcus water quality standard is implemented nation-wide, has not been revised since 1983, and is the criteria upon which the Board must evaluate the exceedances shown.

Attachment #3

Bacteria Transport in Groundwater

Dr Silverstein comments that a reduction in pathogen density is expected between the OWDSs and the ocean. In fact, the rate and manner of bacteria and virus transport is not fully understood. The hydraulic and microbiological setting of the Civic Center beaches contains characteristics which may prevent bacteria and viruses destruction in the subsurface and enhance transport through the beach sand to the ocean on occasion in some locations.

In 2007, Nathalie Tufenkji provided a survey of particulate transport in the groundwater and noted that the existing models are deficient in successfully predicting the movement of organic particles. The survey specifically notes that work predicting the subsurface slowing of bacteria movement has not been paralleled by equally vigorous exploration of the subsurface enhancement of bacteria movement.

> "A substantial research effort has been aimed at elucidating the role of various physical, chemical and biological factors on microbial transport and removal in natural subsurface environments. The major motivation of such studies is an enhanced mechanistic understanding of the processes for development of improved mathematical models of microbial transport and fate. In this review, traditional modeling approaches are systematically evaluated. A number of these methods have inherent weaknesses or inconsistencies (pg 1455)....For instance, calculations based on Tufenkji and Elimelech (TE) equation indicate that particles in the size range of [about] 2 um (e.g. many bacteria) are nearly twice as mobile in porous media than previously believed (pg 1461)....The release (detachment) of microorganisms from sediment grain surfaces can be of considerable importance in natural subsurface environments and engineered water treatment systems...an improved understanding of....factors controlling microbial release is required before practical incorporation of this process into mathematical transport models (pg 1646)... Future areas for fundamental research in this area have been identified and include (i) inactivation kinetics of microorganisms in soils, (ii) role of protozoan grazing in removal of bacteria, (iii) mechanisms of microbial detachment from sediment grain surfaces, (iv) interactions between cell/cyst surface biomolecules and mineral surfaces, and (v) the influence of physical and geochemical aquifer heterogeneity on microbial transport (page 1468) (Tufenkji, N. 2007, *Modeling Microbial Transport in Porous Media: Traditional Approaches and Recent Developments.* Advances in Water Resources vol. 30, pages 1455-1469)

Referred literature shows that colloids travel at elevated rates in discrete macro-pores instead of through uniform concentration fronts like dissolved species. Further, changes in colloidal movement have been attributed to chemistry, such as the difference between freshwater and saltwater, with more rapid colloid movement freshwater. As another example, a 2001 study showed that bacteria move more rapidly in 'dirty' packed sand than in clean sand.

> "We characterize the filtration and deposition profiles of a recombinant analog of Norwalk virus, an important waterborne pathogen, in packed beds of saturated quartz sand under both 'clean-bed' and 'dirty-bed' conditions. Under clean-bed conditions with

> NaCl as the electrolyte, the retained Norwalk virus particles decline like a power-law with depth. The power-law decay in retained particle concentration is consistent with the predictions of a recently proposed filtration model which assumes that microscale heterogeneity leads to particle filtration length scales of all sizes, i.e. the filtration is fractual in nature. However, under dirty-bed conditions with either groundwater or wastewater as the pore fluid, the deposited Norwalk virus particles profiles are considerably more complex. Analysis of these data using both the traditional filtration model and the fractal filtration model suggest that, under dirty-bed conditions, macroscale heterogeneity dominates virus removal rates. (Redman, J. A., Estes, M.K., and Grant, S.B, 2001, *Resolving macroscale and microscale heterogeneity in virus filtration*, Colloids and Surfaces A: Physicochemical and Engineering Aspects. Vol. 191, Issues 1-2, pg 57- 70)

Staff found literature both supporting and refuting the conclusion that the method and rate of groundwater well pumping may affect the reliability of bacteria samples collected. Higher pressure extraction rates are discussed as a possible mechanism for the destruction of bacteria. Staff proposes that well testing may not successfully sample the zones of preferential transport described above. Heterogeneity in aquifer properties and bacteria transport may not be represented by the homogeneous conditions assumed in traditional groundwater modeling.

Future research is desirable to resolve these challenges to existing groundwater modeling methods and introduce a measure of caution in predicting microbiological transport based solely on water movement. The prediction that variations in subsurface flow conditions can affect bacteria transport is consistent with Izbicki's recent studies at Santa Barbara, his ongoing hydrology at Surfrider Beach, as well as De Sieyes work which links episodic nutrients pulses correlated with tides, to septic systems, and Boehms work which links groundwater to bacteria.

Staff offers the comment that rapid change in the subsurface hydrology, such as with breaching of the lagoon, may create variations in the proportion of septic bacteria which are present at the beaches. Just as swimming next to a flowing storm drain is currently discouraged, additional study may identify an elevated risk with summer swimming during periods of increased septic discharge, such as during neap tides or during low ebb of a spring tide.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #3:
Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

By

Dr. Robert Arnold
Chemical & Environmental Engineering
The University of Arizona
P.O. Box 210011
Tuscon, AZ 85721-0011

520-621-2591
520-621-6048 FAX

TM3-77

College of Engineering and Mines
Department of Chemical
and Environmental Engineering

THE UNIVERSITY OF
ARIZONA
TUCSON ARIZONA

P.O. Box 210011
Tucson, AZ 85721-0011
(520) 621-6044
FAX: (520) 621-6048

Memorandum

5 October 2009

To: Ms. Wendy Phillips; Chief, Groundwater Cleanup and Permitting Section, CA Regional Water Quality Control Board

From: Bob Arnold

Subject: Review of Regional Board Staff Technical Memorandum #3: *Pathogens in wastewaters that are in hydraulic connection with beaches represent a source of impairment for water contact recreation.*

I will first cover the technical issues delineated for review in an attachment to your email dated 10 September.

1. The interpretation of four technical documents selected to support Technical Memorandum #3—emphasis on the Haile documents (1996, 1999) and the 1983 EPA criteria for recreational risk in marine water.

- **An Epidemiological Study of Possible Adverse Health Effects of Swimming in Santa Monica Bay**—Haile et al., 1996. This is a detailed and convincing piece of research that illustrates the type of health effects and relative risk associated with bathing on Santa Monica beach sites that are proximate to discharge points for overland runoff. Although the document does not bear directly on situations in which the presumed source of contamination is the proximate groundwater, the study shows very clearly that runoff containing contaminants of fecal origin produces both elevated concentrations of fecal indicators and higher incidence of waterborne disease among those bathing in impacted waters. The study also establishes the relevance of enterococcus concentration as a useful indicator and the usefulness of the disease parameters (symptoms such as gastrointestinal and respiratory problems, rash and so forth) eventually selected for use in Technical Memorandum #3.
- **Haile, R.W., Witte, J.S., Gold, M. *et al.* 1999. The health effects of swimming in ocean water contaminated by storm drain runoff. *Epidemiology 10*: 355-363.** This is apparently the peer reviewed form of the same study in Santa Monica Bay. The fact that the work withstood peer review for archival publication is noteworthy and adds to the credibility of the study and interpretation of findings. The authors note that their findings may have widespread relevance since the indicators of fecal contamination are similar to those at a great number of other

beaches. They also indicate that incremental risk upon exposure to waters containing those levels of the indicator organisms is probably significant based on the results of their work (incremental risk on the order of >1 per 100 exposed). Finally, they make the point that the standards for fecal indicators in marine recreational areas appear to be relevant since exposure at lower levels had no statistically significant health outcome. The article did not stress use of enterococcus results in predicting incidence of disease, but relied on coliform measurements and direct measurement of virus.

- **Gold, M. 1994. What are the health risks of swimming in Santa Monica Bay: an examination of the issues surrounding the public health debate. Ph.D. dissertation, UCLA.** The dissertation largely set the stage for the subsequent epidemiological study (above). The major finding related to high concentrations of fecal indicators including enteric viruses across the bay. There was comment about higher than acceptable levels of indicator organisms in Malibu Bay, but that was not the primary focus of the work. The importance of the work was that it was done competently and that it provoked the subsequent study.
- **Cabelli, V.J. 1983. Health effects criterin for marine recreational waters. EPA-600/1-80-031.** This is an exceptional piece of work, as evidenced in part by the fact that we are still reading it. The document uses data from a variety of studies in the United States and Egypt to establish the methodologies for epidemiological work of this kind, selection of disease indicators, and justification for use of specific indicator organisms. The fact that findings are appropriate to several locations attests to their utility. Interestingly, the response of Egyptians to enterococci-indicated exposure was reduced, but that of visitors was not, in the Alexandria study. The current standards for enterococci in seawater can be justified on the basis of the study results, since significant swimming-related disease incidence was provided by exposure to waters containing 10-100 enterococci per 100 mL. In fact, the swimming related incidence of HCGI illness was about double that of the endemic rate among non swimmers when waters contained ~50 enterococci per 100 mL. The author concluded that enterococci have a survival behavior more similar to the infectious agents that do other indicator organisms tested. The linear relationship suggested between swimming related incidence and log transformed enterococci data seems justified based on the studies reviewed.

2. Discussion of correlation coefficients among annual frequency distributions for enterococcus MPN data at Malibu beaches.

The contention here is that the correlations among annual frequency distributions provides evidence of annual similarities at each beach for which data are provided and thus an indication that fluctuation in enterococcus numbers is probably the

result of some regular pattern of events as opposed to random odd events like direct contamination by bathers, etc.

I am unable to provide a convincing statistical analysis as part of this review. Nevertheless, I feel that this is a weak argument, primarily because the statement does not seem to rest on statistically valid hypothesis testing. That is, do the calculated correlation coefficients in fact justify the conclusion that the distribution of values observed is derived from the same population of actual values each year—that the distribution of enterococcus MPNs does not change from year to year. Even if that distribution of concentrations is time invariant (as suggested) it seems that the population of enterococcus concentrations in the waters tested may take on a distribution of this sort for any number of reasons, including a somewhat randomly generated source of contamination due to bathing and so forth. It seems difficult to justify the elimination of such an explanation based on the data provided.

As a minor point, the text on p. T3-15 indicates that correlation coefficients for MPN-dependent frequencies at the Surfrider Beach ranged from 0.82-0.98. The values provided in the Appendix T3-B table indicate that the correlation coefficient varies from 0.72-0.98. For those not statistically well informed (including me), the method of calculation of the correlation coefficient might be provided.

3. Validity of conclusion that water quality during dry weather at Surfrider Beach, Malibu Colony Beach, Malibu Pier Beach, Carbon Beach and Marie Canyon persistently fails to meet water quality objectives. This statement is well supported by the enterococcus data provided.

4. Conclusions regarding the groundwater origin of microbial contamination at Malibu Lagoon and beaches. Since this is the crux of the technical paper, it is well to consider the evidence presented in total. The staff report and references therein establish the validity of enterococcus measurements as an indicator of fecal contamination that provides a potential source of health risk. There is no reason to question the validity of the enterococcus standards for protection of public health. That is, consistent violations of the marine standard for recreational use will likely produce a significant disease increase among bathers. Consequently, the waters off Malibu, which do not meet standards, probably present a health-related problem. There are high concentrations of bacterial indicators of fecal contamination in the ground waters of heavily populated and commercial sections of the Malibu community. Furthermore, groundwater contaminants appear to add contamination to the enterococcus levels in the Malibu Lagoon at the MCW-1 sampling station, downstream from the Malibu Civic Center area. Finally, there are somewhat speculative, but increasingly accepted, mechanisms for the transport of bacteria and viruses from proximate ground waters, through near-surface beach sands and into the surf zone. Observations regarding transport through the beach front were derived from

studies outside the Malibu area, but in southern California, from multiple lines of experimentation. These have been described in peer-reviewed archival journals, adding to their credibility.

No other credible sources of near-shore marine pollution are described in the technical report. If land surface runoff is a possibility, it seems unlikely that the effects would be so general or unmanageable during summer months, particularly since the period 2005-2008—the period of record for the measurements provided—was apparently an unusually dry period for the region. In any case, rainfall would likely increase the efflux of groundwater bacteria into the surf zone as well as increasing the rate of surface runoff.

Considering the entire argument presented and supporting information provided, the staff has made an adequate case for improving the microbial quality (indicators of fecal contamination) in Malibu ground water in order to improve the water quality in the nearshore marine area off the Malibu coastline in order to reduce associated threats to human health.

Additional comments. On page T3-2, it is indicated that several changes were made to the technical memorandum based on an Early Technical Review. These changes include generation of statistical support for conclusions, recommendations regarding additional supporting studies, emphasis on the hydrological and microbiological complexity of the subsurface intertidal region and verification of the relationship between human illness due to marine recreational activities and coastal OWDSs. In my opinion, statistically based inference remains largely missing from the document. The treatment of incremental risk at Surfrider Beach (Table 6) is apparently based on results reported in the 1983 EPA report and published information regarding bathing near stormwater discharge point in Santa Monica Bay. However, the connection here is not well developed and results of those studies that contribute to the staff position should be clearly laid out.

At this point, I feel that the case is well made for construction of sewerage in the Malibu area, but I was convinced in part by information from the supporting documents that might be included directly in the technical memorandum. The epidemiological case in particular requires supporting information. In my opinion, further studies are not required to justify Board action, so that recommendations specific to such studies are unnecessary. The complexity of the hydrological conditions, microbiological transport mechanism and so forth are sufficiently plain.

The technical memorandum (#3) is clearly written and easy to understand. The staff has done its work very well.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #3:
Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

By

Dr. Jörg E. Drewes
DREWES ENVIRONMENTAL
798 Cressman Court
Golden, CO 80403
Phone 303-884-9746
E-mail: jdrewes@mines.edu

TM-82

DREWES ENVIRONMENTAL
Professor Dr. Jörg E. Drewes

798 Cressman Court
Golden, CO 80403
Phone 303-884-9746
E-mail: jdrewes@mines.edu

October 7, 2009

California Regional Water Quality Control Board
Attn.: Wendy Phillips
Chief, Groundwater Permitting and Landfills Section
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Re: Peer Review of Technical Memorandum #3 in support of an amendment to the Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Mrs. Phillips,

Please find enclosed my review of the Technical Memorandum #3 *"Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation"* prepared by Elizabeth Erickson.

The review is providing responses to questions formulated in Attachment 2.

Please feel free to contact me if you have any further questions.

Thank you very much.

Sincerely,

Professor Jörg Drewes

Scientific Review Report of Technical Memorandum #3
Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation
by Elizabeth Erickson

a. The interpretation of key literature identifying factors that increase the levels of pathogen indicators and risks to human health at the beach

General:
The reviewer concurs with the interpretation of key literature considering in this Technical Memorandum identifying factors that increase the levels of pathogen indicators and risk to human health. The reviewer also concurs with the selection of entercoccus bacteria, since it is more persistent in water and sediments as compared to coliforms, as a recreational water quality indicator illustrating the presence of human waste at the sites studied. However, the author neglects to state that there are also non-human sources for enterococcus, which could potentially contribute to the concentrations observed in beach samples, although the likelihood for non-human contributions is small in the given settings.

Specifics:
- Table 1: Please clarify what the numbers reported for each site represent? —Are these replicates or discrete measurements at different days? What is the time period of data collection?

b. In particular, the interpretation of Haile et al. (1996 and 1999) epidemiology study and the 1983 EPA marine health criteria for health risk
Haile et al. (1996 and 1999) are representing the same experimental dataset published as a final research report (1996) and a subsequent peer-reviewed journal article (1999). Both Haile et al. studies (1996 and 1999) are reporting findings of epidemiological studies conducted in areas that are highly representative and directly linked to surface water and beaches targeted in this Technical Memorandum, - the Santa Monica Bay, Will Rogers Beach, and the Surfrider Beach. It is noteworthy that Haile et al. (1999) represents a journal article that was subject to a peer review process. The reviewer agrees with the key findings of this study that exposure to water impacted by storm run-off exhibits a higher risk of a broad range of human health symptoms, including both upper respiratory and gastrointestinal effects. The strength of the Haile et al. (1996, 1999) study is the size of the study population, the diversity of the population studied, and the assessment of adverse health outcomes through exposure to coliforms, enterococci, and viruses.

Staff's interpretation of the 1983 EPA marine health criteria for health risk agrees with the general published literature in this field (see review article by Pruess, 1998).

Pruess, A. (1998). Review of epidemiological studies on health effects from exposure to recreational water.

c. The application of correlation coefficients in Figures 7, 8, and 9

Plotting enterococcus occurrence data as frequency graphs is appropriate to illustrate distribution changes over several years for May-October Summer time periods. These graphs illustrate that exceedance of the ocean standard of enterococcus is occurring consistently across the three study sites (MC-2, MC-1, and MC-3). The data also illustrate the gradient of severity in impact and as a consequence health effect outcomes. The classification scheme of either "safe" or "unsafe" based on meeting or failing ocean water standards does not seem to reflect this dynamic.

Correlation coefficients between annual enterococcus frequency distributions are reported for the Surfrider Beach (MC-2) data set only and they demonstrate that the variability of the distribution is small from year-to-year.

d. The conclusion, on pages T3-7 through T3-9, that water quality persistently fails to meet water quality objectives during dry weather at Surfrider Beach, Malibu Colony Beach, Malibu Pier Beach, Carbon Beach, and Marie Canyon

Data presented in this Technical Memorandum provide support that beach water quality in the vicinity of the Malibu Creek watershed repeatedly fails to meet water quality objectives. The data presented would not support that the water quality "persistently" fails to meet the water quality objectives since only a limited data set is presented. For some tables, information is missing regarding the size of the data set considered. For example regarding Table 2, what is the total number of samples collected? Exceedance reported for the Surfrider Beach (2006 and 2007) in Table 2 seems to be based on data collected during six weeks in 2006 only, whereas the 2007 data set represents data collected over a four-month period. Are results presented in Tables 3-5 all data that is available for these sampling locations? At a minimum, a clarification should be provided in the Memorandum.

e. The conclusion that groundwater, contaminated with indicators of pathogens, is a source of impairment to lagoon and beaches

The reviewer agrees with staff's determination of impairment through pathogenic organisms and the conclusion that groundwater in this area is a source of impairment to lagoon and beaches.

Overarching questions:

(a) In reading Tech Memos #3 and #4, are there any additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

Regarding Tech Memo #3, there are not additional scientific issues that need to be addressed.

(b) Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices?

Regarding Tech Memo #3, with the exception of comments provided above, the conclusions presented in this Tech Memo are based on sound scientific knowledge, methods, and practices.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #3:
Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

By

Dr. Joann Silverstein
Dept. Civil, Environmental & Architectural Engineering
University of Colorado
Boulder, CO 80309-0428 USA
tel: (303) 492-7211
fax: (303) 492-7317

TM3-87

Peer Review of Technical Memorandum #3:

Pathogens in Wastewaters that are in Hydraulic Connection with Beaches Represent a Source of Impairment for Water Contact Recreation

Revised Draft dated September 10, 2009

a. Interpretation of key literature, identifying factors that increase the levels of pathogen indicators and risks to human health at the beach.

Caution should be used in association of indicator bacteria with human waste, as is suggested on page T3-3, in two places. In the first sentence, referring to Table 1: "Highlighted measures on the chart are fecal-indicator-bacteria values in human waste which [sic, grammar incorrect] the water quality objectives for protection of body contract [sic, typo, should be "contact"] recreation." [emphasis added] The data in Table 1 are not per se values in human waste. The table caption is more accurate: "End-of-pipe Effluent Bacteria Densities," and should be used in the text. Also on page T3-3, paragraph 2, the last sentence mischaracterizes the link between Enterococcus and human waste: "Importantly, the occurrence of Enterococcus in groundwater at these wells illustrates that human waste is present in the groundwater at the study site." [emphasis added] The EPA document provided: Health Effects Criteria for Marine Recreational Waters, reported the results of a study at Lake Ponchartrain which stated that although Enterococcus may have been the most reliable indicator of recreational water quality, it was "not specific for human wastes." Other studies, including the epidemiologic studies of Haile et al (1999; 1996) found Enterococcus in storm water. In the glossary of Haile et al (1996), Enterococcus is described as: "A bacteria that is part of the normal flora found in human and animal waste." [emphasis added] Therefore, the sentences in the report overstate the association of Enterococcus with human waste compared with scientific literature.

Although not directly related to literature, some of the data in Table 1 (page T3-3) seem questionable. For the Malibu Colony Plaza, the numbers of total and fecal coliform are identical, and typically fecal coliform are a log unit less than total. Also the number for Enterococci is higher than either total or fecal coliform, which is atypical in general, and not consistent with other samples. For Fire Station 88, the data are more puzzling. In all samples, the MPN for Enterococcus is equal to or greater than either total or fecal coliform MPNs. Other sources (Metcalf and Eddy, 2003, citing Crook, 1998) suggest Enterococci density is two to three logs less than fecal coliform and three to four logs less than total coliform bacteria density in raw sewage. In one sample from the Fire Station the Enterococcus MPN is one log higher than the total coliform. MPN in one sample; total and fecal coliform and Enterococcus are identical in another sample. These data would be questioned by anyone familiar with the typical trends for these three indicators reported in the literature and therefore some explanation of the differences should be offered.

There is a small inconsistency in the 1996 study by Haile et al and Technical Memo #3 in the use of the high cutoff for Enterococcus. Haile et al report the exceedences of a high cutoff of 106 MPN/100 ml (Tables 12 and 13); while the Memo uses 104 MPN/100 ml, the actual standard.

b. Interpretation of the Haile et al epidemiology study and the 1983 EPA marine health criteria for health risk

The Haile et al epidemiology study was based on illness resulting from swimming at or near storm drain outfalls. The 1983 EPA document, Health Effects Criteria for Marine Recreational Waters was based on studies of illness linked with treated wastewater outfalls. These are both point sources at beaches. The mechanism for transport of septic tank and subsurface infiltration systems such as those in Malibu is through porous media, which may alter the risk of these discharges. One source of difference resulting from subsurface discharge is the removal of particulate matter and attached bacteria. The 1983 EPA Health Effects document noted that removal of suspended solids during wastewater treatment reduced the density of Salmonella.

c. Application of correlation coefficients (Figures 7, 8, and 9) referring to attached table sent 9/10/09

Use of correlation coefficients to show consistency of Enterococcus density frequency distributions from 2005-2008 at the three beach sites is acceptable, if unusual. Typically, bacteria counts, in this case for any year at any location, can be fitted to a Poisson Distribution by regression, and then comparing the mean, μ (which also equals the variance for the Poisson Distribution). Also, showing the frequency distributions as histograms rather than line graphs is more typical.

d. The conclusion, on pages T3-7 through T3-9, that water quality persistently fails to meet water quality objectives during dry weather at Surfrider Beach, Malibu Colony Beach, Malibu Pier Beach, Carbon Beach, and Marie Canyon

The conclusion that water quality is impaired at the five beaches as measured by Enterococcus counts exceeding the single count maximum (104 MPN/100 ml) is justified, although the degree of bacterial impairment varies among the five sites. It is interesting that there were no exceedences of the 104 MPN/100 ml standard at three of the beaches (Surfrider, Malibu Pier, and Carbon) in 2008. Haile et al. (1999) reported large increases in relative risk of a number of adverse health effects (skin rash, highly credible gastrointestinal illness, diarrhea with blood) when swimmers were exposed to these levels of Enterococcus.

e. The conclusion that groundwater, contaminated with indicators of pathogens, is a source of impairment to lagoon and beaches.

This conclusion is addressed on pages T3-20 – T3-23. There are two issues in this section. First is that septic tank discharge causes bacterial (and other pathogen) contamination of groundwater,

and the second, implied, is that the discharge of groundwater contaminated with pathogens is a source of ocean/beach water quality impairment, presumably a significant source if removal of OWDS's from the Malibu Civic Center area is to result in improvement of beach water quality. The section *OWDS Systems and Transportation* [sic, "Transport" is probably the more appropriate term] *of Pathogens*, needs some editing for grammatical errors, e.g., "filtrated" instead of filtered in paragraph 1, line 6 on page T3-20 and "septic bacteria" in the same paragraph, line 9 which probably should be indicator bacteria. Paragraph 3, which cites the results of Stramer and Cliver which concern septage, not septic tank effluent, is irrelevant and should be deleted unless its relevance is explained. Most of the literature cited on pathogen indicator transport from OWDS's concerns viruses, and the last paragraph of this section, in paragraph 1 on page T3-21, provides a good explanation of the limitation of using bacterial indicators, which have different transport characteristics than viruses, to predict viral pathogens. In addition, as the paragraph points out, bacterial indicators are conservative, and also have been correlated with viruses from OWDS's.

The next section cites literature related to beach pathogens. The first paragraph summarizing the papers of Yamahara et al and DeSieyes et al does not provide strong support for the importance of septic systems with beach Enterococcus, especially as compared with other sources and transport mechanisms. A later citation of Yamahara et al (paragraph 5, page T3-21) is similarly weak support for the importance of OWDS's as a source of Enterococcus. The work of Borchardt et al was done in central Wisconsin and is not relevant to beaches. Paragraph 1 on page T3-22, citing DeSieyes, is almost impossible to understand. The AAAS review of MRSB has no mention of OWDS's and should be deleted unless a better connection besides ocean water and beaches is made.

The scientific basis for Figure 11 is weak, both as support for transport and Enterococcus density. The MPN values for Enterococcus shown in Figure 11 are very difficult to justify compared with other reports (see comments above). Metcalf and Eddy report a range of $10^4 - 10^5$ MPN/100 ml for Enterococcus in raw sewage. Figure 11 has residential septic tank effluent Enterococcus at 10^7/100 ml, and one commercial system as high as 10^8/100 ml. Also the ranges of non-detect (ND) to 10^7/100 ml and ND to 10^6/100 ml are so large as to be meaningless. The one very high MPN value in Table 1 which provides only minimal evidence is suspect (as discussed above).

Overall, the movement of groundwater from the area served by OWDS's is well documented in other reports (Tech Memo 4). Literature cited confirms that pathogens, especially viruses, are transported in the subsurface from OWDS's, and would therefore reach the ocean water, especially in a sandy aquifer with short travel time. The presence of Enterococcus in septic tank effluent, nearby groundwater, and the beaches is credible support for the contribution of OWDS's to contamination of the Malibu beaches by bacteria.

Overarching questions:

a. Are there additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

A particular source of pathogen risk is associated with the fact that OWDS's serve a small number of people. This was discussed in the EPA Health Effects Criteria for Marine Recreational Waters (1983, page 49). That document notes that when the number of individuals who are sources of fecal waste becomes smaller, the ratio of pathogen-to-indicator density will vary highly from numbers based on aggregate wastes from a large population. If one or a small number of individuals in these small systems have an infectious disease, the ratio could approach 1, making the risk significantly higher than that addressed by the water quality standard. The EPA document advises in that case, which may include OWDS's: "The solution is administrative action prohibiting such discharges into recreational waters."

b. Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices.

Taken as a whole, the conclusions of Technical Memos #3 and #4 are based on sound scientific principles and reasoning. Epidemiologic studies cited provide a strong basis for increased health risks to swimmers and the presence of indicator bacteria measured at the beaches, especially Enterococcus, at concentrations higher than marine recreational water quality standards. There are some relatively minor concerns about interpretations of literature and some of the reported data as discussed above and in the previous comments on Tech. Memo #4. Addressing these will acknowledge real uncertainties that always exist with environmental studies, but will not weaken the conclusions.

TM #4

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway,* P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

** The authors would like to thank Regional Board staff, Joe Luera and intern Gina Ho, Justin Tang, and Ben Leu for their assistance in preparing map and tables.*

REVISED OCT 2 1 2 0 0 9

Technical Memorandum #4:

Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway, P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

1. Purpose

Aquatic life in Malibu Lagoon is impaired by eutrophication resulting from excessive nitrogen loads. One of the sources of nitrogen loading is from discharges of wastewaters through on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area.

The purpose of this evaluation was to quantify cumulative nitrogen loads from OWDSs to Malibu Lagoon and compare the result with targets established through the TMDL for restoration of Malibu Lagoon.

2. Method

a. Malibu Civic Center Area Description and Data Collection

The City of Malibu does not provide regional sewage collection or treatment. Most wastewater generated in Malibu is treated by on-site wastewater disposal systems (OWDS) is the terminology used to describe wastewater discharged from both septic and advanced treatment systems (defined as more advanced than primary treatment, i.e. secondary and tertiary treatment with disinfection). The Malibu Civic Center area for this evaluation corresponds to the lower two miles of the Malibu Creek watershed, which discharges to the Malibu Lagoon and the ocean, and was divided into 5 sectors as shown in Map 1. The Malibu Civic Center area includes the Malibu Valley, Winter Canyon, and the surrounding hills and the beaches located immediately north and south of the Lagoon[1].

The main commercial area in the Malibu Valley has historically been referred to as the Malibu Civic Center area. Both Los Angeles County and the City of Malibu have administrative

[1] The area subject to the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1). The area was defined using topographic features and drainage patterns, and encompasses the hydrologic areas of Malibu Valley (also referred to as the lower Malibu Creek watershed), Winter Canyon, and adjacent coastal strips including Amarillo Beach, Malibu Beach, Malibu Lagoon, and Malibu Lagoon Beach (aka Surfrider Beach, including First, Second, and Third Points at Surfrider). For more discussion on the prohibition boundaries defining the Malibu Civic Center area, refer to the Technical Staff Report Overview and the Environmental Staff Report.

3-949

REVISED OCT 2 1 2 0 0 9

offices there. Commercial development is concentrated along Pacific Coast Highway, Malibu Road, Civic Center Way, and Cross Creek Road located adjacent to Malibu Creek just above the Malibu Lagoon.

Malibu Civic Center area has high groundwater and is also subject to flooding and tidal fluctuations. Shallow groundwater located in the Cross Creek area closest to Malibu Lagoon rises and drops in response to daily tides (Figure 1) and provides direct evidence of communication with Malibu Lagoon and the ocean. Each Waste Discharge Requirements (WDR) includes a monitoring and reporting program that requires quarterly submission of self-monitoring data. These data include mass loading from wastewater discharged at commercial properties located in the Malibu Civic Center area. The subsequent evaluation of such data incorporates information from monitoring reports submitted to the Regional Board from the 4th quarter 2004 to the 2nd quarter 2009. The time interval for data inclusion is post release of the Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", in 2004 (2004 Stone Report).

This evaluation of nitrogen loading from the subsurface discharge of sewage incorporates information from Regional Board records. WDRs have been issued to most of the larger commercial dischargers in the area; and for these sites, a Monitoring and Reporting Program (MRP) is issued with every permit. For smaller businesses and private residents, staff have used inventory listed in 2004 Stone Report.

Staff identified all of the commercial and residential properties located in the Malibu Civic Center area. The inventory consists of 392 residential properties and 38 commercial properties. When it was available, real data on wastewater volumes and total nitrogen (TN) concentrations from self-monitoring reports were used for this evaluation. When actual data were not available, conservative assumptions, based on information from published literature, were used to calculate nitrogen mass loading from all wastewater discharged in the Malibu Civic Center area. Results from the summation of the wastewater TN load are used to model attenuation of the nitrogen load as it moves from the point of discharge to groundwater and from groundwater as it flows to the Lagoon.

Commercial Sites - Several sources were used for the inventory of commercial properties located in the Malibu Civic Center area. The Regional Board's databases for permitted and un-permitted commercial facilities were the primary sources of information (Table 1). Other sources of information were the 2004 Stone Report, the City of Malibu, and the (2002) Malibu Survey by S. Groner & Associates. Wastewater discharge volumes from commercial properties located in the Malibu Civic Center area were extracted from the self- monitoring reports submitted for those facilities which are permitted. For the un-permitted commercial properties, additional information regarding business activities, population served, and the OWTS was utilized to estimate discharge volumes and wastewater strength.

Residential Sites – An inventory of residential properties located in the Malibu Civic Center area was listed in the 2004 Stone Report and used for its assessment of nitrogen loads

REVISED OCT 2 1 2009

contributed by residential properties in the Malibu Civic Center area[2]. This inventory was originally extracted from Los Angeles County's Assessor's data of 2002. Information is posted in the Assessor's web-page by Assessor Identification Number (AIN). The number of bedrooms and bathrooms at each residence was used to estimate the wastewater discharge volume for each home. Calculations for the total nitrogen load discharged at residential property in the Malibu Civic Center area used the estimated wastewater discharge volumes. The residential property inventory sorted by sector location is listed in Table 2.

Geographic Sectors – Earlier evaluations approached the assessment of nitrogen loading by estimating the percentage of the groundwater flow from the entire lower Malibu Creek watershed, which discharges to the Lagoon versus the Pacific Ocean. Staff evaluation of nitrogen loading to the Lagoon used a different approach. All sectors of the entire watershed do not have an equal flow contribution to impairment of the Lagoon. Therefore, staff divided the Malibu Civic Center area into geographic sectors to evaluate groundwater flow and nitrogen load contribution to evaluate impairment of the Lagoon from OWDS discharges. Initially, the area surrounding Malibu Lagoon was divided into five geographic sectors on the basis of surface topography (Map 1). Surface geographic features marking boundaries for the sectors are the gently sloping Valley floor, Malibu Creek, Pacific Coast Highway (PCH), and the Pacific Ocean. After considering flow gradients, subsurface hydrologic, and geologic conditions, two of the sectors were further divided on the basis of estimated flow contribution to the Lagoon. Each sector has a unique flow contribution to the Lagoon.

b. Total Nitrogen Loading from On-site Wastewater Treatment Systems

Slightly different approaches had to be taken to calculate total nitrogen loads from wastewater discharged at commercial and residential sites. Because the Regional Board issues permits or WDRs for wastewater discharges from commercial sites, there has been much more information on file for commercial properties. Historically, permitting of residential wastewater discharges has been delegated to local agencies.

i. Commercial Wastewater

Staff calculated the nitrogen loading from the commercial facilities dividing the commercial facilities into three groups. One group includes permitted facilities with advanced wastewater treatment, effluent volume limits, and discharge volume limits. At these permitted facilities, a Discharger is required to measure wastewater volumes, total nitrogen concentrations at "end of pipe," and submit this information to the Regional Board per the MRP issued with the WDR. Staff was able to use actual data from these sites to calculate the nitrogen loads. The second group includes smaller permitted commercial facilities where monitoring of wastewater discharge volume is required, but not effluent monitoring, because these facilities discharge domestic-type wastewater. In these cases, staff estimated nitrogen loading by using the provided flow information and published information on total nitrogen concentrations for domestic wastewater from similar types of businesses. The third group includes all un-permitted commercial facilities. In these cases, staff conducted drive-by inspections and

[2] Stone Environmental. Inc., "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu. California," 2004.

REVISED OCT 21 2009

collected information from several other sources regarding the OWTS, the business activity, and the population served in order to estimate wastewater flow, nitrogen concentration, and nitrogen loading from these commercial sites. A list of commercial facilities is provided (See Table 1).

General Characterization of Wastewater Strength

Biochemical oxygen demand (BOD) - BOD is the measurement of the rate of oxygen uptake used by microorganisms to oxidize or consume organic matter over a specified period. The 5-day BOD (BOD_5, 5-day, 20°C) value is a widely used single strength measure of wastewater and/or polluted surface water containing degradable wastes. Thereafter, in this technical memorandum the term BOD refers to BOD_5, 5-day, 20°C; although BOD_5 does not measure nitrification, staff found there was a consistant TN/BOD ratio in the wastewater from the mixed-use shopping centers in Malibu (see Table 4 which summarizes 106 septic tank samples). The strength of wastewater is commonly expressed in terms of BOD, suspended solids, and chemical oxygen demand (COD). COD is commonly used to measure the amount of oxygen consumed under specific conditions in the oxidation of organic and inorganic material in both sewage and industrial waste. Both BOD and COD greatly impact the amount of dissolved oxygen in receiving water and determine the waste assimilative capacity of that surface water, an example being the Malibu Lagoon.

There are several chemical, physical, and biological parameters which provide information on water quality and organic pollution. These parameters are total and fecal coliform density, pH, nitrite, nitrate, Kjeldahl nitrogen which includes, ammonia nitrogen, and organic nitrogen, phosphates, chlorides, turbidity, suspended solids, temperature, grease fats and oils. BOD is commonly used for the characterization of domestic wastewater and the sizing and design of wastewater treatment systems. In this study, BOD is used to estimate total nitrogen when total nitrogen data is unavailable.

Total Nitrogen Concentration Milligrams per Liter (mg/L) - Total nitrogen concentration in milligrams per liter (mg/L) measured at "end of pipe" (e.o.p.) was used for load calculations when this information was available. Staff also used previous analyses of samples taken directly from the septic tanks. There is considerable information in Regional Board files on the septic tank composition for commercial sites in the Malibu Civic Center area.

Where neither e.o.p nor septic tank effluent analyses was available, staff based the estimation of total nitrogen on typical total nitrogen (TN) concentrations seen in the published literature on domestic wastewater composition. BOD values for commercial wastewater are more widely available than total nitrogen values and total nitrogen can be estimated as a proportion of BOD. Most wastewater engineering textbooks have tables showing the concentration of various elements in typical untreated domestic wastewater. Review of this information yields a percentage proportion or TN/BOD ratio[3] of 21%

[3] Table 4-14, on page 181 in Crites and Tchobanoglous, "Small and Decentralized Wastewater Management Systems," 1998.

REVISED OCT 2 1 2009

between total nitrogen (TN) and BOD. Another widely used textbook on wastewater engineering shows TN/BOD ratios ranging from 18% to 21%.[4] An average TN/BOD ratio of 20% was used to estimate the total nitrogen load at selected commercial sites.
In the nitrogen load spreadsheet, either a total nitrogen value from "end of pipe" or an estimated total nitrogen value derived from the TN/BOD ratio in the above tables was used for the nitrogen load spreadsheet, where no "end of pipe" total nitrogen value was available.

Assumptions Made for Commercial Nitrogen Loading Calculations

Most of the larger commercial wastewater discharges have been permitted. There are 38 commercial sites located in the Malibu Civic Center area, 25 of which have been permitted. Total nitrogen concentrations measured at "end of pipe" and wastewater discharges volumes are available and were used for nitrogen loading calculations for these sites. When wastewater effluent analysis was not available, estimation of the total nitrogen load (TN) was based on published information for similar businesses or typical nitrogen concentrations for domestic wastewater. The total nitrogen load spreadsheet developed as Table 1 has two key assumptions: 1) BOD value based on the type of business, and 2) a total nitrogen load based on the average TN/BOD ratio found in the above wideky used college textbooks on wastewater treatment such as Metcalf and Eddy (1991 and 2003). The volume of wastewater discharged is known for most commercial properties in the Malibu Civic Center area, but an estimate of wastewater volume had to be made for 10 of the smaller unpermitted commercial sites. Basic assumptions are listed below:

TN/BOD Ratio - Most of the larger commercial discharges in the Malibu Civic Center area, such as Malibu Colony Plaza, Malibu Creek Plaza, and the three Malibu Country Mart shopping centers, were permitted by the Regional Water Quality Control Board, and as a result staff have analysis of septic tank samples, or "end of pipe" effluent where advanced OWTS have been installed.

For commercial dischargers such as small offices where staff have no data, staff choose a low BOD of 220 mg/L, and estimated the TN to be 40 mg/L.

For wastewater generated by commercial facilities, such as schools, mid-range to high-range effluent strength and nitrogen concentrations were assumed. Performance of the OWDS depends primarily on the soil profile and groundwater separation. Footnotes were added to Table 3 to indicate additional critical factors such as failed leachfields or the use of seepage pits for disposal which impact estimated total nitrogen reducing TN values ranging from 75 mg/L to 45 mg/L for these sites.

Flow Rate - For the purpose of calculating nutrient load due to wastewater discharges from OWDS, staff have used actual flow data from monitoring reports for commercial facilities permitted by the Regional Water Quality Control Board. As stated previously, the septic discharge volume or flows for residential and smaller un-permitted commercial properties

[4] Table 3-16, page 109, Metcalf & Eddy, Inc. "Wastewater Engineering Treatment, Disposal and Reuse," 3rd Edition, 1991.

REVISED OCT 2 1 2 0 0 9

were estimated. For the residential properties, the flow estimate was based on the number of bedrooms.

Some of the smaller commercial properties remain unpermitted because the City of Malibu agreed to assume responsibility for any non-food preparation commercial properties discharging less than 2,000 gpd. For most of the smaller unpermitted commercial properties under the jurisdiction of the City of Malibu, Regional Board staff assumed a flow of 400 gpd. Many of the smaller commercial properties were not included in previous Malibu inventories and surveys.

2001 Tetra Tech[5] and 2003 U.S. Environmental Protection Agency [6] studies on Total Mass Daily Loads generated in the Malibu Civic Center area used total commercial wastewater flow of 75,000 gallons per day (gpd). Since 2001, the inventory of commercial properties located in the City of Malibu has increased. Current total wastewater volume generated by the commercial properties located in the Malibu Civic Center area is 127,241 gpd. This reflects a greater than 100% increase in the wastewater discharge volume estimated for commercial properties in the Malibu Civic Center area made by in earlier nitrogen loading studies, e.g. 2004 Stone Report, 2005 Questa Report, and 2001 Tetra Tech Report.

The Regional Board staff estimate of the wastewater discharge volume associated with residential OWDS located in the Malibu Civic Center area is 139,300 gpd. This volume was, virtually identical to the residential volume in the 2004 Stone Report. Staff estimation of the commercial wastewater discharge volume is greater than commercial discharge volume estimate of 62,166 gpd in the 2004 Stone Report. This Regional Board staff assessment of total nitrogen load does not include non-septic or OWDS nitrogen load contributions.[7]

Formula Used for Calculation of Commercial Nitrogen Loading

Calculations of nitrogen loading from commercial properties were made with the equation (4-4, page 193) shown below.[8]

Mass Load, lb/d = (concentration, mg/L)(flow rate Mgal/d) [(8.345* lb/Mgal x mg/L)]

The above formula has two variables, including: 1) concentration of total nitrogen (TN) in milligrams per liter (mg/L), and 2) flow rate in million gallons per day (Mgal/d). (8.345* is a unit conversion factor)

[5] Tetra Tech, Inc., 2001, "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.
[6] U.S. Environmental Protection Agency, "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.
[7] HRL industrial wastewater nitrogen load of .31 lbs/d; TN load from use of treated wastewater for landscape irrigation on Pepperdine University Campus; TN load carried by Malibu Creek from upper watershed; and the TN load from the Malibu Colony private golf course.
[8] Page 196, Crites and Tchobanoglous, "Small and Decentralized Wastewater Management Systems," 1998.

REVISED OCT 2 1 2 0 0 9

For the permitted commercial properties, staff used reported average wastewater discharge volumes and total nitrogen values compiled from quarterly monitoring reports for the loading calculations. This evaluation includes more "end of pipe" nitrogen concentrations for our total nitrogen load calculations. Using reported or estimated wastewater discharge volumes and total nitrogen concentrations, wastewater flow was multiplied by the nitrogen concentration to obtain the nitrogen loading rate.

For unpermitted commercial facilities, flow and nitrogen concentration in the wastewater discharge for each business was estimated based on the information searched about the business activities and number of people working or type of business.

ii. Residential Wastewater

A different approach was needed to determine nitrogen mass loading from residential areas. Both discharge volume and nitrogen concentration of the residential domestic wastewater had to be estimated. Wastewater flow was based on the total number of houses and the bedrooms and bathrooms in each house. Residential property located in the Malibu Civic Center area was listed by Los Angeles County's Assessor Identification Number (AIN) from 2004 Stone Report. With AIN numbers, staff found the address and the number of rooms and baths for each residence posted on the County Assessor's web-page.

Staff assigned houses per their address into the five sectors. Addresses were viewed with aerial photo location guides to insure their section location. Once houses were grouped by sector, the total flow from each sector was calculated by multiplying the total number of homes by 100 gpd produced per bedroom. The next step was to estimate the nitrogen concentration in the domestic wastewater. Staff consulted published literature on wastewater to estimate the nitrogen load. The research indicated that typical untreated domestic wastewater has a range of total nitrogen concentrations. Review of standard engineering literature found nitrogen concentrations of 20 mg/L, 40 mg/L and 85 mg/L, defining domestic wastewater strength[9] as weak, medium or strong. Staff chose a nitrogen concentration of 45 mg/L for calculating the nitrogen load from residential sites. The residential property inventory was sorted by sector location is listed in Table 2.

Assumptions for Residential Flow and Total Nitrogen Concentration

Assumptions made to determine the flow and nitrogen loading from each residence in the absence of wastewater meter and sampling and analytic data of each discharge are listed below.

100 Gallons per Day per Bedroom - Regional Board staff estimated the flow by making the assumption that at least there is one user per bedroom (personal private bedroom/bathroom combination) at home with a total water use per person of 100 gallons per day. The 100

[9]Table 3-16. page 109, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment. Disposal and Reuse", revised by Tchobanoglous. G. and Burton, F., McGraw-Hill, 3rd Edition , 1991

REVISED OCT 21 2009

gallons per person is widely used number for design and estimation purpose of wastewater flow[10].

45 mg/L for Domestic Wastewater - The nitrogen level in the domestic wastewater depends on the wastewater strength or organic load type discharged to OWDS. Waste strength is determined by considering food preparation practices, type of food prepared and consumed (e.g. high protein foods have higher nitrogen content), the use of garbage disposal units, left-over food handling and disposal practices, etc. The sewage generated by affluent neighborhoods has higher strength, measured by BOD and higher total nitrogen concentrations. Domestic wastewater with levels of TN as high as 80 mg/L, are associated with residential affluence.[11] Considering affluence and other factors, Regional Board staff selected a septic tank influent value of 60 mg/L of nitrogen, a concentration exactly mid-range of nitrogen concentration values assigned to untreated domestic wastewater, which ranges between low (20 mg/L) medium (40 mg/L) and high (85 mg/L) strength.

Another source of nitrogen reduction occurs within a septic tank, especially when the septic tank is oversized for the wastewater volume and the retention time is several days. This nitrogen load reduction is called "in-tank denitrification" and it can reduce a large percentage of total nitrogen from the effluent. Also, ammonia nitrogen can be incorporated into microbial or plant biomass in the septic tank systems as well as in the subsurface effluent disposal zone given certain environmental conditions. In general, this is not considered a major mechanism for nitrogen removal from septic tanks, but the total nitrogen concentration in residential effluent in the Malibu Civic Center area was further reduced from 60 mg/L to 45 mg/L before calculating the total nitrogen load from residential OWTS. The value of 45 mg/L TN concentration reflects an in-tank reduction of TN with equivalent to the soil reduction values given in Table 3-19, USEPA (2002) Onsite Wastewater Treatment System Manual treatment and removal. Table 14-7,[12] indicates that the total nitrogen concentration in the septic tank effluent ranges from 25 mg/L to 60 mg/L. A nitrogen concentration of 45 mg/L for OWDS treated wastewater is mid-range of typical domestic wastewater strengths.

Formula Used for Calculation of Residential Nitrogen Loading

The same basic formula is used to calculate mass load of nitrogen from residential wastewater, but with no data or metering of the discharge volume, residential flow volume was estimated using, the number of bathrooms is multiplied by 100 gpd. Flow volume is converted to million gallons per day by multiplying (10^{-6}). Nitrogen load is calculated by multiplying flow volume by the effluent nitrogen concentration of 45 mg/L and unit conversion values. The formula shown below shows the complete calculations described:

[10]Table 2-9, page 27, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition , 1991

[11] Rich Stowell, personal communication, Notes from State Board Training Academy training course "Wastewater Engineering 2, Volume 1, The Advanced Class," 2009.

[12] Table 14-7, page 1040. Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

REVISED OCT 2 1 2 0 0 9

$$\text{Mass Load, lb/day} = \frac{\text{No. of}}{\text{bathrooms}} \times 100\text{gpd} \times 3.785\frac{\text{L}}{\text{gal}} \times \frac{\text{Total}}{\text{Nitrogen}}\frac{\text{mg}}{\text{L}} \times 2.205\times10^{-6}\frac{\text{lb}}{\text{mg}}$$

iii. Summary of Total Nitrogen Loading from Commercial and Residential Sites

Staff's inventory of commercial wastewater flows in the Malibu Civic Center area consists of 25 permitted sites and 13 unpermitted sites. The total wastewater discharge volume released from these commercial properties is 127,241 gallons per day (gpd). The total nitrogen load carried to groundwater by these wastewater discharges is 42.1 lbs/day or 15,368 lbs/year.

Total residential flow is 139,300 gpd and the total nitrogen load from residential sites is 52.3 lbs/day or 19,093 lbs/year.

Total nitrogen loading from commercial and residential wastewater is summarized in Table 1. Total flow of 266,541 gpd and total nitrogen loading of 94.4 lbs/day are used for both spreadsheet and numerical models to estimate the mass loading to Malibu Lagoon.

c. Modeling to Estimate Nitrogen Load to Malibu Lagoon

i. Numerical Model

Using an updated total nitrogen release of 94.4 lbs/d in the numerical fate and transport model, the estimation of wastewater derived nitrogen load transported by groundwater flow to the Lagoon is 30.2 lbs/day. When the estimated total nitrogen load is greater, the numerical model indicates load to the Lagoon is greater. Details of the numerical modeling approach to estimate mass loading to the Lagoon, using updated total nitrogen load, and older load assessments were prepared by Dr. C.P. Lai, and are appended to this Technical Memorandum #4 as Attachment 4-1.

ii. Spreadsheet Model by Flow Reduction via Geographic Sectors and Soil Reduction

Flow Reduction Factor

Flow portioning reduces the TN load reaching the Lagoon. Factors governing flow contribution include: wastewater discharge locations, surface topography, and groundwater contours, which control the direction of groundwater flow. Different proportions of the total wastewater discharged in each reach the Lagoon.

Sector I - consists of the Winter Canyon drainage and the bedrock highlands that extend above the western side of the Malibu Valley. Sector 1 corresponds to the Winter Canyon and West Alluvium areas described in the 2004 Stone Report. Exclusive of Pepperdine University, there are nine commercial wastewater discharges located in this sector. The wastewater discharged from the commercial facilities in Sector 1 is a mixture of treated and only primary treated wastewater and the total discharge volume is 52,397 gpd. There are 61 homes in Sector 1, discharging an estimated 19,800 gpd of wastewater.

REVISED OCT 21 2009

The highland area is bisected by Malibu Canyon Road and includes 61 homes and a portion of the Pepperdine University campus. Winter Canyon is not eroded to the depth of the Malibu Valley and thickness of the alluvium is less. Sector I is subdivided into two sub-sectors with significant differences in contribution to the Lagoon. The greatest volume of wastewater from Sector I is discharged in the Winter Canyon drainage, but the Winter Canyon load is assumed to have a small contribution to Malibu Lagoon via tidal inflow (USEPA, 2003, p34, estimated as much as 5 percent of nitrogen is from tidal inflow). Most of the wastewater discharged in Winter Canyon is assumed to discharge between Amarillo Beach and Malibu Beach.

Sector I is divided into the Winter Canyon drainage and drainage from highland area southeast toward Malibu Valley. The division is based on topography. Wastewater in this sub-sector is discharged from mostly single family homes, private schools, nurseries, and the HRL facility. Flow is directed by topography southeast to the western edge of Malibu Valley and east toward Malibu Creek Canyon.

Regional Board staff assumed that the maximum contribution to the Lagoon from this sub-sector is 45% of the total flow. The fractured bedrock highlands outside of the Winter Canyon drainage have a thin veneer of soil. It has been assumed in some previous studies that all wastewater from septic discharges to this highland area flows into the alluvial sediments on the west-side of Malibu Valley. Where flow through the relatively impermeable alluvium is slow and travel times to the Lagoon of 30 years to 50 years. A portion of the wastewater flow from this highland sub-sector does enter the alluvium, as evidenced by the relatively high nitrogen concentrations and high bacteria found in the monitoring wells located near the Valley walls (e.g. monitoring wells located at the Mira Mar Properties on Stuart Ranch Road and behind the County Administration Center on Civic Center Way). Monitoring wells used for the Stone risk assessment study were all located in the alluvium of the Malibu Valley and none of the groundwater table contours extend to the bedrock highlands, which represent over 50% of the Malibu Civic Center area.

Groundwater takes the path of least resistance. It can be logically assumed that some portion of the septic wastewater will percolate down into the fractured bedrock, until it reaches the water table. Low permeability sediments are not recharged at high rates; flow is restricted. There should be sufficient hydrostatic head for groundwater flow through the highly fractured bedrock underlying the Valley. Unconfined, this groundwater will rise to potentiometric surface.

Malibu Water Company records and geologic reports[13] indicate that the deep and shallow alluvial aquifers in the Malibu Valley are recharged by groundwater in the fractured bedrock exposed in the surrounding highlands. All unconfined groundwater in the Malibu Civic Center area rises to the same potentiometric surface, a surface that slopes from the bedrock highlands to sea level. Groundwater in the bedrock highlands derived from

[13] Old records for the Malibu Water Company, owned and operated by the Adamson Family, are kept in storage at Mariposa Land Company, LLC, offices on Cross Creek Rd.

REVISED OCT 30 2009

rainfall, infiltration from septic discharges, and irrigation preferentially would not flow into relatively impermeable alluvial layers of silt and clay when high permeability sands, gravels, and fractured bedrock underlying the Malibu Valley provide a relative super highway for groundwater flow. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. There are no confining layers in this relatively coarse alluvium. These sediments have high conductivities and travel times of 400 feet a day (ft/d).

Sector II – Sector II consists of area along the ~~west~~ **east** side of Malibu Creek including the residential area surrounding Serra Retreat and the surrounding highlands, which drain to this area. In the Stone Environmental report, Sector II corresponds to the Malibu Tributary, Serra Retreat, North Alluvium, and East Alluvium areas. There is only one commercial facility located in Sector II; that is Serra Retreat with a relatively low wastewater discharge of 428 gpd. There are 83 homes located in this sector with an estimated wastewater discharge volume of 30,900 gpd.

Percolate from septic systems following topography flows toward Malibu Creek. Most of Malibu Water Company's water supply wells were located in this area. It was implied in previous nitrogen load studies that flow from the wastewater discharged into the thin alluvium draped over the bedrock highlands in this sector was confined to this thin soil layer until it reaches the alluvial sediments in the Valley. Alluvium adjacent to Malibu Creek on the east-side of Malibu Valley has very high conductivities, 400 ft/d, and travel times of less than one year for the alluvium in this area of the Malibu Valley were estimated in the (2004) Stone report[11]. Regional Board staff estimated that as much as 95% of the total wastewater flow from this sector reaches the Lagoon.

Sector III – Sector III consists of the relatively flat, gently sloping floor of Malibu Valley located north of Pacific Coast Highway. Sector III is generally described as the Malibu Civic Center area and most of the commercial development is located here. Many of these commercial facilities are located close to Malibu Creek and the Lagoon where the alluvial sediments have high conductivity. Travel time to Malibu Creek and the Lagoon for wastewater discharged in this area can be less than one day. Staff estimates 95% of the wastewater flow from this area reaches Malibu Creek and Lagoon. An exception to this high percentage of total flow is the wastewater discharged from two commercial properties located near the western edge of Malibu Valley. The (2004) Stone report found travel times to the Lagoon from this area can be as much as 50 years[14]. The Racquet Club and Miramar Properties are located in this area. It is estimated that only 20% of the wastewater discharged at these two sites reaches the Lagoon.

Only two homes with an estimated wastewater of 800 gpd are located in Sector III. There are 16 commercial facilities located in Sector III. An estimated 51,598 gpd, consisting of wastewater from both septic and advanced wastewater treatment systems, is discharged in Sector III.

[14] Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", 2004.

REVISED OCT 30 2009

Sector IV – Sector IV consists of commercial facilities located south of Pacific Coast Highway along Malibu Road and 223 homes located in Malibu Colony and Amarillo Beach. All of the wastewater generated at Malibu Colony Plaza, which encompasses all of the commercial facilities located between Malibu Road and Pacific Coast Highway, is pumped under Pacific Coast Highway to Winter Canyon for treatment and disposal and assigned to Sector 1. Most of the wastewater from commercial development in this sector is collected and treated in Winter Canyon. Only five commercial properties located in Sector IV are not connected to the Malibu Colony Plaza wastewater collection system. The collective, wastewater discharge from these commercial properties is only 2,490 gpd.

There are 223 homes located in Sector IV. Wastewater, from the five commercial properties and most of the homes (150), discharges directly to the ocean and beaches north of Malibu Lagoon. A portion of the nutrient and bacteria load discharged to the beach can be transported with sediments toward the Lagoon by the prevailing long-shore movement of northwest to southeast. Once transported toward the Lagoon, it can enter the Lagoon through tidal inflow. The U.S. Environmental Protection Agency estimated that tidal inflow contributed only 1% of the nutrient load in Malibu Lagoon. Staff estimates that 1% of the 52,300 gpd of wastewater discharged in the main area of Sector IV could reach the Lagoon, but acknowledges the proportion could be much smaller.

There are alluvial sediments, estuary sediments, and beach sand beneath Sector IV. Both high and low permeability are found in this mixture of sand, silt and clay. Generally, nutrient removal by soil bacterial action would be high, but it is not because there is little separation between septic discharges and groundwater. Much of this coastal area has little elevation above sea level.

Sector IV has a sub-sector located near the Lagoon and subject to Lagoon tidal fluctuations. A collective wastewater flow of 25,900 gpd from 73 homes is assigned to the near Lagoon sub-sector. It is estimated that nearly 45% of the 25,900 gpd of the wastewater discharged in this sub-sector reaches the Lagoon.

Sector V – Sector V consists of a narrow coastal corridor located east of Malibu Lagoon and adjacent to Pacific Coast Highway and the Pacific Ocean. Sector V is smallest section and contributes little groundwater flow to the Malibu Lagoon. The topography of the area directs groundwater flow to the ocean. This area is described as the East Shore in the 2004 Stone Report. Bacteria and nitrogen from wastewater discharged directly to the ocean pollute the public beaches in this sector. Nitrogen and bacteria discharged to the beaches south of the Lagoon can be transported toward the Lagoon during short intervals when there is a southern swell, usually in the summer and early fall months when storm center highs are located to the south off the coast of Baja California. At such times, coastal long shore transport can reverse direction.

There are nine commercial facilities and 23 homes located in Sector V. The commercial wastewater discharge volume is estimated at 20,328 gpd. Three of the commercial facilities have advanced OWTS and thus, this volume is a mixture of septic and more treated

REVISED OCT 2 1 2 0 0 9

wastewater. The estimated residential wastewater discharge volume from the 23 homes located in Sector V is 9,600 gpd.

Staff estimates a very small proportion of the wastewater discharged in Sector V, approximately 1% of the total flow, has a chance of being transported northward toward the Lagoon where it could be carried by tidal inflow.

Soil Treatment Reduction Factor

Soil Nitrogen Load Reduction Factor for Commercial Sites - Given sufficient separation between the point of wastewater effluent discharge and groundwater, soil bacteria can remove significant amounts of nitrogen. This soil bacteria activity is called "soil treatment". Another factor that influences the removal of nitrogen in the wastewater disposal zone is the soil composition and permeability. This characteristic of the soil is the reason that most permitting agencies require soil percolation testing. If the percolation is too fast (e.g. clean, coarse grained, uniform sand), wastewater flow through the near surface oxygenated zone does not allow time for nitrogen removal by soil bacteria. If the percolation rate is too slow (e.g. very fine soils with high clay content), subsurface disposal of wastewater may not be possible. Table 3 contains information on the depth to groundwater and soil type was utilized to estimate total nitrogen load reduction factors by "soil treatment" ranged from 0% to 20% (modified from Table 3-19 on page 3-29, USEPA, 2002, to account for leachfield failure or seepage pit disposal).

No Soil Treatment Factor for Residential Sites - Permitting of OWDS for residential property is delegated to local agencies, and staff do not have information on site-specific conditions needed to make an estimate of "soil treatment" or load reduction factor. Therefore, a nitrogen load reduction factor could not be applied to the nitrogen load estimated for residences located in the Malibu Civic Center area. It is known that many of the Malibu Colony residences lack adequate separation from groundwater. In addition, many residences in the highland sectors of the Malibu Civic Center area use seepage pits rather than leachfields for wastewater disposal. Nitrogen load reduction factors for soil bacteria activity are not applicable where seepage pits are used for wastewater disposal. Filtration of wastewater discharged into seepage pits located in soil or permeable bedrock will remove some bacteria load, but the nitrogen load carried in solution, is not removed by filtration.

Detail calculations for flow reduction and soil treatment reduction are summarized in Table 3.

3. Results

Using staff's loading factors for the numerical fate and transport model, staff estimates that wastewaters transport 30 lb/day of total nitrogen into Malibu Lagoon. This model also indicates that loads are increasing. Details of this numerical modeling approach are in the Mass Loading Estimate prepared by Dr. C.P. Lai that is appended to Technical Memorandum #4 as Attachment 4-1.

REVISED OCT 2 1 2009

Also, using the same load factors applied to the 'spreadsheet' model, which characterized the wastewater transport into five hydrogeologic sectors, staff estimates that wastewaters transport 35 lb/day into Malibu Lagoon.

Staff's estimates of 30 lb/day to 35 lb/day fr om the numerical and 'spreadsheet' models are above two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

- Commercial Flows: The third-party models used significantly lower assumptions of commercial wastewater flows.
- Residential Concentrations: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are less than one-half of what staff assumed.
- Nitrogen concentration of commercial wastewater: The average nitrogen concentration of commercial wastewater discharges has decreased. Since 2004, eight additional OWTS have been installed at commercial properties in the Malibu Civic Center area.

The ranges in estimates of nitrogen loads to the Lagoon and key factors are shown in the following Table 5:

	Third-Party Estimates			Staff Estimates	
	Stone (2004) Model	**Questa (2005) Model**	**Tetra Tech (2002)**	**Staff Spreadsheet Model**	**Staff Numeric Model**
Commercial Flow Rate (gal/day)	62,166	100,000	75,000	127, 241	127, 241
Commercial Concentration (mg/L)	50.0	50.0	59.2	3-110	3-110
Commercial Load (lb/day)	26	42	35	42.1	42.1
Residential Flow Rate (gal/day)	126,121	126,121	54,800	139,300	139,300
Residential Concentration (mg/L)	20.0	20.0	59.2	45	45
Residential Load (lb/day)	21	21	27	52.3	52.3
Ratio of Mass loading	36%	32%	50%	37%	32%
Gross Load released from OWDSs	47	63	64	94.4	94.4
Net Load to Malibu Lagoon	17	20	32	34.9	30.2

REVISED OCT 21 2009

Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the waste load allocation of 6 lb/day established in a TMDL[15] adopted by the US EPA on March 21, 2003.

4. Conclusion

Staff has determined that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 30 lb/day to 35 lb/day as well as third-party estimates that range from 17 lb/day to 32 lb/day. All estimates are well above targets needed to restore water quality and protect beneficial uses in Malibu Lagoon.

REVISED OCT 21 2009

[15] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003). the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies load allocations for on-site wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

References:

American Water Works Association (AWWA). 1999. Residential End Users of Water. AWWA Research Foundation.

California Division of Mines and Geology, 2001, "Seismic Hazard Zone Report for the Malibu Beach 7.5- Minute Quadrangle, Los Angeles, California", Seismic Hazard Zone Report 050, dated 2001.

California Department of Water Resources, Bulletin 63-5, "Seawater Intrusion in California", October 1965.

Crites, R. and Tchobanoglous. G., "Small and Decentralized Wastewater Management Systems" McGraw-Hill, 1998.

Dibblee, T. W., 1982, "Geology of Santa Monica Mountains and Simi Hills, Southern California" , pages 94-130, in Geology and Mineral Wealth of the California Transverse Ranges", 1982.

Dibblee, T. W., "Geologic Map of the Malibu Beach Quadrangle, Los Angeles, California", published by Dibblee Geological Foundation, 1993.

Fife, D. and Minch, J., eds., "Geology and Mineral Wealth of the California Transverse Ranges", South Coast Geological Society, Inc., 1982.

Fugro West, Inc., 2005, "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development, Project No. 3354.001.06, dated March 7, 2005.

Geosyntec Consultants, Inc., 2007, "Geotechnical Site Exploration and Intrepretation of Subsurface Conditions, Malibu Legacy Park Site", Project No. LA0142-02, dated July 30, 2007.

Leighton and Associates, Inc. 1994, "Report of Geotechnical Studies for Planning Purposes in the Civic Center Area, City of Malibu, California", Project No. 2920647-01, dated July 30, 2007.

Malibu Water Company, personal communication between Grant Adamson and Toni Callaway. The Adamson Family owned the Malibu Water Company. Records on water supply wells located in the lower Malibu Creek watershed, are stored at Mariposa Land Company, LLC, offices on Cross Creek Road (2009).

Metcalf & Eddy, Inc., " Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

Metcalf & Eddy, Inc., "Wastewater Engineering. Treatment and Reuse" McGraw-Hill, 4th Edition, 2003.

Peter Warshall and Association (PWA). 1992. Malibu Wastewater Management Study.

REVISED OCT 21 2009

Salvato, J. A., 1982, "Environmental Engineering and Sanitation". John Wiley & Sons. 1982.

Stone Environmental, Inc., 2004, "Final Report, Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Project No. 011269-W, dated August 30, 2004.

Stowell, R., personal communication, Notes from State Board Training Academy training course "Wastewater Engineering 2, Volume 1, The Advanced Class,"2009.

Tetra Tech, Inc., 2001, "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.

U.S. Environmental Protection Agency, 2003, "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.

U.S. Environmental Protection Agency, 2002, "On-site Wasterwater Treatment Systems Manual", 2002.

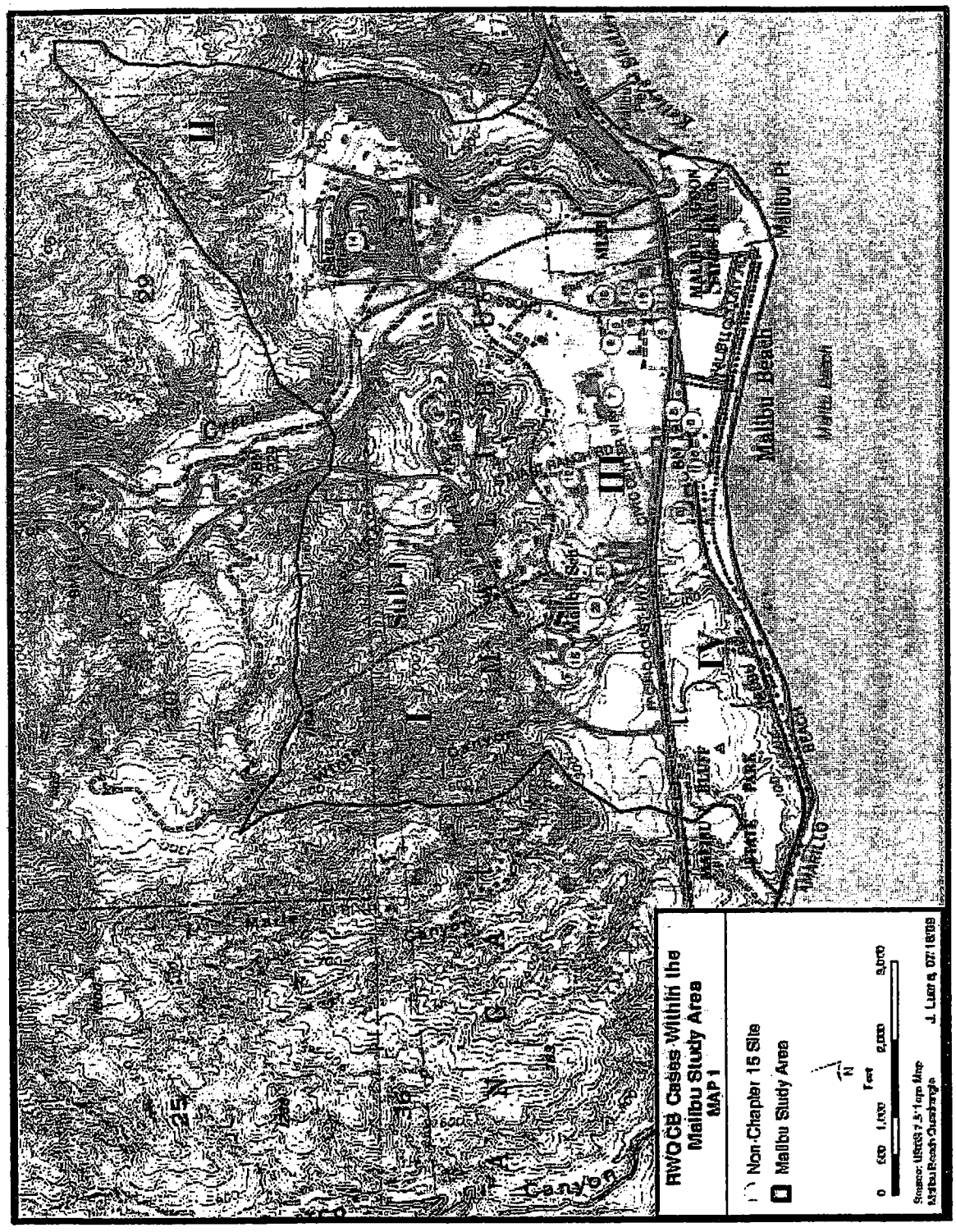
URS Greiner Woodward Clyde, 1999, "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon From On-Site Septic Systems". Project No. 964P170, dated June 7, 1999.

Van Beveren & Butelo, Inc., 2007, "Report of Geotechnical Investigation, Proposed Remodeling of Malibu Lumber Facility", Project No. 07-020, dated July 26, 2007.

Van Beveren & Butelo, Inc., 2007, "Report of Hydrologic Study, Proposed Legacy Park Discharge Area", Project No. 07-020.2, dated September 26, 2007.

REVISED OCT 2 1 2 0 0 9

Map 1 – Malibu Civic Center Area



REVISED OCT 21 2009

REVISED OCT 21 2009

Figure - 1
Correlation of Groundwater and Tidal Levels

Figure -1 Adapted from Figure 4-3 in "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon From On-site Septic Systems", 1990, URS Greiner Woodward Clyde

Table 1 –Commercial and residential nitrogen loading (continue to next page)

Sector 1	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg N/L)	TN Load (lbs/day)	TN Load (lbs/year)
HRL -3011 Malibu Cyn Rd	3,428	[B]3	45.0	1.29	469.9
L.A. Co. Main. Yard -3637 Winter Cyn Rd	252	[B]4	40.0	0.08	30.7
Malibu Colony Plaza -Disposal in Winter Cyn[D]	16,617	2	18.1	2.51	916.1
Malibu WPCP -3260 Vista Pacifica[D]	22,500	2	20.4	3.83	1,398.1
Webster Elementary -3602 Winter Cyn Rd	5,000	[B]3	75.0	3.13	1,142.2
Our Lady of Malibu -3625 Winter Cyn Rd	3,100	[B]3	75.0	1.94	708.2
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	[B]3	75.0	0.94	342.7
Commercial - 7 Business Facilities	52,397			13.72	5,007.8
Residential 61 homes	19,800	[B]1	45.0	7.44	2,713.9
Total				21.16	7,721.7

Sector 2	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Serra Retreat -3401 Serra Rd	428	[B]3	60.0	0.21	78.2
Commercial - 1 Business Facility	428			0.21	78.2
Residential 83 homes	30,900	[B]1	45.0	11.60	4,235.4
Total				11.82	4,313.6

Sector 3	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Malibu Animal Hospital -23431 PCH	1,260	[B]4	40.0	0.42	153.5
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	[B]7	40.0	1.35	492.0
Raquet Club -23847 Stuart Ranch Rd	1,500	[B]4	75.0	0.94	342.7
Prudential Realty -23405 PCH	450	[B]7	40.0	0.15	54.8
Malibu Country Mart I -3835 Cross Creek Rd	8,400	[B]4	80.0	5.61	2,046.9
Malibu Country Mart II 23410 Civic Ctr Wy	6,300	[B]4	80.0	4.21	1,535.1
Malibu Country Mart III -3900 Cross Creek Rd	3,400	[B]4	80.0	2.27	828.5
Malibu Shell -23387 PCH[D]	300	2	4.2	0.01	3.8
Malibu Prof. Arts Bldg -23440 Civic Ctr Wy	450	[B]7	40.0	0.15	54.8
Malibu Lumber -23479 PCH[D]	8,500	2	5.7	0.40	147.6
Mira Mar Properties -23805-23815 Stuart Ranch Rd	3,200	[B]7	40.0	1.07	389.9
J & P Limited -3806 Cross Creek Rd	500	[B]7	40.0	0.17	60.9
So. Calif. Edison	400	[B]7	40.0	0.13	48.7
Verizon South, Inc. -3705 Cross Creek Rd	400	[B]7	40.0	0.13	48.7
Mariposa Land Company, LLC -3728 Cross Creek Rd	1,500	[B]7	40.0	0.50	182.8
Malibu Creek Plaza/Malibu Village[D]	11,000	2	3.0	0.28	100.5
Commercial - 16 Business Facilities	51,598			17.78	6,491.3
Residential 2 homes	800	[B]1	45.0	0.30	109.7
Total				18.08	6,600.9

REVISED OCT 21 2009

Sector 4	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Malibu Rd., LLC -23676-23712 Malibu Rd	1,000	[B]7	40.0	0.33	121.8
Morton-Gerson -23730 Malibu Rd	150	[B]7	40.0	0.05	18.3
L.A. Co. Fire Station #88 -23720 Malibu Rd	540	6	30.0	0.14	49.3
Lisa Krasnoff -23655 Malibu Colony Rd	400	[B]7	40.0	0.13	48.7
Mesa, LLC 23915 PCH	400	[B]7	40.0	0.13	48.7
Commercial - 5 Business Facilities	2,490			0.79	286.9
Residential 223 homes	78,200	[B]1	45.0	29.37	10,718.6
Total				30.15	11,005.5

Sector 5	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Surfrider Co. Beach -23060 PCH	3,188	[B]4	40.0	1.06	388.4
Malibu Pier State Park -23000 PCH[D]	3,000	2	11.7	0.29	106.9
Malibu Shores Motel -23033 PCH	1,797	[B]4	60.0	0.90	328.4
Malibu Beach Inn -22878 PCH[D]	2,843	2	31.9	0.76	276.2
Jack-in-the-Box -23017 PCH[D]	1,800	6	26.3	0.39	144.0
Malibu Plaza 22917 PCH[B]	1,500	[B]7	40.0	0.50	182.8
Malibu Inn & Restaurant 22969 PCH[C]	6,200	6	110.0	5.69	2,077.3
Surfshack/Fish Grill -22935 PCH	400	[B]4	80.0	0.27	97.5
Spic & Span Cleaners/Chabad -22941 PCH[B]	1,000	[B]4	40.0	0.33	121.8
Commercial - 9 Business Facilities	20,328			9.60	3,504.0
Residential 23 homes	9,600	[B]1	45.0	3.61	1,315.8
Total				13.21	4,819.9

Malibu Civic Center Area	Flow Rate (Gallon/day)[A]	Category	Effluent TN (mg N/L)	TN Load (lbs/day)	TN Load (lbs/year)
Commercial	127,241			42.10	15,368.3
Residential	139,300			52.31	19,093.4
Total	266,541			94.42	34,461.6

Note:

[A] Measured or discharger reported flow underlined

[B] Estimated flow and TN concentration

[C] Discharger reported TN concentration

[D] Advanced OWDS treatment

Category

1-Residential discharge after "in-tank treatment" reduction

2-Multi-Use commercial with advanced wastewater treatment

3-Facilities such as schools with food service and high restroom usage

4-Multi-Use commercial with septic system

5-Stand alone restaurant with septic system

6- Assigned TN concentration from another site with the same advanced treatment system

7- Office building with low domestic strength wastewater

REVISED OCT 2 1 2009

Table 2 –List of Residential Septic Systems

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458027034	3547 Malibu Colony Rd	Multi Family	6	3	On-site
I	4458026007	3400 Coast View Dr	Residential	4		On-site
I	4458027002	3401 Coast View Dr	Residential	4	4	On-site
I	4458026006	3436 Coast View Dr	Residential	2	2	On-site
I	4558026015	3502 Coast View Dr	Residential	4	3	On-site
I	4458026014	3504 Coast View Dr	Residential	3	4	On-site
I	4458026004	3524 Coast View Dr	Residential	3	3	On-site
I	4458026003	3536 Coast View Dr	Residential	2	2	On-site
I	4458027030	Coast View Dr	Residential			On-site
I	4458025020	3207 Colony View Cir	Residential	3	3	On-site
I	4458025016	3213 Colony View Cir	Residential	4	4	On-site
I	4458025015	3215 Colony View Cir	Residential	3	4	On-site
I	4458025012	3216 Colony View Cir	Residential	3	4	On-site
I	4458025010	3217 Colony View Cir	Residential	3	2	On-site
I	4458025011	3220 Colony View Cir	Residential	3	3	On-site
I	4458025025	3211 Colony View Cir	Residential	5	5	On-site
I	4458024004	32701 Harbor Vista Dr	Residential	3	3	On-site
I	4458024043	23702 Harbor Vista Dr	Residential	3	2	On-site
I	4458024025	23704 Harbor Vista Dr	Residential	4	3	On-site
I	4458024031	23706 Harbor Vista Dr	Residential	3	2	On-site
I	4458024001	23708 Harbor Vista Dr	Residential	3	2	On-site
I	4458024029	23721 Harbor Vista Dr	Residential	3	3	On-site
I	4458025014	23722 Harbor Vista Dr	Residential	3	4	On-site
I	4458024034	23741 Harbor Vista Dr	Residential	3	2	On-site
I	4458025013	23748 Harbor Vista Dr	Residential	3	3	On-site
I	4458024009	23803 Harbor Vista Dr	Residential	6	7	On-site
I	4458025019	23812 Harbor Vista Dr	Residential	3	2	On-site
I	4458024010	23813 Harbor Vista Dr	Residential	3	2	On-site
I	4458024011	23831 Harbor Vista Dr	Residential	5	4	On-site
I	4458024012	23837 Harbor Vista Dr	Residential	3	1	On-site
I	4458025024	23838 Harbor Vista Dr	Residential	5	6	On-site
I	4458025006	23850 Harbor Vista Dr	Residential	3	3	On-site
I	4458025018	23858 Harbor Vista Dr	Residential	3	3	On-site
I	4458024013	23843 Harbor Vista Dr	Residential	3	2	On-site
I	4458025017	3224 Malibu Canyon Rd	Residential	2	2	On-site
I	4458025004	3338 Malibu Canyon Rd	Residential			On-site
I	4458024038	23800 Malibu Crest Dr	Residential	4	3	On-site
I	4458024042	23805 Malibu Crest Dr	Residential	4	4	On-site
I	4458024041	23806 Malibu Crest Dr	Residential	5	6	On-site
I	4458024039	23808 Malibu Crest Dr	Residential	3	2	On-site
I	4458024040	23812 Malibu Crest Dr	Residential	3	4	On-site

REVISED OCT 21 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458024022	23814 Malibu Crest Dr	Residential	4	5	On-site
I	4458024023	23816 Malibu Crest Dr	Residential	3	2	On-site
I	4458024021	23854 Malibu Crest Dr	Residential	2	3	On-site
I	4458024015	23870 Malibu Crest Dr	Residential	3	4	On-site
I	4458024014	23880 Malibu Crest Dr	Residential	4	4	On-site
I	4458026010	23901 Malibu Knolls Rd	Residential	4	1	On-site
I	4458026011	23903 Malibu Knolls Rd	Residential	4	3	On-site
I	4458026012	23905 Malibu Knolls Rd	Residential	3	2	On-site
I	4458026013	23907 Malibu Knolls Rd	Residential	3	3	On-site
I	4458026009	23908 Malibu Knolls Rd	Residential	3	3	On-site
I	4458025001	23915 Malibu Knolls Rd	Residential	3	2	On-site
I	4458026008	23916 Malibu Knolls Rd	Residential	4	4	On-site
I	4458025022	23933 Malibu Knolls Rd	Residential	2	2	On-site
I	4458027904	Winter Canyon Rd	Multi-Family			
I	4458027025	3625 Winter Canyon Rd	Residential	6	6	On-site
I	4458027003	3431 Coast View Dr	Residential	3	2	On-site
I	4458027004	3453 Coast View Dr	Residential	5	5	On-site
I	4458027005	3505 Coast View Dr	Multi-Family	4	3	On-site
I	4458027029	3525 Coast View Dr	Residential	3	3	On-site
subtotal			61	198	178	

II	4452015035	3501 Cross Creek LN	Residential	4	4	On-site
II	4452015034	3509 Cross Creek LN	Residential	3	4	On-site
II	4452015023	3510 Cross Creek LN	Residential	4	4	On-site
II	4452015033	3511 Cross Creek LN	Residential	5	6	On-site
II	4452015025	3512 Cross Creek LN	Residential	3	4	On-site
II	4452015026	3520 Cross Creek LN	Residential			On-site
II	4452015031	3535 Cross Creek LN	Residential	4	4	On-site
II	4452015027	3538 Cross Creek LN	Residential	4	3	On-site
II	4452015030	3539 Cross Creek LN	Residential	4	4	On-site
II	4452015042	3550 Cross Creek LN	Residential	5	4	On-site
II	4452014006	3415 Cross Creek Rd	Residential	3	3	On-site
II	4452015024	Cross Creek LN	Residential	5	5	On-site
II	4458023003	3469 Cross Creek Rd	Residential	4	9	On-site
II	4458023009	3515 Cross Creek Rd	Residential	4	4	On-site
II	4452015029	3551 Cross Creek LN	Residential			On-site
II	4458022021	3565 Cross Creek Rd	Residential	4	3	On-site
II	4458022004	Cross Creek Rd	Residential			On-site
II	4458022003	3661 Cross Creek Rd	Residential	2	2	On-site
II	4452015003	23110 Mariposa De Oro St	Residential	5	5	On-site
II	4452015014	2311 Mariposa De Oro St	Residential	3	3	On-site
II	4452015007	23122 Mariposa De Oro St	Residential	4	4	On-site
II	4452015010	23140 Mariposa De Oro St	Residential	5	4	On-site

REVISED OCT 21 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452015040	23146 Mariposa De Oro St	Residential	6	5	On-site
II	4452015006	23155 Mariposa De Oro St	Residential	4	5	On-site
II	4452015036	23160 Mariposa De Oro St	Residential	2	1	On-site
II	4452015021	23210 Mariposa De Oro St	Residential	5	5	On-site
II	4452015020	23215 Mariposa De Oro St	Residential	3	2	On-site
II	4452015022	23222 Mariposa De Oro St	Residential	5	5	On-site
II	4452015019	23233 Mariposa De Oro St	Residential	3	3	On-site
II	4452015018	23255 Mariposa De Oro St	Residential	5	5	On-site
II	4452027018	23247 Palm Canyon Ln	Residential	5	6	On-site
II	4452027016	23267 Palm Canyon Ln	Residential	2	2	On-site
II	4452027013	23301 Palm Canyon Ln	Residential	4	7	On-site
II	4452027012	23333 Palm Canyon Ln	Residential	3	4	On-site
II	4452027011	23333 Palm Canyon Ln	Residential	6	5	On-site
II	4452014004	23344 Palm Canyon Ln	Residential	4	3	On-site
II	4452012028	23500 Palm Canyon Ln	Residential	5	5	On-site
II	4452027021	3200 Retreat Ct	Residential	8	8	On-site
II	4452027022	3201 Retreat Ct	Residential	6	7	On-site
II	4452027019	3210 Retreat Ct	Residential	5	6	On-site
II	4452027023	3211 Retreat Ct	Residential	5	6	On-site
II	4452026008	3216 Serra Rd	Residential	5	5	On-site
II	4452026009	3220 Serra Rd	Residential	4	3	On-site
II	4452026007	3226 Serra Rd	Residential	5	5	On-site
II	4452026006	3226 Serra Rd	Residential			On-site
II	4452026010	3250 Serra Rd	Residential	4	6	On-site
II	4452026011	3264 Serra Rd	Residential	5	5	On-site
II	4452026019	3268 Serra Rd	Residential	4	4	On-site
II	4452026018	3270 Serra Rd	Residential			On-site
II	4452026012	3314 Serra Rd	Residential	4	3	On-site
II	4452026013	3350 Serra Rd	Residential	5	4	On-site
II	4452026016	3410 Serra Rd	Residential	5	4	On-site
II	4452026014	3426 Serra Rd	Residential	4	3	On-site
II	4452026015	3434 Serra Rd	Residential	4	4	On-site
II	4452018006	3611 Serra Rd	Residential	4	3	On-site
II	4452026003	Serra Rd	Residential			On-site
II	4452018011	3549 Serra Rd	Residential	3	3	On-site
II	4452013001	3556 Serra Rd	Residential	4	3	On-site
II	4452018012	3557 Serra Rd	Residential	3	3	On-site
II	4452013002	3560 Serra Rd	Residential	3	2	On-site
II	4452018013	3567 Serra Rd	Residential	4	4	On-site
II	4452013003	3574 Serra Rd	Residential	6	7	On-site
II	4452018015	3609 Serra Rd	Residential	2	3	On-site
II	4452013009	3610 Serra Rd	Residential	4	4	On-site
II	4452018008	3615 Serra Rd	Residential			On-site

REVISED OCT 2109

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452018016	3621 Serra Rd	Residential	4	4	On-site
II	4452018009	3623 Serra Rd	Residential	4	2	On-site
II	4452018017	3625 Serra Rd	Residential	4	2	On-site
II	4452018018	3627 Serra Rd	Residential	5	4	On-site
II	4452018019	3629 Serra Rd	Residential	4	3	On-site
II	4452018020	3631 Serra Rd	Residential	5	4	On-site
II	4452012014	3633 Serra Rd	Residential	4	4	On-site
II	4452012012	3635 Serra Rd	Residential	3	3	On-site
II	4452012015	3637 Serra Rd	Residential	1	1	On-site
II	4452013005	3644 Serra Rd	Residential	4	7	On-site
II	4452017001	3700 Serra Rd	Residential	4	3	On-site
II	4452012007	3701 Serra Rd	Residential	3	3	On-site
II	4452012016	3705 Serra Rd	Residential	4	3	On-site
II	4452012013	3707 Serra Rd	Residential	2	3	On-site
II	4452012022	3227 Serra Rd	Residential	4	4	On-site
II	4452012009	3737 Serra Rd	Residential	4	4	On-site
II	4452012011	3751 Serra Rd	Residential	3	4	On-site
II	4452012020	3811 Serra Rd	Residential	4	6	On-site
subtotal			83	309	311	
III	4452027010	3200 Cross Creek RD	Residential	3	3	On-site
III	4452027009	3232 Cross Creek RD	Residential	5	5	On-site
subtotal			2	8	8	
IV	4458004044	70 Malibu Colony Rd	Residential	4	3	On-site
IV	4452008025	112 Malibu Colony Rd	Residential	5	5	On-site
IV	4452008017	23314 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008016	23316 Malibu Colony Rd	Residential	4	4	On-site
IV	4452008014	23318 Malibu Colony Rd	Residential	3	5	On-site
IV	4452008030	23324 Malibu Colony Rd	Residential	5	7	On-site
IV	4452010017	23325 Malibu Colony Rd	Residential	2	2	On-site
IV	4452008028	23330 Malibu Colony Rd	Residential	2	4	On-site
IV	4452010024	23331 Malibu Colony Rd	Residential	2	3	On-site
IV	4452008027	23334 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010023	23337 Malibu Colony Rd	Residential			On-site
IV	4452008026	23338 Malibu Colony Rd	Residential	3	4	On-site
IV	4452008024	23346 Malibu Colony Rd	Residential	3	2	On-site
IV	4452010032	23349 Malibu Colony Rd	Residential	4	4	On-site
IV	4452008023	23350 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010031	23351 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008022	23354 Malibu Colony Rd	Residential	2	3	On-site
IV	4452008021	23356 Malibu Colony Rd	Residential	3	3	On-site
IV	4452008020	23360 Malibu Colony Rd	Residential	3	4	On-site

REVISED OCT 21 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4452010012	23401 Malibu Colony Rd	Residential	4	6	On-site
IV	4452008019	23402 Malibu Colony Rd	Residential	6	4	On-site
IV	4452009027	23410 Malibu Colony Rd	Residential	3	3	On-site
IV	4452009017	23416 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009016	23418 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010008	23425 Malibu Colony Rd	Residential	3	4	On-site
IV	4452009024	23426 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010028	23431 Malibu Colony Rd	Residential	4	4	On-site
IV	4452010009	23435 Malibu Colony Rd	Residential			On-site
IV	4452009018	23438 Malibu Colony Rd	Residential	4	6	On-site
IV	4452009019	23440 Malibu Colony Rd	Residential	5	6	On-site
IV	4452010029	23441 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009022	23444 Malibu Colony Rd	Residential	4	3	On-site
IV	4452010027	23445 Malibu Colony Rd	Residential	5	3	On-site
IV	4452009021	23446 Malibu Colony Rd	Residential	5	4	On-site
IV	4452010005	23449 Malibu colony Rd	Residential	3	5	On-site
IV	4452009020	23450 Malibu Colony Rd	Residential	4	6	On-site
IV	4452009015	23456 Malibu Colony Rd	Residential	3	4	On-site
IV	4452010003	23457 Malibu Colony Rd	Residential	3	4	On-site
IV	4458004031	23460 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004032	23500 Malibu Colony Rd	Residential	3	5	On-site
IV	4452010002	23501 Malibu Colony Rd	Residential	2	1	On-site
IV	4452010019	23505 Malibu Colony Rd	Residential	4	4	On-site
IV	4458004033	23506 Malibu Colony Rd	Residential	2	4	On-site
IV	4458004034	23510 Malibu Colony Rd	Residential	3	3	On-site
IV	4458003023	23511 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004035	23512 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003022	23515 Malibu Colony Rd	Residential	5	5	On-site
IV	4458004036	23516 Malibu Colony Rd	Residential	3	2	On-site
IV	4458003021	23517 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004037	23520 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004038	23524 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004039	23526 Malibu Colony Rd	Residential	5	7	On-site
IV	4458004040	23530 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003019	23531 Malibu Colonr Rd	Residential	4	5	On-site
IV	4458003018	23533 Malibu colony rd	Residential	4	3	On-site
IV	4458004041	23536 Malibu colony rd	Residential	4	3	On-site
IV	4458004042	23538 Malibu Colony Rd	Residential	5	4	On-site
IV	4458003017	23543 Malibu Colony Rd	Residential	5	3	On-site
IV	4458004043	23544 Malibu Colony Rd	Residential	5	4	On-site
IV	4458003015	23555 Malibu Colony Rd	Residential	1	1	On-site
IV	4458004046	23556 Malibu Colony Rd	Residential	2	2	On-site
IV	4458004047	23560 Malibu Colony Rd	Residential	4	4	On-site

REVISED OCT 21 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458003014	23561 Malibu Colony Rd	Residential	5	4	On-site
IV	4458004048	23562 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004049	23566 Malibu Colony Rd	Residential	3	1	On-site
IV	4458003013	23567 Malibu Colony Rd	Residential	3	2	On-site
IV	4458004050	23570 Malibu Colony Rd	Residential	5	3	On-site
IV	4458004051	23600 Malibu Colony Rd	Residential	2	3	On-site
IV	4458003012	23601 Malibu Colony Rd	Residential			On-site
IV	4458004052	23604 Malibu Colony Rd	Residential	2	3	On-site
IV	4458004053	23608 Malibu Colony Rd	Residential	4	5	On-site
IV	4458004054	23610 Malibu Colony Rd	Residential	5	6	On-site
IV	4458003027	23611 Malibu Colony Rd	Residential	4	6	On-site
IV	4458004055	23614 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003026	23615 Malibu Colony Rd	Residential	4	5	On-site
IV	4458005040	23618 Malibu Colony Rd	Residential	4	5	On-site
IV	4458005039	23620 Malibu Colony Rd	Residential	3	7	On-site
IV	4458005038	23622 Malibu Colony Rd	Residential	7	4	On-site
IV	4458003009	23623 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005037	23626 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003008	23629 Malibu Colony Rd	Residential			On-site
IV	4458005036	23630 Malibu Colony Rd	Residential	4	3	On-site
IV	4458005035	23632 Malibu Colony Rd	Residential	5	3	On-site
IV	4458005034	23634 Malibu Colony Rd	Residential	4	5	On-site
IV	4458003030	23639 Malibu Colony Rd	Residential	2	2	On-site
IV	4458005033	23640 Malibu Colony Rd	Residential	3	4	On-site
IV	4458003004	23641 Malibu Colony Rd	Residential			On-site
IV	4458005032	23644 Malibu Colony Rd	Residential	5	6	On-site
IV	4458005031	23648 Malibu Colony Rd	Residential	3	4	On-site
IV	4458003029	23649 Malibu Colony Rd	Residential	4	4	On-site
IV	4458005030	23652 Malibu Colony Rd	Residential	3	2	On-site
IV	4458005029	23654 Malibu Colony Rd	Residential	4	4	On-site
IV	4458003028	23655 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005028	23660 Malibu Colony Rd	Residential	4	5	On-site
IV	4458002014	23661 Malibu Colony Rd	Residential	5	5	On-site
IV	4458005027	23664 Malibu Colony Rd	Residential	3	2	On-site
IV	4458002011	23667 Malibu Colony Rd	Residential	3	3	On-site
IV	4458005026	23668 Malibu Colony Rd	Residential	3	2	On-site
IV	4458005025	23672 Malibu Colony Rd	Residential	4	5	On-site
IV	4458002010	23673 Malibu Colony Rd	Residential	4	2	On-site
IV	4458005024	23674 Malibu Colony Rd	Residential	3	4	On-site
IV	4458005023	23678 Malibu Colony Rd	Residential	6	6	On-site
IV	4458005022	23684 Malibu Colony Rd	Residential	4	3	On-site
IV	4458002006	23687 Malibu Colony Rd	Residential	5	4	On-site
IV	4458005021	23700 Malibu Colony Rd	Residential	8	8	On-site

REVISED OCT 21 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458006041	23704 Malibu Colony Rd	Residential	6	3	On-site
IV	4458002004	23705 Malibu Colony Rd	Residential	4	5	On-site
IV	4458006040	23708 Malibu Colony Rd	Residential	5	5	On-site
IV	4458002003	23709 Malibu Colony Rd	Residential	4	3	On-site
IV	4458006038	23712 Malibu Colony Rd	Residential	6	7	On-site
IV	4458002017	23713 Malibu Colony Rd	Residential	2	1	On-site
IV	4458006037	23716 Malibu Colony Rd	Residential	5	4	On-site
IV	4458006036	23720 Malibu Colony Rd	Residential	2	3	On-site
IV	4458006035	23730 Malibu Colony Rd	Residential	5	5	On-site
IV	4458006034	23736 Malibu Colony Rd	Residential	4	4	On-site
IV	4452005025	23006 Malibu Rd	Residential	3	3	On-site
IV	4458004045	23554 Malibu Rd	Residential	3	2	
IV	4458006033	23740 Malibu Rd	Residential	5	4	On-site
IV	4458006032	23746 Malibu Rd	Residential	4	3	On-site
IV	4458006031	23750 Malibu Rd	Residential	4	5	On-site
IV	4458006030	23752 Malibu Rd	Residential	4	4	On-site
IV	4458006029	23754 Malibu Rd	Residential	4	4	On-site
IV	4458006028	23758 Malibu Rd	Residential	3	4	On-site
IV	4458006027	237562 Malibu Rd	Residential	3	4	On-site
IV	4458006026	23764 Malibu Rd	Residential	3	5	On-site
IV	4458006025	23768 Malibu Rd	Residential	3	4	On-site
IV	4458006023	23800 Malibu Rd	Residential	9	10	On-site
IV	4458006022	23808 Malibu Rd	Residential	4	4	On-site
IV	4458007028	23812 Malibu Rd	Residential	4	1	On-site
IV	4458007027	23816 Malibu Rd	Residential	2	3	On-site
IV	4458007026	23822 Malibu Rd	Residential	4	7	On-site
IV	4458007025	23826 Malibu Rd	Residential	4	3	On-site
IV	4458007024	23832 Malibu Rd	Residential	5	3	On-site
IV	4458007023	23834 Malibu Rd	Residential	2	3	On-site
IV	4458007022	23844 Malibu Rd	Residential	3	2	On-site
IV	4458007021	23850 Malibu Rd	Residential	7	5	On-site
IV	4458007016	23858 Malibu Rd	Residential	5	6	On-site
IV	4458007015	23864 Malibu Rd	Residential			On-site
iV	4458007020	23868 Malibu Rd	Residential	5	6	On-site
IV	4458007019	23872 Malibu Rd	Residential	3	2	On-site
IV	4458007018	23900 Malibu Rd	Residential	3	2	On-site
IV	4458007017	23910 Malibu Rd	Residential	3	6	On-site
IV	4458008017	23917 Malibu Rd	Residential	5	4	On-site
IV	4458008016	23920 Malibu Rd	Residential	5	7	On-site
IV	4458008015	23926 Malibu Rd	Residential	6	5	On-site
IV	4458008014	23930 Malibu Rd	Residential	4	5	On-site
IV	4458008013	23936 Malibu Rd	Residential	4	4	On-site
IV	4458008018	23940 Malibu Rd	Residential	6	7	On-site

REVISED OCT 2 1 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458008003	23950 Malibu Rd	Residential	4	5	On-site
IV	4458008002	23952 Malibu Rd	Residential	2	3	On-site
IV	4458008001	23956 Malibu Rd	Residential	5	3	On-site
IV	4458009013	23962 Malibu Rd	Residential	3	2	On-site
IV	4458009012	24000 Malibu Rd	Residential	4	3	On-site
IV	4458009009	24016 Malibu Rd	Residential	3	3	On-site
IV	4458009001	24056 Malibu Rd	Residential	2	1	On-site
IV	4458010015	24058 Malibu Rd	Residential	4	2	On-site
IV	4458010016	24102 Malibu Rd	Residential	4	4	On-site
IV	4458010017	24108 Malibu Rd	Residential	3	4	On-site
IV	4458010019	24116 Malibu Rd	Residential	3	3	On-site
IV	4458010018	24116 Malibu Rd	Residential	3	3	On-site
IV	4458010012	24120 Malibu Rd	Residential	3	3	On-site
IV	4458010011	24124 Malibu Rd	Residential	2	2	On-site
IV	4458010010	24128 Malibu Rd	Residential	3	4	On-site
IV	4458010008	24134 Malibu Rd	Residential	2	3	On-site
IV	4458010007	24138 Malibu Rd	Residential	3	3	On-site
IV	4458010006	24142 Malibu Rd	Residential	2	2	On-site
IV	4458010005	24146 Malibu Rd	Residential	4	4	On-site
IV	4458010004	24150 Malibu Rd	Residential	4	3	On-site
IV	4458010003	24154 Malibu Rd	Residential	2	2	On-site
IV	4458010001	24172 Malibu Rd	Residential	3	2	On-site
IV	4458011002	24212 Malibu Rd	Residential	2	2	On-site
IV	4458011003	24216 Malibu Rd	Residential	3	2	On-site
IV	4458018005	24001 Malibu Rd	Residential	3	3	On-site
IV	4458018020	24031 Malibu Rd	Residential	3	2	On-site
IV	4458018011	24109 Malibu Rd	Residential	3	2	On-site
IV	4458018012	24111 Malibu Rd	Residential	3	2	On-site
IV	4458010019	24112 Malibu Rd	Residential	4	4	On-site
IV	4458011004	24222 Malibu Rd	Residential	2	2	On-site
IV	4458011005	24228 Malibu Rd	Residential	2	2	On-site
IV	4458011007	24236 Malibu Rd	Residential	3	3	On-site
IV	4458011008	24246 Malibu Rd	Residential	2	2	On-site
IV	4458011009	24254 Malibu Rd	Residential	3	4	On-site
IV	4458011010	24266 Malibu Rd	Residential	2	2	On-site
IV	4458011012	24314 Malibu Rd	Residential	3	3	On-site
IV	4458011013	24320 Malibu Rd	Residential	1	4	On-site
IV	4458011032	24330 Malibu Rd	Residential	4	4	On-site
IV	4458011018	24348 Malibu Rd	Residential	2	1	On-site
IV	4458011019	24352 Malibu Rd	Residential	3	2	On-site
IV	4458011021	24380 Malibu Rd	Residential	4	5	On-site
IV	4458011022	24402 Malibu Rd	Residential	2	3	On-site
IV	4458011023	24408 Malibu Rd	Residential	3	3	On-site

REVISED OCT 21 2009

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458011024	24414 Malibu Rd	Residential	3	3	On-site
IV	4458011027	24434 Malibu Rd	Residential	7	6	On-site
IV	4458011028	24436 Malibu Rd	Residential	5	4	On-site
IV	4458011029	24444 Malibu Rd	Residential	3	3	On-site
IV	4458011030	24450 Malibu Rd	Residential	3	3	On-site
IV	4458011031	24456 Malibu Rd	Residential	2	3	On-site
IV	4458012001	24460 Malibu Rd	Residential	3	5	On-site
IV	4458012002	24466 Malibu Rd	Residential	5	4	On-site
IV	4458012003	24470 Malibu Rd	Residential	3	3	On-site
IV	4458012004	24476 Malibu Rd	Residential	3	3	On-site
IV	4458012005	24508 Malibu Rd	Residential	6	5	On-site
IV	4458012006	24514 Malibu Rd	Residential	2	2	On-site
IV	4458012007	24518 Malibu Rd	Residential	3	2	On-site
IV	4458012008	24524 Malibu Rd	Residential	2	2	On-site
IV	4458012009	24528 Malibu Rd	Residential	3	2	On-site
IV	4458012010	24534 Malibu Rd	Residential	2	1	On-site
IV	4458012011	24538 Malibu Rd	Residential	2	1	On-site
IV	4458012012	24542 Malibu Rd	Residential	3	3	On-site
IV	4458012013	24548 Malibu Rd	Residential	3	3	On-site
IV	4458012014	24554 Malibu Rd	Residential	3	2	On-site
IV	4458012035	24560 Malibu Rd	Residential	3	4	On-site
IV	4458012036	24572 Malibu Rd	Residential	3	4	On-site
IV	4458012017	24604 Malibu Rd	Residential	3	4	On-site
IV	4458012018	24608 Malibu Rd	Residential	3	4	On-site
IV	4458012019	24612 Malibu Rd	Residential	3	4	On-site
IV	4458012020	24616 Malibu Rd	Residential	4	5	On-site
IV	4458012021	24620 Malibu Rd	Residential	3	3	On-site
IV	4458012021	24626 Malibu Rd	Residential	3	3	On-site
IV	4452008018	23406 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009026	23414 Malibu Colony Rd	Residential	4	3	On-site
IV	4452009025	23422 Malibu Colony Rd	Residential	4	4	On-site
IV	4452009023	23430 Malibu Colony Rd	Residential	6	6	On-site
subtotal			223	782	793	On-site
V	4452025006	3395 Sweetwater Mesa Rd	Residential	2	2	On-site
V	4452016004	3401 Sweetwater Mesa Rd	Residential	5	10	On-site
V	4452016019	3415 Sweetwater Mesa Rd	Residential	6	7	On-site
V	4452016020	3431 Sweetwater Mesa Rd	Residential	5	7	On-site
V	4452016007	3451 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452017004	3509 Sweetwater Mesa Rd	Residential	5	8	On-site
V	4452017005	3535 Sweetwater Mesa Rd	Residential	6	7	On-site
V	4452017009	3620 Sweetwater Mesa Rd	Residential	6	8	On-site
V	4452013008	3655 Sweetwater Mesa Rd	Residential	4	4	On-site

REVISED OCT 2109

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
V	4452013007	3669 Sweetwater Mesa Rd	Residential	2	2	On-site
V	4452016008	3330 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016018	3362 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016017	3380 Sweetwater Mesa Rd	Residential	4	3	On-site
V	4452016016	3416 Sweetwater Mesa Rd	Residential	3	3	On-site
V	4452016015	3464 Sweetwater Mesa Rd	Residential	4	4	On-site
V	4452017008	3556 Sweetwater Mesa Rd	Residential	6	6	On-site
V	4452005004	23018 Pacific Coast Hwy	Residential	3	3	On-site
V	4452005022	23022 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005018	23030 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005002	23034 Pacific Coast Hwy	Residential	2	2	On-site
V	4452005001	23038 Pacific Coast Hwy	Residential	3	2	On-site
V	4452019008	22931 Pacific Coast Hwy	Residential	2	3	On-site
V	4452005020	22860 Pacific Coast Hwy	Multi Family	12	13	On-site
subtotal			23	96	108	
TOTAL			392	1,393	1,398	

REVISED OCT 2 1 2 0 0 9

Table 3 - Total Nitrogen Load to the Lagoon After Adjustment of Flow and Leach Field Reduction

Table 3 Total Nitrogen Loading to the Lagoon After Adjustment of Flow and Leach Field Reduction

Sector 1	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
HRL -3011 Malibu Cyn Rd*	3,428	45%	1,543	45.0	>10	soil & bedrock	0%	45.0	0.58
L.A. Co. Main. Yard -3837 Winter Cyn Rd	252	1%	3	40.0	10	sand, silt & clay	20%	32.0	0.00
Malibu Colony Plaza -Disposal in Winter Cyn*	16,617	1%	166	18.1	varies	sand & silt	0%	18.1	0.03
Malibu WPCP -3260 Vista Pacifica*	22,500	1%	225	20.4	varies	sand & silt	0%	20.4	0.04
Webster Elementary^ -3802 Winter Cyn Rd	5,000	1%	50	75.0	15	sand & silt	20%	60.0	0.03
Our Lady of Malibu^ -3625 Winter Cyn Rd	3,100	1%	31	75.0		sand & silt	0%	75.0	0.02
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	45%	675	75.0		sand & silt	0%	75.0	0.42
Commercial - 7 Business Facilities	52,397		2,692						1.11
Residential 61 homes	19,800	45%	8,910	45.0				45.0	3.35
Total									4.46

*Seepage Pit Disposal or Failed Leachfield = 0% soil treatment

Sector 2	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Serra Retreat -3401 Serra Rd	428	95%	407	60.0	>10	sand & silt	20%	48.0	0.16
Commercial - 1 Business Facility	428		407						0.16
Residential 83 homes	30,900	95%	29,355	45.0				45.0	11.02
Total									11.19

Sector 3	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Malibu Animal Hospital -23431 PCH	1,260	95%	1,197	40.0	10	sand, silt & clay	20%	32.0	0.32
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	60%	2,423	40.0	>10	sand, silt & clay	20%	32.0	0.65
Raquet Club -23847 Stuart Ranch Rd	1,500	20%	300	75.0	ukn.	sand, silt & clay	0%	75.0	0.19
Prudential Realty -23405 PCH	450	95%	428	40.0	10	mostly sand	20%	32.0	0.11
Malibu Country Mart I -3835 Cross Creek Rd*	8,400	95%	7,980	80.0	<5	sand & silt	0%	80.0	5.33
Malibu Country Mart II 23410 Civic Ctr Wy*	6,300	95%	5,985	80.0	<5	sand & silt	0%	80.0	4.00
Malibu Country Mart III -3900 Cross Creek Rd*	3,400	95%	3,230	80.0	<5	mostly sand & silt	0%	80.0	2.16
Malibu Shell^^ -23387 PCH	300	95%	285	4.2	5 to 10	mostly sand	20%	3.4	0.01
Malibu Prof. Arts Bldg -23440 Civic Ctr Wy	450	60%	270	40.0	10	sand, silt & clay	10%	36.0	0.08
Malibu Lumber -23479 PCH	8,500	60%	5,100	5.7	5 to 10	fill, sand, silt & clay	20%	4.6	0.19
Mira Mar Properties -23805-23815 Stuart Ranch Rd*	3,200	20%	640	40.0	>10	sand, silt & clay	0%	40.0	0.21
J & P Limited -3806 Cross Creek Rd	500	95%	475	40.0	10	mostly sand	20%	32.0	0.13
So. Calif. Edison	400	95%	380	40.0		mostly sand	20%	32.0	0.10
Verizon South, Inc. -3705 Cross Creek Rd	400	95%	380	40.0		sand & silt	20%	32.0	0.10
Mariposa Land Company, LLC -3728 Cross Creek Rd	1,500	95%	1,425	40.0		mostly sand	20%	32.0	0.38
Malibu Creek Plaza/Malibu Village -PCH & Cross Creek	11,000	95%	10,450	3.0	<5	mostly sand	10%	2.7	0.24
Commercial - 16 Business Facilities	51,598		40,947						14.19
Residential 2 homes	800	95%	760	45.0				45.0	0.29
Total									14.5

Sector 4	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Malibu Rd., LLC -23678-23712 Malibu Rd	1,000	1%	10	40.0	<10	sand, silt & clay	20%	32.0	0.00
Morton-Gerson -23730 Malibu Rd	150	1%	2	40.0	<10	sand, silt & clay	20%	32.0	0.00
L.A. Co. Fire Station #88 -23720 Malibu Rd	540	1%	5	30.0	<10	sand, silt & clay	20%	24.0	0.00
Lisa Krasnoff -23655 Malibu Colony Rd	400	1%	4	40.0	<10	sand & silt	0%	40.0	0.00
Mesa, LLC 23915 PCH	400	1%	4	40.0	ukn.	ukn.	0%	40.0	0.00
Commercial - 5 Business Facilities	2,490		25						0.01
73 of 223 Res.@50% Flow to Lagoon	25,900	45%	11,655	45.0				45.0	4.38
150 of 223 Res.@20% Flow to Lagoon	52,300	1%	523	45.0				45.0	0.20
Total									4.59

Sector 5	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Surfrider Co. Beach -23060 PCH	3,188	10%	318	40.0	>10	mostly beach sand	0%	40.0	0.11
Malibu Pier State Park -23000 PCH	3,000	1%	30	11.7	<10	mostly sand	10%	10.5	0.00
Malibu Shores Motel -23033 PCH	1,797	1%	18	60.0	10	sand & silt	10%	54.0	0.01
Malibu Beach Inn -22878 PCH	2,843	1%	28	31.9	<10	mostly sand	0%	31.9	0.01
Jack-In-the-Box -23017 PCH	1,800	1%	18	26.3	>10	fill, sand & silt	20%	21.0	0.00
Malibu Plaza 22917 PCH	1,500	1%	15	40.0	~10	fill, sand & silt	0%	40.0	0.01
Malibu Inn & Restaurant^ 22969 PCH	6,200	1%	62	110.0	~10	sand, silt & clay	0%	110.0	0.06
Surfshack/Fish Grill -22935 PCH	400	1%	4	80.0	~10	fill, sand & silt	0%	80.0	0.00
Spic & Span Cleaners/Chabad -22941 PCH	1,000	1%	10	40.0	~10	fill, sand & silt	0%	40.0	0.00
Commercial - 9 Business Facilities	20,328		504						0.20
Residential 23 homes	9,600	1%	96	45.0				45.0	0.04
Total									0.23

Study Area	Discharge (gpd)	Estimated Percent Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent TN (mg-N/L)	Depth to GW	Soil Type	Leach Field Reduction	Eff. TN to Lagoon (mg/L)	TN Load to Lagoon (lb/day)
Commercial	127,241		44,575						15.67
Residential	139,300		51,299						19.26
Total	266,541		95,874						34.93

REVISED OCT 2 1 2009

Table 4 Monitoring results of TN/BOD ratio of mixed usage commercial sources

#	Location	Date	Parameter	TN	BOD	TN/BOD
1	Malibu Colony Plaza	03/30/01	Composite	54.2	420	12.9%
2	Malibu Colony Plaza	04/30/01	Composite	49.6	332	14.9%
3	Malibu Colony Plaza	05/23/01	Composite	56.0	772	7.3%
4	Malibu Colony Plaza	07/27/01	Composite	70.5	552	12.8%
5	Malibu Colony Plaza	08/22/01	Composite	72.8	551	13.2%
6	Malibu Colony Plaza	09/07/01	Composite	65.3	705	9.3%
7	Malibu Colony Plaza	09/21/01	Composite	55.1	385	14.3%
8	Malibu Colony Plaza	09/28/01	Composite	72.8	635	11.4%
9	Malibu Colony Plaza	10/05/01	Composite	67.2	477	14.1%
10	Malibu Colony Plaza	10/12/01	Composite	60.7	491	12.4%
11	Malibu Colony Plaza	10/19/01	Composite	65.3	34	192.1%
12	Malibu Colony Plaza	10/26/01	Composite	56.0	542	10.3%
13	Malibu Colony Plaza	11/02/01	Composite	56.0	383	14.6%
14	Malibu Colony Plaza	11/09/01	Composite	53.7	441	12.2%
15	Malibu Colony Plaza	11/17/01	Composite	44.7	359	12.5%
16	Malibu Colony Plaza	12/29/01	Composite	62.3	279	22.3%
	Malibu Colony Plaza	**2001 Yearly**	**Composite**	**60.1**	**460.0**	**24.2%**
17	Malibu Colony Plaza	01/11/02	Composite	18.1	386	4.7%
18	Malibu Colony Plaza	02/15/02	Composite	38.4	539	7.1%
19	Malibu Colony Plaza	03/14/02	Composite	69.4	424	16.4%
20	Malibu Colony Plaza	04/16/02	Composite	25.3	201	12.6%
21	Malibu Colony Plaza	05/17/02	Composite	18.7	592	3.2%
22	Malibu Colony Plaza	06/21/02	Composite	60.7	461	13.2%
23	Malibu Colony Plaza	07/19/02	Composite	45.5	210	21.7%
24	Malibu Colony Plaza	08/15/02	Composite	68.4	566	12.1%
25	Malibu Colony Plaza	09/26/02	Composite	41.0	359	10.8%
26	Malibu Colony Plaza	10/17/02	Composite	43.9	344	12.8%
27	Malibu Colony Plaza	11/12/02	Composite	60.4	384	15.7%
28	Malibu Colony Plaza	12/19/02	Composite	60.5	394	15.4%
	Malibu Colony Plaza	**2002 Yearly**	**Composite**	**45.9**	**406.7**	**12.1%**
29	Malibu Colony Plaza	01/22/03	Composite	48.4	515	9.4%
30	Malibu Colony Plaza	02/21/03	Composite	45.6	291	15.7%
31	Malibu Colony Plaza	03/27/03	Composite	35.8	318	11.3%
32	Malibu Colony Plaza	04/24/03	Composite	61.2	346	17.7%
33	Malibu Colony Plaza	05/27/03	Composite	62.1	641	9.7%
34	Malibu Colony Plaza	06/10/03	Composite	40.3	334	12.1%
35	Malibu Colony Plaza	07/17/03	Composite	54.7	286	19.1%
36	Malibu Colony Plaza	08/14/03	Composite	64.9	308	21.1%
35	Malibu Colony Plaza	09/18/03	Composite	55.8	469	11.9%
38	Malibu Colony Plaza	10/16/03	Composite	51.3	431	11.9%
39	Malibu Colony Plaza	11/19/03	Composite	81.3	441	18.4%
40	Malibu Colony Plaza	12/17/03	Composite	68.1	402	16.9%

3-981

REVISED OCT 21 2009

	Malibu Colony Plaza	**2003 Yearly**	**Composite**	**55.8**	**398.5**	**14.6%**
41	Malibu Colony Plaza	01/15/04	Composite	35.8	250	14.3%
42	Malibu Colony Plaza	02/19/04	Composite	35.4	288	13.0%
43	Malibu Colony Plaza	03/11/04	Composite	47.6	403	11.8%
44	Malibu Colony Plaza	04/08/04	Composite	43.2	410	10.5%
45	Malibu Colony Plaza	08/12/04	Composite	70.2	344	20.4%
46	Malibu Colony Plaza	11/18/04	Composite	45.5	466	9.8%
	Malibu Colony Plaza	**2004 Yearly**	**Composite**	**46.6**	**360.2**	**13.3%**
47	Malibu Colony Plaza	02/24/05	Composite	19.0	91	20.8%
48	Malibu Colony Plaza	05/13/05	Composite	58.0	617	9.4%
49	Malibu Colony Plaza	08/12/05	Composite	82.1	483	17.0%
50	Malibu Colony Plaza	11/10/05	Composite	101.7	287	35.4%
	Malibu Colony Plaza	**2005 Yearly**	**Composite**	**65.2**	**369.5**	**20.7%**
51	Malibu Creek Plaza	01/30/02	Single Sample	53.5	352	15.2%
52	Malibu Creek Plaza	02/28/02	Single Sample	33.9	122	27.8%
53	Malibu Creek Plaza	03/14/02	Single Sample	25.6	177	14.5%
54	Malibu Creek Plaza	04/16/02	Single Sample	15.5	62	25.0%
55	Malibu Creek Plaza	05/17/02	Single Sample	12.7	141	9.0%
56	Malibu Creek Plaza	06/21/02	Single Sample	30.5	64	47.7%
57	Malibu Creek Plaza	07/19/02	Single Sample	25.3	181	14.0%
58	Malibu Creek Plaza	08/15/02	Single Sample	49.6	147	33.7%
59	Malibu Creek Plaza	09/26/02	Single Sample	20.8	136	15.3%
60	Malibu Creek Plaza	10/17/02	Single Sample	30.8	148	20.8%
61	Malibu Creek Plaza	11/12/02	Single Sample	47.5	191	24.9%
62	Malibu Creek Plaza	12/19/02	Single Sample	42.2	127	33.2%
	Malibu Creek Plaza	**2002 Yearly**	**Single Sample**	**32.3**	**154.0**	**23.4%**
63	Malibu Creek Plaza	01/22/03	Single Sample	41.5	214	19.4%
64	Malibu Creek Plaza	02/21/03	Single Sample	43.4	133	32.6%
65	Malibu Creek Plaza	03/27/03	Single Sample	35.0	152	24.3%
66	Malibu Creek Plaza	04/24/03	Single Sample	39.2	142	27.6%
67	Malibu Creek Plaza	05/27/03	Single Sample	45.9	207	22.2%
68	Malibu Creek Plaza	06/10/03	Single Sample	32.8	171	19.2%
69	Malibu Creek Plaza	07/17/03	Single Sample	7.6	22	34.7%
70	Malibu Creek Plaza	08/14/03	Single Sample	44.1	133	33.2%
71	Malibu Creek Plaza	09/18/03	Single Sample	51.7	161	32.1%
72	Malibu Creek Plaza	10/15/03	Single Sample	38.0	129	29.4%
73	Malibu Creek Plaza	11/19/03	Single Sample	45.9	113	40.6%
74	Malibu Creek Plaza	12/17/03	Single Sample	35.3	82	43.0%
	Malibu Creek Plaza	**2003 Yearly**	**Single Sample**	**38.5**	**138.3**	**29.8%**
75	Malibu Creek Plaza	01/15/04	Single Sample	33.2	117	28.4%
76	Malibu Creek Plaza	02/19/04	Single Sample	28.9	147	19.6%
77	Malibu Creek Plaza	03/11/04	Single Sample	42.3	148	28.6%
78	Malibu Creek Plaza	04/08/04	Single Sample	33.7	142	23.7%
79	Malibu Creek Plaza	05/27/04	Single Sample	42.3	151	28.0%
80	Malibu Creek Plaza	06/17/04	Single Sample	64.9	145	44.8%

REVISED OCT 21 2009

81	Malibu Creek Plaza	07/22/04	Single Sample	42.7	205	20.8%
82	Malibu Creek Plaza	08/12/04	Single Sample	56.1	131	42.8%
83	Malibu Creek Plaza	09/09/04	Single Sample	41.7	143	29.2%
84	Malibu Creek Plaza	10/14/04	Single Sample	55.6	116	47.9%
85	Malibu Creek Plaza	11/18/04	Single Sample	45.1	145	31.1%
86	Malibu Creek Plaza	12/16/04	Single Sample	53.9	92	58.6%
	Malibu Creek Plaza	**2004 Yearly**	**Single Sample**	**45.0**	**140.2**	**33.6%**
87	Malibu Creek Plaza	01/13/05	Single Sample	35.39	164	21.6%
88	Malibu Creek Plaza	02/24/05	Single Sample	9.3	56	16.6%
89	Malibu Creek Plaza	03/04/05	Single Sample	23.81	79	30.1%
90	Malibu Creek Plaza	04/14/05	Single Sample	44.8	162	27.7%
91	Malibu Creek Plaza	May	Single Sample	31.97	140	22.8%
92	Malibu Creek Plaza	June	Single Sample	19.91	82	24.3%
93	Malibu Creek Plaza	07/21/05	Single Sample	22.64	132	17.2%
94	Malibu Creek Plaza	Aug	Single Sample	39.55	149	26.5%
95	Malibu Creek Plaza	Sept	Single Sample	35.82	160	22.4%
96	Malibu Creek Plaza	10/20/05	Single Sample	40.2	125	32.2%
97	Malibu Creek Plaza	11/10/05	Single Sample	27.94	188	14.9%
98	Malibu Creek Plaza	12/22/05	Single Sample	83.11	156	53.3%
	Malibu Creek Plaza	**2005 Yearly**	**Single Sample**	**34.5**	**132.8**	**25.8%**
99	Malibu Country Mart I	06/15/00	Single Sample	29.4	355	8.3%
100	Malibu Country Mart I	06/15/00	Single Sample	101.0	207	48.8%
101	Malibu Country Mart I	06/15/00	Single Sample	66.2	2853	2.3%
102	Malibu Country Mart I	06/15/00	Single Sample	75	897	8.3%
103	Malibu Country Mart I	06/15/00	Single Sample	70.5	882	8.0%
104	Malibu Country Mart I	06/15/00	Single Sample	70.9	935	7.6%
	Malibu Country Mart I	**2000 Yearly**	**Single Sample**	**68.8**	**1021.5**	**13.9%**
105	Malibu Country Mart II	06/15/00	Single Sample	77.0	1098	7.0%
106	Malibu Country Mart II	06/15/00	Single Sample	77.9	403	19.3%
	Malibu Country Mart II	**2000 Yearly**	**Single Sample**	**77.5**	**750.5**	**13.2%**
				Average		**20.4%**

REVISED OCT 2 1 2 0 0 9

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

Attachment 4-1

Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loadings from OWDS to the Lagoon

C.P. Lai, Ph.D., P.E.

This memorandum summarizes the findings of previous studies on the mass loadings of nitrogen to Malibu Lagoon from on-site wastewater disposal systems (OWDS). Using recent data, staff then estimated the nitrogen loading into Malibu Lagoon based on previous numerical modeling results and a spread sheet model. Finally, staff estimated the nitrogen concentration in Lagoon water resulting from this mass loading by using a continuous stirred tank reactor (CSTR) mass balance model.

1.0 Briefing of Previous Studies

Three previous studies about the subject topics have been reviewed and their estimates of mass loadings of nitrogen at the edge of the Lagoon are summarized as follows:

1.1 Stone Report
(Groundwater-Flow and Solute Transport Modeling as Appendix 3 of the Final Report "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", August 2004)

A numerical model was used to simulate groundwater flow and solute transport in the alluvium deposited along Malibu Creek and Lagoon near the Malibu Civic Center area. The groundwater flow model used in this study is the USGS MODFLOW model and the solute transport model is the USEPA MT3D groundwater transport model. The model is limited by the amount of data that was used to build, calibrate, and verify the model.

The purposes for constructing a model for the Malibu Civic Center area were to develop a water budget, to determine directions of groundwater flow, to identify which parts of the study area contribute groundwater flow to the beaches and to Malibu Lagoon, to estimate how long it takes groundwater from various parts of the study area to reach the beaches and Malibu Lagoon, and to estimate how much nitrogen is transported by the groundwater from OWDS to the Lagoon and to the ocean. No attempt was made in this model to estimate the mass loading for bacteria.

Results from the flow modeling were used to evaluate directions of groundwater flow, groundwater travel times in the flow system, and the contributing area for the Lagoon and ocean. The transport simulation was run for the period from 1930 through 2090, for a total of 160 years.

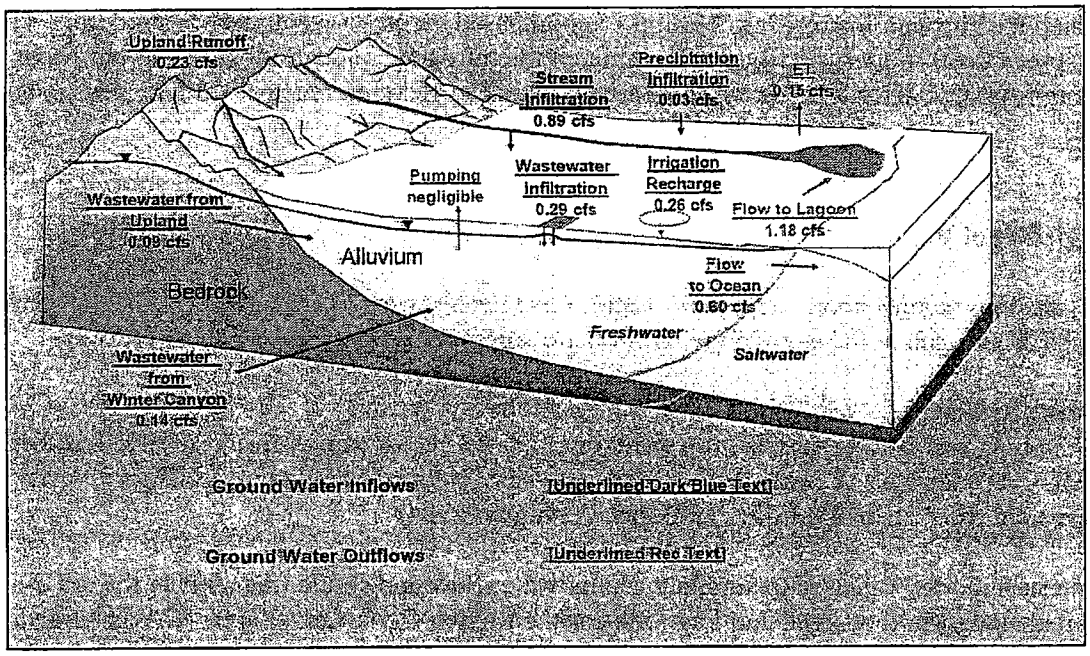
3-984

REVISED OCT 2 1 2 0 0 9

The total amount of wastewater disposal assumed as input for the model is approximately 0.52 cubic feet per second (cfs). Commercial wastewater disposal is estimated to be about 0.115 cfs. Source concentrations of nitrogen from OWDS were assumed to be 20 mg/l from domestic wastewater disposal systems and 50 mg/l from commercial systems.

The total average annual inflow to the alluvial groundwater flow system was estimated and is presented in Figure 1 below. The estimated total annual inflow to the alluvial groundwater flow system is approximately 1.93 cfs. The estimated total annual outflow is also 1.93 cfs, which includes 1.18 cfs to Malibu Lagoon, 0.60 cfs to the Pacific Ocean and 0.15 cfs for evapotranspiration.

Figure 1 Average Annual Groundwater Budget for the Malibu Alluvium

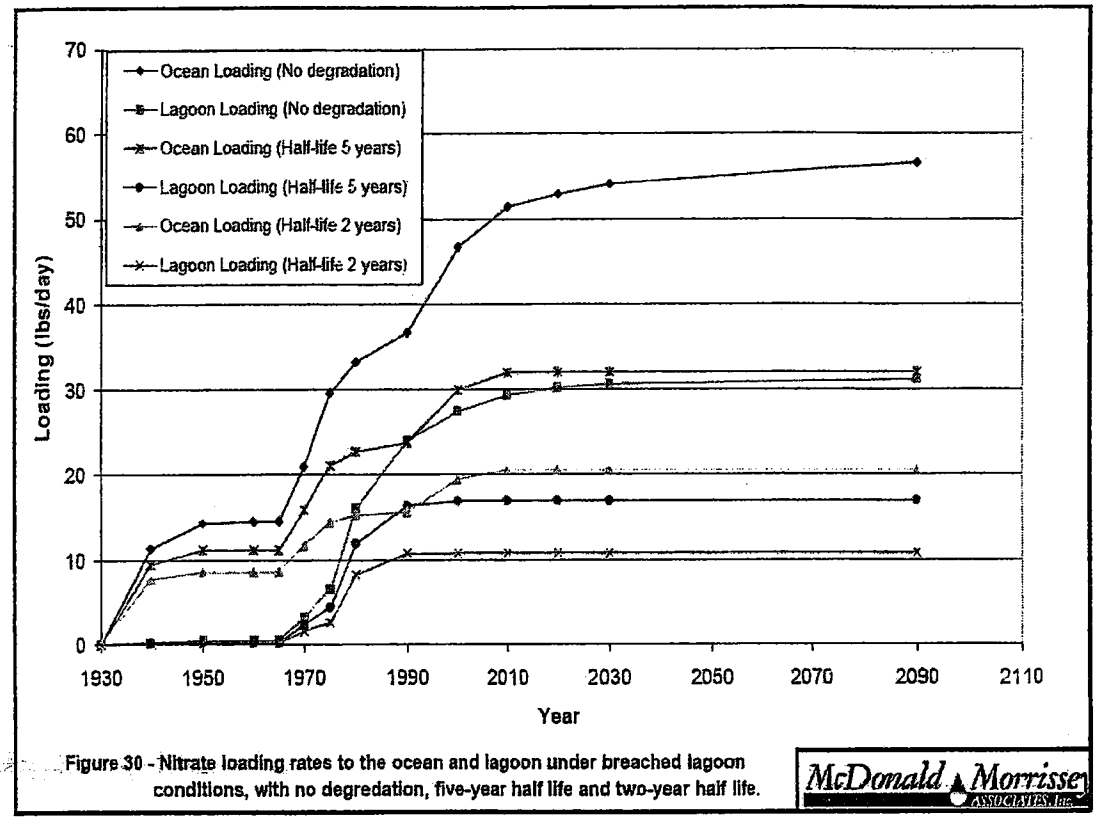


Transport model simulations were run with four steady-state hydraulic stresses, which represent changing source loadings over different time periods, for un-breached and breached Lagoon conditions in order to estimate nitrogen loadings to the ocean and Lagoon from OWDS. Depending upon the assumptions of nitrate degradation, the calculated maximum nitrogen loading to the Lagoon resulting from OWDS ranges from 31 lbs/day (un-breached Lagoon with no degradation) to 11 lbs/day (breached Lagoon with a 2-year half life). The calculated nitrogen mass loading rates to the Malibu Lagoon and the ocean under the breached Lagoon condition are shown in Figure 2. Figure 2 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Additionally, the study modeled groundwater movement to determine the time of travel to Malibu Creek, Malibu Lagoon, the surf zone, and the ocean. Some areas had times of travel as short as six months and others as long as 50 years.

REVISED OCT 2 1 2 0 0 9

Figure 2 Calculated Nitrogen Loading Rates to the Malibu Lagoon and the Ocean under the Breached Condition



1.2. Questa Report

(Groundwater Modeling Report as Appendix D of the Final Report "Civic Center Integrated Water Quality Management Feasibility Study for City of Malibu", April 2005)

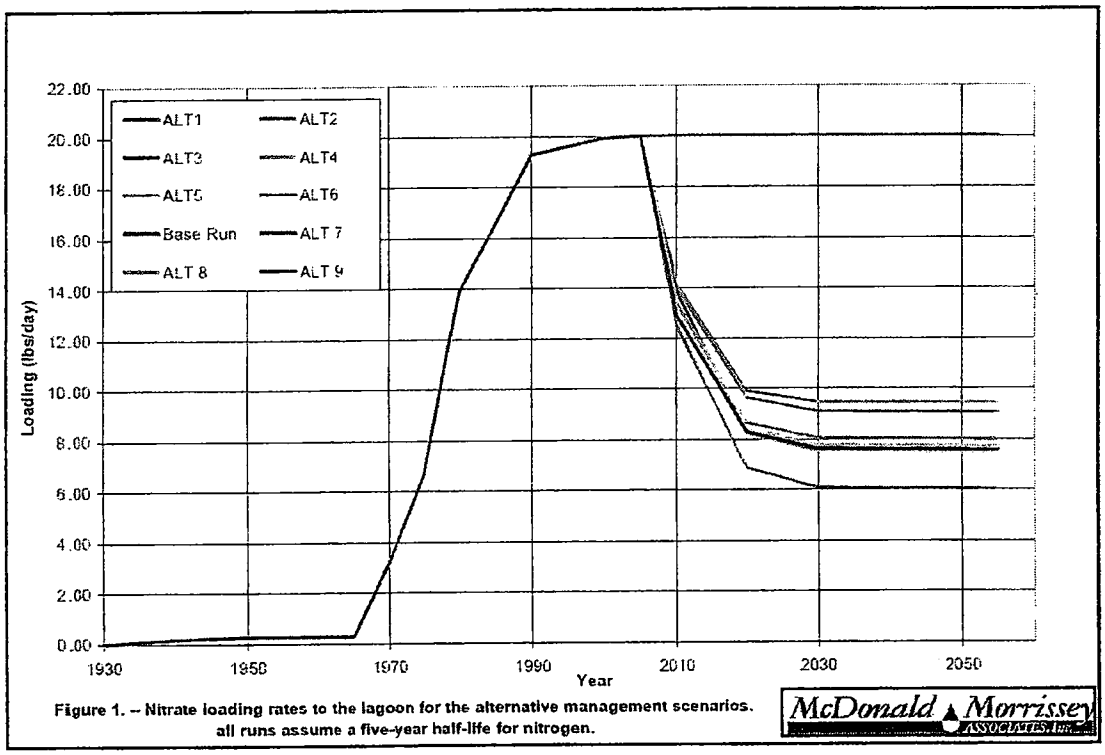
The three-dimensional groundwater flow and solute transport model developed for the Risk Assessment study (the Stone Report) was refined by McDonald Morrissey Associates to assess the potential water quality implications of various combinations of wastewater collection, treatment and dispersal options. Nine options were evaluated along with a baseline condition. Estimated wastewater flows from future development, as well as existing wastewater flows, were considered in the analysis. The model results of nitrogen mass loadings into the Malibu Lagoon for each wastewater management alternative, including the existing condition, are shown in Figure 3.

The nitrogen load at the present condition was estimated to be approximately 20 lbs/day. This result is slightly greater than the result obtained in the Stone Report (17 lbs/day) because

REVISED OCT 2 1 2 0 0 9

additional loading from commercial OWDS was included. Figure 3 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Figure 3 Calculated Nitrogen Loading Rates to the Malibu Lagoon for the Alternative



Management Scenarios

1.3 Tetra Tech Report (Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies, December 2002)

The TMDL modeling report estimated that nitrogen loading from residential OWDS is 59.2 milligram/liter (mg/l) with 274 gallons per day (gpd) average effluent flow rate. It also assumed that there are two billion coliform counts per person per day discharged into OWDS, and an average population of 3.4 persons per household.

For "normal" OWDS, the TMDL report assumed 100% of the bacteria load is removed prior to reaching surface water bodies, and that 50% of the nitrogen loading reaches the surface water (TetraTech, 2002). For the "failed" OWDS, it was assumed that 40% of the bacteria reaches the Lagoon and 50% of the nitrogen reaches the Lagoon. For "short circuited" systems, 87% of the nitrogen loads and 20% of the bacteria loads were assumed to enter the Lagoon.

3-987

REVISED OCT 2 1 2 0 0 9

Based on the above assumptions, TetraTech (2002) estimated the current total annual bacteria load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 1,176,760 x 10^9 counts per year (3,224 x10^9 counts per day) for fecal coliform.

Similarly, the report estimated the current total annual nitrogen load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 23,434 pounds per year, or 64.2 lb/day (TetraTech, 2002).

2.0 Staff Estimate of Mass Loading Rates into the Malibu Lagoon

2.1 Estimate using Questa Numerical Model Results

The Questa groundwater flow and transport modeling assumed that the unsaturated zone had a negligible effect on nitrogen species and that the tidal actions and influences had a negligible effect on the water table and solute transport. Based on local soil properties, the soil is mostly sand and less clay. As such, the assumption that infiltration flows directly into the saturated zone is reasonable. As far as tidal influences are concerned, the varied tidal level will slightly affect the local water table and will not have much of an effect on the up-gradient groundwater water elevation. Therefore, staff concludes that the model results obtained from the Questa Report can be used to estimate the nitrogen mass loading to the Malibu Lagoon using recent OWDS loading data.

From Figure 2, it can be seen that the maximum loading rate to the Malibu Lagoon for the breached Lagoon condition varies from 31 lbs/day (no degradation) to 17 lbs/day (5-year half life) depending on different nitrate degradation coefficients. To be conservative, staff assumed the breached condition and a 5-year half life for the nitrate degradation rate to estimate nitrogen mass loading to the Malibu Lagoon. The relationship of nitrogen mass loading from OWDS and mass loading entering the Lagoon from the Questa Report is presented in Figure 4. There are four loading periods shown in Figure 4 to represent general changes in rates of mass loading into the Lagoon based on changes in source loading to the groundwater system. The loading period A is the period during 1930 to 1964 in which the simulated sources were from Malibu Colony only. During loading period B from 1965 to 1974, the simulated source loading includes the additional loading from residential areas in uplands adjacent to the alluvium. The loading period C from 1975 to 1989 includes all sources in loading period B plus commercial systems in the main body of alluvium. For the loading period D from 1990 to 2009, the source loading includes all sources in the loading period C plus loading from increased commercial and wastewater disposal at the Malibu Bay Colony plant.

To estimate the current loading to the Malibu Lagoon, the flow rate and concentration of wastewater from OWDS for commercial and residential areas from 2008-2009 were used to calculate the mass loading from OWDS to groundwater in the study area and then, based on the relationship for the loading period D as shown in Figure 4, to estimate the mass loading of nitrogen to the Malibu Lagoon. The resulting estimate of nitrogen mass loading into the Lagoon is 30.2 lbs/day based on mass loading from OWDS of 94.4 lbs/day as shown in Table 1.

REVISED OCT 2 1 2009

2.2 Estimate using Spread Sheet Model

Since there are no numerical model input data available, the estimate of mass loading into the Lagoon assumes that the relationship between mass loading from OWDS and mass loading to the Lagoon is linear and the ratio of mass loading of 0.32 obtained from the Questa Report was used. However, the relationship between mass loading from OWDS and mass loading into the Lagoon may not be linear because the increased mass loading from OWDS could contribute more mass loading into the Lagoon due to the limited nitrogen capacity of groundwater during long term discharge and the effect of local groundwater flow net patterns. As such, Regional Board staff in the Groundwater Permitting Unit used a spread sheet model to estimate the mass loading entering the Lagoon based on local geotechnical data, hydraulic conductivity and groundwater flow net patterns. The estimate of mass loading into the Lagoon based on this spread sheet model is ~~39.4~~ **34.9** lbs/day resulting from a mass loading from OWDS of 94.4 lbs/day.

The comparisons of the three previous modeling results and staff estimates of nitrogen mass loading to the Malibu Lagoon using a numerical model and a spreadsheet model are presented in Table 1.

2.3 Evaluation of Nitrogen Mass Loadings into the Lagoon using a Mass Balance Model

To evaluate which estimate of mass loading to the Lagoon presented in Table 1 is the best fit with actual conditions and to understand the effect of mass loading from OWDS to the Malibu Lagoon on nitrogen concentrations in Lagoon water, staff used a continuous stirred tank reactor (CSTR) mass balance model to estimate the resulting concentration due to the mass loading. The CSTR model results for different mass loadings are presented in Figure 5. The results are compared with actual Lagoon nitrogen concentration data. It can be seen from Figure 5 that the predicted nitrogen concentration in the Lagoon due to a mass loading entering the Lagoon of 20 lbs/day (as predicted by the Questa Report) is a good comparison with the average nitrogen concentration of 1.4 mg/L for receiving water data collected by the Tapia wastewater treatment plant from 1995-1999. In addition, the predicted nitrogen concentration due to the load allocations for OWDS developed in the TMDL of 6 lbs/day is less than the nitrogen numeric target of 1.0 mg/L. The maximum of nitrogen mass loading into the Lagoon to maintain the nitrogen numeric target of 1.0 mg/L is about 13 lbs/day.

Staff estimates that the current mass loading into the Lagoon from OWDS may vary from 30 lbs/day to 35 lbs/day based on the predicted nitrogen concentrations in the Lagoon water and measured Lagoon nitrogen concentrations for 2002-2003 data (SCCWRP Technical Report 441) as shown in Figure 5. The current estimate of mass loading into the Lagoon of 34.9 lb/day using the spread sheet method would produce a nitrogen concentration in the Lagoon water of 2.9 mg/L and the current estimate of mass loading of 30.2 lb/day using the Questa numerical model results would cause the nitrogen concentration in the Lagoon water to be 2.5 mg/L. According to the measured data during 1995-1999 and 2002-2003, the nitrogen concentration in the Lagoon water is increasing. As such, the resulting nitrogen concentration of 2.9 mg/L for 2008-2009 falls within the trend of measured data from 1995 to 2003. Thus, the mass loading into the Lagoon of 34.9 lb/day is considered to be an appropriate and reasonable estimate.

REVISED OCT 21 2009

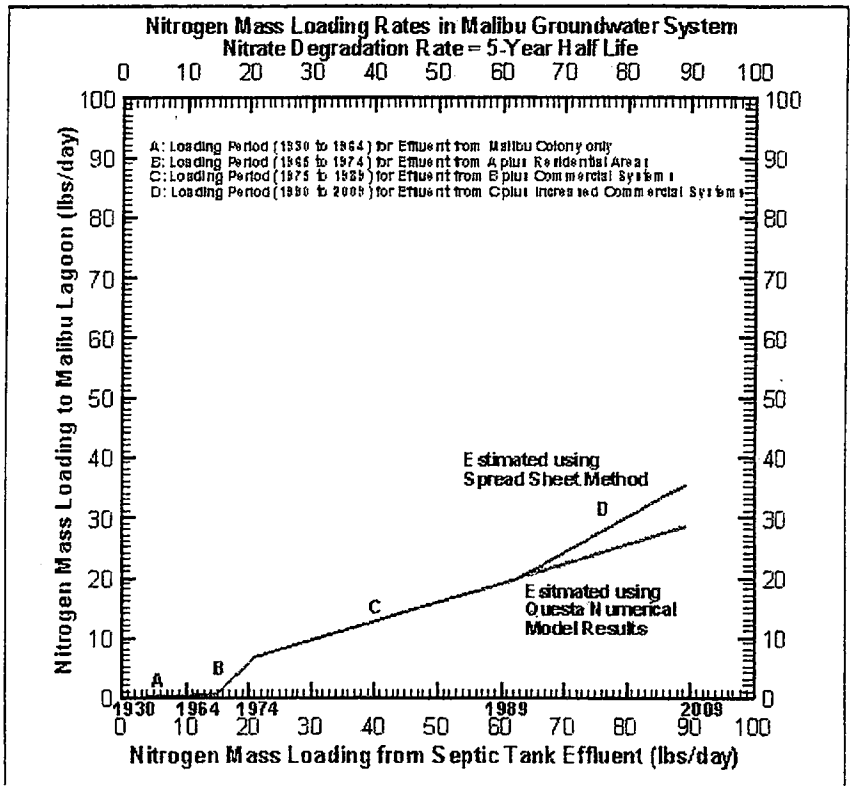
In summary, staff finds that the previous model developed by McDonald Morrissey Associates as presented in the Questa Report was calibrated with measured nitrate data and its modeling results can be used and have been used in this memo to estimate current nitrogen mass loading into the Lagoon. The spreadsheet model also provides a reasonable estimate of current mass loading to the Lagoon. By comparing the results of these two models with measured nitrogen concentration data in the Lagoon, staff estimates that 29-35 lbs/day of nitrogen are loaded to the lagoon, which exceeds the TMDL load allocation and results in exceedances of the TMDL numeric target.

3.0 References

1. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Final Report, prepared for Santa Monica Bay Restoration Commission, prepared by Stone Environmental, Inc., August 30, 2004.
2. "Ground-Water Flow and Solute Transport Modeling, Malibu, California", prepared for Santa Monica Bay Restoration Project, prepared by McDonald Morrissey Associates Inc., July 28, 2004.
3. "Malibu Civic Center Integrated Water Quality Management Feasibility Study", prepared for City of Malibu, prepared by Questa Engineering Corporation, April 28, 2005.
4. "Groundwater Modeling Report in the Appendix D of Malibu Civic Integrated Water Quality Management Feasibility Study", prepared by McDonald Morrissey Associates, Inc., April 26, 2005.
5. "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", United States Environmental Protection Agency, Region 9, 2003.
6. "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development", prepared for Sterling Capitol, prepared by Furgo West, Inc., March 2005.
7. "Final Malibu Lagoon Restoration and Enhancement Plan", prepared for the California State Coastal Conservancy & California State Department of Parks and Recreation, prepared by Moffatt & Nichol, June 17, 2005.
8. "Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon", prepared for City of Malibu, prepared by RMC, March 26, 2008.
9. "Lower Malibu Creek and Lagoon Resource Enhancement and Management ", Final Report to the California State Coastal Conservancy, prepared by Richard F. Ambrose and Antony R. Orme, University of California, Los Angeles, May 2000.
10. "Malibu Wetland Feasibility Study", prepared for Malibu Coastal Land Conservation, prepared by Huffman and Carpenter, Inc., August 2000.
11. "Sediments as a Non-Point Source of Nutrients to Malibu Lagoon, California, USA", Southern California Coastal Water Resources Project (SCCWRP) Technical Report 441, October 2004.
12. Las Virgenes Municipal Water District (LVMWD),Tapia Water Reclamation Facilities, Malibu Creek Monitoring Program, 1995-1999 Annual Report, NPDES Permit No. CA0056014.

REVISED OCT 2 1 2 0 0 9

Figure 4 Relationship of nitrogen mass loading from OWDS and mass loading into the Lagoon



3-991

REVISED OCT 2 1 2 0 0 9

Table 1 Comparisons of nitrogen mass loading to the Malibu Lagoon for three previous studies and staff estimates

	Stone Report (2004)[b]	Questa Report (2005)[b]	Tetra Tech Report (2003)[c]	Staff Estimate Using Spread Sheet Method[d]	Staff Estimate Using Numerical Model Method[e]
1.Wastewater Flow Rate from Commercial OWDS (gal/day)	62166	100000	75000	127241	127241
2.Concentration in Commercial Wastewater (mg/L)	50	50	59.2	3 - 110	3 – 110
3.Mass Loading from Commercial OWDS (lbs/day)	25.94	41.73	37.05	42.1	42.1
4.Wastewater Flow Rate from Residential OWDS (gal/day)	126121	126121	54800	139300	139300
5.Concentration in Residential Wastewater (mg/L)	20	20	59.2	45	45
6.Mass Loading from Residential OWDS (lbs/day)	21.05	21.05	27.07	52.3	52.3
7.Mass Loading from OWDS (lbs/day)	46.99	62.78	64.12	94.4	94.4
8.Ratio of Mass Loading[a]	0.36	0.32	0.50	0.38	0.32
9.Mass Loading to Malibu Lagoon(lbs/day)	17	20	32	34.9	30.2

Note: [a] the ratio of mass loading entering Malibu Lagoon versus mass loading from OWDS, i.e., value of row 9 divided by value of row 7.

[b] the nitrogen loads were assumed to be mostly nitrate in the OWDS and the model only simulated the nitrate in the Stone and Questa Modeling Reports.

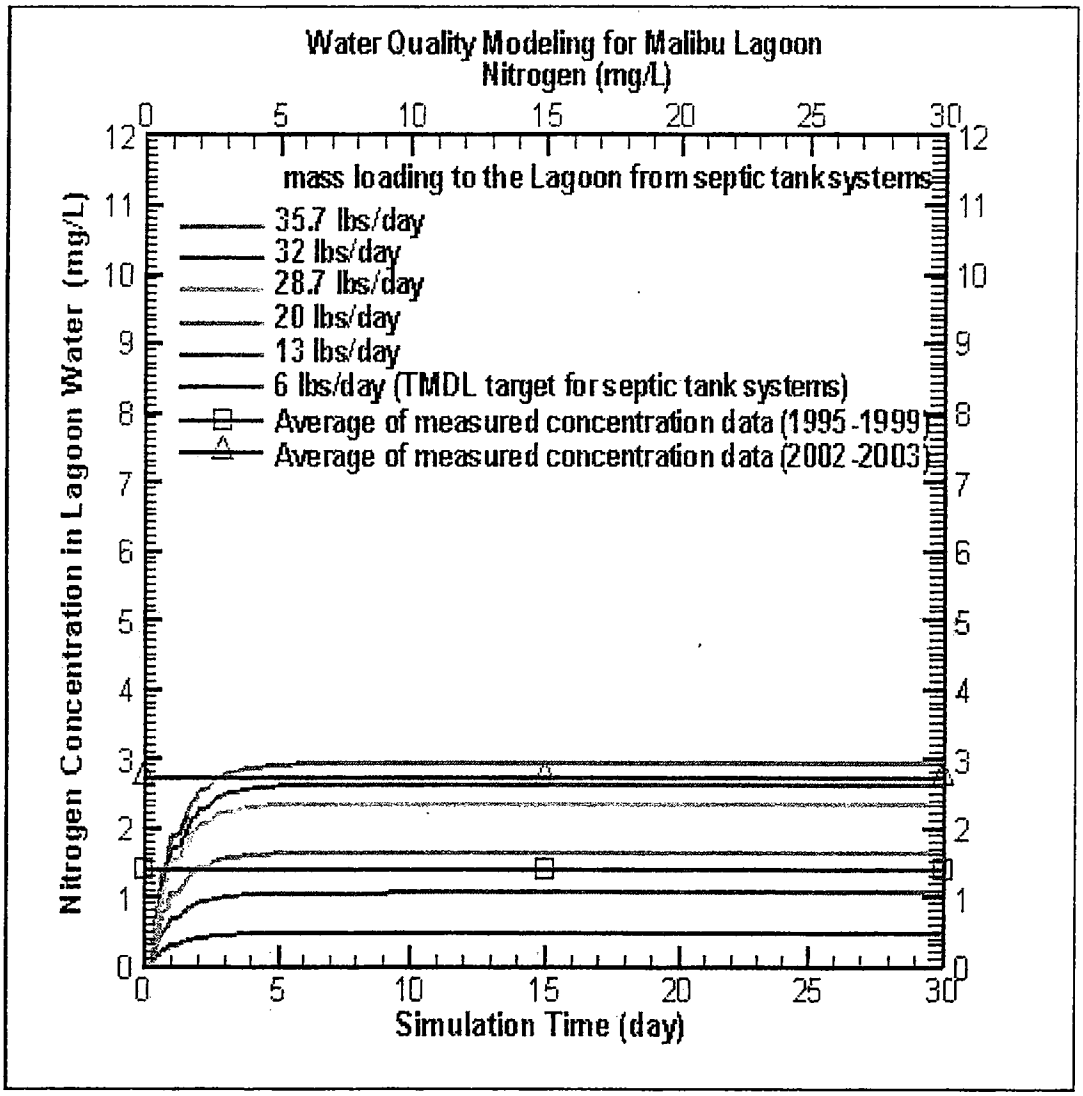
[c] 50 percent of nitrogen loads from the OWDS were assumed to enter the Malibu Lagoon.

[d] the nitrogen mass loading from OWDS was estimated based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L for OWDS. Staff estimated the nitrogen mass loading to Malibu Lagoon by using the spread sheet method.

[e] the nitrogen mass loading based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L from OWDS were used in the model. Staff estimated the nitrogen mass loading to Malibu Lagoon by using Questa numerical model results.

REVISED OCT 21 2009

Figure 5 Nitrogen concentrations in Lagoon water resulting from different mass loadings entering the Lagoon



REVISED OCT 2 1 2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review – Staff Memorandum

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Toni Callaway, P.G., Engineering Geologist

TM4-46

California Regional Water Quality Control Board
Los Angeles Region

320 W. 4th Street. Suite 200. Los Angeles. California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.waterboards.ca.gov/losangeles

Linda S. Adams
Cal/EPA Secretary

Arnold Schwarzenegger
Governor

Date: October 21, 2009

To: Rebecca Chou, Ph.D., P.E., Chief of Groundwater Permitting Unit
Wendy Phillips, PG, CHG, CEG, Chief of Groundwater Permitting and Landfill Section

From: Toni Callaway, P.G., Engineering Geologist, Groundwater Permitting Unit

Subject: **Peer Review Response to Comments - Technical Memorandum #4: Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life**

Attachments:

1. Comment dated September 5, 2009 from Dr. Robert Arnold of Arizona State University
2. Comments dated September 10, 2009 from Dr. Jörg Drewes of Colorado School of Mines
3. Comments dated September 12, 2009 from Dr. JoAnn Silverstein of the University of Colorado at Boulder

---

To ensure that the proposed amendment to the *Basin Plan*[1] is based on sound science and engineering principles, the scientific elements of Technical Memorandum (Tech Memo) #4: *Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life,* draft dated August 5, 2009 (Tech Memo #4), were peer reviewed. This peer review was conducted in accordance with requirements and guidelines from the Cal/EPA Scientific Peer Review Program, Office of Research, Planning and Performance.

All three peer reviewers responded promptly and provided valuable comments. In summary, all three peer reviewers found that the basic approaches and methods used to calculate the nitrogen loading to Malibu Lagoon in Tech Memo #4 incorporated sound scientific and engineering principles.

Suggestions were made to clarify the assumptions made by staff. Staff responded to these suggestions and revised Tech Memo #4 as appropriate and noted that none of the changes materially altered the conclusion of Tech Memo #4. That is: On-site subsurface disposal systems (OWDSs) in the Malibu Civic Center area cumulatively release nitrogen to Malibu Lagoon at

[1] Proposed amendment to the *Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)* to prohibit on-site subsurface disposal systems (OWDSs) in the Malibu Civic Center area.

rates that violated the total maximum daily limit (TMDL) adopted by the US Environmental Protection Agency in 2003 for the Malibu Lagoon (USEPA, 2003).

Comments have been summarized into three main issues and presented in *italics*, followed by staff's response. The main issues raised in the comments are: 1) Residential Loading - Is the 100 gallons per day per person (gpd/person) wastewater flow rate assumed in the Tech Memo for single-family homes realistic? 2) Commercial Loading - Are the flow rates estimated for un-permitted commercial properties in the Tech Memo accurate? and 3) TN/BOD Ratio - Is the TN/BOD Ratio of 0.20 in wastewater used in the Tech Memo an appropriate estimation for total nitrogen (TN) when biochemical oxygen demand (BOD_5) data is available while TN data is not available? Comments related to these issues are addressed in paragraphs 1 through 3 below:

1. ***Residential Loadings**: Comparing to the typical rate of wastewater generation per capital in the literature (40 to 90 gpd/person), the 100 gpd/person rate used in Tech Memo #4 for the Malibu Civic Center area may be too high.*

   Staff considers the residences in the Malibu Civic Center area luxury homes, because almost all the 392 residences in the area are large single family homes with more than 3.5 bath/bedrooms per house. Many studies have shown that luxury homes use more water than ordinary homes and therefore generate more wastewater. For example, Metcalf and Eddy (1991, Table 2-9, page 27) reported that the average water usage for luxury homes in residential areas was 75-150 gpd/person, while the water usage for the average home nationwide was 70 gpd/person. The higher than typical wastewater flow rate used in Tech Memo #4 is also supported by historical water use data of Malibu City. In 2008, the population of the Malibu City was 13,009 and the water consumption of the City was 2,200 million gallons for both commercial and residential usage. It has been estimated that approximately 54% of urban water usage is residential (Department of Water Resource in California) and that 50% of residential water usage is for irrigation (American Water Works Association). Assuming these percentages are applicable to the Malibu Civic Center area, the net per capita water consumption (excluding irrigation use) would be 125 gpd/person. Because the bulk of residential water consumption becomes wastewater at the end, the 100 gpd/person of wastewater flow rate used for the Malibu Civic Center area is a reasonable estimate. Tech Memo #4 has therefore not been modified in response to this comment.

2. ***Commercial Loading**: In Tech Memo #4, wastewater flow rates from small businesses were estimated using on-site population and business activity information. A few details or examples of the process by which wastewater flows were assigned might provide a feel for this work.*

A new column (category) has been added to Table 1 in Tech Memo #4 to characterize each commercial facility, including whether flow rate of the facility was estimated. New footnotes have also been added to Table 1 to better explain the data source for each facility. Of the 38 commercial facilities in the Malibu Civic Center area that discharge wastewater with OWDSs, the flow rates of 7 facilities were not available and had to be estimated. This constitutes 5.4% of the total commercial flow.

3. ***TN/BOD Ratio**: Staff assumed a constant fraction (0.20) of total nitrogen concentration to five-day biochemical oxygen demand (TN/BOD_5) to estimate nitrogen load of commercial sources where only BOD_5 measurements were available. More appropriate references should be used to provide the accurate representation of single source waste streams. TN/BOD ratios from single sources should be site-specific and highly depending on the types of dischargers (i.e. lower in restaurant effluents). If local data exist with which to make this distinction, they should be cited in the text. It is advisable that samples be taken to verify the TN:BOD ratio from specific dischargers with higher flow.*

BOD_5 is a measurement of the amount organic substances in wastewater. Because nitrogen in wastewater is mostly derived from organic substances (proteins), the concentration of total nitrogen generally increases with the increase of BOD_5. The 0.20 TN/BOD_5 ratio used in Tech Memo #4 is consistent with tables characterizing residential wastewater found in college textbooks, such as Metcalf and Eddy (1991) and Crites and Tchobanoglous (1998). Staff has added Table 4 which summarizes TN and BOD analytical data from 106 septic tank wastewater samples from large mixed usage commercial facilities located in the Malibu Civic Center area. The average TN/BOD_5 ratio for these samples was 20.4%, which is essentially the same as what was used in Tech Memo #4. The mixed use commercial properties include restaurants, but there are few stand-alone restaurant in the Malibu Civic Center area.

Staff responses to comments requiring minor clarification summarized in paragraphs A through H below:

A. Staff should provide more information regarding the OWDSs being used in the Malibu Civic Center area, such as a definition of "advanced" OWTS treatment. In the interest of defining the most significant sources of nitrogen load, the facilities that provide advanced treatment, the nature of the treatment provided, and typical BOD_5 and total nitrogen removal efficiencies might be added to the report. The credits between OWDSs and soil profile to the removal of nitrogen/BOD should be clarified.

"Advance OWTS treatment" is defined as more advanced than primary treatment, i.e. secondary and tertiary treatment with disinfection. The advanced systems in the Malibu

Civic Center area vary greatly, no two are alike, but a footnote (Footnote D) has been added to Table 1 to identify advanced OWTSs. As stated in Tech Memo #4, the Regional Board lacks site specific information for the hundreds of residential septic systems in the Malibu Civic Center area. When available, the effluent loads (nitrogen concentration) in Table 1 listed real "end-of-pipe" data.

In Table 3 of Tech Memo #4, credits for TN reduction in the soil profile are based on soil type (e.g. sandy loam), sufficient groundwater separation (e.g. 5 feet to 10 feet from bottom of leachfield to groundwater), and demonstrated unsaturated soil assimilative capacity. The high density of wastewater discharges in many of the commercial and residential areas of Malibu preclude adequate subsurface assimilative capacity. Available data indicates that site conditions in the coastal strips (high groundwater) and the highland residential area (fractured bedrock with the prevalent usage of seepage pits for disposal) do not warrant further reduction of nitrogen loads by soil treatment.

B. Because many calculations in the spreadsheet model were based on assumptions, a sensitivity analysis of the eventual nitrogen load estimates in response to the variation of key input parameters, such as flow rate, TN, and soil attenuation factor, is recommended.

Staff has conducted a sensitivity analysis to the spreadsheet model, but little impact was observed to the eventual nitrogen load estimates. Sensitivity analysis was made by changing the estimated flow rate and TN concentration in the spreadsheet model. All of the variations tried resulted in values much higher than the assigned TMDL load for septic systems in the lower Malibu Creek watershed).

C. Is it possible that seasonal effects are of importance to the average nitrogen load estimation in the Malibu Civic Center area?

Since most homes in the Malibu Civic Center area are owner occupied, little seasonal variation is expected on the wastewater flows from the single homes. Monitoring data large multi-family residences located in the area do not display seasonal significant variation. Wastewater flows from commercial sources do change by season as a function of the number of visitors. Staff observed slightly higher TN loads in the prime summer tourist season. Because the flow rate data in Tables 1 and 3 of Tech Memo #4 are annual averages over several years, seasonal variations were minimized.

D. Staff's judgment regarding the fate of nitrogen during on-site treatment and subsequent transport seems arbitrary. The discussion makes no distinction between ammonium ion absorption, which is both efficient and fast on soil particles, and

nitrification/de-nitrification reactions, which can lower the concentrations of available nitrogen forms and dramatically affect nitrogen transport in the subsurface.

Because of variations of local site conditions, it is impractical to distinguish the form of nitrogen transport for all wastewater sources in the area. However, as detailed in Tech Memo #2, there are indications showing that natural attenuation (treatment of pollutants in soil) is not occurring in many areas of the Malibu Valley and the nearby Winter Canyon. There are numerous indications that the high density of subsurface wastewater discharges in the Malibu Civic Center Area has exceeded the natural assimilation capacity of the soil profiles. Because the goal of Tech Memo #4 is to determine the long term total nitrogen load of the Malibu Civic Center area to the Malibu Lagoon, the form of nitrogen transport should have little effect to the conclusion of the study. Both the numeric and spreadsheet models assume that total nitrogen is converted to nitrate after reaching surface waters.

E. Staff might comment on the form in which nitrogen is present in the Malibu Lagoon since this bears on the forms in which nitrogen is transferred from on-site disposal locations.

Malibu Lagoon is a unique aquatic system which opens to ocean during raining season and close during dry season. During dry seasons that nitrogen can be accumulated, significant breakthrough of nitrate or ammonia was not observed in the lagoon, but serious eutrophication has been observed. Staff assumes that total nitrogen in groundwater converts in the Lagoon to nitrate.

F. There are some inconsistencies between Tables 1 and 3. Since all the designed parameters are the same for all models, the calculated total nitrogen loads should be the same.

The inconsistencies between Tables 1 and 3 in Tech Memo #4 have been verified and corrected.

G. The non-point source nitrogen contributions to the Lagoon did not appear to have been considered. If these are available from the TMDL calculation, they should be considered as part of the total load.

The total load allocation of nitrogen in the Lagoon is 27 lbs/day. Because non-point sources have already been considered in the TMDL for Malibu Lagoon, they are not included in Tech Memo #4, which is to determine whether the total nitrogen load from OWDSs in the Malibu Civic Center area exceeds the 6 lbs/day allocation required in the TMDL for OWDSs sources. Details of total nitrogen load allocations from non-point sources in the

larger Malibu Creek watershed are detailed in the TMDL (USEPA, 2003) and available on the Regional Board website at http:www.waterboards.ca.gov/losangeles.

H. How much a 6 lbs/day of nitrogen addition to the lagoon is likely to increase the available nitrogen levels in Malibu Lagoon?

An evaluation of nitrogen mass loading in Malibu Lagoon is given in Attachment 4-1 (by Dr. Lai) of Tech Memo #4. Figure 5 of Attachment 4-1 indicates that, assuming no other sources exist, a 6 lbs/day of total nitrogen load into the lagoon would bring the nitrogen concentration in the water from 0 to approximately 0.5 mg/L.

Editorial and grammatical suggestions have been followed as appropriate, but are not addressed here. A revised Tech Memo #4 that incorporates changes made in response to peer review comments is posted on the Regional Board website at http:www.waterboards.ca.gov/losangeles.

Staff would like to thank all three peer reviewers for their thoughtful review of Tech Memo #4 and providing their comments in a very timely, professional manner.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Dr. Robert Arnold
Chemical & Environmental Engineering
The University of Arizona
P.O. Box 210011
Tuscon, AZ 85721-0011

520-621-2591
520-621-6048 FAX

TM4-53

3-1001

Memorandum

5 September 2009

To: Ms. Wendy Phillips; Chief, Groundwater Cleanup and Permitting Section, CA Regional Water Quality Control Board

From: Bob Arnold

Subject: Review of Regional Board Staff Technical Memorandum #4. Nitrogen loads from wastewater flowing into Malibu Lagoon.

I will first address the technical issues that were identified for peer review in attachments to your email note dated 28 August. Issues are taken in the order that you suggested.

1. The approach used to inventory wastewater discharges in the Malibu Civic Area (255,000 gallons per day). The flows inventoried fell into the following four classes:

(i) Large, permitted commercial enterprises with Waste Discharge Requirements (WDRs). A subset of these sources provide advanced wastewater treatment (undefined in the report) prior to effluent discharge. The other subset provides only septic treatment prior to discharge. For these sources there is a record of both wastewater volume generated and total nitrogen concentration (Kjeldahl, nitrate, nitrite) discharged to the environment.

(ii) Smaller permitted commercial sources, which also produced a record of wastewater volumes, but were not required to analyze for nitrogen forms in treated effluent. These sources seldom if ever provided advanced treatment prior to discharge.

(iii) Small businesses that were not regulated by the state and for which there was no official record of wastewater volume generated or probable total nitrogen concentration in treated waste.

(iv) Private residences, for which there was no record of wastewater flow or effluent quality.

Thus a complete inventory of the required wastewater volume generated required the authors to find or otherwise estimate the following information, generally from the tertiary sanitary engineering literature and/or the assumptions noted below:

- For dischargers in class (i) the volume flows and nitrogen levels provided all information necessary to calculate flows and respective nitrogen loads at points of discharge.
- For smaller, permitted commercial sources (class (ii), above) flow data were available, but nitrogen levels would depend on an assumption (see below) regarding total nitrogen level.
- Small business flows were estimated using information derived by staff regarding on-site population and business activity. Detailed information/methods for these steps are not described in Technical Memorandum No. 4.

- Flows from residences were estimated based on 100 gallons per day per residence bathroom.

There is very little to criticize in this approach to volume estimation. A few details or perhaps examples of the process by which flows were assigned to small, unpermitted businesses might provide a feel for this work. However, the magnitude of flow generated by this class of dischargers must have been fairly small and probably insignificant — making the quality of assumptions used or accuracy of related estimates almost irrelevant within the context of the overall exercise. To make this plain, it would be useful to organize the eventual flow information by class of discharger within each of the geographical sectors within the study area. It also seems possible that water use data, if uniformly available for small businesses could have been used to generate estimates of wastewater flows. It seems very unlikely that such an alternative approach, however, would have led to materially different results at the conclusion of the nitrogen analysis. In a sense, assumptions regarding domestic flows are the most critical, inasmuch as treated domestic wastewater is a major contributor to the eventual calculation of the nitrogen load to Malibu Lagoon. Again, water demand data might have been used to generate wastewater flow estimates.

In general, I am satisfied that no set of alternative (rational) assumptions would have materially improved the quality of the analysis to this point.

2. Methods for calculating nitrogen load contributions from individual OWDSs. Again relying on the four classes of dischargers within the Malibu Civic Area:

(i) Total nitrogen data were available for large, permitted commercial sources with WDRs. Again, there is no clear indication of which specific sources fell within this category in any of the summary tables, so that the efficiency of advanced wastewater treatment processes (unspecified) for nitrogen management cannot be determined from the Table 3 data.

(ii) It was assumed that the smaller, permitted, commercial sources produced an effluent that was similar to domestic effluent quality following septic treatment. The report indicates that some effort was undertaken to express effluent strength, including total nitrogen concentration as a function of the type of business practiced on site. Details and intermediate results from that work are not provided, however.

(iii) Site-specific information was used to anticipate total nitrogen concentration at unpermitted commercial facilities. Again, essentially no information is provided with which to illustrate the type of information collected, methodology for its conversion to nitrogen concentration or nitrogen load, and so forth.

(iv) The total nitrogen concentration in residential wastewater was estimated by assuming that the concentration of total nitrogen (as N) was a constant fraction (0.21) of the five-day biochemical oxygen demand. The correlation was taken from an exceptionally important sanitary engineering text and should be at least approximately correct.

I have the following reservations regarding the approach taken to estimation of nitrogen concentrations for the purpose of nitrogen load allocation at respective discharge points:

- Although the correlation between total nitrogen concentration and BOD_5 (0.21 mg/L as N per mg/L BOD_5 as O_2) may be accurate for domestic wastes, the justification for its use in this context is misleading. The authors contend that nitrogenous oxygen demand is a consistent contributor to BOD_5 (p. T4-4). In fact, the kinetics of biochemical oxygen demand may be dominated by carbonaceous oxygen demand over the first five days of the BOD measurement. This does not invalidate the approach taken, inasmuch as both total nitrogen and BOD_5 are useful indicators of the strength of a waste and are likely correlates in domestic wastewater. Since BOD_5 data were more broadly available than total nitrogen data, the method of estimation probably has merit. For those cases in which both BOD_5 and total nitrogen data are available, however, the authors should provide them — to demonstrate the strength of the correlation.

- No attempt is made in the report to define "advanced" OWTS treatments. In the interest of defining the most significant sources of nitrogen load, the facilities that provide advanced treatment, the nature of the treatment provided and typical BOD_5 and total nitrogen removal efficiencies might be added to the report.

- The choice of BOD concentrations , absent data, and thus total nitrogen concentrations (21% of BOD_5) seems arbitrary:

Facility Type	BOD_5 (mg/L)	TN (mg/L as N)
Shopping centers with restaurants	800	160*
Small Offices	220	40
Schools		45-75**

* reduced to 80 mg/L to reflect frequent pumping of septic tanks at Malibu Country Mart.

** dependent on soil type and groundwater separation.

Nevertheless, any other assignment of values would be equally arbitrary and probably no more reasonable than the values chosen for the nitrogen loading models. At the end of the exercise, however, it isn't possible to determine which facilities were included in each class (large commercial, small commercial without water quality data, etc.) so it is not possible to reproduce the spreadsheet calculations from the data provided. Given that reviewers will be incapable of performing independent calculations, the authors might carry out their own sensitivity analysis——to determine which parameters are the primary determinants of the eventual nitrogen load estimates. A good candidate for sensitivity analysis, for example, is the 80 mg/L (as N) total nitrogen concentration that is assumed for some of the commercial sources. Were this value actually 40 mg/L, would the outcome of the analysis change dramatically? The spreadsheet approach is well suited to make such repetitive calculations, and the results could be illuminating. This comment applies to several of the assumed parametric values.

- Various data elements are missing from table 1, page T4-20. Is there a reason for this?

- The apparent importance of residential contributions to regional nitrogen loading suggests that it may be important to distinguish between reported literature values (20, 45, 85 mg/L as N)—to make a selection that is appropriate for Malibu. If local data exist with which to make this distinction, they should be cited in the text. I failed to find data related to nitrogen levels in septic tank effluents, although staff suggested that measurements in septic tank effluent had been made. Absent data, the sensitivity of spreadsheet results to the assumed value should be determined.

- Finally, is it possible that seasonal effects are of importance to average nitrogen load estimation in the study area? No mention was made of variation in population or commercial activity in the Malibu study area. However, since estimated groundwater travel times to Malibu were sometimes on the order of decades, it is conceivable that winter occupancy rates and seasonal commerce might lower annual average nitrogen loading rates in a way that also lowers the average nitrogen load at the Malibu Lagoon. Since neither this study nor previous studies seem to have considered seasonal effects, it seems likely that they are unimportant in this context.

3. **Division of the Malibu Civic Center area in hydrologic zones.** There is clear justification for division of the study area into hydrologic zones. This seems like a very good way to account for substantial differences in fractional contributions of wastewaters to the Malibu Lagoon that arise from consideration of topography, water table contours and groundwater travel times to the lagoon. The breadth of both fractional contributions and estimates of groundwater travel times is a little unnerving. That is, travel times are held to vary from up to 50 years, for at least a portion of the wastewater discharged in sector I to less than one year for a portion of the flow that originates in sector II. The estimated fractions of discharged wastewater that reach the Malibu Lagoon range from 1% (Winter Canyon, main area sector IV, Sector V) to 95% (sector II much of sector III). The approach is sound, in my opinion, and potentially allows planners and engineers to discriminate geographically in making decisions regarding the importance of new sewerage to the quality of water in the Malibu Lagoon. That is, based on nitrogen considerations alone, it seems probable that new construction would be best deployed in sectors II, III and part of IV. The effects of that construction on lagoon water quality should be relatively rapid due to the short, estimated travel times. The staff's own spreadsheet model can be used to estimate fractional reductions in annual nitrogen load to Malibu Lagoon as consequence of several possible sewerage configurations. Staged construction and water quality response in the lagoon could then be used to avoid unnecessary extension of the sewage system.

I offer just a few comments in this area— use of hydrological sectors, etc:

- Since water table contours are not provided in the report, readers are obliged to accept staff's opinion on gradients and groundwater flow directions. A contour map would undoubtedly lead those reviewing the document to the same conclusion that was reached by staff and would better ground the very significant assumptions about flow routing and

contribution to Malibu Lagoon that are presented in the document. Such a contour map should be developed and included in the report if it is practical to do so.

- Where the selection of flow contribution by sector or sub-sector has an element of uncertainty, staff should examine the sensitivity of their general findings to the fraction adopted. The spreadsheet solution should make such an exercise accessible, and the results would likely show that staff findings are robust with respect to selection of sector-dependent factors governing respective fractions of on-site discharges that reach the lagoon.

- Judgment regarding the fate of nitrogen during on-site treatment and subsequent transport seems arbitrary. While estimated nitrogen losses may have been conservatively high, contributing to the strength of the staff's eventual findings and recommendations, it would be preferable to cite local data for the loss of total nitrogen during on-site treatment, and the discussion of nitrogen fate and transport following discharge is inadequate. That discussion makes no distinction between ammonium ion absorption, which is both efficient and fast on soil particles, and nitrification/de-nitrification reactions, which can lower the concentrations of available nitrogen forms and dramatically affect nitrogen transport in the subsurface. Furthermore, the availability of molecular oxygen in groundwaters affected by on-site discharges deserves attention since oxygen is required for nitrification. Finally, staff might comment on the form in which nitrogen is present in the Malibu Lagoon since this bears on the forms in which nitrogen is transferred from on-site disposal locations.

4. Model adjustment using new nitrogen load factors. I have nothing to say about the use of updated nitrogen load factors to adjust model results. This activity seems well justified and takes advantage of previous modeling work.

5. Other comments. I could make about a dozen grammatical suggestions but have not since this lies outside the scope of my review. I can send a marked up electronic version of the draft technical memorandum if you like.

In the end, I think that none of the comments offered here will materially alter the results of staff's analysis. Sensitivity analysis can be better used to show that analytical results are in fact robust with respect to tributary assumptions. Staff is well positioned to use their spreadsheet model for that purpose.

Although it goes beyond the limits of my review, I would like to know how much 6 lbs/day of nitrogen addition to the lagoon is likely to increase available nitrogen levels in Malibu Lagoon. To that end, what would be the incremental change in total nitrogen concentration in effluent from the Malibu Creek due to 6 lbs/day (as N) of supplemental nitrogen under some sort of critical flow condition?

Staff's analysis suggests that parts of the study area might be excluded from a sewer construction program since their collective on-site discharge contributes little or nothing to nitrogen levels in Malibu Lagoon. Staged construction would allow regulators to determine the effects of

sewerage in areas that are the likeliest source of anthropogenic nitrogen in the lagoon, before extending sewer construction into the other geographic sectors of the study area.

In summary, staff's work is very well done. No set of alternative assumptions is likely to affect the general findings of the report. Sensitivity analysis could be used to demonstrate that point.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Dr. Jörg E. Drewes
DREWES ENVIRONMENTAL
798 Cressman Court
Golden, CO 80403
Phone 303-884-9746
E-mail: jdrewes@mines.edu

TM4-60

3-1008

DREWES ENVIRONMENTAL
Professor Dr. Jörg E. Drewes

798 Cressman Court
Golden, CO 80401
Phone 303-884-9746
E-mail: jdrewes@mines.edu

September 10, 2009

California Regional Water Quality Control Board
Attn.: Wendy Phillips
Chief, Groundwater Permitting and Landfills Section
320 W. 4th Street, Suite 200
Los Angeles, CA 90013

Re: Peer Review of Technical Memorandum #4 in support of an amendment to the Water Quality Control Plan for Coastal Watersheds of Los Angeles and Ventura Counties to Prohibit On-Site Subsurface Disposal Systems – Malibu Civic Center Area

Dear Mrs. Phillips,

Please find enclosed my review of the Technical Memorandum #4 "Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life" prepared by Toni Calloway, Orlando Gonzalez, and Dr. C.P Lai.

The review is providing responses to questions formulated in Attachment 2.

Please feel free to contact me if you have any further questions.

Thank you very much.

Sincerely,

Professor Jörg Drewes

Scientific Review Report of Technical Memorandum #4
Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life
by Toni Calloway, P.G, Orlando Gonzalez, and Dr. C.P Lai, P.E.

a. The approach used to compile an inventory of wastewater discharges from OWDSs in the Malibu Civic Center area, which staff estimates to total 255,000 gallons per day.

Wastewater discharges in the Malibu Civic Center area originate from commercial and residential sources. Flow data for commercial sources were available from monitoring reports for facilities permitted by the Regional Water Quality Control Board. Therefore, the flow estimate for commercial sources can be considered to be fairly accurate.
For residential sources, the number of individual residencies was determined using public records and aerial photographs that were used to confirm the number of residencies. This number can be considered as very accurate. Flow data for residential sources was based on the number of bedrooms and bathrooms at each residence, which served as a surrogate for the number of persons living at a given residence. A per capita water consumption of 100 gal/day was assumed referencing Table 2-9 (Metcalf and Eddy 1991). This table provides a range of "typical" water consumptions for individual residencies ranging from 40 to 90 gal/day and person (Metcalf & Eddy 1991). The latest edition of Metcalf and Eddy (2003) suggests a typical per capita water consumption of 74 gal/capita day without water conservation and 51.9 gal/capita day with water conservation. A study conducted by the Awwa Research Foundation on 1,100 households determined a per capita water consumption of 60.5 gpcd (Mayer et al. 1999). These more recent numbers would suggest that the assumption of 100 gal/capita day is too high and considering the national average should be corrected to 60-70 gal/capita day. Assuming 70 gal/capita day would reduce the total residential flow to 88,410 gpd and the total flow to 216,879 gpd.

Mayer, P.W., W.B. DeOreo, E.M. Optiz, J.C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson (1999). *Residential End Uses of Water*, American Water Works Association Research Foundation, Denver, CO, 310 p.

b. The methodology used to calculate loads of nitrogen from wastewaters discharged from OWDSs in the Malibu Civic Center area; specifically, staff's interpretation of published literature and assumptions used to calculate nitrogen loads released from OWDSs for those discharges where real data were not available.

General:
- Using BOD concentrations to estimate total nitrogen concentrations when total nitrogen data is unavailable is in principal a reasonable approach. Where neither end-of-pipe nor septic tank effluent analyses were available, staff based the estimation of total nitrogen on typical total nitrogen concentrations reported in the published literature on domestic wastewater composition. In section 1) (Commercial Wastewater), the authors refer to two key sources

(Crites and Tchobanoglous 1998 and Metcalf and Eddy 1991) that have been considered regarding ranges of concentrations in typical untreated domestic wastewater. The authors proposed a TN/BOD ratio of 0.2.

The reviewer notes that these particular sources did not distinguish between water characteristics of single sources and raw sewage collected in a centralized sewer system. The wastewater discharged in the Malibu Civic Center area originates from single sources, which have a different make-up regarding organic matter and nitrogen than raw sewage collected in a centralized system. Thus, more appropriate references should be considered to provide a more accurate representation of single source waste streams. A very useful reference that the authors might want to consider is a recent research report published by the Water Environment Research Foundation (*Lowe, K., et al. 2007, Influent Constituent Characteristics of the Modern Waste Stream from Single Sources: Literature Review. Water Environment Research Foundation (WERF), Alexandria, VA*). Based on a comprehensive literature review of waste streams from single sources, findings of this report suggest the following median concentration for septic tank effluents:

Source	BOD (mg/L)	TN (mg/L N)	TN/BOD ratio
Single source	156	55.4	0.36
Multiple sources	184	46	0.25
Food	561	86.5	0.15
Non-medical	244	84	0.344

These results would suggest that a TN/BOD ratio of 0.3 might be more appropriate for single domestic as well as commercial sources (non-medical) than the ratio of 0.2 considered by the authors.
In addition, the authors considered "typical untreated domestic wastewater". Since in this case, septic tank effluents contribute to groundwater contamination, a water quality leaving the tank rather entering a tank should be considered. While septic tanks achieve little to none nitrogen removal, the EPA Onsite Wastewater Treatment Manual (2002) reports 30 to 50 percent of BOD is removed whereas Lowe et al. (2007) reported 55 percent removal during septic tank treatment. In both cases, BOD changes occurring during septic tank treatment will result in shifting the TN/BOD ratio to higher numbers.
Since this ratio was used in the nitrogen load spreadsheet, that was not available to the reviewer, in cases where no "end-of-pipe" total nitrogen concentrations were available, which percentage was also not available, the reviewer cannot assess whether changing the TN/BOD ratio from 0.2 to 0.3 would have a significant effect.

- p. T4-5, third paragraph. "For commercial dischargers such as small offices where we have no data, we choose a low BOD of 220 mg/L, and estimated the TN to be 40 mg/L."
What is the basis for this estimation? As mentioned above, the authors might want to consider findings reported in Lowe et al. (2007). Findings reported in this study would suggest that the BOD concentration for "small offices" is matching the median concentration of 244 mg/L for non-medical sources, but the total nitrogen concentration is only 50 percent of what was

determined for non-medical sources (i.e., 84 mg/L N). Thus, the release of nitrogen from these sources is potentially significantly underestimated.

- p. T4-5, fourth paragraph, last sentence. What is the basis (reference?) for reducing estimated total nitrogen concentrations depending on soil profile and groundwater separation? Why is credit given to subsurface treatment where no credit is given to BOD during septic tank treatment?

- The estimation of the total commercial flow seems reasonable and supported by actual flow data.

- In section ii) (Residential Wastewater), the underlying assumption to estimate the residential flow is 100 gal/capita day. Please see discussion under a.), but the water consumption based on more recent studies would suggest 60-70 gal/capita day.
The estimation of nitrogen concentrations in domestic wastewater is referencing Metcalf and Eddy (1991) with three values (20, 40 and 85 mg/L) for weak, medium and strong wastewater. In the most recent edition of Metcalf and Eddy (2003) these values were revised to 20, 40 and 70 mg/L N.
The recent study by Lowe et al. (2007) reported a median total nitrogen concentration for residential single sources of 63 mg/L N for raw sewage and 55.4 mg/L N for septic effluent, respectively. These values provide support for the total nitrogen concentration of 60 mg/L for septic tank influent proposed by the Regional Board staff in this memorandum.
Although the staff acknowledged that septic tank systems are limited in their ability to remove nitrogen, which is supported by multiple studies (EPA 2002, Lowe et al. 2007), credit was given to OWDS treatment and the estimated total nitrogen concentration of septic tank effluents in the Malibu Civic Center area was reduced from 60 to 45 mg/L N. The basis for this reduction is weak at best.

- Summary of Total Nitrogen Loading from Commercial and Residential Sites
The estimation of total nitrogen releases from commercial sources could be affected by the used TN/BOD ratio of 0.2, which was suggested to be closer to 0.3. For the residential sources, considering a 70 gal/capita day water consumption and nitrogen concentration of 45 mg/L N, the nitrogen load would have been reduced to 12,118 lbs/year or 33.2 lbs/day. Considering the lower water consumption (70 gpcd) and 60 mg/L N, would reduce the total nitrogen loading from 17,311 lbs/year as stated in the report to 16,157 lbs/year or 44.3 lbs/day. This number is close to the estimate of 47.4 lbs/day provided by the Regional Board staff.

Specifics:
- p. T4-4, first subheading. BOD is defined as "biochemical oxygen demand", not "biological oxygen demand" as stated. Please revise.

- p. T4-5, first paragraph. "...TN/BOD ratio found in the above popular wastewater textbooks." The term "popular" doesn't buy credibility and I'd suggest "peer-reviewed", which represents a

better term. Regardless, the author might want to consider other references (see discussion above) that might be more suitable.
- p. T4-6, last paragraph, third sentence. "Using reported or estimated using wastewater...". Typo, deleted "using".

U.S. EPA (2002). *Onsite Wastewater Treatment Systems Manual*. Report No. 625/R-00/008. U.S. Environmental Protection Agency, Cincinnati, OH.

c. Staff's characterization of groundwater flow regimes in the Malibu Civic Center area into five hydrogeologic sectors, and staff's application of the nitrogen loads (calculated from #2 above) into a 'spreadsheet' model that estimates attenuation of nitrogen loads released from OWDSs and transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon) for each hydrogeologic sector.

The proposed characterization of groundwater flow regimes into five hydrogeologic sectors seems reasonable and is well supported. The number of residencies/sources in these sectors is well known. The estimated flow of wastewater in each section could potentially be revised considering a lower per capita water consumption (60-70 gpcd) as discussed above. The same holds true for the considered total nitrogen concentrations for individual sources, which could be adjusted from 45 mg/L to 60 mg/L N.
The assumed total nitrogen load reduction factors by "soil treatment" for commercial sites is reasonable. Given that little is known about site specific conditions of residential sites, the assumption that no soil treatment is occurring is appropriate.

d. Staff's use of the updated nitrogen loads released from OWDSs (calculated from #2 above) to adjust (update) estimates of nitrogen transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon), using a relationship already established by a groundwater flow and transport model (which is already accepted by stakeholders in the community).

Besides the comments provided above regarding flow estimation and nitrogen loading from both commercial and residential sites, the use of updated nitrogen loads released from OWDSs to adjust estimates of nitrogen transported to Malibu Lagoon seems reasonable. The adjustments made in these calculations are appropriate (concentrations might change and discharge volumes, see comments above). The only aspect that is somewhat inconsistent is the assignment of a "Leach Field Reduction". What constitutes a reduction of 10 percent vs. 20 percent? In Sector 3, sites with a soil type "sand, silt & clay" and depth to groundwater of 10 or >10 were assigned reduction credits between 0 and 20 percent!?

Overarching questions:

(a) In reading Tech Memos #3 and #4, are there any additional scientific issues, not described above, that are part of the scientific basis of the proposed rule? If so, please comment with respect to the statute language given above.

Regarding Tech Memo #4, there are not additional scientific issues that need to be addressed.

(b) Taking each of Tech Memo #3 and #4 as a whole, is the conclusion of each tech memo based on sound scientific knowledge, methods, and practices?

Regarding Tech Memo #4, with the exception of comments provided above regarding flow estimation and nitrogen loads, the conclusions presented in this Tech Memo are based on sound scientific knowledge, methods, and practices.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Peer Review

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

By

Dr. Joann Silverstein
Dept. Civil, Environmental & Architectural Engineering
University of Colorado
Boulder, CO 80309-0428 USA
tel: (303) 492-7211
fax: (303) 492-7317

3-1015

Peer Review of Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life, by Tony Calloway, P.G., Orlando Gonzalez, and Dr. C.P. Lai, P.E.

JoAnn Silverstein, Ph.D., P.E.
September 12, 2009

Determination for issues requested in Attachment 2: Description of Scientific Issues to be addressed by Peer Review.

a. *Approach used to compile an inventory of wastewater discharges from OWDSs in the Malibu Civic Center area, which staff estimates to total 255,000 gallons per day.*

Residential wastewater flow was estimated to be 100 gal/toilet/day, which is assumed to represent the wastewater generated by one person. The 349 residences had 1,263 bathrooms producing the estimate in Table 1 of 126,300 gal/day of residential wastewater. The rationale for the one person per toilet equivalent is not given. However, accepting that equivalent, 100 gallons per capita per day (gpcd) is high for households of more than two persons. A more recent text estimate for domestic wastewater flow rates for households of 3 – 4 persons is 41-71 gpcd (Metcalf and Eddy, 2003). The Onsite Wastewater Treatment Systems Manual (USEPA, 2002) reports estimates of residential wastewater ranged between 50 and 70 gpcd for homes built before 1994. For newer homes with water-saving fixtures, the reported range of wastewater flow rates was 40 – 60 gpcd. The US Census Bureau estimated that the average household size (1998) was 2.7 people per residence. With 349 residences with on-site systems, the population equivalent based on Census data would be 942, and the corresponding wastewater flow rate using the more conservative EPA flow rate range (pre-1994 homes) would be 47,000 to 66,000 gal/day, approximately half or less than the flow rate estimated in Table 1: 126,300 gal/day. Another method to estimate wastewater flow is to use the number of bedrooms, and assume 1 – 1.5 people/bed. Since the number of bathrooms and bedrooms are nearly identical in Malibu, this would produce a population range of 1,263 to 1,894, and a flow rate range, using the EPA per capita flow rate range of 63,000 to 133,000 gpcd. Only the most conservative assumptions of 1.5 persons per bedroom (or bathroom) and 70 gpcd wastewater flow produce flow rate close to the value in Table 1. For one person per bathroom (and bedroom), at the high per capita flow rate, the estimated residential flow is 88,400, 30% lower than the Table 1 value. The high residential wastewater flow rate estimated in Table 1 is not well justified given estimation methods reported in the literature. Consideration should be given to characterizing the uncertainty in the residential wastewater flow estimates, including reporting values with fewer significant figures than 4 – 6 significant figures in Table 1 entries.

For commercial properties, flow data were available for permitted sites that were assumed to be representative of average flow rates. Flow data for unpermitted sites was estimated but the method used was not reported. For example, the basis for 400 gal/day for small commercial facilities should be given. Also, it would be useful to indicate in Table 1 which commercial facilities were unpermitted. In addition, the percent of the commercial flow estimate of 128,469 gal/day that was estimated would provide a better indication of the uncertainty in the commercial flow rate estimates.

b. *The methodology use to calculate loads of nitrogen from wastewaters discharged from OWDS's in the Malibu Civic Center area; specifically staff's interpretation of published literature and assumptions use to calculate nitrogen loads released from OWSDS's for those discharges where real data were not available.*

Residential nitrogen loads were estimated assuming that wastewater discharged from septic tanks contained 45 mg/L total nitrogen. Estimates of residential septic tank effluent (STE) nitrogen concentration range from 40 to 100 mg/L, depending on influent water quality, tank hydraulic and solids residence times (USEPA, 2002). The total nitrogen mass loading from residential on-site systems was estimated to be 47.439 lb/day (too many significant figures!), based on the estimated residential flow rate of 126,300 gal/day and average STE total nitrogen of 45 mg/L. As a check, the estimate of 0.03 lb-TKN/cap/day (Metcalf and Eddy, 2003) and the population estimate based on bathroom number were used to calculate a total nitrogen loading from residences in the study area: to be 38 lb/day. Assuming no attenuation of nitrogen in a septic tank, this is ~19% lower than the estimated daily loading rate from residences of 47 lb/day in Table 1. Most literature reports indicate that almost 90% of the nitrogen in STE is in the form of ammonium. Removal of nitrogen in a subsurface wastewater infiltration system (SWIS) or leach field occurs by a combination of sorption, biomass uptake, and nitrification-denitrification and was estimated in the groundwater loading section of Technical Memorandum #4, as summarized in Table 3.

Eight businesses served by package plants appeared to be the only commercial discharges where effluent total nitrogen data were available. These plants constituted 46% of the estimated commercial flow (59,000 gal/day) but had consistently lower effluent nitrogen than other commercial discharges, constituting 8 lb-TN/day, which was only 19% of the daily total nitrogen load in the study areas (42 lb/day).

Commercial septic tank effluent not reported was estimated, typically as a fraction of BOD, the second of two key assumptions (page T4-5, paragraph 1). (By the way, the callout for Table 2 in this paragraph appears to be wrong. The nitrogen loading spreadsheet is Table 1.) It is widely recognized that some commercial facilities, particularly restaurants, have very high BOD concentrations compared with residential wastewater. However, the 0.18 – 0.21 TN:BOD ratio from the literature which was used to estimate the total nitrogen concentration in commercial wastewater effluent was based on residential wastewater characterization, where as much as 78% of the nitrogen comes from toilet waste (urea) (USEPA, 2003, Table 3.8). In restaurants, the excess BOD probably comes from food waste, oil, and grease, which should have a generally lower TN:BOD ratio. One study (Converse et al, 1984) found restaurant that septic tank effluent total nitrogen ranged from 30 to 82, with a flow-weighted mean of 57 mg/L and an average TN:BOD ratio of 15.6 g-N/g-BOD_5. This is a concern in the reliability of the commercial wastewater nitrogen loading estimate. Nine commercial discharges had estimated nitrogen concentrations ≥ 75 mg/L and were 27% of the commercial wastewater flow. Together the nitrogen discharged from them was 9,000 lb-TN/year, which was 58% of the total commercial nitrogen loading estimate. The effluent nitrogen concentration in just one of these, (Malibu Inn and Restaurant) was estimated to be 110 mg/L at a flow rate of 6,200 gal/day, which means that the discharge from this one facility constituted over 13% of the total commercial nitrogen load. Given the impact of the commercial discharges with high nitrogen on the total loading estimate,

it is advisable that samples be taken verify the high nitrogen discharge numbers, particularly if the nitrogen concentration estimates were based on the TN:BOD ratio characteristic of residential wastewater. Moreover, characterization of the uncertainty in these estimates, incorporating better values of restaurant wastewater from the literature, and perhaps analysis of the sensitivity of the total nitrogen loading rate to estimated high nitrogen loading rates should be done.

c. *Staff's characterization of groundwater flow regimes in the Malibu Civic Center area into five hydrogeologic sectors, and staff's application of the nitrogen loads (calculated from #2 above [should be b?]) into a spreadsheet model that estimates attenuation of nitrogen loads released from OWDS's and transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon) for each hydrogeologic sector.*

Division of the region into topographic and hydrogeologic sectors to calculate groundwater flow and associated nitrogen loading rates to the Malibu Lagoon, summarized in Table 3, is a good approach. Estimates of attenuation of nitrogen in SWIS's were very conservative, from 0 to 20%, whereas typical estimates in the literature ranged from 10 – 40% based on soil type. Given that most of the soil in the region was high permeability sand and silt, this may be reasonable. It appeared that the 0% removal was applied when the depth to the ground water table was < 5 ft, regardless of soil characteristics. The other assumption was that nitrate could be used as a surrogate for total nitrogen discharged to the groundwater. This assumes significant nitrification (bacterial oxidation of ammonia to nitrate) in the unsaturated zone, which is supported by the literature. In one case study, the average nitrate concentration in a fine sand SWIS peaked at 21.6 mg/L NO_3-N at a depth of 0.6 m (2 ft), but was still high, 13 mg/L NO_3-N, after percolating to a depth of 1.2 m (4 ft), although there was clearly some attenuation, probably by denitrification, even in the sandy soil (USEPA, 2002). Particularly in wastewater SWIS systems, there will be residual organic matter in the soil that can be used by denitrifying bacteria to reduce nitrate to N_2 gas, so the zero attenuation factor for shallow groundwater table may be too conservative. As with the nitrogen loading estimates, it would be useful to perform a sensitivity analysis for SWIS (leach field) attenuation estimates. Also, if there are monitoring wells near leach fields, nitrate concentrations could be measured to verify these estimates.

d. *Staff's use of the updated nitrogen loads released from OWDS's (calculated from #2 [b?] above) to adjust (update) estimates of nitrogen transported to Malibu Lagoon (i.e. to the point of groundwater recharge into the lagoon), using a relationship already established by a groundwater flow and transport model (which is already accepted by stakeholders in the community).*

The staff's estimate of total nitrogen loading to Malibu Lagoon using the spreadsheet model (Table 4) was 36 lb/day with 38% of the TN mass loading from OWDS reaching the Lagoon, compared with 32% in the numeric model. There is an inconsistency between the spreadsheet column estimate in Table 4 and Table 1 in Attachment 4-1 (page T4-41). In the attachment Table 1, the ratio is given as 40%, with an associated mass loading of 35.7 lb/day. This is a small discrepancy, and may just be rounding difference. However since all the input data are the same, the two tables should be consistent for the spreadsheet estimate. An overall concern is that the rationale for increased commercial loading was not clear, either in section 2.2 of Attachment 4-1

or in Section 3 of the Report (page 4-13-14). Commercial flows increased, but this was captured in the nitrogen loading estimates. The possibility of exceeding soil uptake capacity for nitrogen removal was mentioned in section 2.2 of Attachment 4-1, but there was no indication of how this resulted in an increase in the fraction of the nitrogen reaching Malibu Lagoon from 32 to 38% (or 40% in Attachment Table 1).

The CSTR model used to compare the estimate mass loading to measured nitrogen concentrations was interesting and appears to support the higher estimates of nitrogen loading to the Lagoon. However, the non-point source nitrogen contributions to the Lagoon did not appear to have been factored in. If these are available from the TMDL calculation, they should be considered as part of the total load.

General comments.

Check document for typos, grammatical errors and erroneous callouts. Examples:
p. T4-2, para. 4, line 5: "conservation" should be conservative.
p. T4-3, last line: "facility" should be facilities.
p. T4-5, para 4, line 1 should read: For wastewater generated by commercial facilities…
p T4-6, para 1, line 3 should read: Since 2001, the inventory of commercial properties (delete "on")
p. T4-6, para 5, line 4 should read: Using reported or estimated wastewater (delete second "using")
page T4-7, section Assumptions for Residential Flow and Total Nitrogen Concentration. The estimate of 100 gallons per day per bathroom is for water use, not wastewater generation. You appear to have made the assumption that wastewater generation = water use. This is generally not the case, and Metcalf and Eddy is not correctly cited. (See comments in part a). Also, instead of using the unit 100 gallons per person, the usual unit is gallons per capita per day (gpcd).

Use appropriate significant figures, especially in Tables. Calculated values with 4-6 significant figures do not reflect the input information.

Overarching questions

(a) The scientific basis for the proposed rule, regarding nitrogen discharges from OWDS's to Malibu Lagoon includes estimates not based on site data but literature values, some of which can be questioned (see specific comments in parts a, b, and c above). Overall, a higher scientific standard would be achieved by better characterization of the uncertainty in the estimates, careful use the most recent literature, and analysis of the sensitivity of the results to variation of key input parameters such as flow rates, effluent nitrogen concentrations from OWDS's, and soil attenuation factors.
(b) Even with the concerns above, the general approach and methods used in Technical Memorandum #4 incorporate sound scientific and engineering principles. Adjustments based on less conservative assumptions could lower the OWDS nitrogen loading rate, even by as much as one-third. However, even the lowered loading rate would still far exceed the TMDL, and the conclusion in the Memorandum that the 6 lb/day maximum loading rate for wastewater nitrogen will not being achieved using OWDS's is reasonable and justified.

References

Converse, J.C., R.L. Siegrist, and D.L. Anderson, Onsite Treatment and Disposal of Restaurant Wastewater, Report 10.13, Small Scale Waste Management Project, Univ. Wisconsin, 1984.

Metcalf and Eddy, Wastewater Engineering Treatment and Reuse, 4th Ed., McGraw-Hill, NY. 2003.

USEPA, National Risk Management Research Laboratory, Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Washington, DC. 2002.

TM #5

State of California
California Regional Water Quality Control Board, Los Angeles Region

DRAFT

OCT

21

2009

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal System in the Malibu Civic Center Area

Technical Memorandum #5:

Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities

by
Dionisia Rodriguez, Environmental Scientist
Ryan Thacher, Student Intern
Groundwater Permitting Unit

3-1021

Technical Memorandum 5: *Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities*

by
Dionisia Rodriguez, Environmental Scientist
Ryan Thacher, Student Intern
Groundwater Permitting Unit

DRAFT OCT 21 2009

Introduction

Relatively intensive land use on commercial facilities in the Malibu Civic Center area[1] (Figure 1) generate wastewater flows at rates that exceed the capacity of the on-site wastewater disposal systems (OWDSs) to discharge wastewaters into the subsurface. Lack of treatment equipment capabilities and capacities and lack of adequate space on their properties limit the dischargers' ability to dispose the treated wastewater into the subsurface. In addition to these limitations, there are hydrogeological constraints in the Malibu Civic Center area, such as a high water table, that further limit the dischargers' ability to transmit flow into the subsurface. Therefore, to avoid OWDS failure, and spills, many dischargers resort to hauling liquid sewage and sludge to communities that have wastewater treatment facilities.

In order to quantify the reliance of dischargers on the practice of hauling, Regional Board staff reviewed the self-monitoring reports submitted by twenty permitted facilities, shown in Figure 1, in the Malibu Civic Center area.

[1] The area subject to the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1). The area was defined using topographic features and drainage patterns, and encompasses the hydrologic areas of Malibu Valley (also referred to as the lower Malibu Creek watershed), Winter Canyon, and adjacent coastal strips including Amarillo Beach, Malibu Beach, Malibu Lagoon, and Malibu Lagoon Beach (aka Surfrider Beach, including First, Second, and Third Points at Surfrider). For more discussion on the prohibition boundaries defining the Malibu Civic Center area, refer to the Technical Staff Report Overview and the Environmental Staff Report.

3-1022

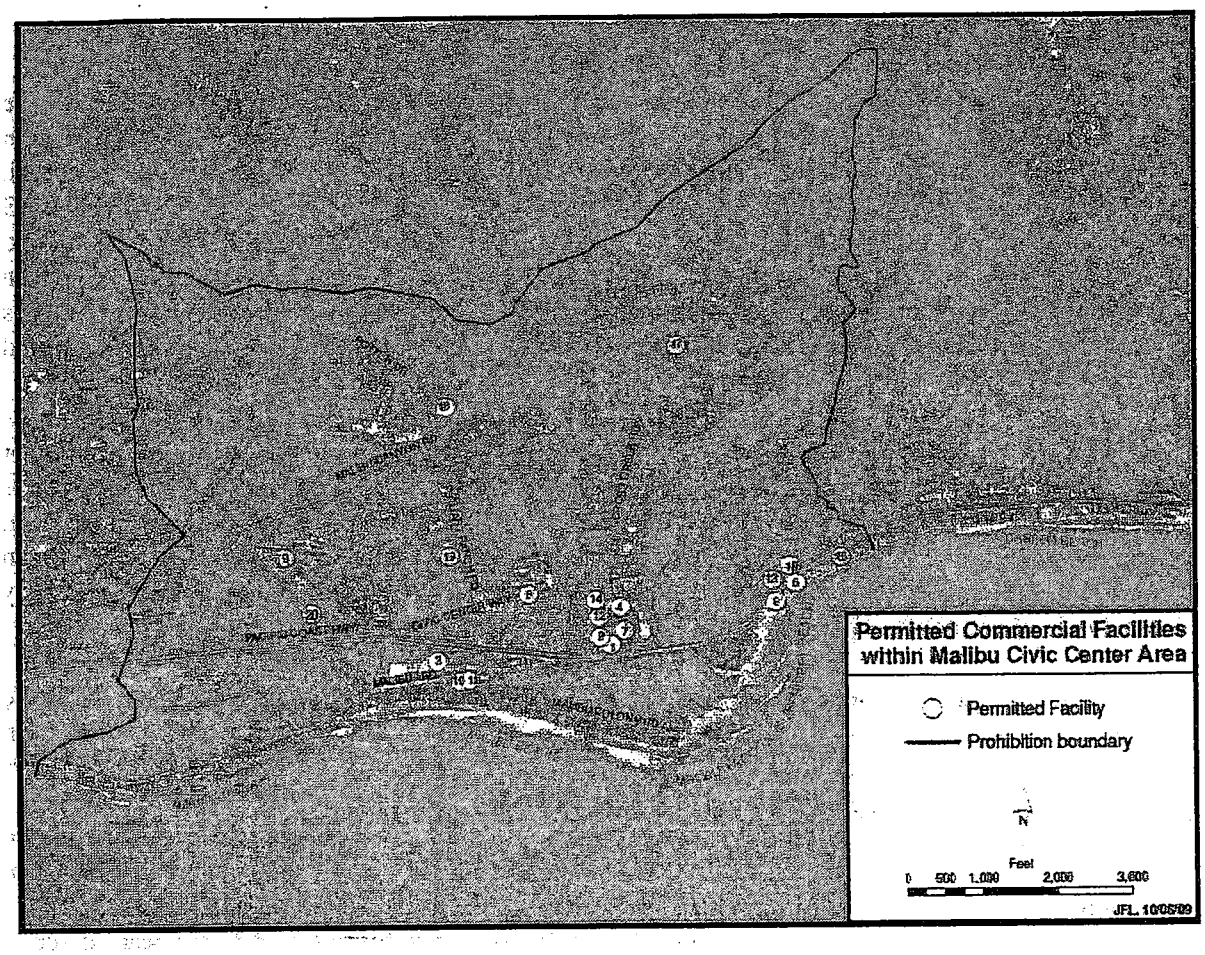


Figure 1. The Malibu Civic Center area includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Locations of twenty commercial facilities with a Waste Discharge Requirement (WDR) through the Regional Board are shown.

1. Prudnetial Malibu Realty	11. Los Angeles County Fire Station #88
2. Malibu Lumber	12. Malibu Country Mart I
3. Malibu Colony Plaza/Colony Plaza LLC	13. Malibu Shores Motel
4. Cross Creek Plaza/Malibu Creek Preservation	14. Malibu Country Mart II
5. Malibu Pier State Park	15. Malibu Beach Inn
6. Malibu Admin. Center (Malibu Civic Center)	16. Hughes Research Lab, Inc. (HRL)
7. Malibu Country Mart III	17. Serra Retreat Center
8. Surfrider Beach	18. Jack in the Box (Checker Board Properties)
9. Los Angeles County Road Maintenance Yard	19. Miramar Properties
10. Morton Gerson Colony Plaza	20. Malibu Water Pollution Control Plant (MWPCP)

DRAFT OCT 21 2009

Background

Septic systems, also known as on-site wastewater disposal systems (OWDSs), are used to reduce or eliminate the pathogenic organisms that are found in wastewater. Pathogenic organisms in wastewater pose a relatively minor threat to water resources when OWDSs are properly sited, designed, constructed, and operated. On the other hand, improperly, designed or operated OWDS can be a significant source of surface water and groundwater contamination that can lead to waterborne disease outbreaks and other adverse health effects. The bacteria and viruses found in the wastewater can cause numerous diseases including gastrointestinal illness, cholera, hepatitis A, and typhoid. Nitrogen, which is also found in the wastewater, primarily from urine, feces, and food waste, can cause methemoglobinemia (blue-baby syndrome) in infants.[2]

Malfunctioning OWDSs can lead to illicit discharges of septic waste, which is the subsurface or surface release, for any reason or cause, of sewage, wastewater effluent, or any material or substance from an improperly functioning OWDS. An illicit discharge includes dumping, leaking, overflowing, pumping and spilling. This technical memo will quantify reliance on pumping and hauling off-site of septic waste to control wastewater generated by relatively intensive land use activity in the Malibu Civic Center area.

Proper operation and maintenance of the OWDSs is a crucial preventive measure to avoid septic system failures. Inadequate septic system operation and maintenance can lead to failure even when systems are designed and constructed according to regulations; therefore, dischargers pump their OWDSs at regular intervals to avoid potential problems or complete failure of the system. Local health officers recommend that residential septic systems be pumped at least once every three years and commercial systems be pumped twice a year. They also recommend that restaurants, as part of their Best Management Practices, pump out their grease interceptors once a month. The presence of grease in the septic system causes scum formation that can lead to septic failure. However, it has come to the attention of Regional Board staff that some of the large commercial establishments in the Malibu Civic Center area are pumping their septic systems multiple times per week, for large volumes of waste. Regional Board staff believes that the septic systems may be adequately treating a portion of the wastewater generated by the relatively intensive land use activities, but lack sufficient on-site capacity to dispose of the effluent. Many of the seepage pits and leach fields in the area have been in use for decades and can no longer serve their purpose. Also there are hydrogeologic constraints, such as the lack of suitable surface area for new leach fields, as well as the extremely limited vertical separation between leach field disposal sites and the groundwater table, that further limit wastewater disposal on-site. These factors cause a trend of increasing reliance on septic pumping and hauling off-site.

Sources of Data

Within the Malibu Civic Center area, there are twenty commercial dischargers (listed in Table 1) with Waste Discharge Requirements (WDRs) from the Los Angeles Regional Water Quality Control Board (Regional Board). A WDR requires each discharger to submit quarterly monitoring reports, which must include septic waste flow data, and details of any septic system

[2] U.S. EPA Source Water Protection Practices Bulletin, "*Managing Septic Systems to Prevent Contamination of Drinking Water.*"

DRAFT OCT 21 2009

hauling and pumping. If pumping and hauling occurred, dates, quantities, and pumping company information must be provided. If no pumping occurred, this must also be stated. Regional Board staff used information supplied in monitoring reports to conduct their analyses.[3]

There are five additional commercial facilities (Equilon Enterprises, J & P Limited, Malibu Animal Hospital, Malibu Professional Arts Building, and Malibu Road, LLC) with discharges of less than 2,000 gallons per day (gpd) that were permitted by the Regional Board, but oversight was transferred to the City of Malibu in February 2005. The City of Malibu does not collect hauling data for the commercial dischargers under their oversight; therefore, no data are available for these five dischargers. Additionally, there are thirteen unpermitted dischargers within the Civic Center area, and no hauling information is available for these dischargers.

Table 1. Dischargers permitted by the Regional Board in the Malibu Civic Center area.

Discharger Name
Checker Board Properties (Jack in the Box)
Cross Creek Plaza/Malibu Creek Preservation
Hughes Research Labs (HRL)
Los Angeles County Fire Station #88
Los Angeles County Road Maintenance Yard 336
Malibu Admin. Center (Malibu Civic Center)
Malibu Beach Inn
Malibu Colony Plaza/ Colony Plaza LLC
Malibu Country Mart I (MCM 1)
Malibu Country Mart II (MCM II)
Malibu Country Mart III (MCM III)
Malibu Lumber
Malibu Pier State Park
Malibu Shores Motel
Malibu Water Pollution Control Plant (MWPCP)
Miramar Properties (MiraMar Investments Co.)
Morton Gerson Colony Plaza
Prudential Malibu Realty
Serra Retreat Center
Surfrider Beach

Seven dischargers included in Table 1 and located within the Civic Center area are left out of this analysis:

[3] Many monitoring reports are incomplete, missing data such as waste flow rates or lacking information about waste hauling (if no hauling was done during a quarter, dischargers are required to report that as well). For a more complete analysis, Regional Board staff made assumptions to fill these gaps in the data based on data that was available. For example, if no fourth quarter data was available for a certain year and the first three quarters contained complete data sets, an average value based on the first three quarters would be used for the fourth quarter data. All assumptions made for this analysis are outlined at the end of Appendix A.

DRAFT OCT 21 2009

- Miramar Properties is omitted because it did not submit monitoring reports. Subsequently the Regional Board issued a Notice of Violation (NOV) to MiraMar Investments Co. for non-submittal of monitoring reports.
- Prudential Malibu Realty, Morton Gerson Colony Plaza, and Los Angeles County Fire Station #88 are not included in the study due to relatively insignificant annual waste flows and volumes of septic waste hauled off-site.
- Malibu Pier State Park data is omitted due to infrequent and relatively low volume septic waste hauling. In 2008, Malibu Pier State Park disconnected its treatment system from the existing leach field and began transporting the effluent to an upgraded system at the Malibu Pier Wastewater Treatment Plant. During its start-up period, Malibu Pier State Park hauled septic waste off-site frequently, but hauling was minimal before and after this time.
- Cross Creek Plaza (Malibu Creek Preservation) is omitted based on the recent facility upgrades. From 2004 through 2007 Cross Creek Plaza was responsible for more combined hauling than any other discharger (combined total of 6.56 million gallons of septic waste hauled off-site), but in late 2007 they completed an upgrade of their treatment and disposal systems. Very little hauling has been done at this location since October of 2007.
- Malibu Lumber was permitted in late 2008 by the Regional Board, and the plant did not start operating until April of 2009.

Commercial dischargers are the main focus of this analysis, but it is also important to consider the impacts from the large number of residential septic systems within the Malibu Civic Center area. Using the list of residential properties in "Risk Assessment of Decentralized Waste Water Treatment System, City of Malibu" prepared by the Stone Environmental, Inc. in August 2004 and records from the Los Angeles County assessor's database, Regional Board staff determined that there are 391 residential homes in the Malibu Civic Center area. Regional Board staff determined the number of bedrooms in each residence using information gathered from the Los Angeles County assessor's database. The waste flows generated from each residence was estimated by multiplying the number of bedrooms in each house by 100 gallons per day, which is an accepted assumption of waste discharge from homes. It was estimated that 139,000 gallons of wastewater per day are discharged from the residences in the Malibu Civic Center area. These residences are regulated by the City of Malibu, which currently does not maintain septic hauling records for residences. However, local health officials recommend pumping residential septic systems once every three to five years depending on tank size, wastewater volume, and types of solids entering the system.[4]

Wastewater Generation Analysis

Waste flow volumes have been steadily increasing in the City of Malibu as shown in Figure 2.[5] Most dischargers do not use continuous flow meters to measure waste flows, but instead assume that 95% of the water used within the facility goes to the OWDSs. The remaining 5% accounts for water use outdoors (i.e. hosing down paved areas, irrigation). As a result, the waste flow values presented are estimates based on dischargers' assumptions.

[4] City of Malibu Clean Water Team. "The City of Malibu's Environmental Programs Office Presents: A Homeowner's Guide to Healthy Habits for Clean Water.".

[5] To further examine factors affecting wastewater discharge and hauling trends, an analysis of potable water consumption with regards to population trends and annual rainfall was performed. The results from these analyses can be seen in Appendix E.

DRAFT OCT 21 2009

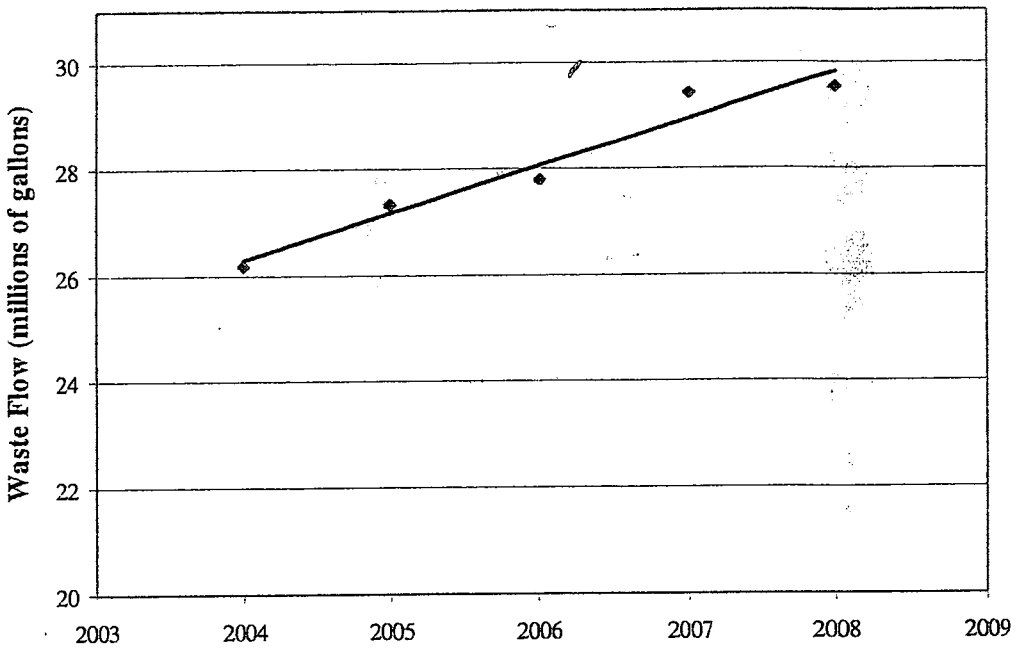


Figure 2. Combined annual waste flow trend for select dischargers in Malibu.

The dischargers included in Figure 2 are MCM I, MCM II, MCM III, Surfrider Beach, HRL, Malibu Shores Motel, Malibu Colony Plaza, Serra Retreat Center, Malibu WPCP, Malibu Civic Center, Road Maintenance Yard No. 336, Jack in the Box, and Malibu Beach Inn. The combined annual waste flows for the dischargers listed above have increased 13% from 26.2 million gallons in 2004 to 29.5 million gallons in 2008.

A breakdown of the total annual waste flows within the Civic Center area by discharger is shown in Figure 3. Among the 13 dischargers, two Winter Canyon dischargers predominate – namely, the Malibu WPCP (which servers several multi-family developments), and Malibu Colony Plaza (which lifts wastewater from multiple commercial activities for disposal in Winter Canyon).

DRAFT OCT 21 2009

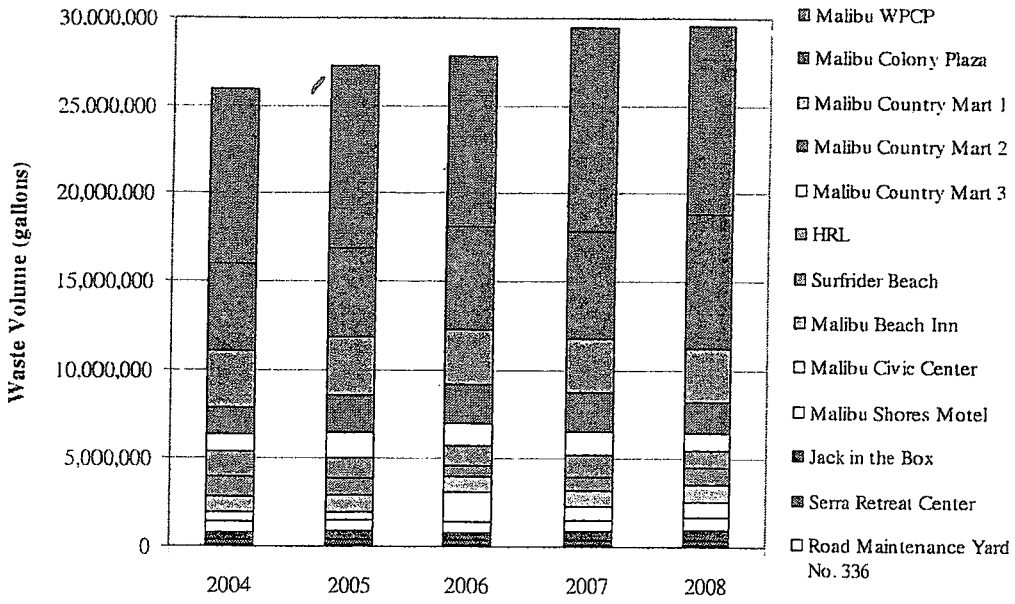


Figure 3. Combined annual waste flows for select dischargers.

Wastewater Hauling Analysis

Septic waste hauling has been steadily increasing in Malibu as shown in Figure 4.

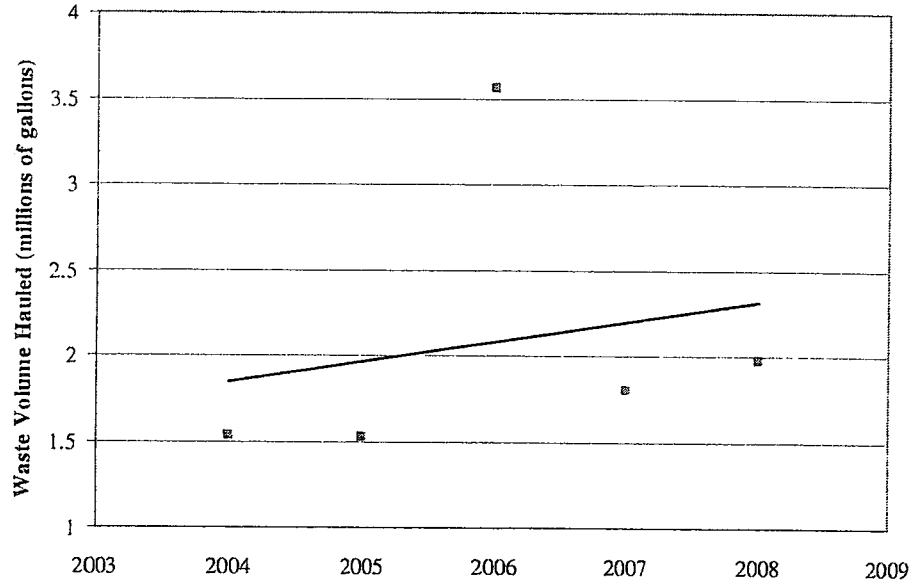


Figure 4. Septic waste hauling trend for select dischargers. The anomaly in 2006 is explained in Figure 5.

The dischargers included in Figure 4 are identical to those in Figure 2. Septic waste hauling increased 29% from 1.5 million gallons in 2004 to about 2 million gallons in 2008. Septic waste hauling data and the waste flow data are attached in Appendix A.

DRAFT OCT 21 2009

A breakdown of annual hauled quantities by discharger is shown in Figure 5. Most septic waste hauled off-site came from Malibu Colony Plaza, Malibu WPCP, MCM I, MCM II, and MCM III. Septic waste hauling records for all three Malibu Country Marts show increasing hauling trends since 2004.

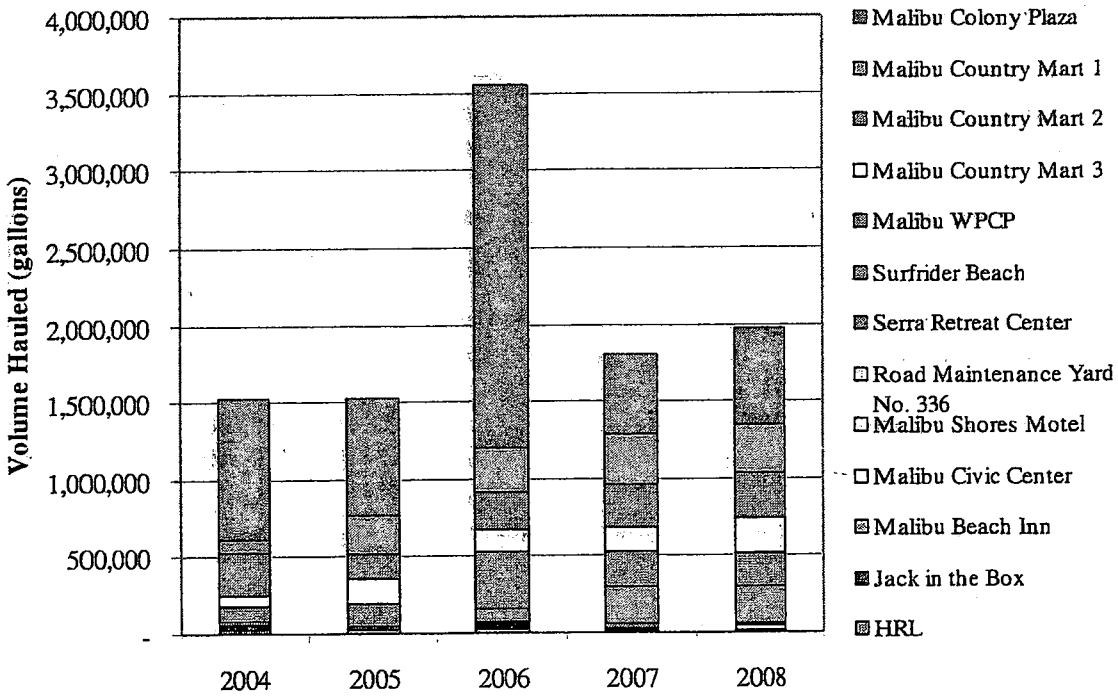


Figure 5. Septic waste hauling for select dischargers. The large spike in hauled waste in 2006 from Malibu Colony Plaza was due to the completion and start-up of its treatment plant. The plant was unable to meet the effluent limitations during its start-up period and the waste had to be hauled off-site for treatment.

In 2004, 5.8% of the total waste generated by the dischargers in Figure 5 was hauled off-site for treatment, and this increased to 6.1% in 2008. Certain dischargers contribute much more to the percent of annual hauled septic waste to total waste flows than others. For example in 2008, Malibu Colony Plaza hauled 41% of its total generated waste flow off-site, MCM III hauled 23.2% of its total waste flow off-site, and MCM II hauled 16% of its total waste flow off-site. Data regarding annual percentages of septic waste hauled are included in Appendix A.

Septic Pumping and Hauling Regulations

Regional Board staff also reviewed regulations related to the pumping and hauling of septic waste. The firms that engage in the business of cleaning of septic tanks, chemical toilets, cesspools, sewage seepage pits, or disposing of the cleanings are regulated under California Health and Safety Code Section 117400-1177450. These firms must register with the local health officer before they can engage in these activities. In Los Angeles and Ventura counties, the

DRAFT OCT 21 2009

county health officers regulate these firms.[6] A public information bulletin from the City of Malibu lists five firms that are engaged in hauling septic waste in the area. They are A & B Malibu Pumping, County Sanitation Company, Ely Jr's. Pumping, McDermott Pumping and W.A.S.T.E.C.[7] All these firms have valid registrations from Los Angeles County Environmental Health. The registrations are good for one year and their vehicles are scheduled for annual inspection each June. The County inspects the vehicles on an annual basis to make sure that they are not leaking, that their openings can be tightly closed and that the pumps are functioning properly. The inspectors also make sure that the drivers of the trucks are trained to handle septic waste properly, and have the necessary safety equipment to handle spills. In the case of a spill, the drivers must make sure that the discharge is contained and the spill area properly sanitized.

There is one recorded complaint against septic waste haulers in the Civic Center area. Residents complained about an odor caused by septic wastes being transferred from a "milk run" truck to a bigger truck for disposal. There are no regulations related to the transfer of waste from one truck to another. However, City of Malibu local health officers directed the truck drivers to transfer waste at locations away from residences to mitigate the odor nuisance.

To further gather information regarding the transportation of septic waste, two Regional Board staff conducted a drive-through type of inspection on June 16, 2009. They observed waste being pumped from one of the dischargers in the Malibu Civic Center area. The observations of that inspection are documented in the inspection report included as Appendix B.

Carbon Footprint Analysis

Sources of Data

Three pumping companies do the majority of septic pumping and hauling in the City of Malibu: Ely Jr's Pumping, A & B Malibu Pumping, and McDermott Pumping. Regional Board staff interviewed representatives from the pumping companies to gather information on the types of trucks used to haul waste and the frequency of waste pick-up done in the City of Malibu. Regional Board staff used this information to calculate the carbon footprint. A carbon footprint analysis was done to determine the impact of septic waste hauling trucks on climate change. A reasonable estimate of carbon dioxide emissions from a truck is based on the miles traveled per trip, the miles driven per gallon of fuel burned, and the amount of carbon dioxide generated per gallon of fuel burned. Miles per gallon estimates were based on truck information provided by each pumping company, and miles per trip estimates were based on the distance from the company's headquarters to the pumping sites, pumping sites to the disposal location (the Joint Water Pollution Control facility in Carson), and disposal location back to headquarters.

Data Analysis

Regional Board Staff used the data obtained from septic waste hauling contractors and septic waste hauling information from monitoring reports to develop Table 2.

[6] Staff determined that the health officer for the County of Los Angeles does not require reports on the location of septic tanks/seepage pits/cesspools being cleaned, the locations of the disposal points, the frequencies of cleanouts, and any observed violations. In the past, the County did require such reports, but no longer has resources to review such reports.

[7] The City of Malibu does not endorse any of these firms. Also, the City provides recommendations for pumping frequencies for properly functioning OWDSs.

DRAFT OCT 21 2009

Table 2. Tons of carbon dioxide emitted each year by tanker trucks from the three main septic waste pumping companies in Malibu.[8]

Pumping Contractors	Round Trip Distance (miles)	Miles per Gallon (MPG)	Frequency[9] (days/week)	Number of Trucks	Tons CO2 per Year
A&B Malibu Pumping	67	6	3	1	19
Ely Jr's. Pumping	178	6	5	2	171
McDermott Pumping	64	6	5	2	62
				Sum	**252**

Diesel engines produce approximately 22.2 pounds of carbon dioxide per gallon of fuel burned according to *Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel*[10]. The diesel trucks used for hauling are estimated to get anywhere from four to ten miles per gallon, but more often on the lower end of that scale. Due to constant stop and go driving on the Pacific Coast Highway, six miles per gallon is used for the calculation. The result of 252 tons of carbon dioxide produced per year from septic waste hauling within the Malibu Civic Center area is an estimate based on available data.

Another possible method of calculation would take the total volume of waste hauled per year, and divide that by the capacity per pumping truck (3,500 gallons to 8,000 gallons), which would yield the number of trips necessary to haul that amount of sewage. The same calculation as above proceeds from here to determine the amount of CO2 produced each year. This leads to a significant underestimate for a two main reasons: One is that this assumes each trip, the tanker truck fills to capacity, which according to hauling records is not the case. Two, our calculated amount of hauled sewage each year is only based on the larger permitted commercial dischargers within the Malibu Civic Center area, as there are no hauling records available for the unpermitted dischargers, meaning there is a large amount of undocumented hauling occurring.

Manhattan Beach, California, is a coastal city with almost three times the population of Malibu, and the city inventories its emissions. Manhattan Beach officials calculated that in 2005, 6,245 tons of carbon dioxide were released into the atmosphere. The inventory includes emissions associated with city operated facilities and parks, vehicle fleet fuel usage, employee commute emissions, water and sewage pump stations, street lights, and traffic signals.[11] If the City of Manhattan Beach reduced its emissions by 252 tons per year (estimated amount of CO_2 produced from hauling in Malibu per year), this would equate to a 4% decrease in carbon dioxide emissions from municipal activities.

[8]Information gathered from interviews with Ely Simental of Ely Jr's' Pumping and Amy McDermott of McDermott Pumping Company.

[9] Both trip frequency and the number of trucks in service at once were determined from conversations with representatives from pumping contractors. The representatives could only provide educated guesses regarding trip frequency and average number of trucks out at once.

[10] http://www.epa.gov/oms/climate/420f05001.html

[11] http://www.ci.manhattan-beach.ca.us/Index.aspx?page=1510

DRAFT OCT 21 2009

Implications

The California Air Resource Board, Local Government Action for Climate Change, does not have standards for Greenhouse Gas Emissions for each municipality at present. Most actions taken by the municipalities are voluntary. Some cities such as Manhattan Beach have conducted an inventory of Greenhouse Gas Emissions from their municipal activities for the purpose of studying how to reduce such emissions, and help meet Kyoto Protocol type goals.

Although currently the State of California does not have a mandate base for carbon dioxide emissions, eliminating septic waste hauling in the City of Malibu has the potential to lower greenhouse gases emitted from Civic Center activities.

Discussion of Spills in the Study Area

In response to comments about the spill data that included many spills on problematic sites outside of the prohibition area, staff deleted these data (Appendix C) and the explanatory text from the July 31, 2009 draft.

Dischargers are taking some extreme actions to prevent spills within much of the prohibition area, through the practice of frequently pumping large quantities of raw sewage and hauling this waste off-site, as analyzed in the tech memo. On some sites where systems have completely failed - e.g. the comfort station at First Point on Surfrider Beach (see Appendix D), large volumes of raw sewage are hauled on a frequent basis to prevent sewage from surfacing on the beach sand, as it has in the past.

Conclusion

Our analyses show that the volume of waste generated by dischargers in the Malibu Civic Center area has increased since 2004 by 13%. Septic waste hauling has increased at an even greater rate, with 2008 values 29% higher than 2004. Because of the pumping frequency and volume of waste that is hauled off-site, Regional Board staff concludes that waste is being hauled off-site for disposal to prevent OWDS failure, and not as part of regular septic system maintenance.

Our study also shows that the ongoing practice of frequently hauling septic waste off-site emits an estimated 252 tons of carbon dioxide per year. All vehicles on the road contribute to greenhouse gas emissions, but tanker trucks contribute much more due to their inefficient miles per gallon rating, and because they run on diesel fuel.

Wastewater flows in the Civic Center area have been increasing consistently each year. Many of the discharge sites are constrained by hydrogeologic conditions mentioned earlier, making them unsuitable for disposal of high flows of wastewater. Many commercial facilities produce wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant volumes into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

DRAFT OCT 21 2009

Appendix A: Septic Waste Flow and Hauling Data

See last page of Appendix A for assumptions used in data sets marked with an asterisk

Site	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Monthly Capacity (gal)	Percent Annual Flow Hauled
Malibu Country Mart 1							
*	2004	85,000	7,083	3,116,916	18,000	540,000	2.73
	2005	255,000	21,250	3,331,380	18,000	540,000	7.65
	2006	290,000	24,167	3,126,045	18,000	540,000	9.28
	2007	320,000	26,667	3,002,800	18,000	540,000	10.66
	2008	320,000	26,667	3,022,084	18,000	540,000	10.59
Malibu Country Mart 2							
	2004	280,000	23,333	1,537,140	14,000	420,000	18.22
	2005	160,000	13,333	2,094,399	14,000	420,000	7.64
	2006	230,000	19,167	2,182,840	14,000	420,000	10.54
	2007	280,000	23,333	2,265,040	14,000	420,000	12.36
	2008	280,000	23,333	1,753,612	14,000	420,000	15.97
Malibu Country Mart 3							
*	2004	70,000	5,833	991,976	5,000	150,000	7.06
*	2005	163,000	9,417	1,388,200	5,000	150,000	11.74
	2006	150,000	12,500	1,249,280	5,000	150,000	12.01
	2007	160,000	13,333	1,292,000	5,000	150,000	12.38
	2008	230,000	19,167	991,576	5,000	150,000	23.20
Malibu Beach Inn							
*	2004	17,000		900,000	12,000		
*	2005	17,000		900,000	12,000		
*	2006	15,000		900,000	12,000		
*	2007	1,400		900,000	12,000		
	2008	26,700	2,225	964,600	12,000	360,000	2.77
Surfrider Beach							
	2004	2,500		1,105,817	2,250	67,500	0.23
	2005	2,500	208	968,801	2,250	67,500	0.26
	2006	86,853	7,238	652,985	2,250	67,500	13.30
	2007	245,430	20,453	764,006	2,250	67,500	32.12
*	2008	238,267	19,856	971,022	2,250	67,500	24.54

DRAFT OCT 21 2009

Site	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Monthly Capacity (gal)	Percent Annual Flow Hauled
Malibu Civic Center							
	2004	8,000		502,514	16,000		
	2005	-		449,254	16,000		
	2006	-		1,602,989	16,000		
	2007	-		745,999	16,000		
	2008	4,800		899,056	16,000		
Malibu Shores Motel							
*	2004	5,000		647,928	2,500		
*	2005	5,000		647,928	2,500		
	2006	6,500		631,629	2,500		
*	2007	5,000		625,494	2,500		
*	2008	3,000		706,767	2,500		
Malibu Colony Plaza							
	2004	918,500	76,542	5,000,000	45,000	1,350,000	18.37
	2005	752,450	62,704	5,000,000	45,000	1,350,000	15.05
*	2006	2,359,700	196,642	5,753,176	45,000	1,350,000	41.02
	2007	515,600	42,967	6,099,999	45,000	1,350,000	8.45
*	2008	625,500	104,250	7,616,840	45,000	1,350,000	8.21
Public Works Road Maintenance Yard No. 336							
	2004	0		123,218			
	2005	0		126,929			
	2006	0		81,943			
	2007	1,500		96,573			
*	2008	0		91,919			
Jack in the Box							
	2004	24,550	2,046	41,2085	1,200		5.96
	2005	2,500	208	48,8005	1,200		0.51
	2006	15,000	1,250	47,0941	1,200		3.19
	2007	200	17	54,8139	1,200		0.04
	2008	10,000	833	60,7299	1,200		1.65

DRAFT OCT 21 2009

Site	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Monthly Capacity (gal)	Percent Annual Flow Hauled
Malibu WPCP	2004	90,000	7,500	9,935,987	45,000		0.91
	2005	140,000	11,667	10,413,640	45,000		1.34
	2006	369,280	30,773	9,750,365	45,000		3.79
*	2007	222,720	18,560	11,584,832	45,000		1.92
	2008	215,540	17,962	10,707,434	45,000		2.01
HRL							
	2004			1,389,829			
	2005			1,192,739			
*	2006	22,000		1,141,598			
*	2007	11,000		1,251,311			
	2008	8,000		923,572			
Serra Retreat				262,800	21,600		
	2004						
	Q1	6,700	2,233				10.3
	Q2	3,750	1,250				5.8
	Q3	9,850	3,283				15.2
	Q4	9,000	3,000				13.9
	Sum	**29,300**	9,767				
	2005						
	Q1	2,200	733				3.4
	Q2	8,000	2,667				12.3
	Q3	8,300	2,767				12.8
	Q4	8,050	2,683				12.4
	Sum	**26,550**	8,850				
	2006						
	Q1	2,700	900				4.2
	Q2	0	0				0.0
	Q3	0	0				0.0
	Q4	10,000	3,333				15.4
	Sum	**12,700**	4,233				
	2007						
	Q1	19,400	6,467				29.9
	Q2	10,200	3,400				15.7
	Q3	3,000	1,000				4.6
	Q4	3,900	1,300				6.0
	Sum	**36,500**	12,167				
	2008						
	Q1	4,200	1,400				6.5
	Q2	3,200	1,067				4.9
	Q3	3,000	1,000				4.6
	Q4	3,000	1,000				4.6
		13,400	4,467				

DRAFT OCT 21 2009

Assumptions for Sewage Hauling Data

Malibu Country Mart I:

2004, Q1: Assume 10,000 gallons hauled based on hauling data from Q2.
2004, Q4: Waste flow estimated based on Q3 waste flows.

Malibu Country Mart III:

2004, Q4: Hauled volume estimated from trends seen from Q1-Q3
2004, Q4: Waste flow estimated based on trends seen from Q1-Q3.
2005, Q1: Hauled volume estimated to be the same as Q2.
2005, Q1: Waste flow estimated based on trends from Q1-Q3.

Surfrider Beach:

2008, Q4: Q4 data estimated as the average value of data from the first three quarters.

Malibu Colony Plaza

2004: No waste flow data was available until the Q3 of 2006, therefore based on available data from 2006, 2007, and 2008, annual waste flow is estimated to be 5 million gallons.
2005: No waste flow data was available until the Q3 of 2006, therefore based on available data from 2006, 2007, and 2008, annual waste flow is estimated to be 5 million gallons.
2006, Q4: Hauled volume estimated to be the same as Q3
2006: Annual waste flow estimated as four times the value reported in Q4 (the only quarter with data provided)
2008: Annual waste flow estimated as two times the sum of Q1 and Q2 (Q3 and Q4 waste flow data missing)

Malibu WPCP

2006, Q4: Q4 data estimated as the average value of data from the first three quarters.

Public Works Road Maintenance Yard No. 336

2008, Q3 and Q4: Q3 and Q4 monitoring reports missing, therefore estimates were made from Q1 and Q2 data.

HRL

2005: Q4 data estimated as the average value of data from the first three quarters.
2006: Only Q3 data available; this was used as data for the other three quarters.
2008: Q3 data estimated as the average value of data from the first three quarters.

DRAFT OCT 21 2009

Appendix B:
INSPECTION REPORT
CITY OF MALIBU HAULERS

Name of Inspectors: Dionisia Rodriguez
Ryan Thacher

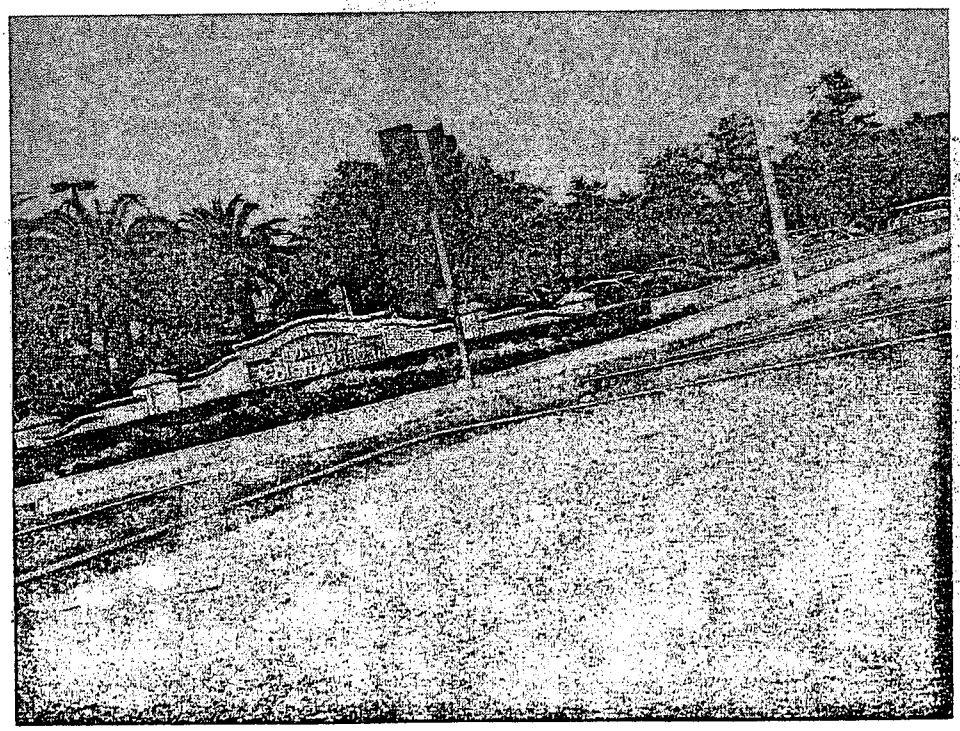
Date of Inspection: June 16, 2009

PURPOSE

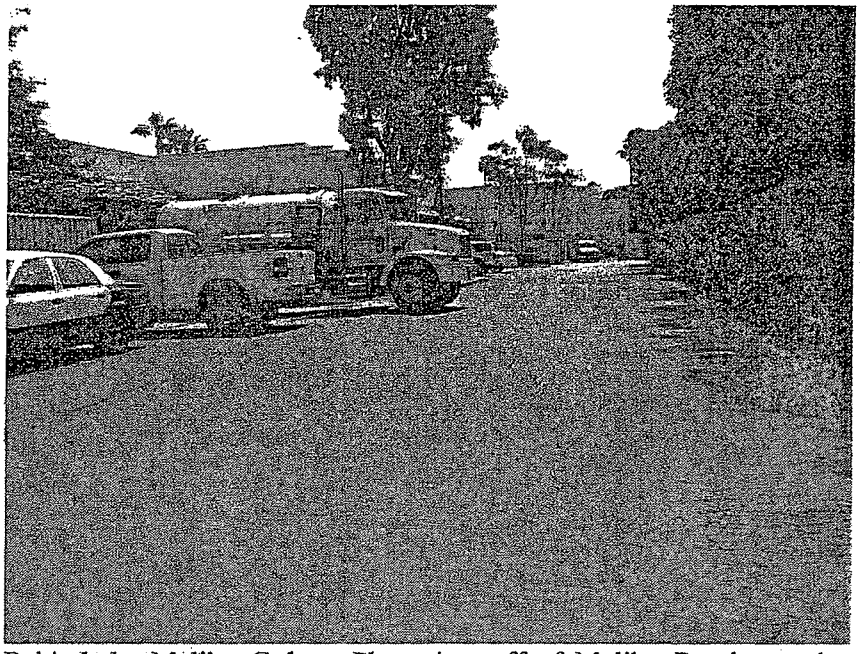
In order to gather some information about septic waste hauling in the City of Malibu, we decided to conduct a drive-through the city. The following pictures were taken during that drive-through conducted on Tuesday, June 16, 2009 between 10:00 a.m. and 11:30 a.m.

OBSERVATIONS

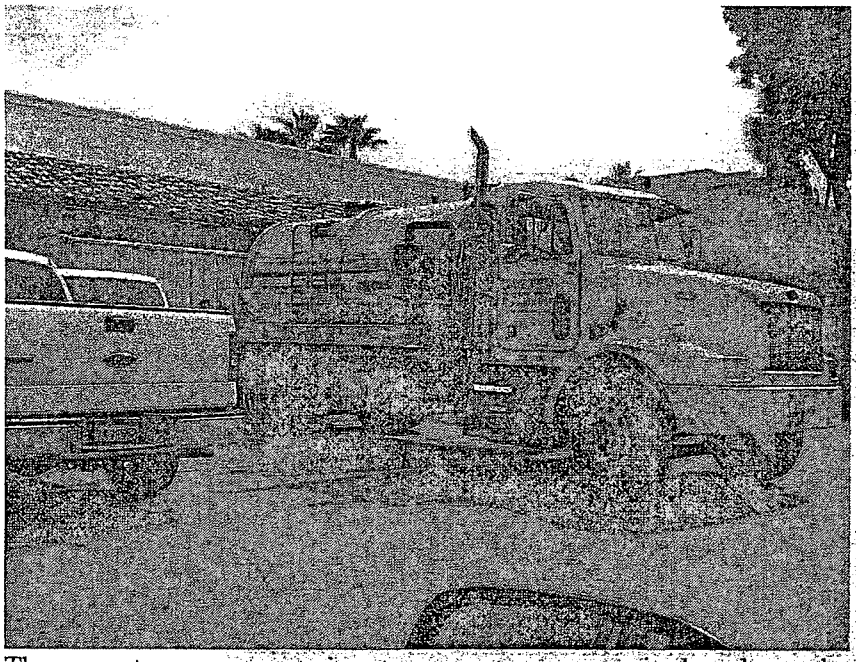
We chose Malibu Colony Plaza as our primary destination due to the frequent pumping of large volumes of waste from its septic system as reported by quarterly Monitoring Reports. We believed this site would provide us the best probability of seeing a pumping truck. This photo is the entrance of Malibu Colony Plaza, at the intersection of the Pacific Coast Highway and Webb Way.



DRAFT OCT 21 2009

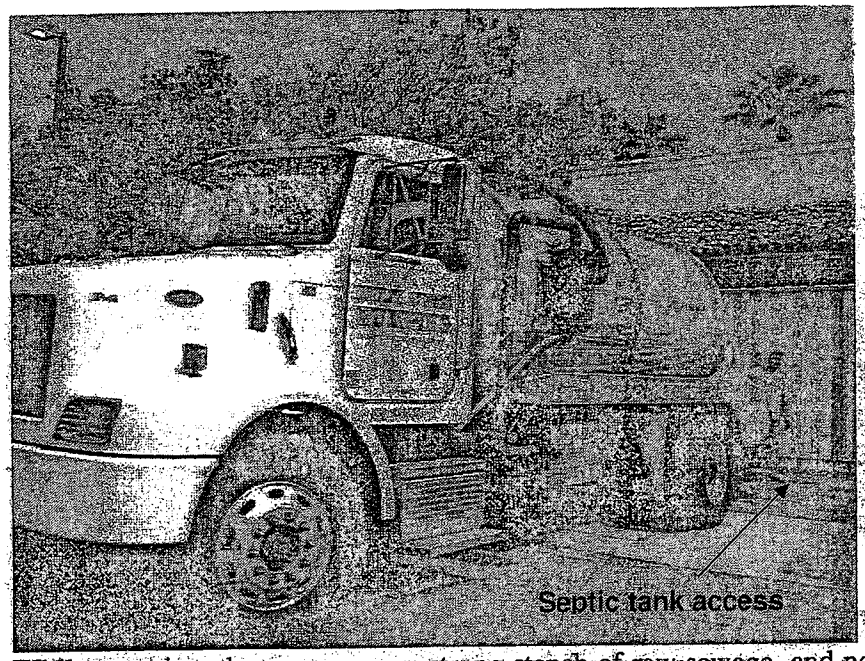


Behind the Malibu Colony Plaza, just off of Malibu Road, we observed an Ely Jr's Pumping truck.

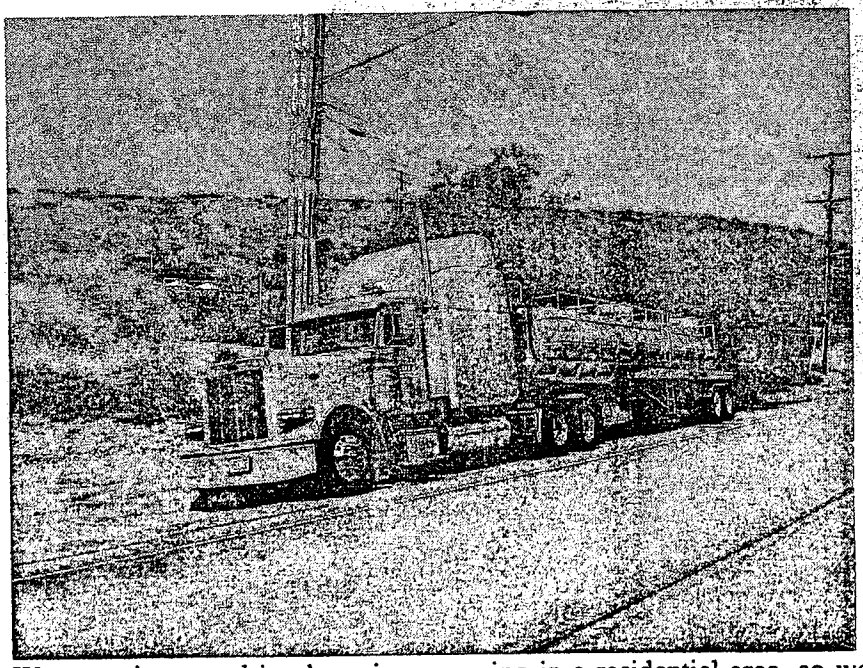


The operator was preparing to pump, so we waited and watched to observe any notable information about this process.

DRAFT OCT 21 2009

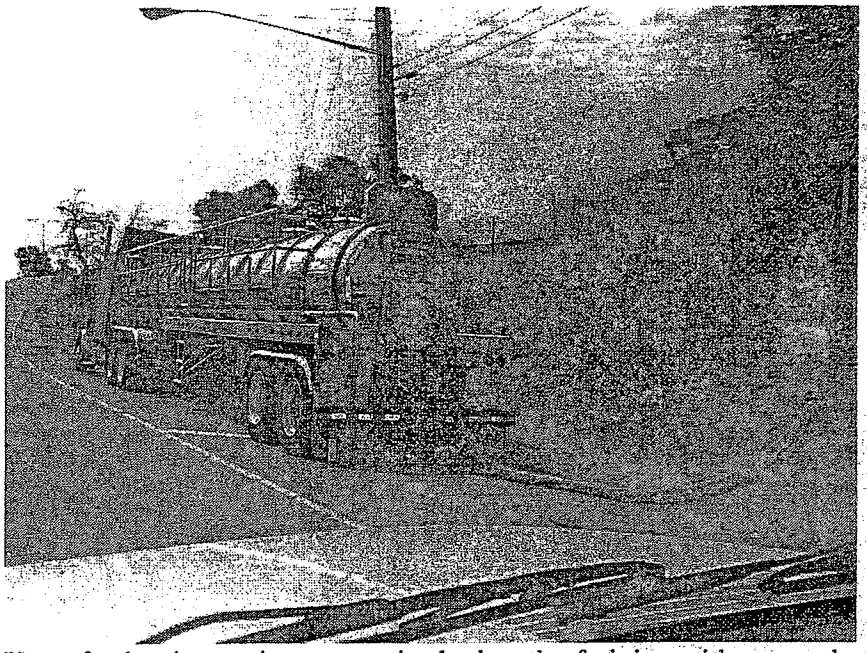


While pumping, there was a very strong stench of raw sewage, and noise levels required raising your voice significantly for conversation. No spills or leaks were observed during the pumping process.

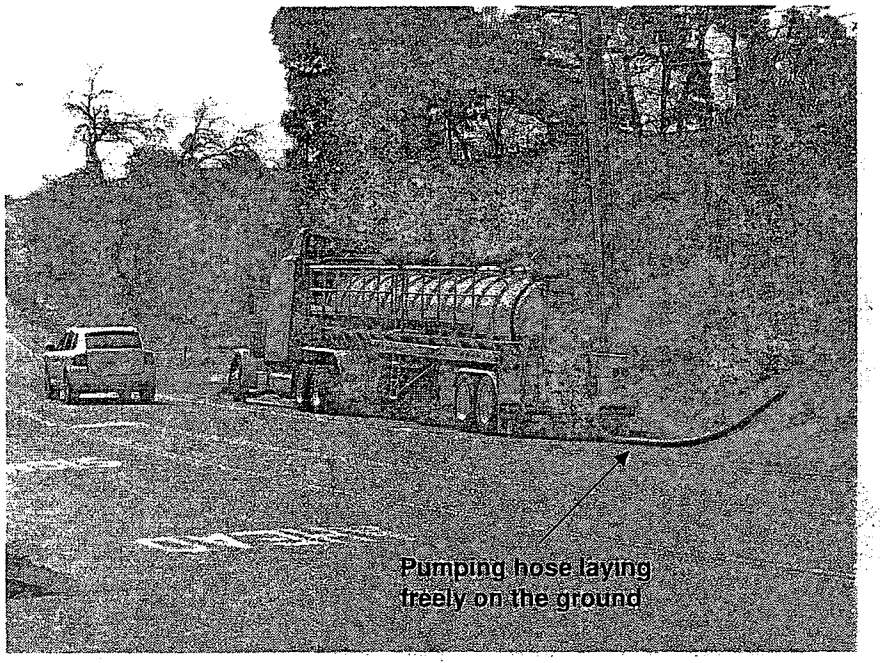


We were interested in observing pumping in a residential area, so we arbitrarily chose to drive north on Winter Canyon Road. At this location at 11:00 a.m. we encountered a large, unmanned sewage hauling truck belonging to Ely Jr's Pumping. We believe it was parked next to the leach field at Winter Canyon Road.

DRAFT OCT 21 2009

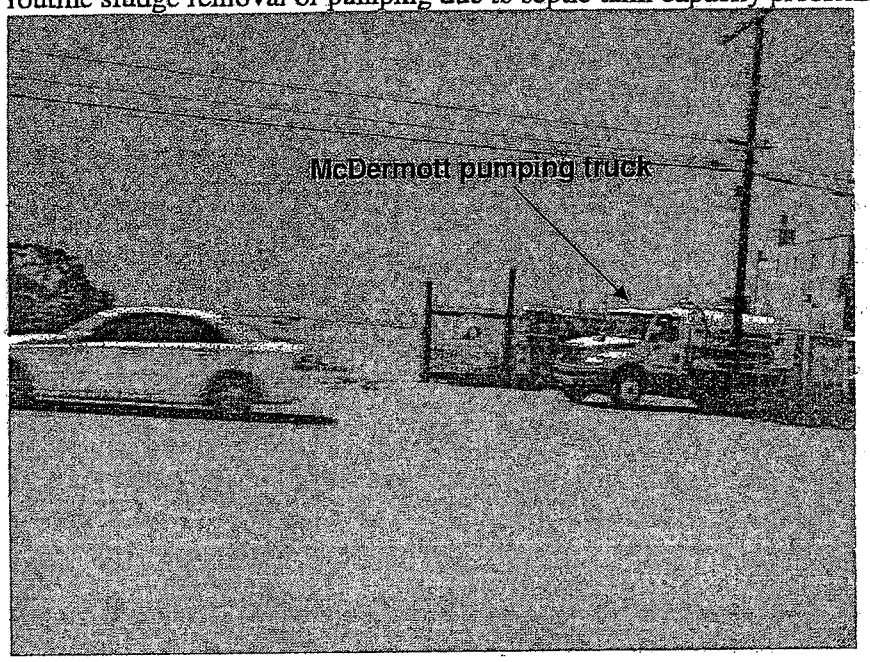


Upon further inspection, we noticed a length of piping with one end attached to the truck's tank, and the other laying freely on the side of the road.



DRAFT OCT 21 2009

Driving on the Pacific Coast Highway we saw three separate pumping vehicles belonging to McDermott Plumbing, apparently pumping residential septic tanks. We were only able to photograph one shown below at 11:20 a.m. It was unclear whether these trucks were performing routine sludge removal or pumping due to septic tank capacity problems.



CONCLUSION

We will use this inspection report for our technical memo regarding septic hauling in Malibu for the Malibu Prohibition case.

Report Prepared by: Dionisia Rodriguez

Ryan Thacher

Report Approved by: Dr. Rebecca Chou

DRAFT OCT 21 2009

Appendix D:
INSPECTION REPORT
SURFRIDER BEACH

FACILITIES INSPECTION REPORT

OFFICE NO: 4 (CA RWQCB - LA) 1870125

INSPECTOR: Wendy Phillips and Rebecca Chou

PCA System Task No.: 12601

	Co of Los Angeles, Dept of Public Works	Surfrider Beach Comfort Station (First Point)
WDID NUMBER	AGENCY NAME OR PARTY RESPONSIBLE FOR DISCHARGE	FACILITY NAME
CI 8532	900 South Fremont Avenue	23060 W Pacific Coast Highway
CI NUMBER	AGENCY STREET	FACILITY STREET
	Alhambra, CA 91803	Malibu, CA 90625
NPDES NUMBER	AGENCY CITY AND STATE	FACILITY CITY AND STATE
	Alexander Villarama	Alexander Villarama
(YY/MM/DAY) SCHED INSPECT DATE	AGENCY CONTACT PERSON	FACILITY CONTACT PERSON
2009/09/23	(626) 458-6102 office; (626) 543-3385 cell	none
ACTUAL INSPECTION DATE	AGENCY PHONE NO.	FACILITY PHONE NO.

INSPECTION TYPE (Check One)

(A1) ___ "A" type compliance -- Comprehensive inspection in which samples are taken (EPA Type S)

(B1) ___ "B" type compliance -- A routine nonsampling inspection. (EPA Type C)

(02) ___ Noncompliance follow-up -- Inspection made to verify correction of a previously identified violation

(03) ___ Enforcement follow-up -- Inspection made to verify that conditions of an enforcement action are being met

(04) ___ Complaint -- Inspection made in response to a complaint

(05) ___ Pre-requirement -- Inspection made to gather info. relative to preparing, modifying, or rescinding requirements.

(06) X Miscellaneous -- Any inspection type not mentioned above. If this is an EPA inspection not mentioned above, please note type

To check on conditions of backup sanitation facilities. (e.g. - biomonitoring, performance audit, diagnostic, etc.)

(Type)

N* Were VIOLATIONS noted during this inspection? (Yes/No/Pending Sample Results)

___ Was this a Quality Assurance-Based Inspection? (Y/N)

___ Were biossay samples taken? (N = No. If YES, then S = Static or F = Flowthrough)

INSPECTION SUMMARY (REQUIRED) (100 character limit)

This inspection focused on presence, in the Surfrider Parking lot, of nine portable toilets that serve as a backup sanitation facility to a comfort station.* See attached photos for details. Conclusion: The portable toilets at the First Point of Surfrider Beach function not only as a backup sanitation system for the Surfrider comfort station, but as additional toilet capacity during periods of heavy demand by visitors at the beach.

*No discharge from the comfort station. Discharge ceased after sewage daylighted onto beach in 2007. (Following this incident, the Discharger disconnected the leachfield and has been holding sewage from the comfort station in a septic tank for periodic pumping and off-site hauling to legal point of disposal.)

INITIALS: WP/RC SIGNATURE: [signature] DATE: 10-7-09

For Internal Use: Reviewed By: (1) [signature] (2) _____ (3) _____ Reg. CIWQS Coordinator

CIWQS Data Entry Date: _____ Regional Board File Number: _____

DRAFT OCT 21 2009

Malibu – Surfrider Beach – First Point (CI 8532)

Comfort Station and Backup Sanitation Facility

September 23, 2009, at approximately 1 p.m. (Phillips/Chou)
page 2 of 3

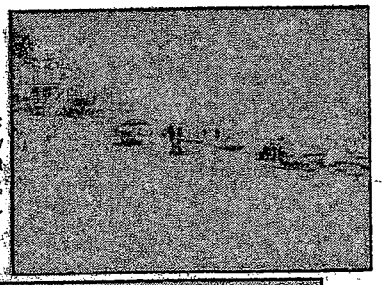


Photo 1 (right): Surfrider Beach – View of beach near First Point, on a warm, weekday afternoon.

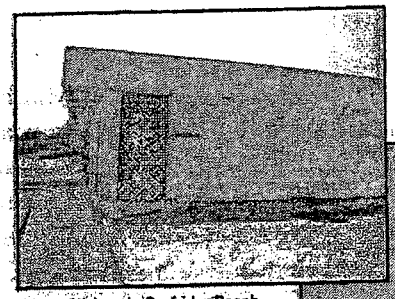


Photo 2 (above): Surfrider Beach – View of comfort station (which was open to the public during the inspection).

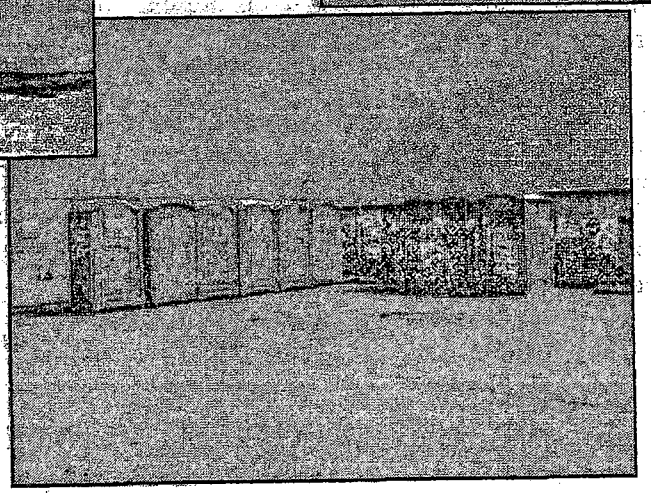
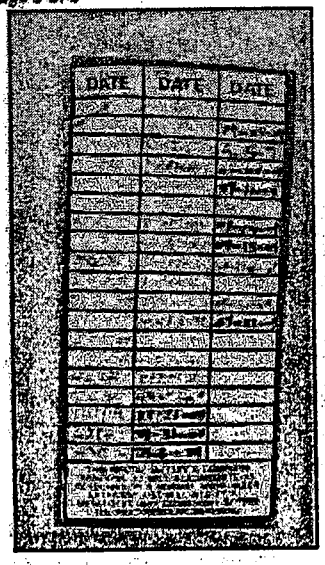


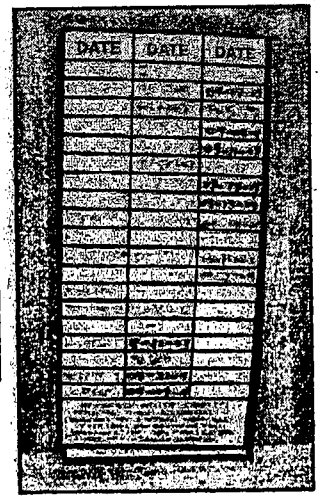
Photo 3 (right): Surfrider Beach – View of nine, free-standing portable toilets, made of molded plastic, in parking lot near First Point. These toilets not only serve as backup sanitation for periods when the comfort station has been shut down, but also to handle a portion of visitors' sanitation needs while the comfort station is open.

Malibu – Surfrider Beach – First Point (CI 8532)

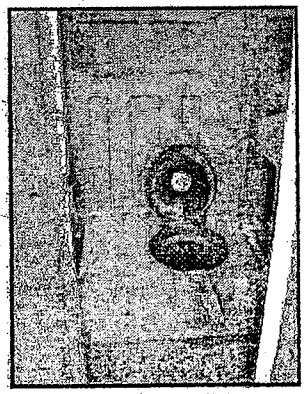
Comfort Station and Backup Sanitation Facility

September 23, 2009, at approximately 1 p.m. (Phillips/Chou)
page 3 of 3





Photos 4 and 5 (above and right): Surfrider Beach – Labels on two of the portable toilets showing maintenance schedule (with a frequency of several cleanouts per week).





Photos 6 and 7 (right): Surfrider Beach – Despite almost daily maintenance, portable toilets, such as the ones in the photos on the right, needed cleaning and emitted a strong odor of raw sewage.

DRAFT OCT 21 2009

Appendix E:
Malibu Potable Water Consumption Trends and Population Analysis

Ryan Thacher, Student Intern, September 30, 2009

DRAFT

OCT 21 2009

Potable Water Consumption and Population Analysis

Figure 1 below illustrates the relationship between potable water use in the City of Malibu and population increase from the late 1980s to the present. The linearization of the data reveals a trend of increasing water demand. Analysis of endpoints from the best fit line of this data shows that between 1989 and 2008 there has been a 49 percent increase in potable water consumption. Due to the yearly fluctuations in potable water consumption, using the best fit line for this calculation provides a more accurate perspective of the increasing water demand in the City of Malibu. The population of the City of Malibu has increased 31 percent from 10,479 people in 1990 to 13,700 people in 2008. Potable water consumption is increasing at a much greater rate than the population (49 percent versus 31 percent), indicating the per capita potable water consumption rate is not a static value, but is increasing as well.

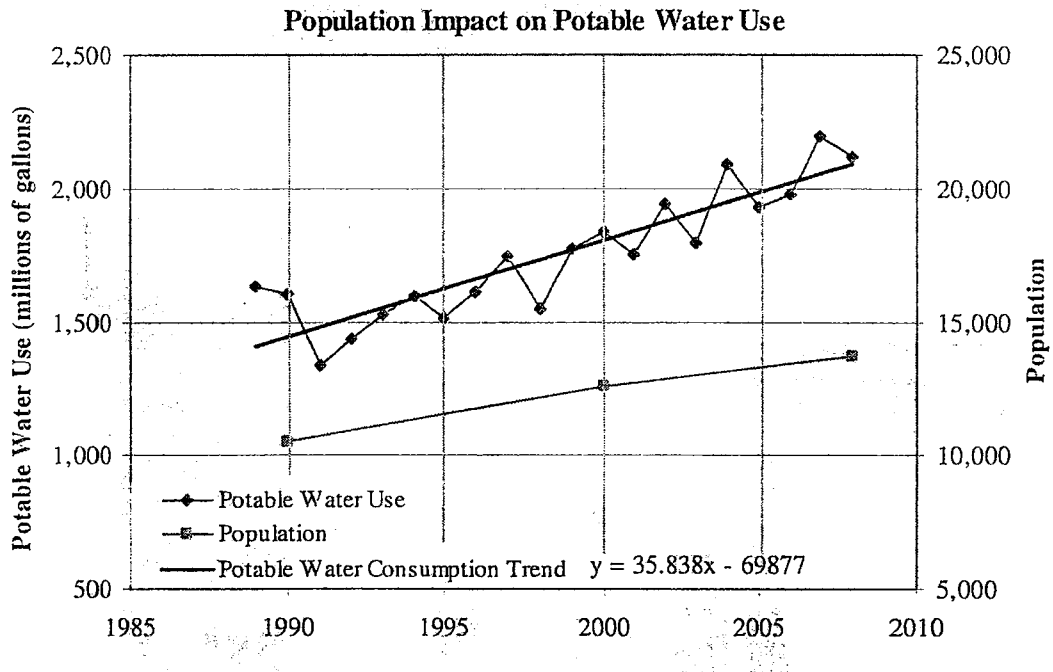


Figure 1. Potable water consumption in the City of Malibu plotted with population increases over the past two decades. Annual potable water consumption is increasing at a greater rate than population.

Potable Water Consumption and Annual Rainfall Analysis

To analyze the large yearly fluctuations in potable water consumption, this data was compared with annual rainfall data gathered from the Lechuza Point/Fire Station 72 rain gauge located in Malibu. Historical rainfall data by month from the early 1980s up to present day was provided to the Regional Board by the Los Angeles County Department of Public Works. This is shown in Figure 2.

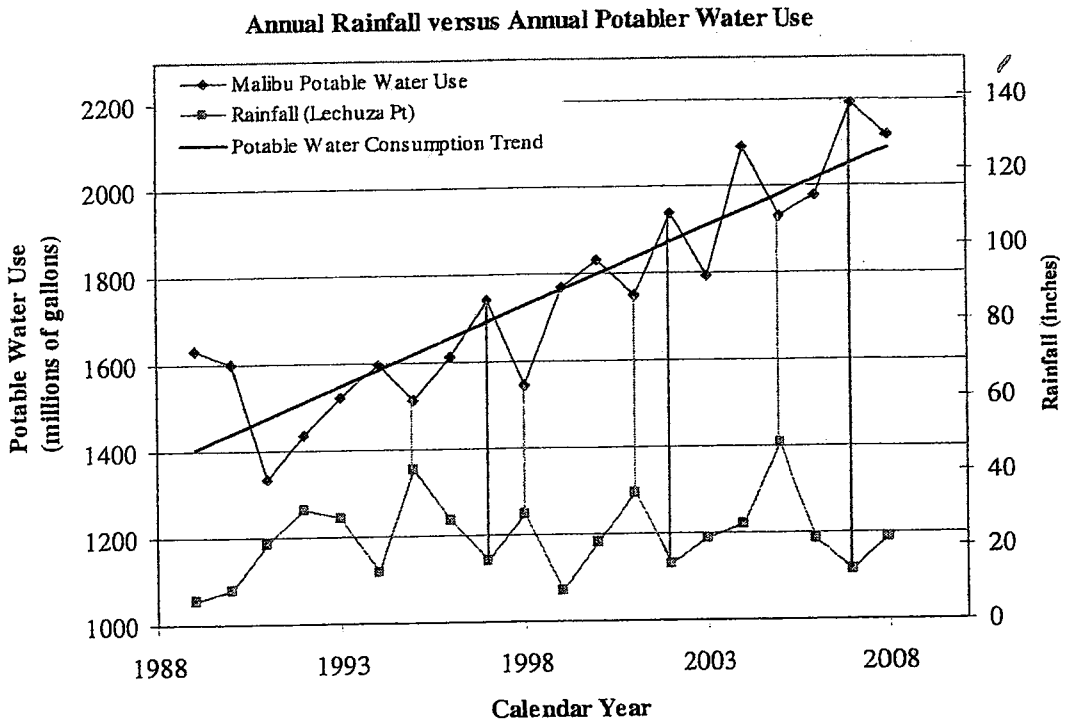


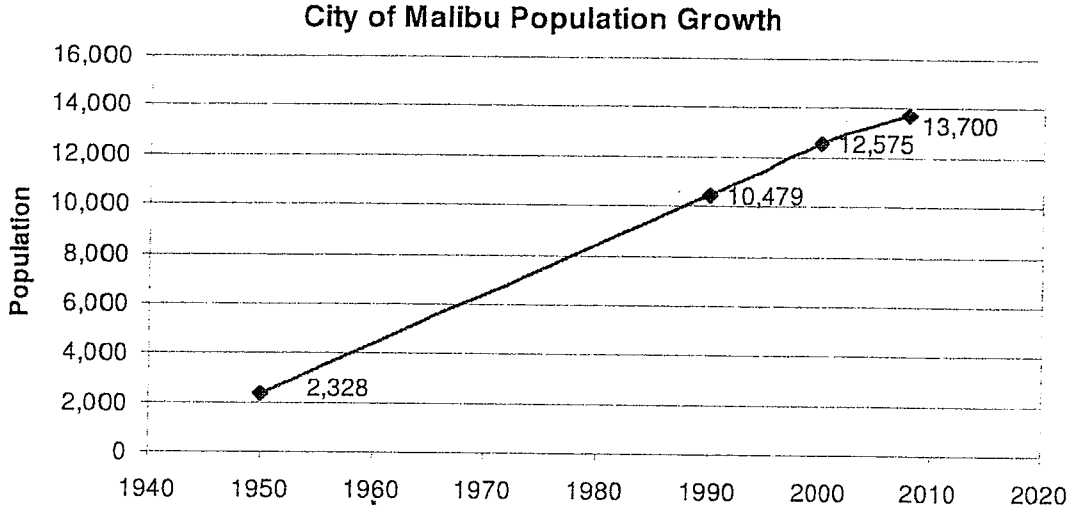
Figure 2. Annual rainfall data (by calendar year) compared with annual potable water use in the City of Malibu.

Looking at the relationship between potable water use in the City of Malibu and the amount of rainfall recorded during the corresponding year shows a strong inverse relationship. The red and green vertical lines emphasize years that clearly exhibit this behavior. Assuming water consumption per capita increases at a fairly constant rate despite weather patterns, the large seasonal fluctuations in annual water consumption seen in the City of Malibu can be attributed to potable water use for irrigation purposes.

DRAFT OCT 21 2009

City of Malibu Population Growth Analysis

Orlando Gonzalez, Staff Water Resource Engineer, September 30, 2009



The population trend of the City of Malibu has increased as shown in the above figure. According to the Malibu Coastal Vision Report titled "Malibu Yesterday, Today, and Tomorrow" (page 9), the population of Malibu was 2,328 in 1950. The 2000 Census indicates that the population in 1990 and 2000 was 10,479 and 12,275, respectively. Updated information presented in the report titled "Profile of City of Malibu" funded by the Southern California Association of Governments and dated May 2009, indicated in page one that the population in 2008 was 13,700. Based in the above information, the population grew at an average rate of 3.83% per year from 1950 to 1990, 1.84% per year from 1990 to 2000, and 1.08% per year from 2000 to 2008.

Regional Board staff estimates the population in 2009 at 1,842 for the proposed prohibition area. Based on the County of Los Angeles Assessor's data, there are 391 single family houses. The average number of bedrooms per house is four and assuming one person per bedroom, the population is 1,564 people for the houses. In addition, there are four multifamily complexes that have a total of 191 units with an estimated of 278 bedrooms. Again, assuming one person per bedroom, this indicates 278 additional people.

The estimated population does not include daytime and evening workers who are employed in the Malibu Civic Center area. Nor does it include daytime and evening visitors, who enjoy the beaches and patronize the businesses and public facilities. Based on Beach Activity Report prepared by Los Angeles County Fire Department, Lifeguard Division, Malibu Beach visitors have increased from 233,500 in August 1999 to 355,000 in August 2006, which is about an average annual increase of 6%.

DRAFT OCT 21 2009

Draft Environmental
Staff Report

State of California
California Regional Water Quality Control Board, Los Angeles Region

D R A F T O C T 2 1 2 0 0 9

Environmental Staff Report

Containing substitute environmental documentation in accordance with the California Environmental Quality Act in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

Draft dated October 21, 2009

3-1047

Table of Contents

Page Number

Introduction 1

Proposed Action 1
Lead Agency 4
Scope of Environmental Staff Report 4
California Environmental Quality Act 5
Public Resources and Water Code Requirements 5

Proposed Action 7

Description of Proposed Action 7
Goal of Proposed Action 7
Environmental Setting 7
Background 7
Water Resources 8
Impairments to Beneficial Uses of Water Resources 8
Technical Evidence in Support of the Proposed Prohibition 9
Schedule for Compliance with the Proposed Prohibition 10

Program Alternatives 12

Program Alternative 1 – Local Government Initiative 12
Program Alternative 2 – No Action 13
Recommendation 14

Options for Compliance Projects 15

Introduction 15
Summary of Economics 16
Compliance Project A – Integrated Water Resources Management Facility 17
Compliance Project B – Interceptor Sewer 17
Compliance Project C – Decentralized Wastewater Management 19

CEQA Analysis 21

Environmental Checklist and Discussion 21
Other Environmental Considerations 43
Cumulative Impacts 43
Growth-Inducing Impacts 44
Unavoidable Significant Adverse Impacts 46
Statement of Overriding Considerations and Determination 47

DRAFT OCT 21 2009

3-1048

Environmental Staff Report

in support of an Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

to Prohibit Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

Introduction

Proposed Action

The California Regional Water Quality Control Board, Los Angeles Region (Regional Board) proposes to amend the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties (Basin Plan)* to prohibit discharges from on-site wastewater disposal systems (OWDSs) in the Civic Center area of the City of Malibu. This proposed regulatory action is referred to as the prohibition, or project, throughout this report.

Prohibition Boundary

The area that would be affected by the proposed prohibition is referred to as the Malibu Civic Center area, and is delineated by the red line shown in Figure 1. The area is not defined according to municipal borders or parcel lines. Rather, the area subject to the prohibition is delineated according to hydrogeologic parameters and drainage patterns; as groundwater flow roughly mimics surface drainage, the prohibition boundary follows a topographic high surrounding both the Winter Canyon and lower Malibu Creek (also known as Malibu Valley) watersheds. All property extending seaward of this boundary to the ocean is subject to the prohibition, including the coastal strips along the Pacific Coast Highway stretching from Amarillo Beach to First Point at Surfrider Beach. This entire area, which is referred to as the "Malibu Civic Center area,"[1] totals 2.2 square miles of which 1.5 square miles and 0.7 square miles are within the City of Malibu and the unincorporated area of County of Los Angeles, respectively. Figure 2 shows the civil boundaries and parcels.

To the west, the prohibition boundary encompasses Winter Canyon not only because this watershed is heavily developed and discharges almost 50,000 gallons per day of wastewater (about 20% of the wastewater in the prohibition area), but also because wastewater management strategies for many commercial activities in the coastal strip adjacent to the Colony – as well as proposed strategies for managing future wastewaters from Malibu Valley – rely on disposal capacity in Winter Canyon, which is severely strained. Note that the prohibition area includes

[1] As the prohibition area covers a small portion of the City of Malibu and an even smaller portion of unincorporated County of Los Angeles, staff avoided designating this as a 'Malibu' prohibition. Nor did staff select hydrologic terms to designate the prohibition area, out of concern that such terminology may not be readily recognized by the affected community. Rather, the designation of 'Malibu Civic Center area' was selected for broad name recognition.

3-1049

DRAFT OCT 2 1 2009

only a small sliver of the Pepperdine University campus, as this sliver is the only portion of Pepperdine that falls within the topographically-defined Winter Canyon watershed.

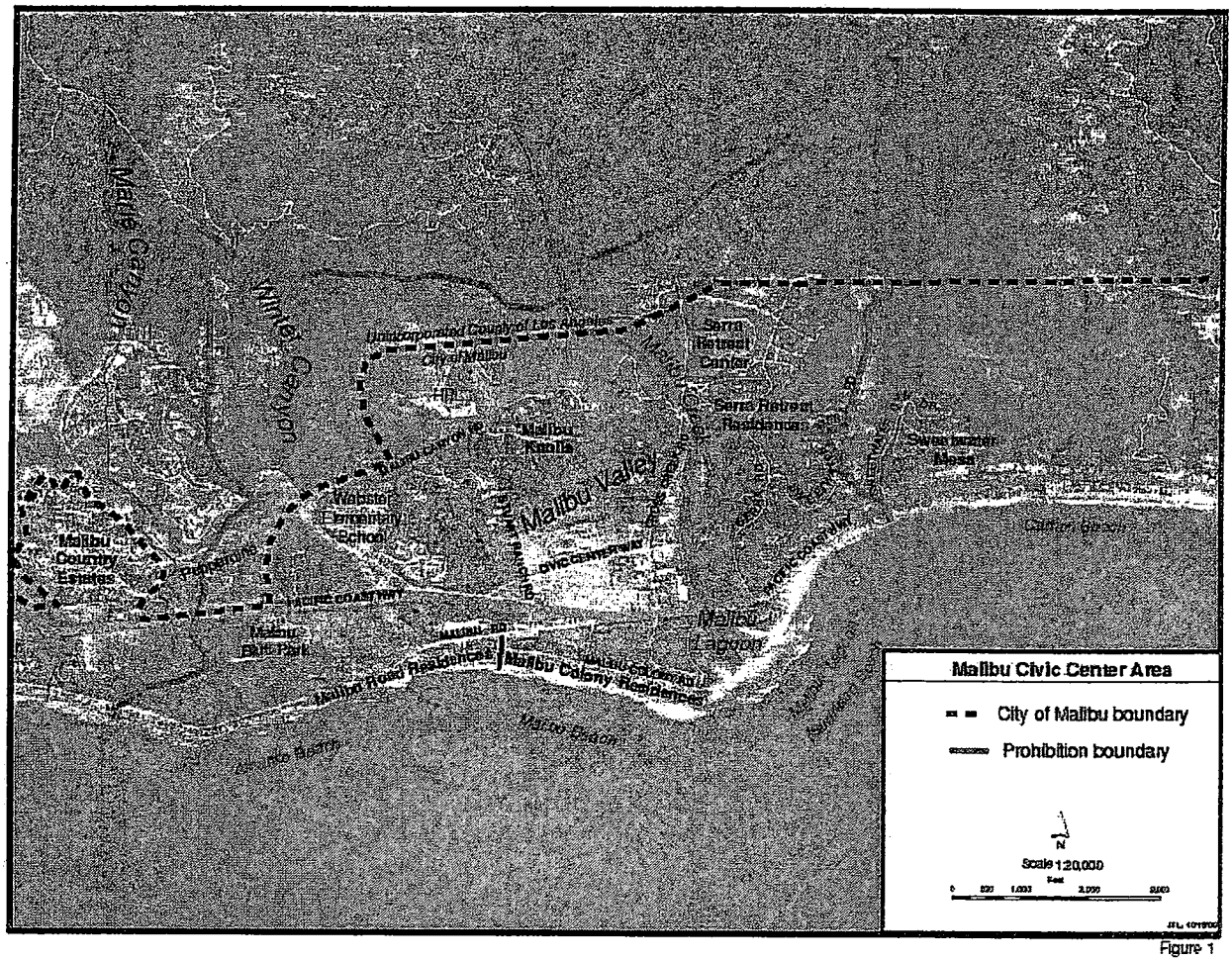


Figure 1

To the east, the prohibition boundary encompasses the Serra Retreat neighborhood, and follows Sweetwater Mesa Road along the eastern topographic high. The boundary was not extended eastward, as the Sweetwater Mesa neighborhood is a lower density residential development. Nor was the boundary extended eastward along the Pacific Coast Highway to capture a stretch of significant commercial development, as the intent of this proposed regulatory action is to encompass priority areas that affect groundwater and are hydraulically connected to impaired surface water resources, including Surfrider, Malibu, and Amarillo Beaches and Malibu Lagoon. Additional areas, such as the stretch of the Pacific Coast Highway eastward of the boundary, may be subject to future regulatory actions.

DRAFT OCT 2 1 2009

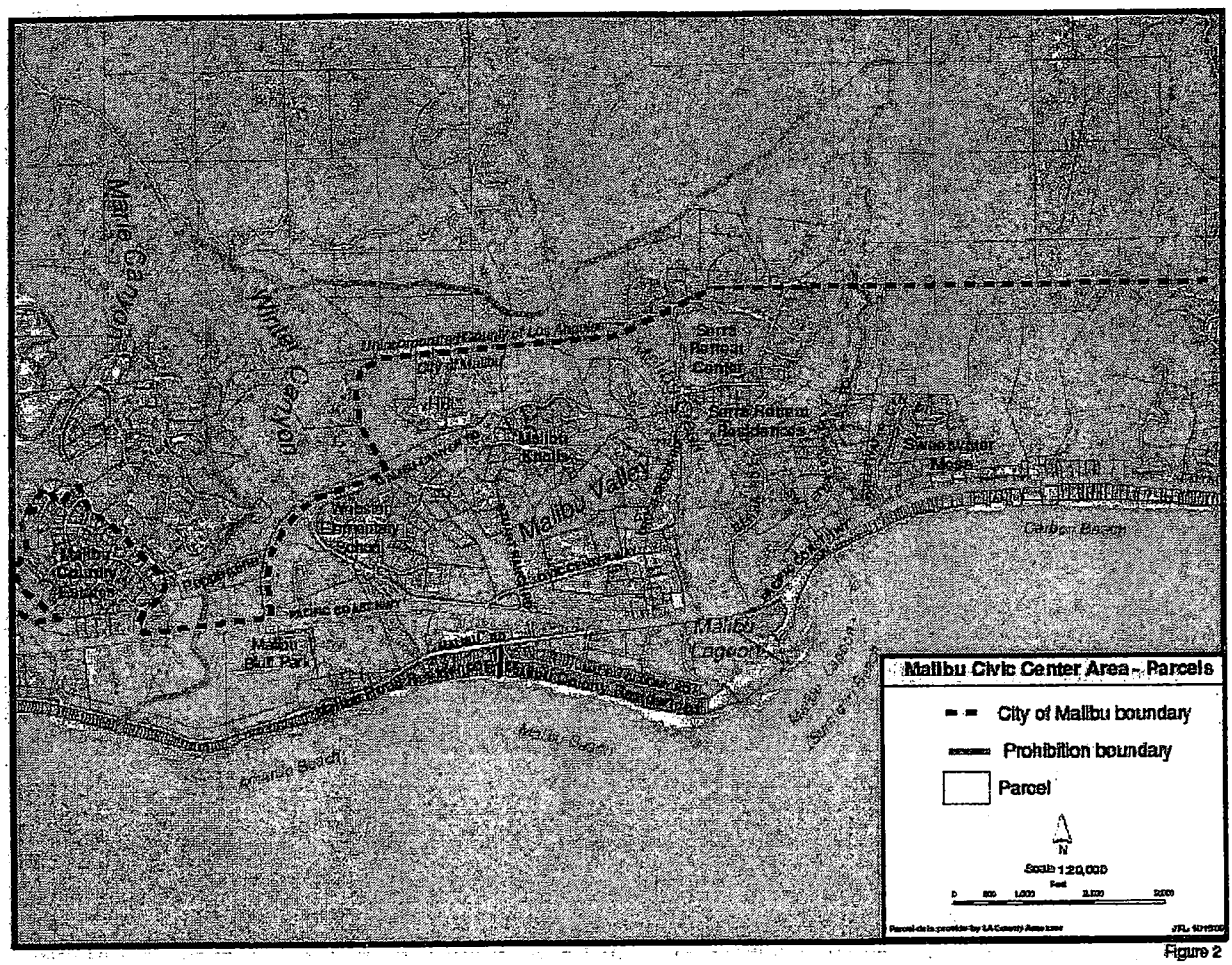


Figure 2

Types of Dischargers Subject to Prohibition

All property owners, including existing residences, businesses, and public facilities that discharge wastes through an OWDS in the Malibu Civic Center area, would be affected by the proposed prohibition as well as future dischargers who may plan to discharge in this area. The regulatory action would immediately prohibit all new discharges from OWDS in the Malibu Civic Center area, and establish a schedule to cease discharges from existing systems by 2014.

Types of Discharges Subject to Prohibition

Collectively, the systems from which wastewaters discharge are referred to as OWDSs. Types of subsurface disposal systems, or OWDSs, that would be prohibited range from passive systems with conventional septic tanks to active systems with equipment that more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would cover an OWDS that serves an individual property (residential, commercial, industrial, and public properties) as well as a group of properties. The prohibition would apply to all OWDSs and regulated

DRAFT OCT 2 1 2 0 0 9

discharges (whether they are regulated by the City of Malibu, County of Los Angeles, or State) as well as any unregulated discharges that may exist.

Lead Agency

The Regional Board is the lead agency for evaluating environmental impacts from the proposed prohibition on OWDSs in the Malibu Civic Center area.

Scope of Environmental Staff Report

The Regional Board's basin planning process is exempt from certain requirements of CEQA, including preparation of an initial study, negative declaration, and environmental impact report (California Code of Regulations, title 14, section 15251(g)). As the proposed amendment to the *Basin Plan* is part of the basin planning process, the Regional Board prepares environmental information and analyses that are the functional equivalent of an environmental impact report. The Regional Board describes it as "substitute environmental documentation," which complies with Public Resources Code section 21080.5. In this substitute environmental documentation, alternatives to the proposed project, reasonably foreseeable environmental impacts arising from those alternatives and from methods of complying with the proposed prohibition are disclosed in accordance with the California Environmental Quality Act (CEQA) and CEQA regulations.

This information is also presented to meet a requirement of section 13283 of the California Water Code (CWC), which requires a preliminary review of possible alternatives to achieve protection of water quality and present and future beneficial uses of water, and prevention of nuisance, pollution, and contamination.

Consideration of the factors in section 13241 of the CWC is required by section 13281. Staff has presented preliminary cost information for conceptual options, or projects, that the community and stakeholders could select and implement to comply with the prohibition. These projects are analyzed on a conceptual basis only, as a local government body will need to select and implement a specific wastewater management strategy and project. As this occurs, it will be the responsibility of a local government body to perform a specific project-level analysis and disclose environmental impacts.

The Regional Board has analyzed environmental impacts. This substitute environmental documentation is based on the proposed prohibition that will be considered by the Regional Board and, if adopted, implemented through an amendment to the *Basin Plan*. Evidence in support of the proposed prohibition is presented in a technical staff report that, together with this environmental staff report and a tentative resolution, are part of the substitute environmental documentation which will be considered on November 5, 2009. Approval of the substitute environmental documentation is separate from approval of a specific project alternative or a component of an alternative. Approval of the substitute environmental documentation refers to the process of: (1) addressing comments, (2) confirming that the Regional Board considered the information in the substitute environmental documentation, and (3) affirming that the documentation reflects independent judgment and analysis by the Regional Board (Cal. Code Regs., tit. 14, section 15090).

DRAFT OCT 21 2009

California Environmental Quality Act

This prohibition is evaluated at a program level of detail under a Certified Regulatory Program and the information and analyses are presented in this substitute environmental documentation as discussed in this section.

CEQA's basic purposes are to: 1) inform the decision makers and public about the potential significant environmental effects of a proposed project, 2) identify ways that environmental damage may be mitigated, 3) prevent significant, avoidable damage to the environment by requiring changes in projects, through the use of alternative or mitigation measures when feasible, and 4) disclose to the public why an agency approved a project if significant effects are involved. (Cal. Code Regs., tit. 14, section 15002(a).)

To fulfill these functions, a CEQA review need not be exhaustive, and CEQA documents need not be perfect. They need only be adequate, complete, and good faith efforts at full disclosure. (Cal. Code Regs., tit.14, section 15151.) The Court stated in *River Valley Preservation Project v. Metropolitan Transit Development Board* (1995) 37 Cal.App.4th 154, 178:

> As we have stated previously, "[o]ur limited function is consistent with the principle that "'"[t]he purpose of CEQA is not to generate paper, but to compel government at all levels to make decisions with environmental consequences in mind. . . ."'" (*City of Santee v. County of San Diego* (1989) 214 Cal.App.3d 1438, 1448 [263 Cal.Rptr. 340]; quoting *Laurel Heights I*, supra, 47 Cal.3d at p. 393.) "We look 'not for perfection but for adequacy, completeness, and a good faith effort at full disclosure.' (Guidelines, section 15151.)" (*City of Fremont v. San Francisco Bay Area Rapid Transit Dist.*, supra, 34 Cal.App.4th at p. 1786.)

Nor does CEQA require unanimity of opinion among experts. The analysis is satisfactory as long as those opinions are considered. (Cal.Code Regs.,tit. 14, section 15151.)

In this document, the Regional Board staff has strived to perform a good faith effort at full disclosure of the reasonably foreseeable environmental impacts that could be attendant with the prohibition. Our analysis and conclusions follow.

Public Resources and Water Code Requirements

While the "certified regulatory program" of the Regional Board is exempt from certain CEQA requirements, it is subject to the substantive requirements of California Code of Regulations, title 23, section 3777(a), which requires a written report that includes a description of the proposed activity, an analysis of reasonable alternatives, and an identification of mitigation measures to minimize any significant adverse environmental impacts. Section 3777(a) also requires the Regional Board to complete an environmental checklist as part of its substitute environmental documents. This checklist is provided within this document.

In addition, pursuant to the California Water Code, section 13281(a), the Regional Board must consider all relevant evidence related to the discharge, including, but not limited to, those factors

DRAFT OCT 2 1 2009

set forth in section 13241 information provided pursuant to section 117435 of the Health and Safety Code, possible adverse impacts if the discharge is permitted, failure rates of any existing individual disposal systems, whether due to inadequate design, construction, maintenance, or unsuitable hydrogeologic conditions, evidence of any existing, prior or potential contamination, existing and planned land use, dwelling density, historical population growth, and any other criteria as may be established pursuant to guidelines, regulations, or policies adopted by the state board. This evidence is presented in the technical and environmental staff reports.

Pursuant to the California Water Code, section 13241, the Regional Board may establish water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance; however, it is recognized that it may be possible for the quality of water to be changed to some degree without unreasonably affecting beneficial uses. In so doing, the Regional Board is to consider factors, including but not necessarily limited to, all of the following:

(a) Past, present, and probable future beneficial uses of water.
(b) Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.
(c) Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area.
(d) Economic considerations.
(e) The need for developing housing within the region.
(f) The need to develop and use recycled water.

Although the proposed regulatory action does not establish a new water quality objective, staff has nonetheless presented such information in the technical and environmental staff reports.

Public Resources Code section 21159(d) specifically states that the public agency is not required to conduct a "project level analysis." Rather, a project level analysis must be performed by the local agencies that are required to implement the requirements of the prohibition. Notably, ***the Regional Board is prohibited from specifying the manner of compliance with its regulations*** (Water Code § 13360), and accordingly, the ***actual*** environmental impacts will necessarily depend upon the compliance strategy selected by the local agencies.

This substitute environmental documentation identifies the reasonably foreseeable environmental impacts of the ***reasonably foreseeable*** methods of compliance (Pub. Res. Code, section 21159(a)(1)), based on information developed before, during, and after the CEQA scoping process that is specified in California Public Resources Code section 21083.9. This analysis is a program-level (i.e., macroscopic) analysis. CEQA requires the Regional Board to conduct a program-level analysis of environmental impacts. (Pub. Res. Code, section 21159(d).) Similarly, the CEQA substitute documents do not engage in speculation or conjecture (Pub. Res. Code, section 21159(a).) When the CEQA analysis identifies a potentially significant environmental impact, the accompanying analysis identifies reasonably foreseeable feasible mitigation measures. (Pub. Res. Code, section 21159(a)(2).) The substitute environmental documentation has identified the reasonably foreseeable alternative means of compliance. (Pub. Res. Code, section 21159(a)(3).)

DRAFT OCT 2 1 2009

Proposed Action

Description of Proposed Action

The proposed regulatory action by the Regional Board would prohibit discharge of wastewater through an OWDS in the Civic Center area of the City of Malibu. The prohibition would be effected through an amendment, set forth in the tentative resolution, to the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties (Basin Plan).*

The area that would be affected by the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1), which includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Existing residents, businesses, and public facilities that discharge wastes through an OWDS in the Malibu Civic Center area, would be affected by the proposed prohibition as well as future dischargers who may plan to discharge in this area. The regulatory action would immediately prohibit all new discharges from OWDS in the Malibu Civic Center area, and establish a schedule to cease discharges from existing systems by 2014.

Types of subsurface disposal systems, or OWDSs, that would be prohibited range from passive systems with conventional septic tanks to active systems with equipment that more aggressively removes pollutant loads from sewage before subsurface disposal. The prohibition would cover an OWDSs that serves an individual property (residential, commercial, industrial, and public properties) as well as a group of properties.

Goal of the Proposed Action

The goal of the proposed prohibition on OWDSs is to remedy pollution of water resources, including beaches, Malibu Lagoon and Creek, and groundwater, that are affected by discharges from OWDSs. The prohibition, together with other efforts, is expected to restore beneficial uses of these water resources.

Environmental Setting

Background

The Malibu Civic Center area supports a population of approximately 2,000 residents and is the core of the City's business, cultural, and commercial activities. The area, which includes the renowned Surfrider Beach, attracts a high volume of visitors.

Residents, businesses, and public facilities in the area discharge wastewaters totaling about 270,000 gallons per day (gpd) through OWDSs to the subsurface and underlying groundwater. These high flows of wastewater, coupled with unfavorable hydrogeologic conditions, have raised concerns about reliance on this wastewater disposal strategy.

D R A F T O C T 2 1 2 0 0 9

Water Resources

Surface waters in the Malibu Civic Center area include Malibu Creek, Malibu Lagoon, a critical fresh/saltwater habitat for rare, threatened, and endangered species, and the ocean beaches that are heavily used by the resident population as well as visitors. Also, groundwater in the area is a historic and potential source of drinking water. In the *Basin Plan*, the Regional Board has formally designated these plus other beneficial uses for water resources as follows:

> **Malibu Lagoon:** Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.
>
> **Malibu Creek:** Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.
>
> **Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach:** Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.
>
> **Groundwater:** Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

Also in the *Basin Plan*, the Regional Board has established water quality objectives to protect the beneficial uses identified above.

Impairments to Beneficial Uses of Water Resources

In a 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses are formally identified for the following water resources:

> Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
> Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
> Malibu Beach: impaired by Indicator Bacteria.
> Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
> Carbon Beach: impaired by Indicator Bacteria.

To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

a. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April

DRAFT OCT 2 1 2 0 0 9

15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential land use activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

b. **Malibu Creek and Lagoon Bacteria TMDL:** The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

c. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for onsite wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including onsite wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

Technical Evidence in Support of the Proposed Prohibition

In the technical staff report, staff presents evidence in support of the proposed prohibition, in accordance with the requirements of the California Water Code, sections 13280 and 13281, for a determination that discharges of OWDSs in the Malibu Civic Center area result in violation of water quality objectives, impairment of present or future beneficial uses of water, pollution, nuisance, or contamination, or unreasonable degradation of the quality of waters of the State. The conclusions, based on the evidence in the technical staff report, are as follows:

DRAFT OCT 2 1 2 0 0 9

i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance. (See Technical Memorandum #1 appended to the technical staff report.)

ii. Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water. (See Technical Memorandum #2 appended to the technical staff report.)

iii. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches represent a source of impairment for water contact recreation. (See Technical Memorandum #3 appended to the technical staff report.)

iv. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication. (See Technical Memorandum #4 appended to the technical staff report.)

v. Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities. (See Technical Memorandum #5 appended to the technical staff report.)

Based on these conclusions, the technical staff report presents a recommendation for Regional Board action to prohibit discharges from OWDSs in order to protect the quality of water resources and to restore beneficial uses of water resources in the Malibu Civic Center area. This recommendation is set forth in a tentative resolution for the proposed amendment to the *Basin Plan*, which the Regional Board will consider for adoption on November 5, 2009.

Schedule for Compliance with the Proposed Prohibition

Although the Regional Board is not specifying the *manner* of compliance with the prohibition, staff has reviewed options for conceptual projects that could provide the community with wastewater services in compliance with federal and state regulations, water quality objectives, and the proposed prohibition. These compliance projects include construction, operation, and maintenance of:

A. Integrated water resources management facilities that would collect and treat wastewaters in, and distribute recycled water from, a centralized plant within the community.

B. A community sewer collection system and interceptor sewer to export sewage for treatment at a facility in another community.

DRAFT OCT 21 2009

C. Decentralized wastewater management facilities that would collect and treat and wastewaters in, and distribute recycled water from, small plants within the community.

The proposed prohibition anticipates that the community would select, design, and construct one of the above projects, or a similar project, and cease discharges from OWDSs by 2014, in accordance with the following schedule:

May 1, 2010:	Completion of 25% of a master facilities plan for possible projects to comply with the prohibition, including initiation of a strong public participation program.
November 1, 2010:	Completion of 50% of a master facilities plan and initiation of environmental review, with strong, on-going public participation. Concurrently, initiation of preliminary engineering and a feasibility study for possible projects to comply with the prohibition.
May 1, 2011:	Substantial completion of a master facilities plan, preliminary engineering and a feasibility study, and engagement of the public in selection of a project to comply with the prohibition.
November 1, 2011:	Completion of a master facilities plan, preliminary engineering and a feasibility study, and selection of a project to comply with the prohibition.
November 1, 2012:	Completion of a final design for selected project.
November 1, 2013:	Completion of 50% of construction of selected project.
November 1, 2014:	Completion of project selected to comply with prohibition, including successful startup of the project and termination of discharge from all OWDSs.

DRAFT OCT 2 1 2009

Program Alternatives

In this section, staff analyzed two alternatives, or actions, to the proposed project within the jurisdiction of the Regional Board, municipalities, and other local agencies. These alternatives include:

1. An initiative by a municipality, utility, or other local authority (local government) to cease discharge through OWDSs by providing community services to collect and dispose/reuse wastewater in a manner that will restore water quality and beneficial uses of impaired waters.

2. A 'no action' alternative, in which dischargers continue to rely on existing OWDSs.

Staff did not analyze an alternative that assumes that dischargers would elect to haul large quantities of sewage off-site, by tanker truck, to other communities with wastewater disposal facilities and capacity to accept liquid wastes from dischargers in the Malibu Civic Center area. As discussed in the technical staff report (Technical Memorandum #5), a subset of ten commercial dischargers haul about 7% of their sewage (almost 2 million gallons) from the Malibu Civic Center area to communities that have wastewater treatment facilities. This need results from on-site hydrogeologic limitations and/or facility limitations. The hauling practice already has impacts to traffic, odor, and aesthetics, and staff did not deem this to be a practical alternative on a larger scale (capable of handling flows of about 250,000 gpd to 300,000 gpd) and on a long-term basis, for reasons among which include:

- Tanker truck capacities are small, ranging from 2,500 gallons to 7,000 gallons.
- Public nuisances, including noise and odor, have been observed during the pumping of raw sewage at various commercial facilities for transfer into the tanker trucks.
- Round trips for the tanker trucks are between 60 miles and 180 miles (including routes through other communities), and are expected to have adverse impacts on roads and transportation flows.
- Air quality impacts from diesel emissions would be significant.
- Staff estimates that this practice of managing raw sewage contributes to climate change, at a rate of 250 tons of carbon dioxide per year.

Program Alternative 1– Local Government Initiative

Under program alternative 1, a municipality, utility or other local authority would provide community services to collect and dispose/reuse wastewater in the Malibu Civic Center area in a manner that will restore water quality and beneficial uses of impaired waters.

While a local government may be an existing entity, such as the City of Malibu or and existing utility or other government authority, it also may be a newly formed utility or government authority. California law provides for a number of institutional options for providing community services. For example, the City can contract for services from a nearby government entity that already has wastewater management capabilities and capacity. Alternatively, an existing utility,

DRAFT OCT 2 1 2009

such as the Los Angeles County Waterworks District No. 29, Malibu, or a regional water authority, such as the West Basin Municipal Water District, could expand their scope of services and provide wastewater management services, integrated with potable water services already offered to the Malibu Civic Center area. Such an option also offers the potential to manage wastewater as a resource for recycling. Finally, a private organization – while not a government entity – could nevertheless be formed by community members and stakeholders to provide wastewater management services.

Program alternative 1 – for a local government initiative – anticipates achieving water quality objectives and TMDL targets through compliance projects that would provide the community with wastewater services in compliance with federal and state regulations, water quality objectives, and the proposed prohibition. These compliance projects could include construction, operation, and maintenance of:

A. Integrated water resources management facilities that would collect and treat wastewaters in, and distribute recycled water from, a centralized plant within the community.

B. A community sewer collection system and interceptor sewer line to export sewage for treatment at a facility in another community.

C. Decentralized wastewater management facilities that would collect and treat and wastewaters in, and distribute recycled water from, small plants within the community.

An overview and analysis of conceptual projects, or options, that the community and stakeholders could implement to comply with these program alternatives is provided in the next section (Options for Compliance Projects). These compliance projects are expected to have positive environmental impacts, in that they are expected to reduce water quality impairments and help restore beneficial uses. However, these projects also have potential significant adverse impacts to the environment that would occur from the construction, operation, and maintenance these community facilities. These impacts, which are of relatively short duration, can either be mitigated or alternative projects to achieve water quality objectives may be available.

Program Alternative 2 – No Action

This "no action" program alternative assumes that neither the Regional Board nor a local government takes action to prohibit discharges from OWDSs. Although dischargers could voluntarily implement projects to achieve water quality objectives and TMDL targets, staff believes that this is unlikely. Staff's technical memos provide evidence that water quality objectives are not being met and there is no evidence that those objectives will be met in the future absent any additional action. Accordingly, under this program alternative, it is assumed that the cumulative rate of pollutant loading does not decline. As a result, this program alternative would result in continuing or worsening impairments to beneficial uses of the water resources in and around the Malibu Civic Center area, including:

DRAFT OCT 2 1 2009

- Malibu Valley groundwater, as a potential source of drinking water.
- beaches, for body contact recreation, and
- Malibu Creek and Lagoon, as support for aquatic and wildlife habitat, including rare, threatened, and endangered species.

Recommendation

Staff concludes that the proposed project (Regional Board prohibition) is the most environmentally advantageous program. Program alternative 2 (no action) is not a preferred alternative because, while it avoids impacts due to construction and operation of wastewater management projects, it allows continued impairment of beaches, Malibu Lagoon and Creek, and underlying groundwater.

Both the proposed project (Regional Board prohibition) and program alternative 1 (local government initiative) have potential to achieve water quality objectives and to restore beneficial uses. However, program alternative 1 relies on an existing or newly formed government entity to voluntarily plan, design, construct, and operate a project that would provide dischargers in the Malibu Civic Center area with community wastewater collection, treatment, and disposal services. Such a voluntary, or discretionary, effort is not currently available. Or, if such an initiative does form, it may not be able to act in a timely manner to complete projects to achieve water quality goals and restore beneficial uses. Therefore, program alternative 1 is not a preferred alternative.

DRAFT OCT 21 2009

Options for Compliance Projects

Introduction

The program alternatives in the previous section do not specify a particular project to achieve compliance,[2] and it will be the responsibility of the community and stakeholders to select a strategy for compliance. Project-level impacts to the environment will depend on the selected strategy and it will be the responsibility of a local government (local agency) to perform a specific project-level analysis and disclose those environmental impacts.

Nevertheless, the Regional Board can analyze and disclose, on a conceptual basis, foreseeable environmental impacts from possible projects that may be selected for compliance. Accordingly, in this section, staff provides an overview and analysis of three conceptual options, or projects, that the community and stakeholders could implement to comply with the proposed prohibition and program alternative 1 – the local government initiative. These possible compliance projects include:

A. "Integrated Facilities," including the construction and operation of a central wastewater treatment plant in the community, a local sewer collection system, and recycled water distribution system. The community may also elect to broaden the scope of such a project, in order to integrate these services with delivery of potable water supplies; however, for purposes of this analysis, a more limited scope was assumed.

B. "Interceptor Sewer," including construction and operation of a local sewer collection system and an interceptor sewer to export sewage for treatment at a facility in another community.

C. "Decentralized Facilities," including the construction and operation of small plants in the community, small sewer collection systems, and limited recycled water distribution systems.

These projects are expected to have positive environmental impacts, in that they are expected to reduce water quality impairments to:

- Groundwater – which has pollutants from OWDSs at levels that would impact human health should the community need groundwater as part of its potable water supply in the future.

- Malibu Lagoon – which has a nitrogen load from OWDSs at levels that contribute to eutrophication and impair habitat for aquatic life and wildlife.

- Nearby beaches – which consistently fail to meet standards set to protect swimmers and surfers from infectious disease resulting from incidental ingestion of or direct exposure to polluted water.

[2] The Regional Board is prohibited from specifying the manner of compliance with its regulations (Water Code § 13360).

3-1063

DRAFT OCT 2 1 2 0 0 9

However, these projects also have potential significant adverse impacts to the environment, which would occur from the construction, operation, and maintenance these facilities. These impacts, which are generally of relatively short duration, can either be mitigated or alternative means of compliance with the Regional Board prohibition may be available.

Summary of Economics

Wastewater costs for systems currently operating in the Malibu Civic Center area vary widely. Many residents had passive septic systems installed decades ago which, if replaced today, would roughly cost between $8,000 to $21,000. Maintenance costs for such systems are not significant; assuming a homeowner pumped sludge on a three-year schedule, operating and maintenance costs would be $600 (or $200 annually spread over three years). At the other extreme are capital costs for the wastewater management systems for larger commercial properties that generate high flows of wastewater relative to land available for plant and equipment and for subsurface disposal. For example, capital costs for the treatment system at Malibu Lumber – the most recent system to come on-line (in April 2009) – totaled millions of dollars.

To estimate costs for the three compliance projects considered in this analysis, staff assumed that the projects would be sized to replace the total existing OWDS capacity in the community, and that the projects would not be designed to accommodate increases in wastewater flows. Accordingly, all three compliance projects were sized to handle a flow of approximately 300,000 gpd.

Based on preliminary estimates for the three compliance projects considered in this analysis, capital costs, in today's dollars, would range from $17 million to $80 million, as follows:

Summary of Capital Costs for Compliance Projects

Components	Integrated Facilities	Interceptor Sewer to a:		Decentralized Facilities
		Hyperion Connection	Tapia Connection	
Local Sewer System	$7,800,000	$7,800,000	$7,800,000	$7,800,000
Interceptor Sewer	--	$49,000,000	$72,500,000	--
Treatment Plant(s)	$5,900,000	--	--	$5,800,000
Recycled Distribution System	$3,000,000	0	0	$3,000,000
Total	***$16,700,000***	***$56,800,000***	***$80,300,000***	***$16,600,000***

Also, in switching from OWDSs to one of the above projects, all dischargers would incur costs for abandonment of their systems. For a residential property, these costs are estimated to range from $1,700 to $2,700.

DRAFT OCT 2 1 2009

Compliance Project A – Integrated Water Resources Management Facilities

Under the "Integrated Facilities" method of compliance, the City of Malibu, an existing utility or local authority, or a newly formed utility or local authority would construct and operate a centrally located wastewater treatment plant, with a local sewer collection system and a local recycled water distribution system. Capital cost estimates for this compliance project total $16,700,000 and include the following major components and key assumptions:

Integrated Water Resources Management Facilities

Component	Capital Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Treatment Plant	$5,900,000	300,000 gpd capacity using activated sludge, filtration, and disinfection to produce a Title 22 recycled water for direct reuse.
		Cost of land not included.
Recycled Water Distribution System	$3,000,000	15,000 ft of 8-inch diameter pipe, to distribute 150,000 gallons of recycled water
		Construction Technique: Open Cut Trenching
		50% of flow recycled; 50% disposed to subsurface.
Total	***$16,700,000***	

For purposes of this preliminary analysis, staff assumed that there would be demand to directly reuse only half of the treated effluent (and a market analysis would need to be conducted to determine the community's capacity for recycling). Community planners may consider the promotion of additional uses for recycled water by requiring dual plumbing for any new development or retrofits.

Staff also assumed that the portion of treated effluent not recycled is discharged through subsurface methods, which will require a larger project footprint, unless the discharge can be integrated into management with other water projects such as stormwater treatment. As an alternative to subsurface disposal, the community may elect to consider an ocean outfall. Costs for construction of this outfall, additional treatment capabilities such as temperature controls for the treated effluent, and diffusers at the outfall, have not been included in this analysis.

Compliance Project B – Interceptor Sewer

Under the "Interceptor Sewer" method of compliance with the proposed prohibition, the community would design and construct a wastewater collection system in the Malibu Civic Center area that would feed into an interceptor sewer that exports the sewage out of the area to another community with wastewater treatment facilities. The nearest connections are sewers that are part of the Hyperion Wastewater Treatment Plant in El Segundo and the Tapia Water Reclamation Facility in Calabasas.

DRAFT OCT 2 1 2 0 0 9

Hyperion Interceptor Sewer: An interceptor sewer designed to export sewage to the Hyperion system is expected to require tunneling under the Pacific Coast Highway to the nearest connection point in Castellammare, which is 7-1/2 miles from the Civic Center area. Cost estimates for this compliance project total $56.800,000 and include the following major components and key assumptions:

Hyperion Interceptor Sewer

Component	Capital Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Interceptor Sewer Line	$49,000,000	40,000 ft of 24-inch diameter pipe, to export 300,000 gpd by gravity flow to a connection point in Castellammare.
		Connection fee of $1,700,000 included
		Construction Technique: Trenchless Tunneling
		California Department of Transportation permitting fees not included.
total	*$56,800,000*	

The interceptor sewer line costs include the capital costs of a local collection system, the interceptor line, and four wet well lift stations that would be needed for gravity flow transport of sewage with a vertical lift of 300 feet over 7-1/2 miles to a connection in Castellamarre.

DRAFT OCT 21 2009

Tapia Interceptor Sewer: An interceptor sewer designed to export sewage to the Tapia Water Reclamation Facility is expected to require tunneling under Las Virgenes Road and installation of pumps to lift the sewage to a connection point with the Tapia plant in Calabasas. Cost estimates for this compliance project total $80,300,000 and include the following major components and key assumptions:

Tapia Interceptor Sewer

Component	Capital Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Interceptor Sewer Line	$72,500,000	58,000 ft of 24-inch diameter pipe, to export and lift 300,000 gpd by pressurized flow Tapia.
		Connection fee of $1,700,000 included
		Construction Technique: Trenchless Tunneling
		Permitting fees not included.
total	*$80,300,000*	

The interceptor sewer scenario includes capital costs for the local collection system, the interceptor line, and ten wet well lift stations needed to lift and transport the sewage 800 vertical feet over a distance of 11 miles to the Tapia connection.

Compliance Project C – Decentralized Wastewater Management Facilities

Under the "Decentralized Facilities" method of compliance, the City of Malibu, an existing utility or local authority, or a newly formed utility or local authority would construct and operate small plants in the community, small sewer collection systems, and limited recycled water distribution systems. Or, alternatively, such projects could be led by private sector developers. Cost estimates for this compliance project total $16,600,000 and include the following major components and key assumptions:

DRAFT OCT 21 2009

Decentralized Wastewater Management Facilities

Component	Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Treatment Plant 1	$1,200,000	67,000 gpd capacity using activated sludge, filtration, and disinfection to produce a Title 22 recycled water for direct reuse.
		Cost of land not included.
Recycled Water Distribution System Treatment Plant 1	$600,000	3,000 ft of 8-inch diameter pipe, to distribute Construction Technique: Open Cut Trenching
		50% of flow recycled; 50% disposed to subsurface.
Treatment Plant 2	$4,600,000	233,000 gpd capacity using activated sludge, filtration, and disinfection to produce a Title 22 recycled water for direct reuse.
		Cost of land not included.
Recycled Water Distribution System Treatment Plant 2	$2,400,000	12,000 ft of 8-inch diameter pipe, to distribute Construction Technique: Open Cut Trenching
		50% of flow recycled; 50% disposed to subsurface.
Total	***$16,600,000***	

For purposes of this preliminary analysis, staff assumed that there would be demand to directly reuse only half of the treated effluent, and a market analysis would need to be conducted to determine the capacity for recycling within each sector served by the treatment plants. Community planners may consider the promotion of additional uses for recycled water by requiring dual plumbing for any new development or retrofits. Staff assumed that effluent that could not be recycled is discharged via subsurface mechanisms, which would require more land. Staff did not expect that an ocean outfall for the non-recycled portion of the treated effluent would be practical for these smaller scale plants.

DRAFT OCT 21 2009

3-1068

DRAFT OCT 21 2009

Environmental Checklist and Discussion

The Regional Board has endeavored to analyze and disclose impacts to the environment that are expected to result from possible projects that would achieve compliance with the proposed Regional Board prohibition. These compliance projects, described in the previous section, include construction, operation, and maintenance of:

A. "Integrated Facilities," including the construction and operation of a central wastewater treatment plant in the community, a local sewer collection system, and recycled water distribution system. The community may also elect to broaden the scope of such a project, in order to integrate these services with delivery of potable water supplies; however, for purposes of this analysis, a more limited scope was assumed.

B. "Interceptor Sewer," including construction and operation of a local sewer collection system and an interceptor sewer to export sewage for treatment at a facility in another community.

C. "Decentralized Facilities," including the construction and operation of small plants in the community, small sewer collection systems, and limited recycled water distribution systems.

These compliance projects are expected to have positive environmental impacts, in that discharges through OWDSs should cease, resulting in improvement to water quality and restoration of beneficial uses. However, these projects also have some potential significant adverse impacts to the environment that would occur from the construction, operation, and maintenance of these community facilities, and from abandonment of OWDSs currently in use. These impacts, which are generally of relatively short duration, can either be mitigated or alternative means of compliance with the Regional Board prohibition may be available.

The impacts from the possible compliance projects are analyzed below on a conceptual basis. A review of possible projects[1] and a more detailed, project specific analysis should be led by community leaders with robust participation among stakeholders. It will be the responsibility of the community and stakeholders to select a strategy for compliance. And as a strategy and compliance project are selected, it will be the responsibility of a local government (local agency) to perform a specific project-level analysis and disclose environmental impacts in accordance with CEQA.

[1] The Regional Board is prohibited from specifying the manner of compliance with its regulations (Water Code § 13360).

3-1069

ENVIRONMENTAL CHECKLIST		Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
1.	**Earth. Will the proposal result in:**				
	a. Unstable earth conditions or in changes in geologic substructures?		X		
	b. Disruptions, displacements, compaction or overcoming of the soil?		X		
	c. Change in topography or ground surface relief features?				X
	d. The destruction, covering or modification of any unique geologic or physical features?				X
	e. Any increase in wind or water erosion of soils, either on or off the site?		X		
	f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion which may modify the channel of a river or stream or the bed of the ocean or any bay, inlet or lake?			X	
	g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?		X		

Discussion:

a. Many of the areas where the compliance projects would be located are already developed and significantly altered, and the projects would not subject people or structures to seismic risk or unstable soils identified on seismic/soil hazard maps. However, portions of the Interceptor Sewer and portions of the collection system for all compliance projects might be constructed through zones of slope instability. During this construction period, compliance with standard design and construction specifications and implementation of recommendations to mitigate geologic hazards, prepared at a project level, would reduce the risk of geologic hazards Such mitigation measures could include among others: shoring sufficient for each excavation, proper location of excavated stockpiled soils, adequate setback from slopes and structures, appropriate compaction of backfilled soils, dewatering excavations as necessary of ground water, and controlling surface run on from stormwater or irrigation.

b. Implementation of any of the compliance projects would disturb soils during excavations and trenching for sewers, pump stations, and/or recycled water distribution lines, and also during foundation work for treatment plant facilities for the Integrated Facilities and Decentralized Facilities. To the extent that any soil is disturbed during construction, standard construction techniques, including but not limited to, shoring, piling and soil stabilization would mitigate any potential impacts. Prior to earthwork, geotechnical studies would be conducted to evaluate geology and soil conditions.

DRAFT OCT 21 2009

Upon completion of any of the compliance projects, trenching for lateral sewer lines and proper abandonment of existing OWDSs may disturb soils. Standard and accepted engineering practices and techniques for stabilizing soils and minimizing erosion and sedimentation during trenching and installation activities should mitigate these impacts, and would be further evaluated on a project basis.

c. No impact, as infrastructure for the compliance projects could be of a size or scale that minimizes impact to topography and relief.

d. No impact as pre-construction studies and mapping should identify any unique structures or features and geologic mapping during excavations would identify potential problems missed during earlier investigations.

e. For all compliance projects, construction activities would require soil displacement and could result in the loss of topsoil. Trenching equipment would be required to install sewer lines, interceptor line, and recycled water delivery lines. Construction activities would include the use of machinery for rough and final grading. To mitigate these impacts, topsoil could be stockpiled and standard best management practices (BMPs), such as minimizing the size and duration of exposed stockpiles, managing stormwater, and revegetating replaced soils as soon as practicable, could be identified and implemented to prevent/control erosion from water and wind.

f. Portions of all compliance projects would occur in loosely consolidated beach sands due to the location near former shorelines. As documented in 1(e) above, construction activities would require soil displacement. Trenching equipment would be required to install sewer lines, an interceptor line, and recycled water delivery lines. Construction activities would include the use of machinery for rough and final grading. To mitigate these impacts, standard BMPs, such as covering and minimizing the amount of disturbed/stockpiled soil and controlling runon/runoff, would be identified and implemented to prevent/control erosion from water and wind.

g. Portions of the Interceptor Sewer and portions of the the collection system for all compliance projects might be sited and constructed in zones of slope instability identified in published seismic/soil hazard maps. As documented in 1(a) above, compliance with accepted standard engineering design and construction specifications and implementation of measures (such as sufficient shoring for each excavation, proper location of excavated stockpiled soils, adequate setback from slopes and structures, appropriate compaction of backfilled soils, dewatering excavations as necessary of ground water, and controlling surface run on from stormwater or irrigation) to mitigate geologic hazards, prepared at a project level, would reduce the risk of geologic hazards.

DRAFT OCT 21 2009

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
2.	**Air. Will the proposal result in:**				
	a. Substantial air emissions or deterioration of ambient air quality?		X		
	b. The creation of objectionable odors?		X		
	c. Alteration of air movement, moisture or temperature, or any change in climate, either locally or regionally?			X	

Discussion:

a. All compliance projects would be located in the South Coast Air Basin, which is classified as an extreme non-attainment area for ozone and serious non-attainment area for PM_{10} and CO. Due to a coastal influence in the area, air quality is generally considered better than much of the South Coast Air Basin.

During construction of all compliance projects, short-term increases in traffic (from construction equipment as well as idling cars) and short-term use of construction equipment would increase air emissions and generate minor amounts of NOx, CO, SO_2, ROG, and PM_{10}; these emissions would be quantified during planning and design at the project level. With mitigation measures, these emissions should be within the South Coast Air Quality Management District's construction significance thresholds. Measures to mitigate these impacts might include use of construction and maintenance vehicles with lower-emission engines, use of soot reduction traps or diesel particulate filters, and use of emulsified diesel fuel.

During operation of treatment facilities associated with the Integrated Facilities, Decentralized Facilities, and pump stations for local sewers associated with all compliance projects, maintenance activities and solid waste removal are not expected to significantly increase air emissions. Furthermore, solid waste removal schedules could be synchronized with general trash removal schedules.

b. All compliance projects have the potential to eliminate existing odors from problematic OWDSs and from pumping excess sewage into tanker trucks for off-site hauling. However, the projects may also create odors during construction (which would be of a short-term nature) and during operation of facilities such as the Integrated Facilities and Decentralized Facilities. The potential for such odors would be evaluated during planning and design at the project level. Mitigation measures, such as siting, design, and buffer zones, would be identified and considered at a project level.

c. No significant impact as construction activities would not increase air emissions to an extent that affects air movement, moisture or temperature, or change in climate.

DRAFT OCT 21 2009

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
3.	**Water. Will the proposal result in:**				
	a. Changes in currents, or the course of direction or water movements, in either marine or fresh waters?				X
	b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X	
	c. Alterations to the course of flow of flood waters?		X		
	d. Change in the amount of surface water in any water body?			X	
	e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?		X		
	f. Alteration of the direction or rate of flow of ground waters?	X			
	g. Change in the quantity or quality of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	X			
	h. Substantial reduction in the amount of water otherwise available for public water supplies?				X
	i. Exposure of people or property to water related hazards such as flooding or tidal waves?			X	

Discussion:

a. No changes in currents or surface water flow are expected because the proposed project and the potential compliance projects are not expected to discharge to any surface waters and create this impact.

b. Decreases in absorption rates, drainage patterns, or the rate and amount of surface water runoff from hardscape at the plant(s) for the Integrated Facilities and Decentralized Facilities are expected to be minimal because the design and construction of these facilities would have to consider and address these factors. These impacts would be evaluated at the project level, and minimized through siting and design of the facilities during the planning stages.

c. Alterations to the course of flow of flood waters may be expected but the compliance projects will have be designed, constructed and operated to take into account the flow of flood waters when the site of the facilities are determined. The City is aware of the flood hazards, as described in the Malibu General Plan, section 7.3.3.1, and will be expected to ensure through its oversight

DRAFT OCT 21 2009

of the design and construction of compliance projects that the sites will account for such hazards. The City will determine the appropriate mitigation measures.

d. No change in the amount of flow of surface water is expected because neither the proposed project nor the compliance projects are expected to discharge flows into surface waters. To the extent that groundwater is dewatering during construction and discharged into surface waters, it is not expected that such discharges will change the amount of flow of surface waters significantly.

e. Water quality problems, including eutrophication in Malibu Lagoon and pathogen levels at beaches that necessitate beach advisories, are well known in the area. Implementation of compliance projects is expected to improve, over the long-term, the quality of surface waters in the area and to restore beneficial uses.

   However, during construction of all of the compliance projects, possible short-term impacts may result. The potential for such impacts, such as increased turbidity and sediment in runoff from construction sites and groundwater dewatering, would be evaluated during planning and design at the project level. Mitigation measures, such as treatment of dewatered groundwater prior to discharge during construction and construction BMPs (such as berms, fiber blankets, soil cover, temporary vegetation) to control pollution in stormwater, would be identified and considered at a project level.

   Furthermore, for compliance projects such as the Integrated Facilities, there may not be sufficient demand for recycling of all of the wastewaters, and a portion of the 300,000 gpd flow may need to be discharged. Should areas with favorable hydrogeologic conditions for subsurface disposal not be identified, such projects may require export of the treated wastewater through an outfall. With proper design and operation of treatment facilities and outfall equipment such as diffusers and temperature controls, an outfall discharge should meet water quality objectives, including temperature and turbidity. These impacts, together with mitigation measures, would be considered at a project level.

f. Upon operation of all compliance projects, termination of discharges from OWDSs would alter, on a local scale, groundwater flow patterns because the discharges from the OWDSs will cease. Should subsurface disposal mechanisms be used for all or a portion of the discharge from the Integrated Facilities and Decentralized Facilities, groundwater flow patterns could be altered on a larger scale. Proper design and siting of the subsurface disposal mechanisms will be necessary to mitigate this impact to the extent possible.

   In anticipation of restoration of groundwater quality, integrated planning and design for disposal field sites should consider potential sites for future production wells to meet a portion of the community's potable water needs or as a short-term water supply in the event of disrupted delivery from the Los Angeles County Waterworks District No. 29 – Malibu. Future groundwater production would significantly alter the direction and rate of flow of groundwater. These and other impacts would be evaluated during planning and design at the project level, and monitored during operation of disposal mechanisms. Possible mitigation measures could include planning efforts to determine the safe yield of the basin and the minimum discharge required for Malibu Creek and Lagoon for aquatic life protection.

g. One of the goals of the Regional Board's proposed prohibition is to improve the quality of groundwater and restore this resource as a potential source of drinking water. This would be a potentially significant beneficial impact. See also 3(f) above.

h. No reduction to public water supplies is expected. One of the goals of the Regional Board's proposed prohibition is to improve the quality of groundwater and restore this resource as a potential source of drinking water. See also 3(f) above.

3-1074

DRAFT OCT 2 1 2009

i. The Malibu General Plan, section 7.3.3.1 states that tsunamis can be expected rarely from distant sources but may be generated offshore by surface ground rupture or submarine landslides. Damage to the Malibu Civic Center area due to flooding from such events can be expected. The Malibu Building Code, specifically Chapter 15.20, contains mitigation measures for flood impacts. Such mitigation includes: requiring bulkheads or other protective barriers be installed at time of construction, control the creation of hazards that contribute to flood, control the location of facilities, and prevent the construction of flood barriers that may increase flood hazards in other areas.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
4.	**Plant Life. Will the proposal result in:**				
	a. Change in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, microflora and aquatic plants)?		X		
	b. Reduction of the numbers of any unique, rare or endangered species of plants?		X		
	c. Introduction of new species of plants into an area, or in a barrier to the normal replenishment of existing species?				X
	d. Reduction in acreage of any agricultural crop?				X

Discussion:

a. As much of the Malibu Civic Center area is urbanized, construction and operation of facilities associated with all compliance projects would not disturb or change plant diversity or change or reduce the number of unique, rare, or endangered species of plants. However, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including special-status species and habitats, wetlands, and trees protected under local ordinances or policies. Important plant communities include the coastal salt marsh and coastal stand. The diversity of species, or number of any species of plants, could be maintained by siting and/or by preserving plants prior, during, and after the construction of facilities by re-establishing and maintaining the plant communities after construction. The City of Malibu's Technical Advisory Committee has completed studies on the ecosystem of Malibu Valley and generated documents recommending the enhancement of the plant and animal life to replicate historic conditions. These plans can provide specific options for the mitigation of removal of plant and animal life through project construction and result in an enhanced ecosystem upon completion.

b. As documented in 4(a) above, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including unique, rare or endangered species of plants. When the specific projects are developed and sites identified, a search of the California Natural Diversity Database could be employed to confirm that any potentially sensitive plant species or biological habitats in the site area are

DRAFT OCT 21 2009

properly identified and protected as necessary. Focused protocol plant surveys for special-status-plant species could be conducted. Responsible agencies should endeavor to avoid compliance measures that could result in reduction of the numbers of any unique, rare or endangered species of plants. If sensitive plant species occur on a project site, a local agency should require mitigation in accordance with the Endangered Species Act. These mitigation measures would be developed in consultation with the California Department of Fish and Game (CDFG) and the United States Fish and Wildlife Service (USFWS). Also, see 4(a) above.

c. No impact because the use of an existing ecosystem study to choose landscaping, as described in 4(a), should minimize the invasion of foreign species.

d. No impact because, according to the Malibu General Plan, page 1-13, traditional ranching and farming is only practiced in a minute fraction of land within the City. Horticulture and horse ranches are more prevalent, usually as a transitional use or adjunct to residential use.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
5.	**Animal Life. Will the proposal result in:**				
	a. Change in the diversity of species, or numbers of any species of animals (birds, land animals including reptiles, fish and shellfish, benthic organisms, insects or microfauna)?		X		
	b. Reduction of the numbers of any unique, rare or endangered species of animals?		X		
	c. Introduction of new species of animals into an area, or result in a barrier to the migration or movement of animals?				X
	d. Deterioration to existing fish or wildlife habitat?		X		

Discussion:

a. As much of the Malibu Civic Center area is urbanized, construction and operation of facilities associated with all compliance projects would not disturb or change the diversity of animal species or change or reduce the numbers of any of species. However, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including the wetlands and riparian habitat. Malibu Lagoon is a refuge for migrating birds. When specific projects are developed and sites identified, measures should also be identified to avoid and mitigate impacts to habitat and direct impacts to animals and wildlife during construction and operation. The City of Malibu's Technical Advisory Committee has completed studies on the ecosystem of Malibu Valley and generated documents recommending the enhancement of the plant and animal life to replicate historic conditions. These plans can provide specific options for the mitigation of removal of plant and animal life through project construction and result in an enhanced ecosystem upon completion.

DRAFT OCT 2 1 2009

b. As documented in 5(a) above, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including unique, rare or endangered species of animals. Construction activities may be proposed within and/or adjacent to areas potentially supporting these species and may result in the temporary and/or permanent modification of their habitat. When the specific projects are developed and sites identified, a search of the California Natural Diversity Database could be employed to confirm that any potentially special-status animal species in the site area be properly identified and protected as necessary. When specific projects are developed and sites identified, measures should be identified that will avoid or mitigate impacts to the habitats and also direct impacts to animals during construction and operation. If a project site is located in a habitat for a sensitive animal species, a local agency should require mitigation in accordance with the Endangered Species Act. These mitigation measures would be developed in consultation with the California Department of Fish and Game (CDFG) and the United States Fish and Wildlife Service (USFWS). See 5(a) above.

c. No impact because the projects will not introduce new species nor will the compliance projects be sited to be barriers to the movement of animals. Proper design and siting analysis will prevent this factor from being a concern .

d. As documented in 5(a) above, portions of the area are environmentally sensitive and, should facilities be located in a habitat supporting fish or wildlife habitat, some short-term deterioration to this habitat might occur during construction. When specific projects are developed and sites identified, standard BMP measures such as soil coverings, fiberglass barriers, and fencing, should be identified that will avoid or mitigate impacts to habitat and to animals during construction and operation.

However, it is expected that all the compliance projects will, over the long-term, considerably improve habitat for aquatic life and wildlife.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
6.	**Noise. Will the proposal result in:**				
	a. Increases in existing noise levels?		X		
	b. Exposure of people to severe noise levels?		X		

Discussion:

a. During construction, all compliance projects would be expected to result in noise and/or vibration. When specific projects are developed, measures should be identified to ensure that noise is kept to levels that comply with any noise standard or ordinance. Mitigation could include requirements for mufflers on noise emitting equipment, or construction during certain times of the day.

During operation, no significant increase in noise is anticipated from any of the possible compliance projects. Design of buildings to capture and muffle noise could be required. There

DRAFT OCT 21 2009

may be a reduction in noise on commercial sites that on tanker trucks to regularly pump raw sewage for off-site hauling once these sites are connected to one of the compliance projects.

b. As noted in 6(a) above, all compliance projects would be expected to result in noise and/or vibration during construction. Machinery used for construction would likely include standard equipment such as graders, dozers, backhoes, and other similar equipment. It is unknown at this time if pile driving equipment would be required to construct any facilities. Noise impacts from vehicles, machines, and equipment, would be short-term and of a temporary duration. When specific projects are developed, measures, such as requiring mufflers on equipment or construction during certain times of the day, should be identified to ensure that noise is kept to levels that comply with any noise standard or ordinance.

During operation, no significant increase in noise is anticipated from any of the possible compliance projects.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
7.	**Light and Glare. Will the proposal:**				
	a. Produce new light or glare?		X		

Discussion:

a. Construction of the compliance projects is not likely to produce new light or glare, unless construction is done at night. For the Interceptor Sewer, however, should construction night-time schedules be used to mitigate traffic impacts during construction, additional lighting will be needed. Such impacts, which would be short-term, should be evaluated at the project level. Mitigation measures could include hoods or shields to direct lighting down onto the work areas.

During operation of all compliance projects, no need for significant lighting is expected. For lighting that may needed, light and glare to passing vehicles, neighborhood homes, and businesses during operation, can be minimized by a lighting plan specifying hoods or shields on all light fixtures and limiting light trespass and glare through the use of shielding and directional lighting methods.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
8.	**Land Use. Will the proposal result in:**				
	a. Substantial alteration of the present or planned land use of an area?	X			

3-1078

DRAFT OCT 2 1 2009

Discussion:

a. The proposed prohibition is intended to be growth neutral, and not have a direct impact on population and housing. Under California law, each county and city must prepare a comprehensive, long term general plan to guide its future. In general plans, counties and cities must address a minimum of seven elements, including housing. The City of Malibu and County of Los Angeles have adopted general plans and amended these plans. Through the general planning process as well as zoning and other land use authorities, the City and the County have authority to meet community goals, including land use goals.

Sewer lines for all three compliance projects should not have impacts on land use, zoning, or the physical arrangement of the community. After installation of the sewer lines, pre-project conditions would be restored.

Land for treatment plant facilities for the Integrated Facilities and Decentralized Facilities might require changes in land use. The Integrated Facilities' wastewater/recycled water plant would require land for construction and operation of this facility. Should disposal of treated wastewater that cannot be recycled be discharged to the subsurface, additional land for infiltration would be required. The Decentralized Facilities also would require land for plant(s) and subsurface disposal, although such land requirements may be on a smaller scale and require a smaller footprint. Impacts would be considered at a project level since the location selected will likely determine if there is a "substantial alteration of the land use of the area. Possible mitigation would involve careful consideration of the siting of the facilities to meet community goals, in accordance with local plans and zoning codes.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
9.	**Natural Resources. Will the proposal result in:**				
	a. Increase in the rate of use of any natural resources?				X
	b. Substantial depletion of any nonrenewable natural resource?				X

Discussion:

a. No impact. The compliance projects would not use or deplete any mineral resources in the area. The use of electrical power and fuel is discussed in the Energy portion of the checklist.

During operations, no impact to natural resources is anticipated, other than land. See the discussion under Land – 8(a).

b. No Impact. See Natural Resources – 9(a) above.

DRAFT OCT 2 1 2 0 0 9

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
10.	**Risk of Upset. Will the proposal involve:**				
	a. A risk of an explosion or the release of hazardous substances (including, but not limited to: oil, pesticides, chemicals or radiation) in the event of an accident or upset conditions?		X		

Discussion:

a. For all compliance projects, it is reasonably foreseeable that hazards or hazardous materials would be used during construction, operation, and maintenance of the facilities. However, the use of these materials is not expected to create a significant hazard to the public or environment through the routine transport, use, or disposal of hazardous materials. The hazardous materials that might be used are controlled substances regulated at the state and local levels. Materials would be delivered by contractors licensed to handle and transport these materials in accordance with applicable laws and regulations. The storage and use of materials would be strictly regulated and a hazardous materials management program would be developed for use by construction contractors and plant operators. This information would also be filed with the fire department. See also the discussion under 14(a). Mitigation could be a requirement that all handlers/transporters receive education about the federal, state and local laws, ordinances, regulations and statutes that govern safe handling/transport of hazardous materials.

Proper design of sewer and plant facilities for all compliance projects, with appropriate redundancy, backup systems, and alarms would lower risk of upset during operation of the plant and sewer facilities for all compliance projects. Backup electrical generators to ensure uninterrupted power supply (redundancy requirement) could be installed to monitor release of hazardous substances in the event of an accident, upset condition, or natural disaster. A warning system could be designed and operated to ensure that responsible personnel provide quick and effective response. During operation, early detection of potential failures can be improved through frequent inspections and wastewater testing. Operators should be trained and certified, and have a safety plan in place for upset conditions. Periodic video surveys of sewer lines could detect rooting or corrosion, allowing for appropriate maintenance and repair to prevent sewer line rupture.

Due to the nature (wastewater management) of all compliance projects, the risk of exposure to raw sewage and partially treated wastewater should be lowered, as the projects are intended to better control and manage wastewaters generated within the community. During abandonment of existing OWDSs, the risk of accidental release of hazardous material can be lowered by complying with local codes for proper decommissioning such systems. See section 16(d).

DRAFT OCT 21 2009

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
11.	**Population. Will the proposal:**				
	a. Alter the location, distribution, density, or growth rate of the human population of an area?			X	

Discussion:

a. All compliance projects would replace existing on-site wastewater disposal systems, and should not affect population and growth. However, during construction of all compliance projects, there may be brief, temporary periods during which construction workers are employed in the area. These workers are not expected to substantially add to new employment and population density.

The compliance projects are expected to be sized to replace existing OWDS flows only, and no population increases are expected. However, depending upon the location of the compliance projects, some of these factors may be impacted. Without a specific compliance project to analyze, any discussion would be speculative. See the discussion under Housing – 12(a).

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
12.	**Housing. Will the proposal:**				
	a. Affect existing housing, or create a demand for additional housing?		X		

Discussion:

a. The proposed prohibition is intended to be growth neutral, and should not have a direct impact on population and housing. However, the project could have an effect on existing housing. The City of Malibu, in its General Plan section 3.3.3, has a strategy of using individual septic systems as a means of reducing the rate and intensity of growth. The building of any of the compliance projects could undermine that strategy. As mitigation, the City of Malibu could update its General Plan to develop a new strategy for reducing the rate and intensity of growth. If none of the compliance projects are developed, the impact could be that all housing is affected adversely. However, that is not a reasonably foreseeable outcome.

The proposed prohibition will not create a demand for additional housing, nor will the development of any compliance project. By itself, the building of some type of community treatment system should not create a demand for additional housing. Further, the Malibu General Plan section 7.3.3.1 states that the opportunity for development of housing is constrained by geologic hazards, flood hazards, and wildland and urban fire hazards. Also, slope instability,

DRAFT OCT 21 2009

expansive soils, and high groundwater are additional constraints on development. Therefore. it seems unlikely that this project will create a demand for additional housing.

Through the general planning process as well as zoning and other land use authorities, the City and the County have the tools to meet community goals, including housing goals.

During construction of all compliance projects, there may be brief, temporary periods during which construction workers are employed in the area. These temporary workers are expected to be present for one shift per work day, and should not add to housing demands.

The compliance projects will presumably be sized to provide capacity for existing wastewater flow rates or for whatever level of growth that the City decides. During operation of all compliance projects, no increased demand for housing stemming from job creation at the compliance projects is anticipated.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
13.	**Transportation/Circulation. Will the proposal result in:**				
	a. Generation of substantial additional vehicular movement?	X			
	b. Effects on existing parking facilities, or demand for new parking?		X		
	c. Substantial impact upon existing transportation systems?	X			
	d. Alterations to present patterns of circulation or movement of people and/or goods?			X	
	e. Alterations to waterborne, rail or air traffic?				X
	f. Increase in traffic hazards to motor vehicles, bicyclists or pedestrians?	X			

Discussion:

a. Construction of all three compliance projects would require construction crews and earthmoving equipment, and may require soil transport, resulting in some traffic congestion of a short-term, temporary duration. Measures to mitigate these impacts, which would be examined more closely on a project level, could include development of a traffic mitigation plan. For the Interceptor Sewer, a project level analysis should consider night-time schedules for construction along the Pacific Coast Highway, which is the most heavily traveled highway in the area and which is an important regional link. This may be a significant adverse impact for a short duration.

DRAFT OCT 2 1 2 0 0 9

During operation of the compliance projects, no impacts are expected to traffic. Traffic conditions may improve upon completion of the compliance projects, as the need for frequent pumping from many commercial facilities will be eliminated.

b. During construction, all compliance projects may cause some loss of parking capacity. However, this impact is temporary. Measures to mitigate such impacts would be examined more closely on a project level, and could include development of a traffic mitigation plan which addresses parking issues, such as park-and-ride lots or temporary increased public transportation.

During operation, no significant impacts are expected.

c. During construction, all compliance projects may impact existing roadways and parking capacity. The Treatment Plants and Interceptor Sewer project would have significant impacts on vehicle traffic on the Pacific Coast Highway; however, this impact will be temporary and limited to the construction phase and for intermittent maintenance activity. Impacts would be examined more closely on a project level, and measures to facilitate traffic movement, such as minimizing construction traffic in peak traffic times and providing temporary traffic signals/flagging could be developed in a traffic mitigation plan.

During operation, no significant impacts are expected

d. During construction of the compliance projects, there may be temporary less than significant impacts to present patterns of circulation due to temporary road closures or detours. No impacts from operation of the compliance projects is expected.

e. No impact. No waterborne, air, or rail traffic is expected to be generated from any of the compliance projects during construction or operation.

f. No permanent road or design hazards are associated with operation of any of the possible compliance projects. However, during construction, all three compliance projects would require construction crews, earthmoving equipment, and – for Interceptor Sewer – possible night-time construction activity. These activities would result in some traffic congestion of a short-term, temporary duration. Hazards arising from such conditions would be considered at a project level, and measures to lower risk to vehicles, bicyclists, and pedestrians might include signage and markings, barricades, and traffic flow controls (signals or traffic control personnel), and coordination with local police and the California Highway Patrol. These methods would be selected and implemented by responsible local agencies considering project level concerns.

DRAFT OCT 21 2009

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
14.	**Public Service. Will the proposal have an effect upon, or result in a need for new or altered governmental services in any of the following areas:**				
	a. Fire protection?		X		
	b. Police protection?			X	
	c. Schools?				X
	d. Parks or other recreational facilities?	X			
	e. Maintenance of public facilities, including roads?				X
	f. Other governmental services?				X

Discussion:

a. Construction of all three compliance projects, and operation of the treatment facilities for the Integrated Facilities and Decentralized Facilities would use hazardous materials, and incidents of upset, such as spills, could result in the need for emergency and/or fire suppression response. Traffic impacts during construction of all compliance projects could result in delays in emergency responses; however, most jurisdictions have in place established procedures to ensure safe passage of emergency vehicles during periods of road maintenance, construction, or other attention to physical infrastructure. Impacts to fire protection and response capabilities, and measures to mitigate these impacts, would be considered at a project level.

b. Mitigation of traffic impacts during construction of all compliance projects would require coordination with local police and the California Highway Patrol. See the discussion under 13(f). These impacts could result in delays in police emergency responses; however, most jurisdictions have in place established procedures to ensure safe passage of emergency vehicles during periods of road maintenance, construction, or other attention to physical infrastructure. Impacts to police protection and response capabilities, and measures to mitigate these impacts, would be considered at a project level.

No impact during operation of any of the compliance projects.

c. No impact is expected to schools, as none of the compliance projects is expected to add new students to elementary, middle, or high schools or to Pepperdine University.

d. See the discussion of land use impacts under 8(a) above and recreational impacts under 14(a) below. The Integrated Facilities – a centralized integrated wastewater/recycled water plant – would require land for construction and operation of this facility. Impacts to parks and measures to mitigate these impacts would be considered at a project level.

DRAFT OCT 2 1 2009

Compliance with the proposed prohibition is a remedy to restore beneficial uses, including avoiding beach closures that currently impair swimming along beaches in the Malibu Civic Center area.

e. No impact to maintenance of public roads is expected. During sewer installation of all three compliance projects, the City of Malibu and other entities with utilities along the public roads will coordinate maintenance and repair activities.

Positive impacts (lower road maintenance) might result from a reduction in tanker truck traffic that will no longer be needed to haul a portion of the community's sewage to facilities in other areas (e.g. Carson).

f. No impact, because it is likely that the City would re-direct its efforts to oversee its existing strategy of OWDS management in the Malibu Civic Center area to an area-wide wastewater collection and treatment strategy, to achieve compliance with the proposed prohibition. Should the City decide to pursue an integrated strategy of managing stormwater, wastewater, and recycled water, it may be better positioned to accomplish conservation and environmental goals.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
15.	**Energy. Will the proposal result in:**				
	a. Use of substantial amounts of fuel or energy?			X	
	b. Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy?			X	

Discussion:

a. During the construction phase of all compliance projects, construction vehicles, equipment, and machinery would require fossil fuel and/or power. These energy demands are not expected to significantly affect the power grid or deplete resources of fossil fuels; nor are the energy demands expected to conflict with energy conservation plans or use non-renewable resources in a wasteful manner. Such impacts, and measures to promote energy efficiency, would be evaluated on a project basis.

As design of treatment plant facilities for Integrated Facilities, Decentralized Facilities and pumping stations to lift wastewater in sewers for all compliance projects is expected to be subject to building codes with energy conservation requirements, operation is expected to result in an incremental amounts of energy, and demand on the power grid is expected to be minimal. Such impacts, and measures to promote energy efficiency, would be evaluated on a project basis.

b. Energy needed for existing OWDSs ranges from zero (for passive septic systems) to low power consumption (for advanced OWDSs). During operation of a compliance project, the demand for energy will increase, as energy would be needed to power lift pumps for the collection system and interceptor sewer, and/or treatment plant. This increase is

DRAFT OCT 21 2009

estimated to range from 300 kilo-watt hours per day to 1,500 kilo-watt hours per day, and is not expected to be a significant impact. Nor are any of the compliance projects expected to result in the need for a new source of energy. Impacts would be evaluated on a project basis.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
16.	**Utilities and Service Systems. Will the proposal result in a need for new systems, or substantial alterations to the following utilities:**				
	a. Power or natural gas?			X	
	b. Communications systems?				X
	c. Water?			X	
	d. Sewer or septic tanks?	X			
	e. Storm water drainage?		X		
	f. Solid waste and disposal?			X	

Discussion:

a. Refer to discussion under Energy, 15(a) and 15(b) above.

b. No impact as none of the compliance projects will place significant demands on existing communication systems.

c. Operation of the Integrated Facilities, if undertaken in conjunction with capital improvements to the community's water supply system, could improve the reliability of water service.

Furthermore, and by their nature, operation of all the possible projects to comply with the prohibition is expected to result in substantial improvements to water quality, including the quality of groundwater (which is a potential source of drinking water for the community, especially in the event of a disruption to deliveries of imported water supplies).

See also the discussion under Water, 3(g) above.

d. The purpose of the prohibition and possible compliance projects is to eliminate reliance on OWDSs, which have severe constraints, including hydrogeological, siting, capacity, and operational constraints. By the nature of the prohibition, elimination of the on-site systems will result in a need for sewers and treatment facilities. The elimination of these on-site systems will require septic tanks, leach fields or seepage pits to be properly abandoned or decommissioned in compliance with the Malibu Plumbing Code (which is Title 28, Plumbing Code, of the Los Angeles County Code, as amended and in effect on January 1, 2008, adopting the California

DRAFT OCT 2 1 2 0 0 9

Plumbing Code, 2007 Edition (Part 5 of Title 24 of the California Code of Regulations)) and/or any other appropriate ordinance, regulations or statutes.

e Refer to discussion under Water, 3(b), 3(c), 3(d), 3(e) above. All three proposed compliance projects would result in earth disturbances during construction activities which may impact storm water drainage. The disturbances would result from site grading and trenching for the construction of the wastewater treatment plant and lift stations, sewer collection systems, and pumped sewer lines. The impacts produced by the storm water run-on and run-off at construction sites could be mitigated by applying good engineering and management practices. Good practices could include construction during the dry season, appropriate soil compaction, slope stabilization, soil stock pile minimization, rapid re-vegetation of affected areas before the rainy season, reduced exposure time of disturbed areas, and appropriate management of storm water to avoid contact with unstable areas

f. During construction of all compliance projects, excavated soils should be re-used as fill material to the extent feasible. However, a minimal amount of soils and other construction materials may be wasted. For example, soils and aggregate wastes could be transported to aggregate recycling centers and prepared for reuse, and/or applied as daily cover at landfills. Wastes generated from the abandonment of existing OWDSs would be handled in compliance with Los Angeles County or City Plumbing Codes and Chapter 7 of the California Plumbing Code. These impacts, which are expected to be less than significant, would be evaluated on a project level.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
17.	**Human Health. Will the proposal result in:**				
	a. Creation of any health hazard or potential health hazard (excluding mental health)?		X		
	b. Exposure of people to potential health hazards?		X		

Discussion:

a. During construction of all three possible compliance projects, there may be an increased risk to the health of construction workers who may be handling hazardous materials. This would be evaluated on a project basis, and appropriate measures – such as Health and Safety Plans and compliance with Cal OSHA regulations – to mitigate these risks should be identified. For a discussion on the risk of Upset, refer to discussion under 10(a).

During operation of the wastewater treatment plants for the Integrated Facilities and Decentralized Facilities and during maintenance of sewers and pump stations for all compliance projects, operating personnel may be exposed to raw sewage and partially treated wastewaters. These possible impacts would be evaluated on a project basis and appropriate measures – such as Health and Safety Plans and compliance with Cal OSHA regulations to provide safety equipment and training – to mitigate these risks should be identified.

DRAFT OCT 21 2009

Due to the nature of the proposed prohibition and possible projects to comply with the prohibition, wastewaters from domestic, commercial, and industrial activities will be better controlled, treated, and discharged (or recycled).

b. See discussion under 17(a) above.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
18.	**Aesthetics. Will the proposal result in:**				
	a. The obstruction of any scenic vista or view open to the public?		X		
	b. The creation of an aesthetically offensive site open to public view?		X		

Discussion:

a. During construction of all three possible compliance projects, the aesthetics of residents and visitors may be offended by construction equipment and activities. These impacts, which would be temporary, together with appropriate mitigation measures such as temporary screens or landscaping, would be considered at a project level.

After installation of sewers for all three compliance projects, pre-project conditions would be restored, and the sewers would not permanently impact aesthetics.

After construction, facilities such as a treatment plant and reservoir for storing recycled water could impact scenic vistas or views open to the public. These impacts would be evaluated on a project level, and designs could be required in locations that are acceptable to the community. Mitigation could include ensuring that the design of the facilities considers appropriate and acceptable shapes, sizes, and colors of the facilities, re-establishment of vegetative cover in disturbed areas, landscaping of graded slopes, and installation of screens or fences. Irrigation with recycled water could result in more rapid growth of the new landscaping.

b. See discussion under 18(a) above.

DRAFT OCT 2 1 2 0 0 9

3-1088

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
19.	**Recreation. Will the proposal result in:**				
	a. Impact upon the quality or quantity of existing recreational opportunities?	X			

Discussion:

a. The Integrated Facilities – a centralized integrated wastewater/recycled water plant – would require land for construction and operation of this facility. During construction of the Integrated Facilities, the park may be temporarily unavailable for recreation. Such impacts, together with mitigation measures, would be considered at a project level. If the facilities are built on lands used for recreational activities, there could be significant impacts. Appropriate mitigation could include improving other recreational sites or creating other locations for recreational use.

Implementation of one of the possible projects to comply with the proposed prohibition is a remedy to restore beneficial uses, including avoiding beach closures that currently impair swimming along beaches in the Malibu Civic Center area. This long-term impact and restoration of water quality in Malibu Lagoon and along beaches will enhance recreational opportunities.

See also the discussions for Land use under 8(a) above and for Public Services—Parks under 14(d) above.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
20.	**Archeological/Historical. Will the proposal:**				
	a. Result in the alteration of a significant archeological or historical site structure, object or building?		X		

Discussion:

a. It is not expected that any of the compliance projects would affect historic structures. Also, it is expected that the compliance projects would not affect archeological resources, as sewers for all the possible compliance projects would generally be located in public streets and on public property that has already undergone significant disturbance.

Should a relatively undisturbed site be selected for a treatment plant for the Integrated Facilities or Decentralized Facilities, impacts and mitigation measures recommended by appropriate agencies and organizations for possible archeological resources would be evaluated on a project level. These measures could include a records search, using resources such as the South Central Coastal Archaeological Information Center at the University of California, Los Angeles. Other

DRAFT OCT 21 2009

measures could include a field survey, to examine the surface of the areas proposed for grading or disturbance and a requirement that an archaeologist be on site during grading, trenching, and excavations.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
21.	**Mandatory Findings of Significance**				
	Potential to degrade: Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?		X		
	Short-term: Does the project have the potential to achieve short-term, to the disadvantage of long-term, environmental goals? (A short-term impact on the environment is one which occurs in a relatively brief, definitive period of time, while long-term impacts will endure well into the future.)			X	
	Cumulative: Does the project have impacts which are individually limited, but cumulatively considerable? (A project may impact on two or more separate resources where the impact on each resource is relatively small, but where the effect of the total of those impacts on the environment is significant.)			X	
	Substantial adverse: Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?			X	

Discussion:

The prohibition does not have the potential to degrade the quality of the environment in the long-term. The possible compliance projects also do not have reasonably foreseeable long-term impacts that will degrade the quality of the environment with significant adverse impacts. As discussed in the checklist herein, there are many standard mitigation measures well known to responsible local agencies that will have jurisdiction over the compliance projects. The short-term construction impacts, however, may be significant in some ways. Those impacts are also described in the checklist and discussion herein.

The prohibition probably will not have the potential to achieve short-term benefits. The prohibition, in conjunction with the TMDLs and other regulatory actions, will provide long-term beneficial impacts to water resources.

DRAFT OCT 2 1 2 0 0 0 9

3-1090

As discussed below, the cumulative beneficial impacts are considerable, while the cumulative adverse impacts are not. The cumulative impacts from implementation of the TMDLs, this prohibition, and the City's efforts will have an immense benefit to the water resources, resulting in more environmental and economic benefits to the City of Malibu.

The project and potential compliance projects do not have the potential to create substantial adverse effects to human beings, directly or indirectly. Assuming the compliance projects are appropriately designed, constructed and operated in conformance with all laws, ordinances, regulations and statutes, it is not foreseeable that there will be substantial effects to human beings. In fact, there should be substantial beneficial effects on human beings as the water resources of the Civic Center area will no longer be impaired.

Other Environmental Considerations

Analyses of other environmental impacts resulting from reasonably foreseeable options of complying with the proposed prohibition include:

- Cumulative Impacts of the Program Alternatives (as required by CEQA Guidelines Section 15130): Cumulative impacts, defined in Section 15355 of the CEQA Guidelines, refer to two or more individual effects, that when considered together, are considerable or that increase other environmental impacts. A cumulative impact assessment must consider not only impacts of the proposed prohibition, but also impacts from other municipal and private projects that would occur in the area during the period of implementation.
- Potential Growth-Inducing Effects of the Program Alternatives (as required by CEQA Guidelines Section 15126).
- Unavoidable Significant Impacts (as required by CEQA Guidelines Section 15126.2).

Cumulative Impacts

On a programmatic level, the Regional Board expects a net environmental benefit to water quality and beneficial uses from the proposed prohibition, TMDLs, and other future regulatory actions. The Regional Board's proposed prohibition is a regulatory action that is related to TMDLs that have been developed by the Regional Board and US Environmental Protection Agency, including:

a. The Malibu Creek Watershed Nutrient TMDL: The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential land use activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.
b. The Malibu Creek and Lagoon Bacteria TMDL: The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan*, to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite

DRAFT OCT 2 1 2009

wastewater treatment systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater treatment systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 – October 31), there are no allowable exceedance days, in winter dry weather (November 1 - March 31), there are three allowable exceedances days, and in wet weather (November 1 - October 31), there are 17 allowable exceedance days.

c. The Santa Monica Bay Beaches Wet and Dry Bacteria TMDL: For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as the major source. The TMDLs did not specify load allocations for onsite wastewater treatment systems. This effectively means that no loading is permissible from discharges from on-site wastewater disposal systems.

The proposed prohibition, in that it is a remedy to water quality impairments, is closely related to the Malibu Creek Watershed Nutrient TMDL, Malibu Creek and Lagoon Bacteria TMDL, and Santa Monica Bay Beaches Wet and Dry Bacteria TMDL. Additionally, the Regional Board has issued other TMDLs that affect the area, such as a trash TMDL in the Malibu Creek watershed. The Regional Board and other agencies may issue future regulations that affect the area.

The cumulative impacts of the proposed project and the TMDLs identified above should not be significant since the implementation time frames for each of the Regional Board actions are staggered and lengthy, allowing the City and other parties to undertake a iterative implementation process towards achieving the ultimate requirements. The Santa Monica Bay Beaches TMDL allows implementation over three phases, with deadlines in 2006, 2009 and then as late as 2021. The Nutrient TMDL, because it was developed by US EPA, does not have set deadlines for implementation. The proposed project sets a feasible and reasonable deadline, of 2014, for compliance.

On a project level, the Regional Board expects a net environmental benefit over the long term from projects undertaken to comply with the prohibition, TMDLs, and other regulatory actions, in that water quality will be improved and beneficial uses will be restored. Specific projects proposed to comply with the prohibition must be environmentally evaluated and cumulative impacts considered as the implementing municipality or agency considers such projects.

Growth-Inducing Impacts

Staff's analyses of other environmental impacts resulting from reasonably foreseeable options of complying with the proposed prohibition also includes growth-inducing impacts, including:

- an overview of the CEQA Guidelines relevant to evaluating growth inducement,
- a discussion of the types of growth that can occur in the Malibu Civic Center area,
- a discussion of obstacles to growth in the area, and

DRAFT OCT 21 2009

- an evaluation of the potential for the Program Alternatives to induce growth.

Growth-inducing impacts are defined by the State CEQA Guidelines as:

> The ways in which a proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are impacts which would remove obstacles to population growth. Increases in the population may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects... [In addition,] the characteristics of some projects.. may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It is not assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.
>
> (CEQA Guidelines, Section 15126.2(d)).

Growth inducement indirectly could result in adverse environmental effects if the induced growth is not consistent with or accommodated by the land use plans and growth management plans and policies. Local land use plans provide for land use development patterns and growth policies that encourage orderly urban development supported by adequate public services, such as water supply, roadway infrastructure, sewer services, and solid waste disposal services.

Public works projects that are developed to address future unplanned needs (i.e., that would not accommodate planned growth) could result in removing obstacles to population growth. Direct growth inducement would result if, for example, a project involved the construction of new wastewater treatment facilities to accommodate populations in excess of those projected by local or regional planning agencies. Indirect growth inducement would result if a project accommodated unplanned growth and indirectly established substantial new permanent employment opportunities (for example, new commercial, industrial, or governmental enterprises) or if a project involved a construction effort with substantial short-term employment opportunities that indirectly would stimulate the need for additional housing and services. Growth inducement also could occur if the project would affect the timing or location of either population or land use growth, or create a surplus in infrastructure capacity.

Types of Growth: The primary types of growth that occur within the area affected by the proposed prohibition are:

- development of land, and
- population growth. (Economic growth, such as the creation of additional job opportunities, also could occur; however, such growth generally would lead to population growth and, therefore, is included indirectly in population growth.)

Growth in land development is the physical development of residential, commercial, and industrial structures in the Malibu Civic Center area. The Malibu General Plan, section 7.3.3.1, describes several constraints on development. The Plan states that hillsides and steep slopes make housing construction expensive or impossible. More than eighty-three percent of Malibu is hillside area; the remaining relatively flat land is either subject to ocean and/or canyon (creek) flooding, or other significant environmental constraints. Other constraints mentioned in the

DRAFT OCT 2 1 2 0 0 9

General Plan include seismic characteristics (citing numerous faults in the area), flood plains, land slides, soil erosion, fire hazards and liquefaction potential. Land use growth is subject to general plans, community plans, parcel zoning, and applicable entitlements and is dependent on adequate infrastructure to support development. The portion of the prohibition area in unincorporated Los Angeles County would be subject to similar plans promulgated by the County.

Population growth is growth in the number of persons that live and work in the Malibu Civic Center area and other jurisdictions within the boundaries of the area. Population growth occurs from natural causes (births minus deaths) and net emigration to or immigration from other geographical areas. Emigration or immigration can occur in response to economic opportunities, life style choices, or for personal reasons.

Although land use growth and population growth are interrelated, land use and population growth could occur independently from each other. This has occurred in the past where the housing growth is minimal, but population within the area continues to increase. Such a situation results in increasing population densities with a corresponding demand for services, despite minimal land use growth. The Malibu Civic Center area that would be affected by the proposed prohibition is within the City of Malibu, which has plans that guide land use development The portion of the prohibition area in unincorporated Los Angeles County would be subject to similar plans promulgated by the County.

Existing Obstacles to Growth: Obstacles to growth could include inadequate infrastructure (e.g. an inadequate water supply that results in rationing or inadequate wastewater treatment capacity that results in restrictions in land use development). Policies that discourage either natural population growth or immigration also are considered to be obstacles to growth. In Malibu, there are several environmental constraints that constitute obstacles to growth, as described above.

Potential for Compliance with the Proposed Prohibition to Induce Growth

The prohibition on OWDSs in the Malibu Civic Center area is not expected to directly induce growth, in that it would not result in the construction of new housing.

Furthermore, the prohibition on OWDSs in the Malibu Civic Center area is not expected to indirectly induce growth, in that it would not generate long-term economic opportunities that could lead to additional immigration, and would not remove an obstacle to land use or population growth. Although the City has cited the use of septic systems as a strategy for reducing the rate and intensity of growth, there are other strategies that the City could employ to maintain that goal. Although construction activities associated with compliance projects for the prohibition would increase the economic opportunities in the area and region, this construction activity is not expected to result in or induce substantial or significant population or land use development growth because the majority of the new jobs that would be created by this construction are expected to be filled by persons already residing in the area or region, based on the existing surplus of unemployed persons in the area and region.

DRAFT OCT 21 2009

Unavoidable Significant Adverse Impacts

Section 15126.2(c) of the CEQA Guidelines requires a discussion of potential significant, irreversible environmental changes that could result from a proposed project. Examples of such changes include commitment of future generations to similar uses, irreversible damage that may result from accidents associated with a project, or irretrievable commitments of resources. Although the proposed prohibition in conjunction with theTMDLs would require resources (materials, labor, and energy), the proposed project does not represent a substantial irreversible commitment of resources.

In addition, compliance with the prohibition and TMDLs will have substantial benefits to water quality and will enhance beneficial uses. Enhancement of the recreational beneficial uses (both water contact recreation and non-contact water recreation) will have positive social and economic effects by decreasing potential trash hazards, reducing bacteria and nutrient loading in the water, and increasing the aesthetic experience at beaches, parks around the lake, and other recreation areas. In addition, pristine habitat carries a significant non-market economic value. Enhancement of the beneficial uses will also have positive indirect economic and social benefits. The environmental checklist identifies the anticipated environmental effects from possible compliance projects, identifies mitigation measures for potentially significant impacts, and determines that most of the impacts after implementation of mitigation are insignificant.

To the extent that there are unavoidable significant adverse impacts, those impacts are temporary in nature, predominantly arising from construction of possible compliance projects, and temporary nuisance impacts associated with abatement of the use of OWDSs.

DISCUSSION OF ENVIRONMENTAL EVALUATION (Based on information in the technical staff report and environmental staff report for the proposed prohibition on OWDSs in the Malibu Civic Center area)

Findings Related to Mitigation for Significant Adverse Impacts (Title 14, California Code of Regulations, section 15091(a)(2).)

This environmental analysis concludes that there are some potentially significant impacts from implementation projects to comply with the proposed prohibition on OWDSs, but notes that there are mitigation measures available to reduce potentially significant environmental impacts to less than significant levels. However, implementation of these mitigation measures is not under the control or discretion of the Regional Board, but is within the responsibility and jurisdiction of other (responsible) agencies, which will be required to comply with or assist affected citizens in complying with the provisions of this prohibition (e.g., the City of Malibu). These agencies have the ability to implement these mitigation measures, can and should implement these mitigation measures, and are required under CEQA to consider whether to implement the mitigation measures when they undertake their own evaluation of impacts associated with compliance with the prohibition. This finding is made pursuant to Title 14, California Code of Regulations, section 15091(a)(2).

DRAFT OCT 21 2009

Statement of Overriding Considerations and Determination (Title 14, California Code of Regulations, section 15093.)

The Regional Board staff has balanced the economic, legal, social, technological, and other benefits of this proposed prohibition on OWDSs against the unavoidable environmental risks in determining whether to recommend that the Regional Board approve the prohibition. Upon review of the environmental information generated for this prohibition and in view of the entire record supporting the need for a prohibition, staff has determined that specific economic, legal, social, technological, environmental, and other benefits of this proposed prohibition outweigh the unavoidable adverse environmental effects, and that such adverse environmental effects are acceptable under the circumstances. This determination is based upon the fact that most of the identified significant adverse impacts from the reasonably foreseeable means of compliance are temporary nuisance impacts associated with abatement of the use of OWDSs, and/or the construction of compliance projects. The foreseeable means of compliance are generally accepted beneficial infrastructure amenities in most municipal jurisdictions, and typically installed for the benefit of the community irrespective of their potential growth inducing and other impacts associated with their construction and operation. Furthermore, the reasonably foreseeable means of compliance with the prohibition are expected to result, over the long term, in positive environmental improvements to the environment, including water quality and restoration of beneficial uses of water resources (including decreased instances of associated illness), and economic benefits associated with increased use from their restoration. This is particularly important at the Malibu beaches which are generally considered to be some of best beach environments in the State of California. Enhancement of recreational uses of beaches, aquatic habitat in Malibu Lagoon, and drinking water potential in groundwater will have positive social and economic effects.

This environmental staff report, together with the technical staff report and tentative resolution provide the necessary information pursuant to Public Resources Code section 21159 to conclude that properly designed and implemented compliance projects generally should not foreseeably have significant permanent adverse effects on the environment. Any potential impacts can be mitigated at the subsequent project level when specific sites and methods have been identified, and responsible local governments can and should implement the recommended mitigation measures.

Specific projects to comply with this prohibition that may have a significant impact will be implemented by local agencies and jurisdictions and would therefore be subject to a separate environmental review. A lead agency for the compliance projects would have the ability to mitigate project impacts, can and should mitigate project impacts, and are required under CEQA to mitigate any environmental impacts it identifies, unless it has reason not to do so. Notably, in almost all circumstances, where unavoidable or unmitigable impacts would present unacceptable hardship upon nearby receptors or venues, a local agency has a variety of alternative implementation measures available instead.

All of the potential impacts must be mitigated at the subsequent project level because they involve specific sites and designs not specified or specifically required by the *Basin Plan* amendment to implement the prohibition. At this stage, any more particularized conclusions

DRAFT OCT 2 1 2009

would be speculative. The Regional Board does not have legal authority to specify the manner of compliance with its orders or regulations (CWC, section 13360), and thus cannot dictate that an appropriate location be selected for any particular project, that it be designed consistent with standard industry practices, or that routine and ordinary mitigation measures be employed. These measures are all within the jurisdiction and authority of an agency, or local government, that would be responsible for implementing this prohibition, and that agency can and should employ those alternatives and mitigation measures to reduce any impacts as much as feasible. (14 Cal. Code Regs., section 15091(a)(2).)

Implementation of the proposed prohibition is both necessary and beneficial. To the extent that the alternatives, mitigation measures, or both, that are examined in this analysis are not deemed feasible by those local agencies, the necessity of implementing the prohibition and restoring beneficial uses (an action required to achieve the express, national policy of the Clean Water Act) remains.

PRELIMINARY STAFF DETERMINATION

☐ The proposed project COULD NOT have a significant effect on the environment, and, therefore, no alternatives or mitigation measures are proposed.

☑ The proposed project MAY have a significant or potentially significant effect on the environment, and therefore alternatives and mitigation measures have been evaluated.

signature	date
Wendy Phillips	July 31, 2009
printed name	Date

Note: Authority cited: Sections 21083 and 21087, Public Resources Code. Reference: Sections 21080(c), 21080.1, 21080.3, 21082.1, 21083, 21083.3, 21093, 21094, 21151, Public Resources Code; Sundstrom v. County of Mendocino, 202 Cal.App.3d 296 (1988); Leonoff v. Monterey Board of Supervisors, 222 Cal.App.3d 1337 (1990).

DRAFT OCT 21 2009

California Regional Water Quality Control Board

Los Angeles Region

Over 51 Years Serving Coastal Los Angeles and Ventura Counties

Recipient of the 2001 *Environmental Leadership Award* from Keep California Beautiful

Linda S. Adams
Agency Secretary

Arnold Schwarzenegger
Governor

320 W. 4th Street, Suite 200, Los Angeles, California 90013
Phone (213) 576-6600 FAX (213) 576-6640 - Internet Address: http://www.swrcb.ca.gov/rwqcb4

NOTICE OF HEARING

To: Interested Persons

From: Wendy Phillips, Chief
Groundwater Permitting/Landfill Section
California Regional Water Quality Control Board, Los Angeles Region

Date: July 31, 2009

Subject: Notice of Public Hearing for a proposed amendment to the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties (Basin Plan)*, to prohibit on-site wastewater disposal systems in the Civic Center area of the City of Malibu.

The California Regional Water Quality Control Board, Los Angeles Region (Regional Board) will consider a proposed amendment to the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties (Basin Plan),* to prohibit on-site wastewater disposal systems (OWDSs) in the Civic Center area of the City of Malibu. Additional regulations or policies, consistent with the general purpose of the proposed amendment and complementary to the proposed prohibition, may be developed at the hearing as a logical outgrowth of discussions. The Regional Board may act on the proposed amendment after hearing staff's presentation and public comments.

The public hearing is scheduled to occur during a public meeting of the Regional Board on Thursday, October 1, 2009 at 9:00 a.m. in the Board Room of the Metropolitan Water District of Southern California, 700 N. Alameda Street, Los Angeles, California. At the public hearing, the public will have opportunity to comment on the proposed prohibition. All exhibits, including charts, graphs and other testimony presented at the public hearing, must be left with the Regional Board for inclusion in the Administrative Record. Please note that the Regional Board may impose time limits on oral testimony at the public hearing.

Copies of a tentative resolution with the proposed amendment to the *Basin Plan*, a technical staff report (including five technical memoranda), and an environmental staff report (containing substitute environmental documentation, including a California Environmental Quality Act analysis) may be downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/Public Hearing-Malibu/index.shtml. For hard copies of these documents, you may contact Ms. Rosie Villar at (213) 576-1364 or rvillar@waterboards.ca.gov. For updates on this proposed regulatory action, you may subscribe to a Lyris list on the Regional Board's Web site by checking "Prohibition - Malibu Civic Center Septics" at http://www.waterboards.ca.gov/resources/email_subscriptions/reg4_subscribe.shtml.

For technical issues, you may contact Dr. Rebecca Chou at (213) 620-6156 (rchou@waterboards.ca.gov) or Ms. Elizabeth Erickson at (213) 620-2264 (eerickson@waterboards.ca.gov).

Written comments and exhibits must be submitted to the Regional Board no later than **2:00 p.m. on September 8, 2009.** Failure to comply with these requirements is grounds for the Board to refuse to admit the proposed written comment or exhibit into evidence (California Code of Regulations, Title 23, Section 649.4). Comments should be submitted to the attention of Dr. Rebecca Chou, Chief of the Groundwater Permitting Unit, at the:

California Regional Water Quality Control Board, Los Angeles Region
320 West 4th Street, Suite 200
Los Angeles, California 90013

Purpose

The purpose of the proposed amendment to the *Basin Plan* to prohibit OWDSs is to stop and prevent impairment of groundwater and surface waste in the Malibu Civic Center area. This proposed regulatory action would help restore beneficial uses designated for groundwater, Malibu Lagoon, and nearby beaches. The prohibition would also reduce public nuisance resulting from reliance by many commercial OWDS dischargers on tanker truck transport for a portion of the sewage generated by activities on their sites.

Structure of the Proposed Prohibition

The proposed prohibition would affect existing and future OWDSs in the Malibu Civic Center area, including Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Types of subsurface disposal systems, or OWDSs, that would be prohibited range from passive systems with conventional septic tanks to active systems that more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would apply to systems that serve individual properties (residential, commercial, industrial, and public properties) as well as groups of those properties.

The prohibition would immediately prohibit all new discharges from OWDSs and would prohibit discharges from existing systems within five years from the date of adoption by the Regional Board of this *Basin Plan* amendment. An exemption would allow for "zero-discharge" projects if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the *Basin Plan.*

Technical Evidence in Support of the Proposed Prohibition

In a technical staff report. staff presents evidence in support of the proposed prohibition and makes the following conclusions:

i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance. (See Technical Memoranda #1 appended to the technical staff report.)

ii. Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water. (See Technical Memoranda #2 appended to the technical staff report.)

iii. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation. (See Technical Memoranda #3 appended to the technical staff report.)

iv. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication. (See Technical Memoranda #4 appended to the technical staff report.)

v. Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities. (See Technical Memoranda #5 appended to the technical staff report.)

Based on these conclusions, the technical staff report includes staff's recommendation for a prohibition on OWDSs in the Malibu Civic Center area to protect the quality of water resources and to restore beneficial uses. See the tentative resolution for the proposed amendment to the *Basin Plan.*

Environmental and Economic Considerations

In an environmental staff report, staff has presented supplemental environmental documentation on the proposed prohibition. program alternatives, and impacts that may occur from reasonably foreseeable means of complying with the prohibition. in accordance with the California

Environmental Quality Act (CEQA) and the Porter-Cologne Water Quality Control Act (Porter-Cologne). The report is organized to provide the public with the following information:

- A description of the proposed action (i.e. the prohibition).
- Summaries of 'program' alternatives, including:
  - a local government initiative to voluntarily select and implement remedies to address water quality pollution and restore beneficial uses,
  - a "no action" alternative by the Regional Board or other authority, and
  - the recommended program alternative.
- Conceptual descriptions of options for projects that could achieve compliance with the prohibition, and estimated costs for construction and operation of these projects, including:
  - integrated water resources management facilities,
  - a community sewer collection system and interceptor sewer line to export sewage to treatment works in another community, and
  - decentralized wastewater management facilities.
- An analysis of impacts to the environmental from the conceptual projects that could be implemented to comply with the prohibition, including:
  - an environmental checklist and discussion of impacts,
  - other environmental considerations, and
  - a statement of overriding considerations and determinations.

Documentation Associated with the Proposed Prohibition

The documents in support of the Regional Board's proposed regulatory action to prohibit OWDSs in the Malibu Civic Center area include:

Tentative Resolution (draft dated July 31, 2009) to prohibit OWDSs and to certify the environmental staff report determining that the prohibition may have a significant or potentially significant effect on the environment, and therefore alternatives, methods of compliance, and mitigation measures have been evaluated.

Technical Staff Report (draft dated July 31, 2009), presenting evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Ventura*

and Los Angeles Counties to prohibit OWDSs in the Malibu Civic Center area (overview), including the following technical memoranda:

- Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.

- Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water.

- Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation.

- Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.

- Technical Memorandum No. #5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.

Environmental Staff Report (draft dated July 31, 2009) in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties*, including substitute environmental documentation pursuant to CEQA and Porter-Cologne.

These documents may be downloaded at http://www.waterboards.ca.gov/losangeles/press_room/announcements/PublicHearing-Malibu/index.shtml. Or you may contact Ms. Rosie Villar at (213) 576-1364 or rvillar@waterboards.ca.gov for a hard copy of any or all of these documents.

State of California
California Regional Water Quality Control Board, Los Angeles Region

Resolution No. R4-2009-xx

Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties
to Prohibit Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

WHEREAS, the California Regional Water Quality Control Board, Los Angeles Region (hereinafter Regional Board), finds that:

1. In the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (hereafter *Basin Plan*), the Regional Board designated beneficial uses and established water quality objectives for the following water resources in the Civic Center area of the City of Malibu:

   Groundwater: Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

   Malibu Lagoon: Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

   Malibu Creek: Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

   Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach: Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.

2. In a 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses were formally identified for the following water resources:

   Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
   Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
   Malibu Beach: impaired by Indicator Bacteria.
   Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
   Carbon Beach: impaired by Indicator Bacteria.

D R A F T

3. To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

i. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

ii. **Malibu Creek and Lagoon Bacteria TMDL**: The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

iii. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for onsite wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including onsite wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

DRAFT

4. Pursuant to Water Code Section 13243, the Regional Board may, in its *Basin Plan*, specify certain conditions or areas where the discharge of waste, or certain types of waste, will not be permitted. During a public meeting on December 14, 1998, the Regional Board directed the Executive Officer to prepare a prohibition for consideration by the Regional Board. During a public meeting on November 13, 2008, the Regional Board discussed the need for a firm time schedule to address water quality problems in the Malibu Civic Center area and again directed staff to prepare a prohibition for Board consideration.

5. In accordance with the California Water Code, sections 13280 and 13281, Regional Board staff presented technical evidence, in a public hearing on October 1, 2009, demonstrating that discharges of wastewater in the Civic Center area fail to meet water quality objectives established in the *Basin Plan* and contribute to impairments of existing or potential beneficial uses of water resources. The evidence, as presented in a Technical Staff Report, includes the following conclusions:

   i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance.

   ii. Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water.

   iii. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation.

   iv. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.

   v. Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

6. A peer review was conducted, pursuant to California Health and Safety Code section 57004.

D R A F T

7. No authorized public agency has offered satisfactory assurance that discharge systems are appropriately designed, located, sized, spaced, constructed, and maintained, such that they are adequate to protect the quality of water for beneficial uses in the Malibu Civic Center area, pursuant to the CWC section 13282.

8. Pursuant to the California Water Code, section 13283, the State Water Resources Control Board (State Board) shall include a preliminary review of possible alternatives necessary to achieve protection of water quality and present and future beneficial uses of water, and prevention of nuisance, pollution, and contamination, including, but not limited to, community collection and waste disposal systems which utilize subsurface disposal, and possible combinations of individual disposal systems, community collection and disposal systems which utilize subsurface disposal, and convention treatment systems. The Regional Board has conducted a preliminary review of possible alternatives, as documented in the staff report.

9. The basin planning process has been certified as functionally equivalent to the California Environmental Quality Act (CEQA), including preparation of an initial study, negative declaration, and environmental impact report (14 CCR, section 15251(g)). As this amendment is part of the basin planning process, staff has prepared an Environmental Staff Report, which is considered a substitute to an initial study, negative declaration, and/or environmental impact report. This Environmental Staff Report satisfies the substantive requirements of the California Code of Regulations, title 23, section 3777(a), and includes a project description, environmental checklist, reasonable alternatives, and mitigation measures.

THEREFORE, be it resolved that:

1. The Regional Board finds substantial evidence that discharges from septic systems in the Malibu Civic Center area fail to meet water quality objectives and impair both existing and potential beneficial uses of water, as documented in the Final Technical Staff Report, dated October 1, 2009. Pursuant to section 13240 of the California Water Code, the Regional Board hereby amends the *Basin Plan* to include a prohibition on discharges from individual/group septic/disposal systems in the Civic Center area. This amendment, as set forth in Attachment A, will:

   - Prohibit all new discharges.
   - Prohibit discharges from existing systems within five years from the date of adoption by the Regional Board of this *Basin Plan* amendment.
   - A specific discharge may be permitted for a "zero-discharge" project if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle

DRAFT

any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the *Basin Plan.*

2. The Regional Board adopts and certifies the Final Environmental Staff Report, including the environmental checklist, dated October 1, 2009.

3. The Regional Board directs the Executive Officer to submit these regulatory actions to the State Board and Office of Administrative Law for review and approval.

4. This prohibition is not intended to prevent repairs and maintenance to existing septic/disposal systems, provided that repairs and maintenance do not expand the capacity of the systems and increase flows of wastewaters.

5. On behalf of dischargers in the Civic Center area, the City is hereby directed to submit quarterly written reports to the Executive Officer, summarizing the strategy and progress toward meeting the five-year prohibition deadline. In the quarterly progress reports, the City shall document progress, to the satisfaction of the Executive Officer, toward the following interim and final deadlines:

   April 1, 2010: Completion of 25% of a master facilities plan for possible projects to comply with the prohibition, including initiation of a strong public participation program.

   October 1, 2010: Completion of 50% of a master facilities plan and initiation of environmental review, with strong, on-going public participation. Concurrently, initiation of preliminary engineering and a feasibility study for possible projects to comply with the prohibition.

   April 1, 2011: Substantial completion of a master facilities plan, preliminary engineering and a feasibility study, and engagement of the public in selection of a project to comply with the prohibition.

   October 1, 2011: Completion of a master facilities plan, preliminary engineering and a feasibility study, and selection of a project to comply with the prohibition.

   October 1, 2012: Completion of final design for selected project.

   October 1, 2013: Completion of 50% of construction of selected project.

   October 1, 2014: Completion of project to comply with prohibition, including successful startup of facilities, residential and commercial connections to the project facilities, and cease discharge from OWDSs.

D R A F T

The first progress report is due December 31, 2009, and subsequent quarterly progress reports are due on March 31st, June 30th, September 30th, and December 31st of the following years.

The City may, upon approval from the Executive Officer, transfer this responsibility to another public agency.

I, Tracy J. Egoscue, Executive Officer, do hereby certify that the foregoing is a full, true, and correct copy of a resolution adopted by the California Regional Water Quality Control Board, Los Angeles Region, on October 1, 2009.

_____

Tracy J. Egoscue
Executive Officer

DRAFT

Resolution No. R4-2009-xx

Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties
to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

Attachment A: Language to be inserted into the *Basin Plan*

The *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties* (*Basin Plan*) contains a section entitled "Septic Systems" in Chapter 4. This amendment to the *Basin Plan* revises the section entitled "Septic Systems," as indicated by italicized, underlined text for additions, and text strikeouts for deletions.

D R A F T

Septic Systems

~~The California Water Code, Chapter 4, Article 5, sets forth criteria for regulating individual disposal systems (i.e., residential septic tanks). Prior to the 1950s, the Regional Board placed certain types of septic tank systems under individual WDRs. In the 1950s, the regional Board delegates local health or public works departments jurisdiction to permit and regulate septic tank disposal systems, typically for single family dwellings. However, the Regional Board could exercise jurisdiction over multiple dwelling units, some non-domestic septic tank systems, and large developments in certain problem areas, as well as in any situation where systems are creating or have the potential to create a water quality problem.~~

Malibu Civic Center Area

On October 1, 2009, the Regional Board amended the Basin Plan *to prohibit on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area (figure 4-xx), pursuant to section 13280 of the California Water Code. Effective immediately:*

- *All new on-site wastewater disposal system discharges are prohibited.*
- *All wastewater discharges from existing on-site wastewater disposal systems are prohibited five years from the date of adoption by the Region Board of this Basin Plan amendment.*
- *A specific wastewater discharge may be permitted if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the Basin Plan.*

This action was supported by technical evidence that concluded:

i. *Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance.*

ii. *Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water.*

iii. *Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease for water contact recreation.*

iv. *Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.*

v. *Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.*

The prohibition is not intended to prevent repairs and maintenance to existing septic/disposal systems, provided that repairs and maintenance do not expand the capacity of the systems and increase flows of wastewaters.

Oxnard Forebay Septic Prohibition

On August 9, 1999, the Regional Board amended the Basin Plan to include a prohibition on septic systems in the Oxford Forebay (figure 4-xx), pursuant to Section 13280 of the California Water Code. The prohibition applies to both future and existing septic systems in the Oxford Forebay. As of August 9, 1999, new septic systems in the Oxford Forebay were prohibited. By January 1, 2008, discharges from existing septic systems must cease. This action was taken in view of:

- The conclusion that discharges of wastewaters from residential and commercial facilities to groundwater underlying the Oxford Forebay do not meet water quality objectives specified in the Basin Plan, and are impairing the present and future beneficial uses of underlying resources of ground water.

DRAFT

- The need to ensure long-term protection of ground water underlying both the Oxford Forebay and the Oxford Plain. Alternatives to replace these supplies of local water, or to treat the water before beneficial use, would be costly and would violate the requirement to protect the water for beneficial uses.

The prohibition is not intended to prevent repairs to existing septic systems in the Oxford Forebay prior to [a date five year from Regional Board adoption of the amendment], provided that the purpose of such repairs is not to increase capacity.

Other Areas

In other areas, where ground water constitutes an important source of drinking water, the Regional Board has adopted general WDRs (Order 91-94) for certain private residential subsurface sewage disposal systems. A lot with size less then 1 acre in not eligible for these general WDRs; for those lots between one and less than five acres in size, the General WDRs require either a hyrdogeologic study or mitigation measures. WDRs are not required for lot sizes greater than five acres.

D
R
A
F
T

Draft Technical Staff Report, July, 31,2009

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit On-site Wastewater Disposal Systems in the Malibu Civic Center Area

July 31, 2009

Table of Content

Page Numbers

Technical Staff Report Overview.....1-10
Wendy Phillips

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.....T1-1 to T1-5
Rebecca Chou

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water
David Koo.....T2-1 to T2-7

Attachment 2-1 Data Tables for 47 Individual Wells.....T2-8 to T2-51
Attachment 2-2 Graphs for 47 Individual Well.....T2-52 to T2-95

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Body Contact Recreation.....T3-1 to T3-47
Elizabeth Erickson

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.....T4-1 to T4-33
Toni Callaway and Orlando Gonzalez

Attachment 4-1 Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loading from WODS to the Lagoon..T4-34 to T4-43
C. P. Lai

Technical Memorandum #5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.....T5-1 to T5-22
Dionisia Rodriguez and Ryan Thacher

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* to incorporate a Prohibition on Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Staff Report Overview

by
Wendy Phillips*, P.G., C.H.G., C.E.G.
Chief, Groundwater Permitting and Landfill Section

In addition to her current colleagues in the Groundwater Permitting Unit, the author expresses appreciation for TMDL contributions from Jenny Newman, CP Lai and Eric Wu, post-production contributions from Rosie Villar, Enrique Casas, Jeff Ogata, Rodney Nelson, and Joe Luera, and contributions from past colleagues Rick Viergutz, Hugh Marley, Morton Price, and Dennis Dickerson.

3-1114

Technical Staff Report Overview

by
Wendy Phillips, P.G., C.H.G., C.E.G.
Chief, Groundwater Permitting and Landfill Section

Introduction

The purpose of this Technical Staff Report is to present evidence in support of an amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan)*, to prohibit subsurface disposal systems in the Malibu Civic Center area. The Malibu Civic Center area, shown in Figure 1, includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Types of subsurface disposal systems that would be prohibited by the amendment to the *Basin Plan* range from passive systems with conventional septic tanks to active systems that more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would apply to systems that serve individual properties (residential, commercial, industrial, and public properties) as well as groups of those properties. Collectively throughout this report, these disposal systems are referred to as on-site wastewater disposal systems, or OWDSs.

Environmental Setting

Background

The Malibu Civic Center area supports a population of about 1,000 residents and is the core of the City's business, cultural, and commercial activities. The area, which includes the renowned Surfrider Beach, attracts a high volume of visitors.

Without community sewers and wastewater treatment infrastructure, residents, businesses, and public facilities in the City of Malibu use thousands of on-site disposal systems to discharge their sewage to the subsurface and underlying groundwater. In several areas of the City, unfavorable hydrogeologic conditions coupled with high flows of wastewaters have raised concerns about reliance on this wastewater disposal strategy. In one of those areas of concern, the Malibu Civic Center area, intensive land use activities by almost 400 dischargers result in the release of wastewaters to the subsurface at a rate that Regional Board staff estimates to be as high as 255,000 gallons per day (gpd).

Water Resources

Surface waters in the Malibu Civic Center area include Malibu Creek, Malibu Lagoon – a fresh/saltwater habitat for rare, threatened, and endangered species, and ocean beaches, which are heavily used by the resident population as well as visitors. Groundwater in the area is a historic and potential source of drinking water. In the *Basin Plan*, the Regional Board has formally designated these plus other beneficial uses for the water resources in the area as follows:

3-1115

Malibu Lagoon: Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

Malibu Creek: Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.

Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach: Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.

Groundwater: Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

Also in the *Basin Plan,* the Regional Board has established water quality objectives to protect the beneficial uses identified above.

Impairments to Beneficial Uses of Water Resources

In a 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses are formally identified for the following water resources:

Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
Malibu Beach: impaired by Indicator Bacteria.
Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
Carbon Beach: impaired by Indicator Bacteria.

To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

a. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

b. **Malibu Creek and Lagoon Bacteria TMDL:** The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric

mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

c. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for onsite wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including onsite wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

Summary of Evidence

Staff investigations focused in five areas and are presented in five technical memoranda that comprise this staff report, and that meet the requirements of the California Water Code, sections 13280 and 13281 for determination that discharges of OWDSs in the Malibu Civic Center area result in violation of water quality objectives, will impair present or future beneficial uses of water, will cause pollution, nuisance, or contamination, or will unreasonably degrade the quality of any water of the state.

Technical Memorandum #1: Permitted Dischargers Have Poor Records of Compliance with Regional Board Orders.

For the privilege of discharging wastewater to a water of the state (including both surface water and groundwater), dischargers must comply with waste discharge requirements (WDRs) that are specified in Orders issued by the Regional Board. The WDRs generally incorporate monitoring and reporting programs that rely on self-monitoring by dischargers. The reports of self-monitoring are used by the Regional Board to determine compliance and to ensure that the

quality of the water into which wastes are discharged is not degraded and that beneficial uses, such as drinking water and swimming (body contact recreation) are protected.

In the Malibu Civic Center area, the Regional Board regulates 21 discharges, all of which are from commercial, industrial, or public facilities. In a review of the compliance records for 20[1] of the 21 discharges, each dischargers had a record of violations. Among the most serious violations are repeated failures to achieve effluent limits specified in WDRs; in particular, limits for pathogens and nutrients (species of nitrogen and phosphorus) that are identified as pollutants in nearby waters that the Regional Board and EPA have designated as impaired under Clean Water Act section 303(d). Also, several dischargers 'failed to submit' monitoring reports, and compliance with technical requirements in their WDRs could not be determined.

Among the minor violations included in Table 1-1 are tardy submittal of reports of self-monitoring required by the WDRs and improper certifications of those monitoring reports – e.g. a perjury statement executed by a party not authorized to certify the accuracy of the results on behalf of the discharger, and/or modifications to the language of the perjury statement that is specified in a WDR.

Staff concludes that dischargers have poor records of compliance with Orders issued by Regional Board, and that discharges are, in general, not meeting requirements prescribed to protect water quality and beneficial uses.

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water.

Although groundwater in the Malibu Valley Groundwater Basin is not an existing source of drinking water to the community, groundwater was the community's source of drinking water until the 1960s. Groundwater production in the area gradually ceased as a newly formed special district – Los Angeles County Waterworks District No. 29, Malibu – started delivering imported water to the Malibu area and Topanga Canyon in the early 1960s. As a future resource – and also in the event of a disruption of deliveries of imported water, groundwater is an important local resource that the community may need to use in the future. The Regional Board recognized this beneficial use, in designating groundwater as a potential source of drinking water in the *Basin Plan*.

To evaluate impacts from OWDSs on groundwater as a potential source of drinking water, staff identified 47 groundwater wells, all of which were designed and constructed for monitoring the quality of groundwater, and compiled data pathogens and nitrogen. To examine the extent of impairment of this groundwater for drinking water, staff compiled all available analytical results of sampling for pathogen indicators and nitrogen species during the period July 2002 through May 2009 and compared these results with drinking water standards for these pollutants. As summarized in graphs and tables for each well:

---

[1] One discharger, Malibu Lumber, did not commence discharge until April 2009, subsequent to the staff's evaluation of compliance records. Since commencement of the discharge, this discharger has been in violation of its WDR.

- *Pathogens in Groundwater do not meet the Drinking Water Standard:* Forty-four wells, or 94% of the 47 wells, had fecal coliform during at least one sampling period. Of the 671 fecal coliform samples collected from the 47 wells during the review period, 360 samples (54%) tested positive and exceeded the maximum contaminant level (MCL) of less than 1.1 MPN/100ml (Most Probable Number per 100 milliliters).

- *Nitrogen in Groundwater does not meet the Drinking Water Standard:* Fourteen wells, or 30% of the 47 wells, had nitrate plus nitrite at levels above the MCL of 10 mg/L (as nitrogen). Of the 671 samples collected from the 47 wells during the review period, 100 (15%) were above the MCL. Although there is no drinking water standard for ammonia, staff also reviewed analytical data for ammonia in view of the likelihood that the ammonia species of nitrogen will nitrify. These results indicate that, when concentrations of ammonia (converted to nitrogen) are added to concentrations of nitrate and nitrite, 163 samples or 24% were above the MCL. Twenty-four wells, or 51% of the 47 wells, had levels above the MCL of 10 mg/L.

As indicated by coliform results, pathogens are present in groundwater at levels that elevate the risk of infectious disease should this groundwater be used for potable purposes. As indicated by the nitrogen results, species of nitrogen are present in groundwater at levels that can cause health problems in humans should this groundwater be used for potable purposes. Infants and fetuses are particularly sensitive and can develop methemoglobinemia (blue-baby syndrome) from ingestion of water with nitrate at levels that deplete oxygen in the blood stream.

Technical Memorandum #3: Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment to Water Contact Recreation.

Malibu Creek, Lagoon, and nearby beaches are popular not only within the local community but as a destination for visitors as well. In the *Basin Plan*, the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, consistently failing to meet standards set to protect swimmers and surfers from infectious disease resulting from direct exposure to or incidental ingestion of polluted waters during recreation. Repeated failures to meet standards for standards have resulted in a 'beach bummer' reputation for the renowned Surfrider Beach.

To examine the hydraulic connection of discharges from OWDSs through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters migrate to surface waters and that, consistent with data supporting the designations of impairments, the levels of pathogens do not meet standards protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center area versus comparable beaches with sewers.

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to beneficial use of water contact recreation.

Technical Memorandum #4: Nitrogen Loads in Wastewaters flowing to Malibu Lagoon Are a Significant Source of Impairment to Aquatic Life.

Malibu Lagoon supports a valuable wetland ecosystem and nearby plant communities such as the the coastal salt marsh and the coastal strand, and also serves as refuge for migrating birds (with over 200 observed species). These beneficial uses are impaired by excessive nutrients levels in the lagoon, depleting dissolved oxygen in the water and stimulating aquatic growth (algae). As established in the nutrient TMDL[2] adopted by the US EPA on March 21, 2003 for Malibu Lagoon, nitrogen from OWDSs in hydraulic connection with the lagoon are subject to a load allocation of six pounds per day.

To quantify current nitrogen loads from OWDSs in the Malibu Civic Center area to the lagoon, staff compiled an inventory of 38 commercial dischargers and 349 residential dischargers. Using real data where available and reasonable assumptions (based on published literature and best professional judgment) for data gaps, staff calculated that the dischargers release about 255,000 gpd through OWDSs and estimated nitrogen loading factors. Applying these nitrogen loading factors to update an existing numerical model designed and calibrated by Questa 2005 for an earlier investigation, staff estimates that nitrogen loads released from OWDSs and transmitted via groundwaters to Malibu Lagoon total 29 pounds per day (lb/day). As a check, staff used the same flows and loading factors to a 'spreadsheet' model which characterized wastewater transport by hydrogeologic sector. Based on the 'spreadsheet' model, staff estimates that wastewaters transport 36 lb/day into Malibu Lagoon.

Staff's estimates of 29 lb/day to 36 lb/day from the numeric and 'spreadsheet' models are greater than two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies, and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

- Commercial Flows: The third-party models used significantly lower assumptions for commercial wastewater flows.
- Nitrogen Concentrations – Residential: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are about one-half of what staff determined is a reasonable assumption.
- Nitrogen Concentration – Commercial: Staff determined that the average nitrogen concentration of commercial wastewater discharges has decreased since 2004, as OWTSs

[2] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003), the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential land use activities. The TMDL specifies a load allocation for onsite wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

with greater treatment capabilities has been brought on-line. However, this declining trend in this subset of OWTSs is not great enough to meet the TMDL goal.

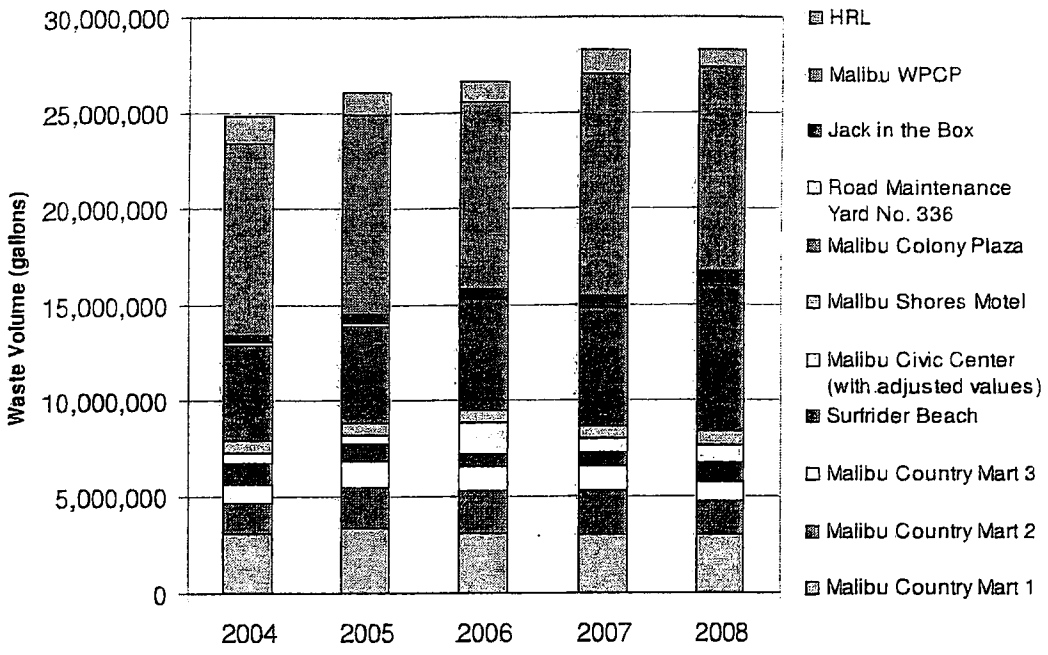
Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the load allocation of 6 lb/day for OWDSs established in a TMDL. Accordingly, staff concludes that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 29 lb/day to 36 lb/day as wells as third-party estimates from 17 lb/day to 32 lb/day, all of which fail to meet targets established to restore water quality and protect beneficial uses in Malibu Lagoon.

Technical Memorandum No. 5: Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities.

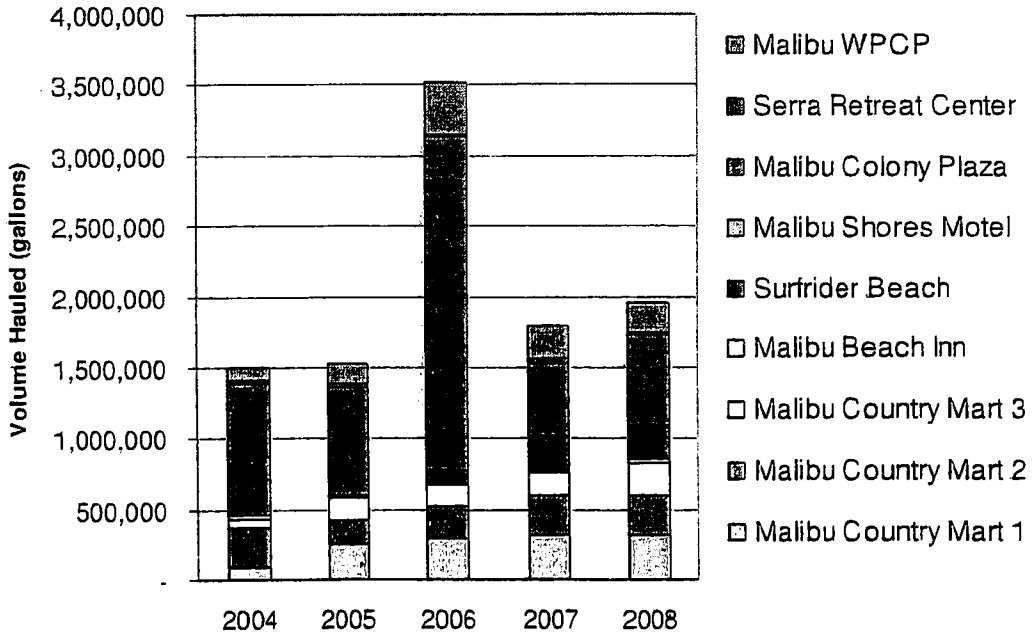
Intensive land use activities on many properties in the Malibu Civic Center area generate wastewater flows at rates that exceed the capacity of OWDSs to transmit the wastewaters into the subsurface. While some dischargers are limited by treatment equipment that has inadequate capacity and/or treatment capabilities, many dischargers do not have adequate disposal capacity on their properties to transmit the wastewaters into the subsurface. Their disposal rates can be constrained not only by lack of space, or area, for on-site disposal fields, but by hydrogeologic constraints as well, such as a high water table or tight soils. Consequently, in order to avoid failure of the OWDSs, a significant number of large dischargers resort to hauling liquid sewage and sludge to communities that have infrastructure to accept their liquid wastes.

To quantify reliance on the practice of hauling, staff reviewed reports of self-monitoring, which include summaries of off-site hauling, submitted by ten large commercial dischargers. In 2008, these ten dischargers, whose activities generated a total of approximately 28 million gallons of wastewater (77,000 gpd), hauled almost 2 million gallons (5,500 gpd), or about 7%, of their raw sewage to off-site disposal facilities. Furthermore, staff quantified trends from 2004 through 2008, which indicate that these ten dischargers have cumulatively increased their rate of wastewater generation by 15% and their rate of hauling by 29%. (Staff was not unable use existing data from dischargers to analyze seasonal hauling trends – e.g. hauling trends during the wet season, and also during warm summer holidays when populations have high peaks.)

Combined Annual Waste Flows for Select Dischargers



Combined Annual Septic Waste Hauling for Select Dischargers



Staff also considered the carbon footprint of hauling practices, which generally use large diesel-powered tanker trucks that have to travel between 60 and 180 miles round trip to transport sewage. Staff estimates that hauling by these vehicles releases over 250 tons of carbon dioxide each year. Eliminating the need for sewage waste hauling would contribute toward the goals of California's Global Warming Solution Act by decreasing greenhouse gas emissions. Also, elimination of excessive hauling can help reduce public nuisances, such as traffic, noise, and odor resulting from these practices.

Conclusions

Discharges of wastewaters to the subsurface through OWDSs have degraded water resources and impaired existing and potential beneficial uses of these waters, as determined by the following conclusions from the technical memoranda.

i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) and Time Schedule Orders (TSOs) have poor records of compliance.

ii. Discharges of wastewaters contain elevated levels of pathogens and nitrogen that impair the underlying groundwater as a potential source of drinking water.

iii. Discharges of wastewaters to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds contain levels of pathogens that elevate risks of infectious disease for water contact recreation.

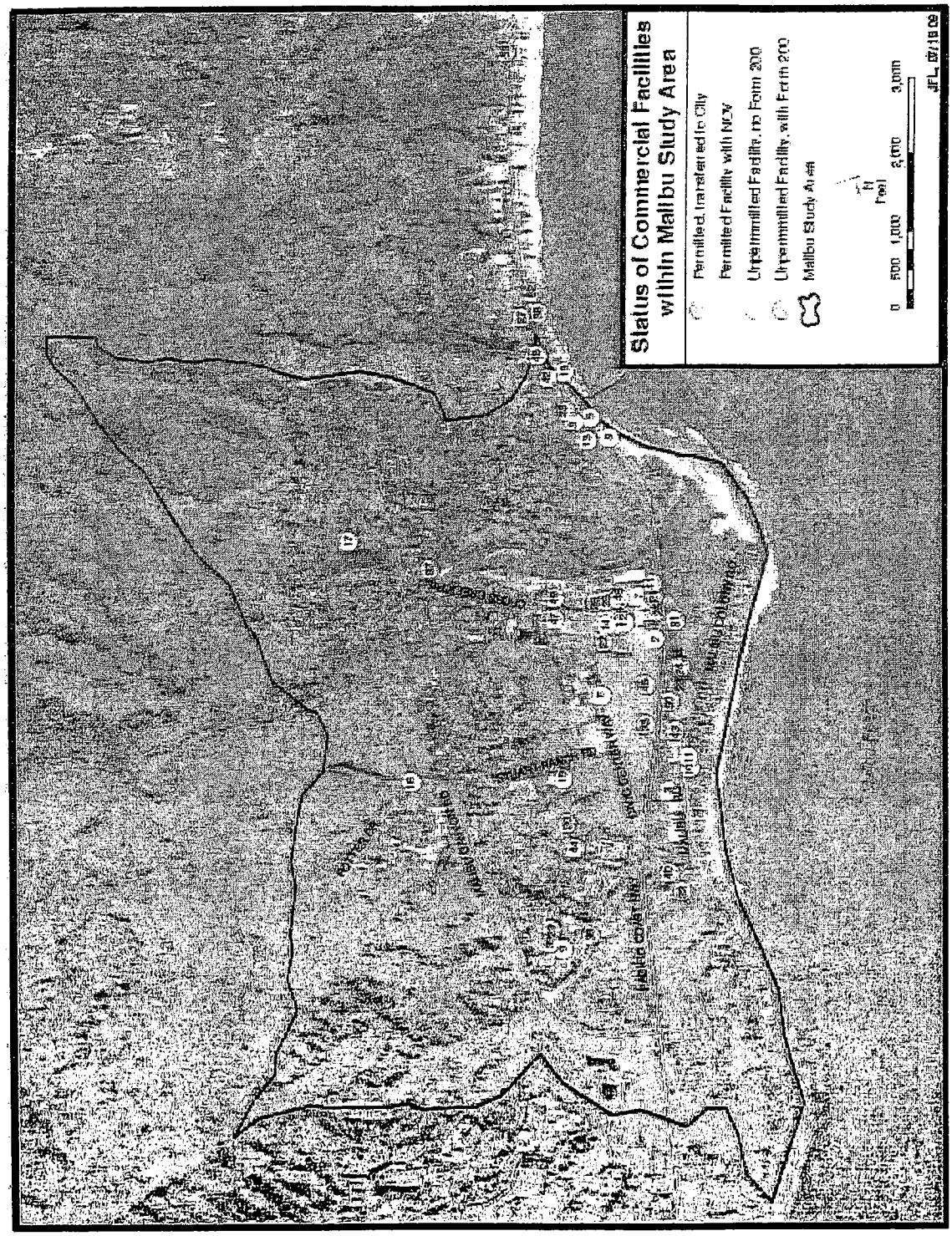
iv. Discharges of wastewaters that flow through groundwater and recharge Malibu Lagoon transport a nitrogen load significantly in excess of the allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication.

v. Generation of wastewater flows in the Civic Center area has been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

Recommendation

Staff recommends that the Regional Board adopt Resolution R4-2009-xx to immediately prohibit all future discharges of wastewaters and to prohibit existing discharges of wastewater within five years of the Regional Board's adoption, i.e. by October 1, 2014.

Figure 1: Malibu Civic Center Area



State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an
Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

to Prohibit Onsite Wastewater Disposal Systems
in the Malibu Civic Center Area

D
R
A
F
T

Technical Memorandum #1:
Dischargers Have Poor Records of Compliance with Regional Board Orders

by
Rebecca Chou*, Ph.D., P.E.
Chief, Groundwater Permitting Unit

* *The author would like to thank Regional Board staff, Joe Luera and interns Albert Chu and Shannon Liou for their assistance in preparing map, tables and graphs.*

Technical Memorandum 1: *Dischargers Have Poor Records of Compliance with Regional Board Orders*

by
Rebecca Chou, Ph.D., P.E.
Chief, Groundwater Permitting Unit

1. Background

Without community sewers and wastewater treatment facilities and infrastructure, dischargers in the Malibu Civic Center study area use on-site disposal systems for discharge of wastewaters from residential, commercial, and other facilities.

The Regional Water Quality Control Board for the Los Angeles Region (Regional Board) and City of Malibu share oversight for discharges of wastewater in the City of Malibu, including the Civic Center area.[1] Pursuant to a memorandum of understanding (MOU) dated August 12, 2004, the Regional Board regulates discharges from commercial land use activities (including discharges from industrial, research, and public facilities) that have wastewater flows that exceed 2,000 gallons per day (gpd), by issuing Orders that specify waste discharge requirements (WDRs) for the privilege of discharging waste to waters of the State. Also pursuant to this MOU, the City regulates discharges from small commercial facilities with wastewater flows equal to or less than 2,000 gpd and from residential land uses.

2. Purpose and Methodology

The purpose of this memorandum is to provide an analysis of compliance with Orders issued by the Regional Board. (Compliance information for dischargers under oversight by the City of Malibu was not available.)

To conduct the analysis, staff, including a team of college-level and graduate-school–level interns, reviewed 224 reports of self-monitoring submitted during the period starting with the fourth quarter 2004 through the fourth quarter 2008. Dischargers who submitted reports of self-monitoring include government organizations (state, county, and special districts) and privately-owned organizations (commercial and industrial organizations) listed in the following Tables 1 and 2.

[1] In 1952, when the Regional Water Quality Control Board for the Los Angeles Region (Regional Board) delegated authority for permitting septic systems to local land use agencies, the County of Los Angeles assumed responsibility for oversight of septic systems incorporated areas, including the area that subsequently incorporated as the City of Malibu in 1991. In the early 2000s, during re-assessments by all nine Regional Boards of permitting authorities delegated to local agencies, the Regional Board chose not to renew delegation (i.e. waivers of requirements to submit a Report of Waste Discharge) of permitting authority to local agencies. Rather, the Regional Board adopted a strategy of entering into Memoranda of Understanding (MOUs) with each municipality in the Los Angeles Region.

DRAFT

3-1127

Table 1 - Permitted Discharges from the Public Sector

Discharger	Facility	Start of Permitted Discharge	# Reports Analyzed	
			Quarterly	Annual
California Department of Parks and Recreations	Malibu Pier State Park	9/26/2002	15	3
Los Angeles County Department of Public Works (LA DPW)	Malibu Administrative Center	10/8/2002	17	5
LA DPW	Fire Station No. 88	8/19/2003	17	5
LA DPW	Surfrider Beach	2/25/2003	17	5
LA DPW	Road Maintenance Yard 336	10/25/2002	17	4
LA DPW	Malibu Water Pollution Control Plant (Winter Canyon)	11/2/1998	17	5

Table 2 - Permitted Discharges from the Private Sector

Discharger	Facility	Start of Permitted Discharge	# Reports Analyzed	
			Quarterly	Annual
HRL	Hughes Research Lab	1/26/1998	17	4
Malibu Beach Inn	Malibu Beach Inn	3/13/2003	16	3
Malibu Bay Company	Malibu Colony Plaza	12/7/2000	17	2
Malibu Country Mart Limited	Malibu Country Mart I	1/30/2003	17	0
Malibu Cross Creek, LTD	Malibu Country Mart II	1/30/2003	17	0
Malibu Country Mart Limited	Malibu Country Mart III	12/12/2002	17	0
Malibu Creek Preservation	Malibu Creek Plaza Shopping Center	1/11/2001	17	5
City of Malibu and Malibu Lumber LLC[2]	Malibu Lumber	April 2009[3]	1	NA
Dave Whitehead	Malibu Shores Motel	12/19/2003	16	4
Morton Gerson	23730 Malibu Road	3/24/2003	16	1
Prudential Malibu Realty	Prudential Malibu Realty	8/28/2002	17	5

[2] Although the City owns the land on which the Malibu Lumber development is sited, this discharger is grouped with private sector instead of public sector.
[3] A discharge from Malibu Lumber did not start until April 2009.

DRAFT

Three permitted dischargers, listed in Table 3, failed to submit any reports of self-monitoring as of April 2009. Although staff identified these cases of 'failure to submit' violations, staff was unable analyze compliance by these dischargers with technical requirements in their WDRs.

Table 3 – Permitted Dischargers from Private Sector-Failure to Submit Reports

Discharger	Start of Permitted Discharge	# Delinquent Reports	
		Quarterly	Annual
Jack in the Box # 160	1/23/2004	20	5
Miramar Building[4]	3/18/2004	19	5
Serra Retreat Center	4/28/2004	19	5

3. Results

Each one of the 20 dischargers under Orders issued by the Regional Board has a record of violations, summarized in Table 4. Among the most serious violations are repeated failures to achieve effluent limits specified in WDRs; in particular, limits for pathogens and nutrients (species of nitrogen and phosphorus) that are identified as pollutants in nearby waters that the Regional Board and EPA have designated as impaired.

Among the minor violations included in Table 1-1 is tardy submittal of reports of self-monitoring required by the WDRs, and improper certifications of those monitoring reports – e.g. a perjury statement executed by a party not authorized to certify the accuracy of the results on behalf of the discharger, and/or modifications to the perjury statement language specified in a WDR.

4. Conclusion

Permitted and unpermitted facilities are shown in Figure 1. Permitted dischargers of wastewaters with wastewater flows of more than 2,000 gpd in the Malibu Civic Center area – including both public and private organizations – have poor records of compliance with Regional Board Orders.

The compliance status for dischargers under oversight by the City of Malibu, including small commercial dischargers and residential dischargers, has not been analyzed.

[4] Although the Miramar Investment Company is landlord to offices occupied by the City of Malibu, staff has included this discharger with the commercial group of dischargers.

DRAFT

Table 4 - Summary of Violations

Facility	TSO	Non Submittal	Late Submittal	Discharge Violations	Perjury Statement	Material Change	Total Violation Counts
Fire Station No. 88*				77	1	1	79
HRL Laboratories		3	2		1		6
Jack In The Box		25					25
Malibu Administrative Center*				44	1	1	46
Malibu Colony Plaza	2	3	9	46	1	1	62
Malibu Beach Inn	2	3		37	1		43
Malibu Country Mart I	1	5	13	133	1		153
Malibu Country Mart II	1	5	14	133	1		154
Malibu Country Mart III	1	5	13	133	1		153
Malibu Lumber				18	1	1	20
Malibu Pier State Park*		4	7	1	1	1	14
Malibu Shores Motel		2	9	13	1	1	26
Malibu Creek Plaza Shopping Center	1		3	38			42
Malibu Water Pollution Control Plant*			9	635**			644
Miramar Investment Co.		24					24
Morton Gerson Property		5	16	2			23
Prudential Malibu Realty		4					4
LA County Public Works Road Maintenance Yard*		1	123		1	1	126
Serra Retreat Center		24					24
Surfrider Beach*			4	3	1		8

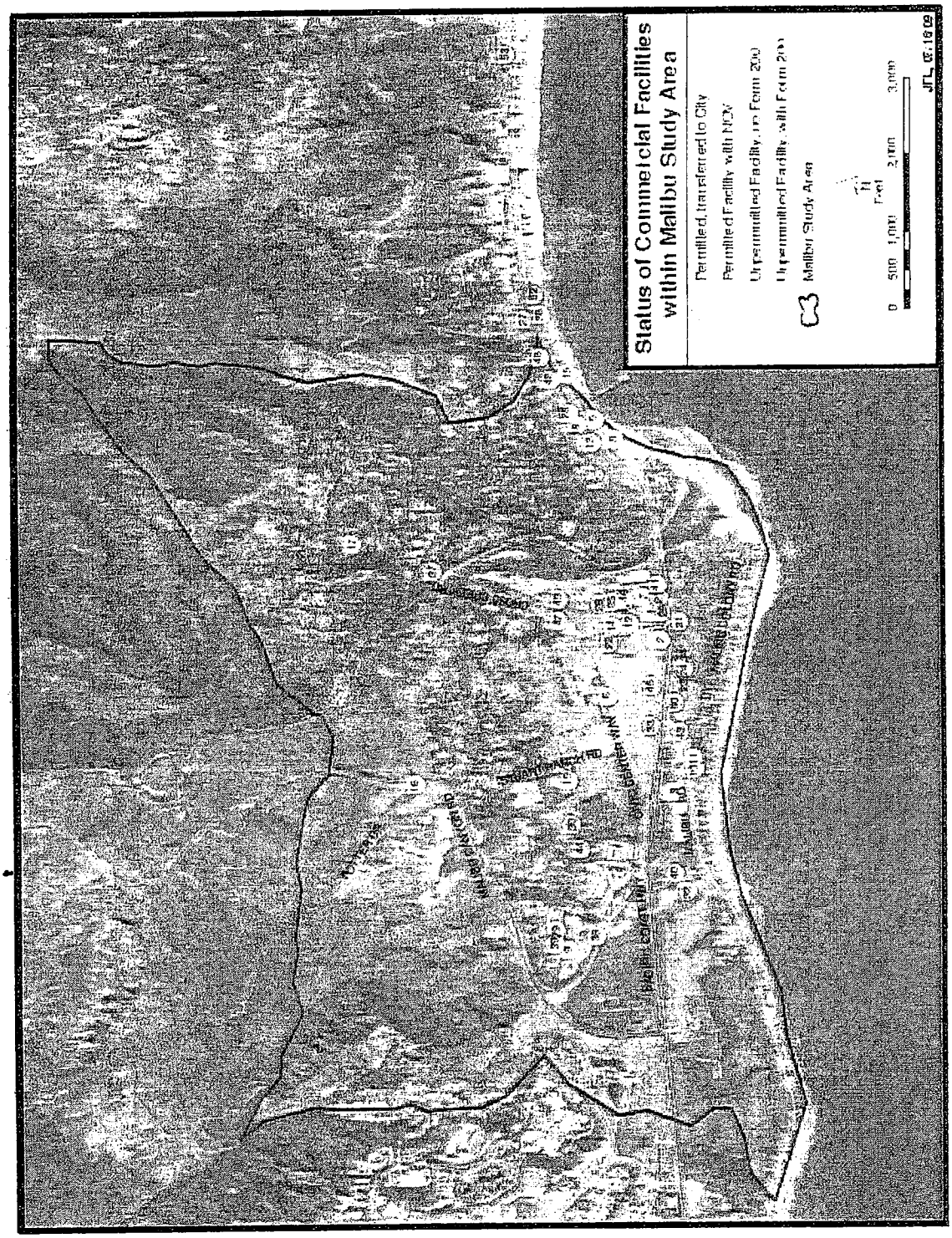
*Public Sector

** including not reported parameters

DRAFT

3-1130

Figure 1: Commercial Facilities within Malibu Civic Center Area



DRAFT

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit on Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

D
R
A
F
T

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

by
David Koo*

* *The author would like to thank Regional Board staff, Joe Luera and interns Yifei Tong, Ryan Thacher, Shentong Lu, and Justin Tang for their assistance in preparing map, tables and graphs.*

3-1132

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

by
David Koo

1. INTRODUCTION

The City of Malibu (Malibu) is located in Los Angeles County on the north shore of the Santa Monica Bay, northwest of the City of Los Angeles, California. The Malibu Civic Center area includes the densely developed areas of the lower Malibu Creek and Malibu Lagoon watersheds (Map 1). The approximate boundaries of the study area are as follows: the beach side of the Pacific Coast Highway from Malibu Canyon Road on the westerly boundary to Sweetwater Mesa Road on the east; inland to Potter Road off Malibu Canyon Road; and including Serra Retreat in the northeast corner of the study area. There are 349 residential properties and 38 commercial properties located in the study area. Surface water includes the lower portion of Malibu Creek, Malibu Lagoon, and Malibu Beach to Malibu Pier State Park.

Wastewater disposal in the City of Malibu falls within the jurisdiction of the Los Angeles Regional Water Quality Control Board (LARWQCB). The regional application of the Porter-Cologne Act is through the *Water Quality Control Plan – Los Angeles Region (Basin Plan)* for the Coastal Watersheds of Los Angeles and Ventura Counties.

According to the *Basin Plan*, the Malibu Civic Center area lies within the Malibu Valley Groundwater Basin. The *Basin Plan* designates this area as having a Potential Beneficial Use for Municipal and Domestic Supply (MUN) and Industrial Service Supply (IND).

2. PURPOSE

The purpose of this study is to determine the extent and severity of contamination of groundwater that is designated as a potential source of drinking water.

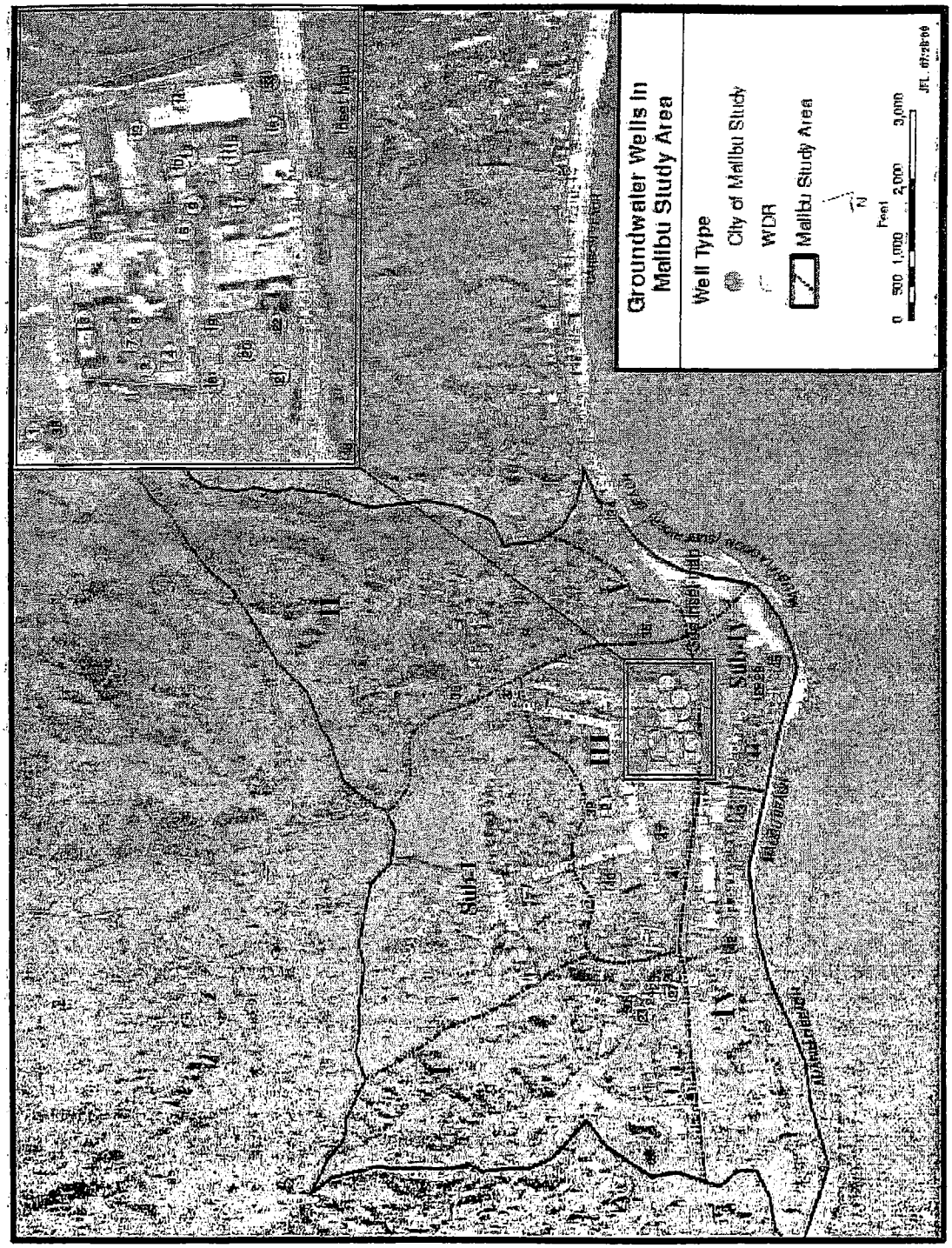
3. BACKGROUND

In addition to 27 miles of coastline which forms the northwest boundary of Santa Monica Bay and includes internationally famous Surfrider Beach, Malibu is also home to two regionally significant aquatic resources, Malibu Creek, which drains the southern slope of the mountains, draining 109 square miles of watershed, and Malibu Lagoon, one of two significant remaining freshwater estuaries in southern California. Both the creek and lagoon have been identified as impaired for bacteria and nutrients under section 303(d) of the Clean Water Act.

DRAFT

3-1133

Map 1 – Groundwater wells in the Malibu Civic Center Area



DRAFT

Malibu Civic Center area consists of a low-lying plain along Santa Monica Bay, plus adjacent steep uplands that rise from sea level to 100 feet, with additional upland areas that rise 500 feet into the foothills to the Santa Monica Mountains. The area contains some undeveloped parcels but sustains the largest commercial development in Malibu along with multi-family and single-family residences that included the Malibu Colony, a dense subdivision where houses are built close together directly on the beach. The Los Angeles County courthouse and library, the county fire department and county sheriff"s offices are also located in this area, which effectively functions as Malibu's town center. Contemporary development is built on what was naturally an estuary-lagoon and wetlands established within an alluvial plain at the mouth of Malibu Creek. Generally the water table is 3 to 36 feet below ground surface and depths fluctuate with tidal and seasonal hydrologic variations.

There are 387 onsite wastewater disposal systems (OWDSs) that serve Malibu Civic Center area. The LARWQCB, which is responsible for regulating waste discharge in the Los Angeles and Ventura County, has evidence that OWDSs in proximity to Malibu's water resources may be among the factors contributing to poor water quality. There are a total of 38 commercial and 349 residential OWDSs in the Malibu Civic Center area. Some of the systems are up to 40 years old; other systems are operated at a much greater wastewater flow capacity than what they were originally designed for.

4. METHODS AND PROCEDURES

The main steps of this study include the following:

- Collect and review existing information from a variety of sources on groundwater quality in proximity to the OWDSs from July 12, 2002 to May 20, 2009.
- Analyze the data, for pollutants that are indicators of wastewater – specifically for fecal coliform, total coliform, ammonia, and nitrogen (nitrate + nitrite).
- Determine the frequency that the groundwater exceeded drinking water standards – i.e., Maximum Contaminant Levels (MCLs)[1] for fecal coliform, total coliform, ammonia, and nitrate + nitrite.

D R A F T

---

[1] The United States Environmental Protection Agency (USEPA) provides Drinking Water Health Advisories for organics, inorganics, radionuclides, and microbiology including total coliform. The MCL goal and MCL for total coliform is zero and 5%, respectively. In a well used for drinking water, no more than 5% samples analyzed each month can test positive for total coliform. Every sample that has total coliform must be analyzed for fecal coliform; no fecal coliform is allowed.

According to Title 22 of the California Code of Regulations, Section 64426.1 Total Coliform MCL" .....(b) A public water system is in violation of the total coliform MCL when any of the following occurs: ...(2) For a public water system which collects fewer than 40 samples per month, more than one sample collected during any month is total coliform-positive; or (3) Any repeat sample is fecal coliform-positive .....", the MCL for total coliform and fecal coliformis zero.

The Water Quality Control Plan – Los Angeles Region or Basin Plan provides that "In ground waters used for domestic or municipal supply (MUN), the concentration of coliform organisms over any seven day period shall be less than 1.1 MPN/100 ml.

Although the MCL for total coliform and fecal coliform is zero, the detection limit used by a majority of laboratories for total coliform and fecal coliform is 1.1 MPN/100 ml. Therefore, unless the sample has a zero concentration for total coliform and fecal coliform, any detection above 1.1 MPN/100 ml means that the sample is above the MCL.

Staff used two sources of groundwater quality data for this study. They are: (1) the compliance files under Waste Discharge Requirements (WDRs) issued by the LARWQCB; and (2) "Final Report – Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California" prepared by Stone Environmental, Inc. in August 2004 (2004 Stone Report).

In all, data from a total of 47 groundwater wells shown in Map 1 are used for this study. Among the 47 wells, 27 of them are identified in the WDR compliance files and the other 20 are identified in the 2004 Stone Report. The two sources of data provided a total of 671 groundwater sampling results with 4,026 individual analyses.

Groundwater quality data for each well was then entered into spreadsheets. Results were compared to drinking water standards. Using these spreadsheets, two graphs – one for fecal and total coliform and the other for nitrogen – were generated for each well to illustrate the exceedance from the MCL.

5. RESULTS

Staff reviewed data for 47 wells in the Malibu Civic Center area that were designed and constructed for monitoring the quality of groundwater. To examine impairment of groundwater as a source of drinking water, staff compiled analytical results of testing for pathogen indicators and nitrogen species, and summarized these results in tables and graphs for each wells as Attachment 2-1 and 2-2, respectively.

For the 47 groundwater monitoring wells in the study area, from July 12, 2002 to May 20, 2009, a total of 671 samples were collected and analyzed for total coliform. Results indicated that out of the 671 samples, 480, or 72%, of the samples exceeded the MCL.Forty-four (44) out of 47, or 94%, of the wells detected total coliform in excess of MCL.

For the 47 groundwater monitoring wells in the study area, from July 12, 2002to May 20, 2009, a total of 671 samples were collected and analyzed for fecal coliform. Results indicated that out of the 671 samples, 360, or 54%, of the samples exceeded the MCL.All 47, or 100%, of the wells detected fecal coliform in excess of MCL.

For the 47 groundwater monitoring wells in Malibu Civic Center area, from July 12, 2002 to May 20, 2009, a total of 671 samples were collected and analyzed for nitrate-nitrogen and nitrite-nitrogen. Results indicated that out of the 671 samples, 100, or 15%, of the samples exceeded the MCL of 10 mg/L.Fourteen (14) out of 47, or 30%, of the wells detected nitrogen (nitrate and nitrite) in excess of MCL.

For the 47 groundwater monitoring wells in the study area, from July 12, 2002 to May 20, 2009, a total of 671 samples were collected and analyzed for ammonia. Results indicated that out of the 671 samples, 163, or 24%, of the samples exceeded the MCL of 10 mg/L. Twenty-four (24) out of 47, or 51%, of the wells detected total nitrogen (ammonia, nitrate and nitrite) in excess of MCL.

DRAFT

In at least one point in time, all 47 wells demonstrated the presence of pathogens and nitrogen at levels that exceeded the MCL for drinking water as summarized in Table 2. Although not all wells were contaminated for each sampling event, of the 47 wells, 44 or 94% of them had fecal coliform exceeding MCL and all 47 or 100% had total coliform exceeding MCL. Fifteen (15) or 31% of the wells had nitrate and nitrite in excess of the MCL of 10 mg/L. Staff also did an analysis including ammonia plus nitrite and nitrate; when using all three nitrogen species, 25 or 52% of the wells had nitrogen present in excess of the MCL of 10 mg/L.

Table 1: Summary of Groundwater Pollution

	Fecal Coliform	Total Coliform	Nitrate+Nitrite	Ammonia + Nitrate+Nitrite
	MPN/100mL	MPN/100mL	mg/L	mg/L
MCL	0	0	10	10
Concentration Range	0 - 140,000	0 - 16,000,000	0 - 120	0 - 120
Total Samples Analyzed	671	671	671	671
# Samples Failing to Meet MCL	360	480	100	163
% Samples Failing to Meet MCL	54%	72%	15%	24%

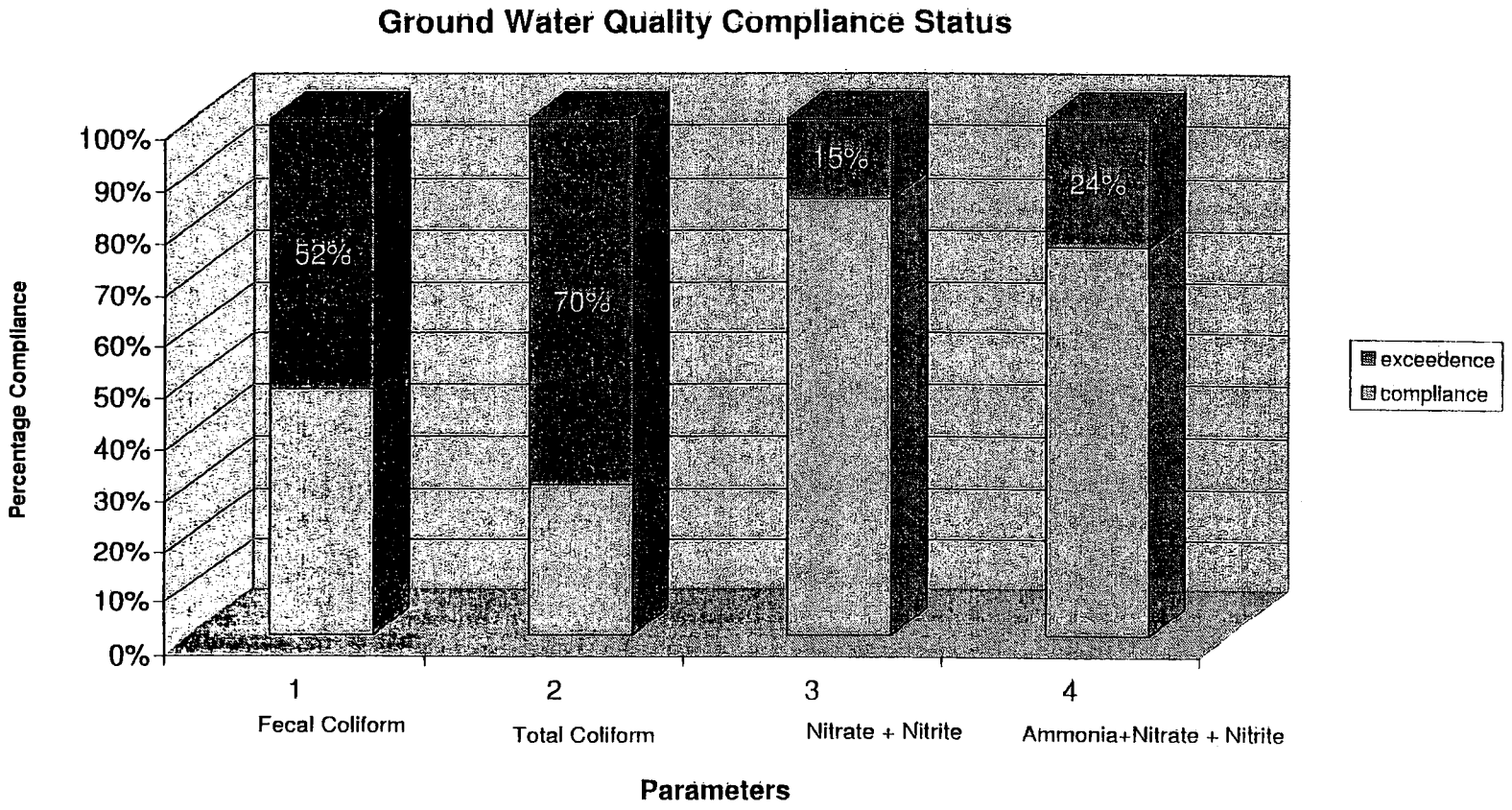
6. CONCLUSION

Pathogens and nitrogen in wastewaters released from OWDSs impair underlying groundwater as a potential source of drinking water.

Indicators of pathogen and nitrogen contaminants released by OWDSs substantially impair the potential use of groundwater as a source of drinking.

Although groundwater in the Malibu Valley Groundwater Basin is not an existing source of drinking water to the community, groundwater was the community's drinking water source up until the early 1960s. In 1963, the County of Los Angeles started delivering imported water to the area. As a future resource, and also in the event of a disruption of deliveries of imported water, groundwater in Malibu Civic Center area is an important local source that the community may need to use. However, continued degradation jeopardizes use of this local resource for beneficial use of potential MUN (drinking water use).

DRAFT


Ground Water Quality Compliance Status
Percentage Compliance
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
52%
70%
15%
24%
exceedence
compliance
1
Fecal Coliform
2
Total Coliform
3
Nitrate + Nitrite
4
Ammonia+Nitrate + Nitrite
Parameters

T E A R D

Table 2: Summary of Groundwater Wells Compliance Status

Location	Well Numbers	Well Names	Fecal Coliform Exceedance	Total Coliform Exceedance	Nitrate+Nitrite Exceedance	Ammonia+Nitrate +Nitrite Exceedance
Malibu Administrative Center	1	Well #7b	Yes	Yes	Yes	Yes
	2	Well # 8	Yes	Yes	Yes	Yes
Malibu Country Mart I	3	Well MW-1	Yes	Yes	Yes	Yes
	4	Well MW-2	Yes	Yes	No	No
	5	Well MW-3	Yes	Yes	Yes	Yes
Malibu Country Mart II	6	Well MW-1	No	Yes	No	Yes
	7	Well MW-2	Yes	Yes	No	Yes
	8	Well MW-3	Yes	Yes	No	Yes
Malibu Country Mart III	9	Well MW-1	Yes	Yes	No	No
	10	Well MW-2	Yes	Yes	No	Yes
	11	Well MW-3	Yes	Yes	No	No
Malibu Creek Plaza	12	Well #1	Yes	Yes	No	No
	13	Well #2	Yes	Yes	Yes	Yes
	14	Well #3	Yes	Yes	No	No
	15	Well #4	Yes	Yes	Yes	Yes
	16	Well #5	Yes	Yes	No	Yes
	17	Well #6	Yes	Yes	Yes	Yes
Malibu Lumber	18	ML MW-1	Yes	Yes	No	No
	19	ML MW-2	Yes	Yes	No	No
	20	ML MW-3	Yes	Yes	No	Yes
	21	ML MW-4	Yes	Yes	No	No
	22	ML MW-5	Yes	Yes	No	No
Malibu Colony Plaza	23	Well #1	Yes	Yes	No	Yes
	24	Well #2	Yes	Yes	Yes	Yes
	25	Well #3	Yes	Yes	Yes	Yes
	26	Well #4	Yes	Yes	Yes	Yes
	27	Well #5	Yes	Yes	Yes	Yes
Malibu Study Area	28	C-1	Yes	Yes	No	No
	29	C-2	Yes	Yes	No	No
	30	Well MW-5	Yes	Yes	Yes	Yes
	31	Well P-1	No	Yes	No	No
	32	Well P-7	Yes	Yes	No	No
	33	Well P-9	Yes	Yes	No	No
	34	Well SMBRP-1	Yes	Yes	No	No
	35	Well SMBRP-2	Yes	Yes	No	No
	36	Well SMBRP-3c	Yes	Yes	No	No
	37	Well SMBRP-6	Yes	Yes	No	No
	38	Well SMBRP-7b	Yes	Yes	No	No
	39	Well SMBRP-8	Yes	Yes	Yes	Yes
	40	Well SMBRP-9	Yes	Yes	Yes	Yes
	41	Well SMBRP-10c	Yes	Yes	No	No
	42	Well SMBRP-11	Yes	Yes	No	No
	43	Well SMBRP-12	Yes	Yes	No	Yes
	44	Well SMBRP-13	Yes	Yes	No	No
	45	Well SMBRP-14	Yes	Yes	No	Yes
	46	Well SMBRP-15b	Yes	Yes	No	No
	47	Well SMBRP-16	No	Yes	No	Yes
Total Number of Wells			47	47	47	47
Number of Wells Exceeded MCL			44	47	14	24
Percentage of Wells Exceeded MCL			94%	100%	30%	51%

DRAFT

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

Attachment 2-1

Data Tables for 47 Individual Wells

DRAFT

3-1140

Malibu Administrative Center
Well #7b

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/24/2003	2419.2	0.99	0.99	0.474	0.18	0	0.278	0.18	0.654	0.932
3/25/2003	2419.21	0.99	0.99	0.608	0.063	0	1.29	0.063	0.671	1.961
6/12/2003	9.99	0.99	0.99	0.43	0.368	0	0.29	0.368	0.798	1.088
7/30/2003	19.9	19.9	19.9	0.179	0.045	0	0.313	0.045	0.224	0.537
8/15/2003	19.9	19.9	230	0.243	0	0	0	0	0.243	0.243
10/28/2003	1.99	1.99	300	0.598	0.14	0.155	0.478	0.295	0.893	1.371
11/19/2003	19.9	19.9	80	0	66.161	0.292	0.197	66.453	66.453	66.65
12/19/2003	0	40	230	0.419	0	0.791	10.9	0.791	1.21	12.11
1/16/2004	0	140	140	0.292	0.79	2.06	0	2.85	3.142	3.142
2/20/2004	0	0	0	0	0.19	2.95	0.18	3.14	3.14	3.32
3/24/2004	0	0	20	0.622	0	0	1.704	0	0.622	2.326
4/27/2004	0	0	3000	0.126	0.24	2.36	0.676	2.6	2.726	3.402
5/21/2004	0	0	2100	0.184	0	0	0	0	0.184	0.184
9/1/2004	0	0	0	0.139	0.126	0	0.483	0.126	0.265	0.748
12/6/2004	300	0	900	0	1.1	0	1.06	1.1	1.1	2.16
3/9/2005	40	0	340	0	0.359	0	0.407	0.359	0.359	0.766
6/10/2005	0	0	130	0	0.133	0	1.16	0.133	0.133	1.293
9/9/2005	3500	0	20	0.261	0.11	0	0.879	0.11	0.371	1.25
11/18/2005	10111	0	1700	0.286	0.176	0	0.274	0.176	0.462	0.736
3/3/2006	3990	20	24000	0.15	0.294	0	0.41	0.294	0.444	0.854
6/2/2006	763	0	20	0.24	0.183	0	0.94	0.183	0.423	1.363
9/8/2006	0	0	0	0.241	0	0	0.359	0	0.241	0.6
12/1/2006	0	0	0	0.4	0	0	0.24	0	0.4	0.64
3/9/2007	0	0	20	0	0.124	0	0.59	0.124	0.124	0.714
6/13/2008	0	0	0	0	0.37	0	1.22	0.37	0.37	1.59
9/12/2008	0	0	0	0.11	0.15	0	0.49	0.15	0.26	0.75

E-1141
T2-9
LEARU

Malibu Administrative Center
Well # 8

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/24/2003	14.1	0.99	0.99	0	92.3	1.95	0	94.25	94.25	94.25
3/25/2003	2419.21	0.99	985	0	65.9	0	0	65.9	65.9	65.9
6/12/2003	31	0.99	0.99	0	72.5	0	0	72.5	72.5	72.5
7/30/2003	30000	19.9	19.9	0	61.4	0	0	61.4	61.4	61.4
8/15/2003	19.9	19.9	130	0	65	0.873	0	65.873	65.873	65.873
10/28/2003	20	2300	2300	0	0.302	0.36	0.758	0.662	0.662	1.42
11/19/2003	19.9	19.9	19.9	0.427	0	0	0.287	0	0.427	0.714
12/19/2003	0	80	800	0	54	0.633	13.8	54.633	54.633	68.433
1/16/2004	0	0	0	0	51	0.834	0.186	51.834	51.834	52.02
2/20/2004	0	0	0	0	51.7	1.26	0.13	52.96	52.96	53.09
3/24/2004	0	0	0	0.154	57.4	0.414	1.098	57.814	57.968	59.066
4/27/2004	0	0	2800	0	60.5	0.119	0	60.619	60.619	60.619
5/21/2004	20	0	70	0.121	60.7	0	0	60.7	60.821	60.821
9/1/2004	20	0	0	0.072	62.77	0	0.258	62.77	62.842	63.1
12/6/2004	300	0	0	0	68.3	0	0	68.3	68.3	68.3
3/9/2005	220	0	17000	0	5.85	0	0.343	5.85	5.85	6.193
6/10/2005	16000000	140000	3000000	18.2	0.142	0	7.4	0.142	18.342	25.742
9/9/2005	281	0	160000	0.303	19.7	0	2.97	19.7	20.003	22.973
11/18/2005	1553	0	30000	0	26.4	1.79	0.551	28.19	28.19	28.741
3/3/2006	155	0	1700	0	27.8	0.313	0.12	28.113	28.113	28.233
6/2/2006	0	0	500000	0	37	0	0.74	37	37	37.74
9/8/2006	1600000	5000	16000000	0.881	44.9	0	3.34	44.9	45.781	49.121
12/1/2006	300	1400	1300000	0.29	31.2	0.204	0.27	31.404	31.694	31.964
3/9/2007	40	0	3000	0	40.2	0	7.17	40.2	40.2	47.37
6/13/2008	1300	0	160000	0	31.6	0	0.19	31.6	31.6	31.79
9/12/2008	40	0	30000	0.2	30.9	0	10.44	30.9	31.1	41.54

EXHIBIT D

Malibu Country Mart I
Well MW-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
12/14/2004	0	0	1601	1.05	0.1	0	0.37	0.1	1.15	1.52
3/15/2005	0	0	0	0.39	1.6	0	0.85	1.6	1.99	2.84
6/15/2005	3880	0	0	0	0.3	0	0.37	0.3	0.3	0.67
9/15/2005	0	0	0	0	5.6	0	0.32	5.6	5.6	5.92
12/14/2005	0	0	0	0.1	11.6	0	0.25	11.6	11.7	11.95
3/20/2006	0	0	23	0.22	4.35	0	0.231	4.35	4.57	4.801
6/21/2006	10	23	2220	0.334	16	0	0.346	16	16.334	16.68
9/13/2006	0	0	0	0.221	9.1	0	0.503	9.1	9.321	9.824
12/27/2006	0	0	0	0.162	5.25	0	0.33	5.25	5.412	5.742
3/20/2007	0	0	0	7.48	0.1	0	8.36	0.1	7.58	15.94
6/13/2007	0	0	0	0.115	1.95	0	0.28	1.95	2.065	2.345
9/14/2007	0	0	0	0	5.5	0	0	5.5	5.5	5.5
12/21/2007	0	0	0	0	2.3	0	0.474	2.3	2.3	2.774
4/4/2008	0	0	0	0	3.45	0	0.335	3.45	3.45	3.785
7/2/2008	0	0	0	0.094	2.45	0	0.122	2.45	2.544	2.666

3-1113

LEARD

Malibu Country Mart I
Well MW-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
12/14/2004	17	2	220	5.8	0	0	2.84	0	5.8	8.64
3/15/2005	0	0	2	5.2	0	0	6.22	0	5.2	11.42
6/15/2005	120	0	0	4.65	0	0	4.75	0	4.65	9.4
9/15/2005	0	0	4	7	0	0	8.5	0	7	15.5
12/14/2005	0	0	0	3.99	0	0	5.1	0	3.99	9.09
3/20/2006	0	0	22	3.64	0	0	3.64	0	3.64	7.28
6/21/2006	52	0	2600	0.56	1.6	0	0.589	1.6	2.16	2.749
9/13/2006	0	0	0	4.95	0	0	4.99	0	4.95	9.94
12/27/2006	0	0	0	4.23	0	0	4.33	0	4.23	8.56
3/20/2007	0	0	0	3.81	0	0	4.3	0	3.81	8.11
6/13/2007	0	0	4	6.34	0	0	6.9	0	6.34	13.24
9/14/2007	0	0	0	8.5	0	0	8.5	0	8.5	17
12/21/2007	0	0	0	7.7	0	0	7.99	0	7.7	15.69
4/4/2008	0	0	0	7.63	0	0	8.94	0	7.63	16.57
7/2/2008	0	0	0	6.5	0	0	6.95	0	6.5	13.45

T F A R D

Malibu Country Mart I
Well MW-3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
12/14/2004	0	0	0	0.18	1.75	0	0	1.75	1.93	1.93
3/15/2005	0	0	4	0.1	3.5	0	0.272	3.5	3.6	3.872
6/15/2005	546	0	8	0	4.9	0	0.153	4.9	4.9	5.053
9/15/2005	0	0	13	0	0.6	0	0.242	0.6	0.6	0.842
12/14/2005	0	0	4	0.12	3.05	0	0.257	3.05	3.17	3.427
3/20/2006	0	0	0	0.175	2.35	0	0.19	2.35	2.525	2.715
6/21/2006	41	23	14000	0.7	12	0	0.797	12	12.7	13.497
9/13/2006	0	0	0	0	1.05	0	0	1.05	1.05	1.05
12/27/2006	0	0	0	0.102	2.05	0	0.166	2.05	2.152	2.318
3/20/2007	0	0	0	0	1.7	0	0.42	1.7	1.7	2.12
6/13/2007	0	0	0	0.149	1.7	0	0.354	1.7	1.849	2.203
9/14/2007	0	0	0	0.08	2	0	0.1	2	2.08	2.18
12/21/2007	0	0	0	0	1.65	0	0.178	1.65	1.65	1.828
4/4/2008	0	0	0	0	1.65	0	0.165	1.65	1.65	1.815
7/2/2008	0	0	0	0.088	2.1	0	0.309	2.1	2.188	2.497

3-11415

FILED

Malibu Country Mart II
Well MW-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TkN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
12/14/2004	11	0	0	0.17	1.75	0	0.15	1.75	1.92	2.07
3/15/2005	0	0	4	0.23	7.4	0	0.317	7.4	7.63	7.947
6/15/2005	2	0	0	0	7.65	0	0.3	7.65	7.65	7.95
12/14/2005	0	0	0	0.06	3.9	0	0.151	3.9	3.96	4.111
3/20/2006	0	0	2	0.36	2.75	0.05	0.36	2.8	3.16	3.52
6/21/2006	52	0	70	0.54	2.9	0	0.55	2.9	3.44	3.99
9/13/2006	0	0	0	0.128	3.4	0	0.128	3.4	3.528	3.656
12/27/2007	0	0	0	0.065	2.55	0	0.207	2.55	2.615	2.822
3/20/2007	0	0	0	11.2	0	0	11.7	0	11.2	22.9
6/13/2007	0	0	0	0.17	1.2	0.05	0.254	1.25	1.42	1.674
9/14/2007	0	0	0	0	1.2	0.05	0	1.25	1.25	1.25
12/21/2007	0	0	0	0	1.25	0.1	0.178	0.7	1.35	1.528
7/2/2008	0	0	0	0.054	1.75	0.05	0.169	0.7	1.854	2.023

DRAFT

Malibu Country Mart II
Well MW-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
12/14/2004	0	0	0	18.8	0	0	15.5	0	18.8	34.3
3/15/2005	0	13	22	0.96	0	0	1.15	0	0.96	2.11
6/15/2005	30.5	0	500	13.7	0	0	15.7	0	13.7	29.4
12/14/2005	0	0	17	11.7	0	0	14.1	0	11.7	25.8
3/20/2006	0	0	2	9.1	0	0	9.2	0	9.1	18.3
6/21/2006	52	0	130	8.59	0	0	8.65	0	8.59	17.24
9/13/2006	0	0	0	1.92	0	0	4.37	0	1.92	6.29
12/27/2007	0	0	220	10.6	0	0	11.7	0	10.6	22.3
3/20/2007	0	0	0	9.2	0	0	11.9	0	9.2	21.1
6/13/2007	0	0	2	12	0	0	12.8	0	12	24.8
9/14/2007	0	0	0	3.61	0	0	3.81	0	3.61	7.42
12/21/2007	0	22000	90000	7.24	0	0	7.59	0	7.24	14.83
7/2/2008	0	16000	16001	14.1	0	0	15.9	0	14.1	30

EXHIBIT D

Malibu Country Mart II
Well MW-3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TkN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
12/14/2004	0	0	0	66	0.1	0	44.3	0.1	66.1	110.4
3/15/2005	0	30	30	55	0	0	58.6	0	55	113.6
6/15/2005	0	0	14	32	0	0	58.3	0	32	90.3
12/14/2005	0	0	7	49.3	0	0	52	0	49.3	101.3
3/20/2006	10	2	17	57	0	0	57.6	0	57	114.6
6/21/2006	52	0	240	8.6	0	0	8.7	0	8.6	17.3
9/13/2006	0	0	0	42.1	0	0	44.5	0	42.1	86.6
12/27/2006	0	0	0	47.3	0	0	49.2	0	47.3	96.5
3/20/2007	0	0	30	53.9	0	0	63	0	53.9	116.9
6/13/2007	0	0	0	55.4	0	0	56.4	0	55.4	111.8
9/13/2007	0	0	0	46.4	0	0	46.4	0	46.4	92.8
12/21/2007	0	0	0	35	0	0	35.3	0	35	70.3
7/2/2008	0	300	16001	28.3	0	0	29.8	0	28.3	58.1

3-1148

T E A R D

Malibu Country Mart III
Well MW-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
3/8/2004	3	17	1601	0.084	1.57	0	1.25	1.57	1.654	2.904
7/9/2004	0	0	0	0.12	1.6	0	1.33	1.6	1.72	3.05
9/23/2004	0.99	0	0	0.11	1.15	0	0.8	1.15	1.26	2.06
12/14/2004	0	0	0	0	1.6	0	0	1.6	1.6	1.6
3/15/2005	0	0	0	0.063	2.6	0	0.103	2.6	2.663	2.766
6/15/2005	31	0	0	0	3.15	0	0.169	3.15	3.15	3.319
9/15/2005	0	4	6	0	3.3	0	0.3	3.3	3.3	3.6
3/20/2006	0	0	0	0.17	2.5	0.1	0.181	2.6	2.77	2.951
6/21/2006	96	0	0	0.1	2.25	0	0.1	2.25	2.35	2.45
9/13/2006	0	0	0	0.079	2.2	0	0.08	2.2	2.279	2.359
12/27/2006	0	0	0	0.177	1.9	0	0.212	1.9	2.077	2.289
3/20/2007	0	0	4	0	1.55	0	0.285	1.55	1.55	1.835
6/13/2007	0	0	0	0.079	1.75	0	0.15	1.75	1.829	1.979
9/14/2007	0	2	2	0	1.4	0	0	1.4	1.4	1.4
12/21/2007	0	0	0	0	1.5	0	0.35	1.5	1.5	1.85
4/4/2008	0	0	0	0	1.9	0	0.235	1.9	1.9	2.135
7/2/2008	0	0	0	0	2.35	0	0.091	2.35	2.35	2.441

3-1416

DRAFT

Malibu Country Mart III
Well MW-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
3/8/2004	0	1.99	1601	0.8	2.32	0	1.07	2.32	3.12	4.19
7/9/2004	0	0	0	30.5	0.6	0	2.5	0.6	31.1	33.6
9/23/2004	4.1	1601	1601	34	0.55	0	12.4	0.55	34.55	46.95
12/14/2004	500	8	22	2.9	1.35	0	1.64	1.35	4.25	5.89
3/15/2005	0	4	22	0.72	3.1	0	0.826	3.1	3.82	4.646
6/15/2005	230	0	9	0.153	3.45	0	0.252	3.45	3.603	3.855
9/15/2005	63	2	2	0.9	2.75	0	1	2.75	3.65	4.65
3/20/2006	10	1100	1100	0.148	2.25	0	0.156	2.25	2.398	2.554
6/21/2006	84	1601	90000	0.291	2.2	0	0.294	2.2	2.491	2.785
9/13/2006	0	0	130	2.25	1.2	0	2.51	1.2	3.45	5.96
12/27/2006	23	0	9000	0.648	1.5	0	0.793	1.5	2.148	2.941
3/20/2007	0	0	0	0	1.2	0	0.231	1.2	1.2	1.431
6/13/2007	0	0	30	0.2	1.05	0	0.201	1.05	1.25	1.451
9/14/2007	0	23	23	0	3.3	0	0	3.3	3.3	3.3
12/21/2007	0	0	0	0	1.15	0	0.502	1.15	1.15	1.652
4/4/2008	0	0	0	0	1.8	0	0.276	1.8	1.8	2.076
7/2/2008	0	0	0	0.074	2.1	0	0.075	2.1	2.174	2.249

3-1152

T E A R D

Malibu Country Mart III
Well MW-3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
3/8/2004	0	1.99	1601	0.086	1.35	0	0.58	1.35	1.436	2.016
7/9/2004	0	0	4	0.12	1.35	0	1.74	1.35	1.47	3.21
9/23/2004	0.99	23	50	0.15	0.25	0	1	0.25	0.4	1.4
12/14/2004	13	1601	1601	0	1.8	0	0	1.8	1.8	1.8
3/15/2005	0	0	0	0.063	1.9	0	0.135	1.9	1.963	2.098
6/15/2005	1860	0	2	0	4.8	0	0.23	4.8	4.8	5.03
9/16/2005	0	0	0	0	3.2	0.05	0.16	3.25	3.25	3.41
3/20/2006	0	2	2	0.107	2.45	0.1	0.1	2.55	2.657	2.757
6/21/2006	97	1601	90000	0.302	2.25	0	0.305	2.25	2.552	2.857
9/13/2006	0	0	8	2.25	1.2	0	2.51	1.2	3.45	5.96
12/27/2006	23	0	8000	0.102	1.35	0	0.106	1.35	1.452	1.558
3/20/2007	0	0	0	0	1.2	0	0.345	1.2	1.2	1.545
6/13/2007	0	0	90	0.093	1.2	0	0.185	1.2	1.293	1.478
9/14/2007	0	0	0	0	1.7	0.05	0	1.75	1.75	1.75
12/21/2007	0	0	0	0	1.45	0	0.33	1.45	1.45	1.78
4/4/2008	0	0	0	0	1.95	0	0.32	1.95	1.95	2.27
7/2/2008	0	0	0	0	1.75	0	0	1.75	1.75	1.75

3-11151

DRAFT

Malibu Creek Plaza
Well #1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
7/12/2002	7.4	0	1600	0.26	2.77	0.03	1.4	2.8	3.06	4.46
9/5/2002	8.4	0	6	0.08	2.47	0.11	1.62	2.58	2.66	4.28
11/6/2002	4.1	0	4	1.2	0.47	0.03	6.47	0.5	1.7	8.17
3/12/2004	20.2	0	22	0.03	3.3	0.03	0.21	3.33	3.36	3.57
5/28/2004	344.8	8	23	0.17	3.8	0.02	0.05	3.82	3.99	4.04
8/13/2004	15.3	0	8	0.23	3.9	0.03	0.28	3.93	4.16	4.44
11/12/2004	0	4	8	0.15	2.06	0.14	0.44	2.2	2.35	2.79
2/15/2005	231.8	0	13	0.08	4	0.02	1.18	4.02	4.1	5.28
5/1/2005	0	0	0	0.01	5.66	0.2	0.2	5.86	5.87	6.07
9/1/2005	4.1	0	0	0.08	2.21	0.02	0.19	2.23	2.31	2.5
11/22/2005	7.4	4	240	0.01	1.73	0.02	0.05	1.75	1.76	1.81
2/15/2006	0	0	0	0.26	2.32	0.13	0.05	2.45	2.71	2.76
5/3/2006	0	0	0	0.01	3.4	0.02	0.49	3.42	3.43	3.92
8/22/2006	0	0	0	0.01	1.99	0.02	0.05	2.01	2.02	2.07
11/15/2006	6.2	0	0	0.15	1.46	0.02	1.29	1.48	1.63	2.92
2/13/2007	11.6	7	50	0.1	1.52	0.02	0.81	1.54	1.64	2.45
5/11/2007	0	0	7	0.92	1.63	0.02	0.26	1.65	2.57	2.83
8/18/2007	42.4	0	8	0.02	1.72	0.02	0.64	1.74	1.76	2.4
11/7/2007	0	0	12	0.11	1.92	0.02	0.23	1.94	2.05	2.28
2/14/2008	84.5	13	50	0.02	2.29	0.02	0.44	2.31	2.33	2.77
5/13/2008	50.5	0	0	0.07	1.97	0.02	0.17	1.99	2.06	2.23
8/26/2008	9.8	0	0	0.05	1.68	0.02	1.02	1.7	1.75	2.77
11/18/2008	7.2	0	23	0.09	1.2	0.02	0.26	1.22	1.31	1.57

T2-20
9-1452
LEAD

Malibu Creek Plaza
Well #2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
7/12/2002	2419.2	80	1600	0.5	0.7	0.03	0.86	0.73	1.23	2.09
9/5/2002	4.1	0	4	1.2	0.47	0.03	6.47	0.5	1.7	8.17
11/6/2002	51.9	0	4	0.01	2.39	0.04	1.07	2.43	2.44	3.51
3/12/2004	0	0	0	0.5	2.09	0.02	0.39	2.11	2.61	3
5/28/2004	10.8	0	0	0.05	1.39	0.02	0.11	1.41	1.46	1.57
8/13/2004	98.1	0	0	0.36	1.96	0.06	0.81	2.02	2.38	3.19
11/12/2004	31.8	0	0	0.47	1.67	0.14	0.43	1.81	2.28	2.71
2/15/2005	866.4	0	8	1.86	1.72	0.02	0.94	1.74	3.6	4.54
5/1/2005	64.5	0	0	0.6	0.02	0.02	0.28	0.04	0.64	0.92
9/1/2005	214.3	11	50	1.49	1.5	0.02	0.63	1.52	3.01	3.64
11/22/2005	0	2	80	0.25	2.84	0.02	0.1	2.86	3.11	3.21
3/2/2006	0	500	1600	0.28	0	0.02	0.05	0.02	0.3	0.3
5/3/2006	18.3	0	0	0.27	2.06	0.02	0.25	2.08	2.35	2.35
8/22/2006	0	0	0	0.08	1.35	0.02	0.05	1.37	1.45	24.45
11/15/2006	0	0	30	0.59	1.46	0.02	0.18	1.48	2.07	2.07
2/13/2007	32.9	0	4	0.74	1.81	0.02	0.78	1.83	2.57	2.57
5/11/2007	0	4	4	2.63	1.52	0.02	2.4	1.54	4.17	4.17
8/18/2007	10.8	0	0	2.71	1.9	0.02	1.56	1.92	4.63	4.63
11/7/2006	5.2	0	280	1.48	1.84	0.02	1.3	1.86	3.34	3.34
2/13/2008	3	0	7	0.98	1.69	0.02	1.31	1.71	2.69	2.69
5/13/2008	3	0	0	4.96	16	0.04	1.22	16.04	21	21
8/26/2008	9.7	0	23	0.55	2.28	0.02	0.56	2.3	2.85	2.85
11/18/2008	0	90	0	1.56	1.33	0.02	0.05	1.35	2.91	2.91

3-4453

T E A R D

Malibu Creek Plaza
Well #3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TkN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
7/12/2002	2	0	0	0.17	1.16	0.03	1.11	1.19	1.36	2.47
9/5/2002	4	0	4	0.5	0.93	0.08	1.12	1.01	1.51	2.63
11/6/2002	18.3	0	4	0.26	1.09	0.03	3.16	1.12	1.38	4.54
3/12/2004	1	0	0	0.62	2.02	0.02	0.35	2.04	2.66	3.01
5/28/2004	17.9	8	8	0.33	2.89	0.02	0.15	2.91	3.24	3.39
8/13/2004	0	0	0	0.69	2.24	0.02	0.53	2.26	2.95	3.48
11/12/2004	0	350	1600	0.76	1.19	0.14	0.48	1.33	2.09	2.57
2/15/2005	2	280	900	0.85	1.81	0.02	0.67	1.83	2.68	3.35
5/1/2005	0	0	13	0.81	4.64	0.02	0.28	4.66	5.47	5.75
9/1/2005	0	0	0	0.74	2.05	0.02	0.3	2.07	2.81	3.11
11/22/2005	2	0	300	0.82	1.36	0.02	0.36	1.38	2.2	2.56
3/2/2006	5.2	50	50	1.43	1.86	0.13	0.05	1.99	3.42	3.42
5/3/2006	8.4	0	4	0.9	1.86	0.02	0.32	1.88	2.78	2.78
8/22/2006	3	0	0	0.01	1.53	0.03	0.05	1.56	1.57	1.57
11/15/2006	5.1	0	240	0.73	0.72	0.02	0.85	0.74	1.47	1.47
2/13/2007	2419.2	1600	1600	0.03	1.07	1.02	2.73	2.09	2.12	2.12
5/11/2007	235.9	11	26	1.98	1.31	0.02	1.41	1.33	3.31	3.31
8/14/2007	165	8	1600	0.63	0.74	0.02	1.5	0.76	1.39	1.39
12/5/2007	16	0	23	0.6	0.87	0.02	1.04	0.89	1.49	1.49
2/13/2008	2419.2	9	1600	0.76	1.12	0.06	2.35	1.18	1.94	1.94
5/13/2008	11.9	0	0	0.76	1.09	0.02	0.48	1.11	1.87	1.87
8/26/2008	0	0	8	0.13	1.46	0.02	0.24	1.48	1.61	1.61
11/18/2008	16.6	1600	280	0.22	0.94	0.09	1.46	1.03	1.25	1.25

3-1154

T E A R D

Malibu Creek Plaza
Well #4

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
7/12/2002	49.6	0	11	0.17	0.34	0.03	1.18	0.37	0.54	1.72
9/5/2002	22	0	240	0.4	0.03	0.09	2.91	0.12	0.52	3.43
11/6/2002	8.2	0	4	1.13	0.06	0.03	2.61	0.09	1.22	3.83
3/12/2004	48.7	0	0	0.06	1.63	0.04	0.24	1.67	1.73	1.97
5/28/2004	0	0	0	0.48	0.09	0.02	0.05	0.11	0.59	0.64
8/13/2004	3	0	0	0.25	3.47	0.12	0.38	3.59	3.84	4.22
11/12/2004	0	0	13	0.26	0.85	0.28	0.18	1.13	1.39	1.57
2/15/2005	2	13	13	0.12	2.54	0.05	0.2	2.59	2.71	2.91
5/1/2005	0	0	0	0.01	0.38	0.95	0.51	1.33	1.34	1.85
9/1/2005	0	50	50	0.06	0.27	0.02	0.16	0.29	0.35	0.51
11/22/2005	2	4	1600	0.08	1.25	0.11	0.07	1.36	1.44	1.51
3/2/2006	0	0	0	0.26	0.02	0.02	0.24	0.04	0.3	0.54
5/3/2006	2	0	0	0.01	1.51	0.06	0.4	1.57	1.58	1.98
8/22/2006	0	0	4	0.01	0.04	0.02	0.05	0.06	0.07	0.12
11/15/2006	15.6	0	0	0.01	0.04	0.02	0.25	0.06	0.07	0.32
2/15/2007	1046.2	0	300		0.03	0.02		0.05	0.05	0.05
5/11/2007	4.1	0	26	11.1	19.5	0.02	2.61	19.52	30.62	33.23
8/17/2007	0	0	22	25.8	1.04	0.02	4.56	1.06	26.86	31.42
12/6/2007	0	23	23	10.3	0.76	0.02	4.71	0.78	11.08	15.79
2/14/2008	2419.2	14	1600	6.44	0.03	0.02	7.76	0.05	6.49	14.25
5/13/2008	2419.2	500	1600	12.6	0.07	0.02	17	0.09	12.69	29.69
8/26/2008	25.4	2	30	6.46	1.57	0.02	3.64	1.59	8.05	11.69
11/18/2008	7.1	1600	240	7.75	0.04	0.02	3.7	0.06	7.81	11.51

3-1155

LEARD

Malibu Creek Plaza
Well #5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
7/12/2002	2419.2	23	900	3.1	7.43	0.03	1.5	7.46	10.56	12.06
9/5/2002	104.6	0	1600	0.15	4.45	0.16	1.13	4.61	4.76	5.89
11/6/2002	184.2	240	1600	0.01	0.03	0.03	2.04	0.06	0.07	2.11
3/12/2004	0	0	4	7.23	0.04	0.02	3.22	0.06	7.29	10.51
5/28/2004	1	0	0	4.28	0.02	0.02	3.54	0.04	4.32	7.86
8/13/2004	2	0	0	3.61	0.02	0.02	4.3	0.04	3.65	7.95
11/12/2004	0	1600	1600	2.98	0.02	0.14	1.99	0.16	3.14	5.13
2/15/2005	0	240	240	4.58	0	0.02	3.42	0.02	4.6	8.02
5/1/2005	0	0	0	4.52	0.09	0.02	3.21	0.11	4.63	7.84
9/1/2005	0	14	22	2.73	0.25	0.02	1.2	0.27	3	4.2
11/22/2005	0	0	0	9.81	0.02	0.02	4.93	0.04	9.85	14.78
3/2/2006	0	0	17	6.58	0.03	0.02	1.06	0.05	6.63	7.69
5/3/2006	12.1	0	0	6.59	0.02	0.02	5.76	0.04	6.63	12.39
8/22/2006	0	0	0	1.17	0.92	0.02	0.12	0.94	2.11	2.23
11/15/2006	103.9	8	80	4.28	0.04	0.05	0.78	0.09	4.37	5.15
2/13/2007	488.4	0	23	4.05	0.02	0.02	0.06	0.04	4.09	4.15
5/11/2007	2	23	30	0.33	0.02	0.02	5.92	0.04	0.37	6.29
8/17/2007	49.7	1600	1600	1.23	0.28	0.03	1.76	0.31	1.54	3.3
12/5/2007	58	50	140	0.98	0.02	0.02	0.74	0.04	1.02	1.76
2/14/2008	2	17	110	1.18	0.11	0.02	0.6	0.13	1.31	1.91
5/13/2008	6.2	0	4	2.82	0.027	0.02	0.22	0.047	2.867	3.087
8/26/2008	5.2	500	1600	0.13	1.4	0.02	0.06	1.42	1.55	1.61
11/18/2008	1	130	14	0.08	1.47	0.02	0.36	1.49	1.57	1.93

DRAFT

Malibu Creek Plaza
Well #6

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
7/12/2002	2	0	0	0.19	0.06	0.03	1.12	0.09	0.28	1.4
9/5/2002	2419.2	0	1600	0.72	0.19	0.06	1.21	0.25	0.97	2.18
11/6/2002	29.1	0	300	0.01	4.22	0.09	2.18	4.31	4.32	6.5
3/12/2004	8.2	0	7	0.03	0.73	0.04	0.73	0.77	0.8	1.53
5/28/2004	79.7	13	23	0.13	3.46	0.02	0.05	3.48	3.61	3.66
8/13/2004	32.9	0	0	0.1	3.9	0.03	0.3	3.93	4.03	4.33
11/12/2004	1	0	4	0.23	1.45	0.19	0.17	1.64	1.87	2.04
2/15/2005	65.7	0	4	0.02	1.49	0.02	0.58	1.51	1.53	2.11
5/1/2005	1	0	0	0.01	13.3	10.4	0.43	23.7	23.71	24.14
9/1/2005	23.4	0	8	0.01	3.99	0.02	0.05	4.01	4.02	4.07
11/22/2005	6.2	4	1600	0.03	0.66	0.02	0.11	0.68	0.71	0.82
3/2/2006	1	0	0	0.16	0.98	0.02	0.05	1	1.16	1601.16
5/3/2006	2	0	4	0.12	0.9	0.02	0.31	0.92	1.04	1601.04
8/22/2006	1	0	0	3.74	0.04	0.02	0.81	0.06	3.8	33.8
11/15/2006	22.1	7	7	0.01	1.18	0.02	0.05	1.2	1.21	241.21
2/13/2007	13.5	0	0	0.11	1.23	0.02	0.31	1.25	1.36	1.36
5/10/2007	290.9	0	4	0.16	0.82	0.02	0.75	0.84	1	1
8/14/2007	58.5	0	30	0.01	7.96	0.02	1.19	7.98	7.99	7.99
11/15/2007	103	0	2	0.01	1.67	0.02	1.61	1.69	1.7	1.7
2/14/2008	5.1	0	11	0.01	1.35	0.03	0.35	1.38	1.39	1.39
5/13/2008	1	0	0	0.03	1.25	0.02	0.39	1.27	1.3	1.3
8/26/2008	9.3	0	0	0.01	10.7	0.02	0.05	10.72	10.73	10.73
11/18/2008	7	0	0	0.01	2.92	0.02	0.05	2.94	2.95	2.95

EXHIBIT B

Malibu Lumber
ML MW-1, ML MW-2, ML MW-3, ML MW-4, ML MW-5

Parameter		Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit		(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL			0	0					10	10	
Sample Number	Sample Date										
ML MW-1	5/20/2009	6	2	2	1.55	1.8	0	0.39	1.8	3.35	3.74
ML MW-2	5/20/2009	2	2	4	1.7	2.3	0	0.39	2.3	4	4.39
ML MW-3	5/20/2009	8	2	4	8.8	1.9	0	0.39	1.9	10.7	11.09
ML MW-4	5/20/2009	62	2	2	0.94	2.2	0	0.39	2.2	3.14	3.53
ML MW-5	5/20/2009	84	2	2	0.74	1.7	0	0.39	1.7	2.44	2.83

3-1158

T F A R D

Malibu Colony Plaza
Well # 1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/28/2003	14.8	8	8	1.59	0.45	0.09	2.96	0.54	2.13	5.09
5/22/2003	0.99	1.99	4	0.22	0.16	0.09	0.84	0.25	0.47	1.31
8/21/2003	1986.3	1.99	1.99	0.4	0.05	0.09	0.41	0.14	0.54	0.95
11/5/2003	0.99	1.99	1.99	0.59	0.04	0.019	0.39	0.059	0.649	1.039
2/25/2004	0.99	1.99	1.99	0.38	0.06	0.019	0.02	0.079	0.459	0.479
4/30/2004	0.99	1.99	1.99	0.82	0.019	0.019	0.26	0.038	0.858	1.118
8/18/2004	0.99	1.99	1.99	0.31	0.03	0.019	0.08	0.049	0.359	0.439
11/12/2004	0.99	1.99	1.99	0.36	0.03	0.14	0.31	0.17	0.53	0.84
2/15/2005	14.1	4	23	0.11	0.07	0.019	0.74	0.089	0.199	0.939
5/12/2005	0.99	1.99	1.99	0.04	0.1	0.019	0.22	0.119	0.159	0.379
8/16/2005	2	1.99	1.99	0.29	0.06	0.019	0.14	0.079	0.369	0.509
11/9/2005	18.9	7	500	0.13	0.04	0.019	0.1	0.059	0.189	0.289
2/14/2006	114.5	2	2	0.17	0.02	0.1	0.05	0.12	0.29	0.34
6/7/2006	4.1	13	23	0.01	0.03	0.02	0.15	0.05	0.06	0.21
9/20/2006	3	2	16	0.01	0.03	0.02	0.05	0.05	0.06	0.11
12/26/2006	10	2	2	7.5	6.5	0	7.9	6.5	14	21.9
3/8/2007	1	1	1	0.93	1.7	0.028	0.99	1.728	2.658	3.648
6/7/2007	2	2	2	0.88	1.85	0.021	0.04	1.871	2.751	2.791
9/6/2007	2	2	10	0.79	2	0.023	0.06	2.023	2.813	2.873
11/15/2007	2	34	480	0.8	1.7	0.024	0.05	1.724	2.524	2.574
2/14/2008	2	2	16	0.82	1.5	0.022	0.04	1.522	2.342	2.382
5/14/2008	2	2	2	0.87	1.9	0.024	0.07	1.924	2.794	2.864

6-1459

LEARD

Malibu Colony Plaza
Well # 2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/28/2003	2	1.99	1.99	11.3	2.31	0.09	6.92	2.4	13.7	20.62
5/22/2003	2419.21	2	23	7.04	0.74	0.1	3.55	0.84	7.88	11.43
8/21/2003	2419.21	1.99	2	7.4	0.23	0.09	7.26	0.32	7.72	14.98
11/5/2003	0.99	1.99	8	12	0.65	0.019	37	0.669	12.669	49.669
2/25/2004	0.99	1.99	1.99	7.51	4.59	0.019	12.3	4.609	12.119	24.419
4/30/2004	0.99	1.99	1.99	11.3	5.69	0.03	4.15	5.72	17.02	21.17
8/18/2004	0.99	1.99	1.99	9.36	1.5	0.07	5.68	1.57	10.93	16.61
11/12/2004	0.99	7	900	8.06	0.22	0.25	5.18	0.47	8.53	13.71
2/15/2005	4.1	14	50	2.16	1.79	0.005	8.87	1.795	3.955	12.825
5/12/2005	0.99	1.99	1.99	2.3	3.83	0.019	11.3	3.849	6.149	17.449
8/16/2005	0.99	1.99	1.99	9.69	1.34	0.06	2.16	1.4	11.09	13.25
11/9/2005	0.99	2	2	9.65	1.76	0.07	0.43	1.83	11.48	11.91
2/14/2006	1	2	2	23.4	0.04	0.09	0.24	0.13	23.53	23.77
6/7/2006	10.1	17	80	12.2	0.05	0.04	10.6	0.09	12.29	22.89
9/20/2006	1	2	2	20.4	0.07	0.03	1.51	0.1	20.5	22.01
12/26/2006	10	2	2	28.7	11	0.021	29.4	11.021	39.721	69.121
3/8/2007	1	1	1	22	11.5	0.024	23	11.524	33.524	56.524
6/7/2007	8	2	2	19.8	10.6	0.023	0.2	10.623	30.423	30.623
9/6/2007	2	2	10	18.1	9.9	0.027	0.9	9.927	28.027	28.927
11/15/2007	10	50	110	16.7	9.4	0.02	0.7	9.42	26.12	26.82
2/14/2008	2	2	2	20.4	10.2	0.021	0.6	10.221	30.621	31.221
5/14/2008	11	2	2	18.5	10.6	0.027	1.2	10.627	29.127	30.327

3-1156

T F A R D

Malibu Colony Plaza
Well # 3

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TkN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/28/2003	1	1.99	1.99	0.2	120	0.009	1.87	120.009	120.209	122.079
5/22/2003	101.4	1.99	4	0.09	21.1	0.1	0.08	21.2	21.29	21.37
8/21/2003	12	1.99	2	0.3	25.7	0.009	0.46	25.709	26.009	26.469
11/5/2003	2	1.99	1.99	0.38	23.4	0.012	1.25	23.412	23.792	25.042
2/25/2004	0.99	1.99	1.99	0.31	22	0.08	0.11	22.08	22.39	22.5
4/30/2004	16.1	1.99	1.99	0.41	30.4	0.08	0.33	30.48	30.89	31.22
8/18/2004	2	1.99	1.99	0.009	52.8	0.27	0.32	53.07	53.079	53.399
11/12/2004	0.99	1.99	1.99	0.009	21	1.82	0.049	22.82	22.829	22.878
2/15/2005	131.3	8	13	0.007	26.1	0.25	0.08	26.35	26.357	26.437
5/12/2005	0.99	1.99	1.99	0.009	24.7	0.019	0.16	24.719	24.728	24.888
8/16/2005	13.4	4	27	0.03	26.6	0.019	0.29	26.619	26.649	26.939
11/9/2005	0.99	7	30	0.09	22.3	0.2	0.049	22.5	22.59	22.639
2/14/2006	133.4	2	2	0.28	34.3	0.26	0.05	34.56	34.84	34.89
6/7/2006	1	23	23	0.01	23.3	0.26	0.05	23.56	23.57	23.62
9/20/2006	2	2	2	0.01	13.7	0.22	0.05	13.92	13.93	13.98
12/26/2006	10	2	2	1.05	30.5	0.251	1.2	30.751	31.801	33.001
3/8/2007	1	1	1	0.11	13.7	0	0.13	13.7	13.81	13.94
6/7/2007	2	2	2	0.1	12.5	0	0.02	12.5	12.6	12.62
9/6/2007	2	2	10	0	11.4	0	0	11.4	11.4	11.4
11/15/2007	2	14	170	0.1	11.6	0	0.02	11.6	11.7	11.72
2/14/2008	2	2	2	0.1	12.6	0	0	12.6	12.7	12.7
5/14/2008	9	2	2	0.1	14	0	0.02	14	14.1	14.12

2-1161

DRAFT

Malibu Colony Plaza
Well # 4

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/28/2003	0.99	1.99	1.99	0.049	99.4	0.009	0.99	99.409	99.458	100.448
5/22/2003	2419.21	1.99	50	0.08	23.1	0.009	0.09	23.109	23.189	23.279
8/21/2003	2419.21	1.99	300	0.2	24.3	0.009	0.049	24.309	24.509	24.558
11/5/2003	109.5	1.99	2	0.83	23	0.03	0.87	23.03	23.86	24.73
2/25/2004	0.99	1.99	1.99	0.26	18.4	0.06	0.049	18.46	18.72	18.769
4/30/2004	3.1	1.99	1.99	0.34	26.8	0.03	0.049	26.83	27.17	27.219
8/18/2004	0.99	1.99	1.99	0.28	30.6	0.1	0.29	30.7	30.98	31.27
11/12/2004	0.99	1.99	1.99	0.08	22.7	1.3	0.049	24	24.08	24.129
2/15/2005	0.99	2	8	0.009	16.5	0.019	0.049	16.519	16.528	16.577
5/12/2005	0.99	2	2	0.009	14.9	0.019	0.049	14.919	14.928	14.977
8/16/2005	2	1.99	1.99	0.04	12.5	0.019	0.28	12.519	12.559	12.839
11/9/2005	1	17	1600	0.02	2.16	0.019	0.049	2.179	2.199	2.248
2/14/2006	133.4	2	2	0.28	34.3	0.26	0.05	34.56	34.84	34.89
6/7/2006	1	23	23	0.01	23.3	0.26	0.05	23.56	23.57	23.62
9/20/2006	1	2	2	0.01	13.7	0.02	0.05	13.72	13.73	13.78
12/26/2006	10	2	2	30	7.5	0.026	31	7.526	37.526	68.526
3/8/2007	1	1	1	0.64	10	0.031	0.7	10.031	10.671	11.371
6/7/2007	2	2	2	0.59	9.7	0.035	0.03	9.735	10.325	10.355
9/6/2007	2	2	10	0.52	9.5	0.03	0.06	9.53	10.05	10.11
11/15/2007	2	6	90	0.52	8.5	0.029	0.06	8.529	9.049	9.109
2/14/2008	2	2	2	12.8	0.52	9.4	0.027	9.92	22.72	22.747
5/14/2008	2	2	2	0.57	9.3	0.028	0.06	9.328	9.898	9.958

3-14162

T E A R D

Malibu Colony Plaza
Well # 5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		1.1	1.1					10	10	
Sample Date										
2/28/2003	4.1	1.9	1.9	11.5	4.64	0.09	3.98	4.73	16.23	20.21
5/22/2003	2419.21	1.9	2	9.71	0.16	0.09	4.83	0.25	9.96	14.79
8/21/2003	103.9	1.9	4	11.8	0.46	0.09	4.56	0.55	12.35	16.91
11/5/2003	6.2	1.9	1.9	18.1	0.34	0.01	15.1	0.35	18.45	33.55
2/25/2004	0.9	1.9	1.9	7.32	0.97	0.01	7.32	0.98	8.3	15.62
4/30/2004	0.9	1.9	17	18	1.44	0.01	18	1.45	19.45	37.45
8/18/2004	0.9	1.9	1.9	16.5	3	0.04	16.5	3.04	19.54	36.04
11/12/2004	0.9	1.9	23	1.65	0.09	0.15	1.65	0.24	1.89	3.54
2/15/2005	2419.21	50	50	2.08	2.08	0.01	2.08	2.09	4.17	6.25
5/12/2005	1.1	26	110	2.17	2.17	0.01	2.17	2.18	4.35	6.52
8/16/2005	0.9	1.9	4	10.6	10.6	0.02	10.6	10.62	21.22	31.82
11/9/2005	2	4	900	7.25	7.25	0.09	7.25	7.34	14.59	21.84
2/14/2006	1986.3	2	2	16	0.02	0.02	16	0.04	16.04	32.04
6/7/2006	1	2	2	19.6	0.06	0.02	19.6	0.08	19.68	39.28
9/20/2006	2419.2	2	1600	21.2	0.02	0.02	4.79	0.04	21.24	26.03
12/26/2006	10	2	2	1.75	16.5	0	1.9	16.5	18.25	20.15
3/8/2007	1	1	1	6	1.9	0.029	6.3	1.929	7.929	14.229
6/7/2007	2	4	2	5.7	1.8	0.03	0.01	1.83	7.53	7.54
9/6/2007	2	2	10	4.8	2.1	0.025	0.2	2.125	6.925	7.125
11/15/2007	68	8	80	4.8	1.9	0.026	0.12	1.926	6.726	6.846
2/14/2008	2	2	2	5.4	1.7	0.025	0.2	1.725	7.125	7.325
5/14/2008	2	2	2	5	1.7	0.031	0.5	1.731	6.731	7.231

3-1163

EXHIBIT

Malibu Study Area
Well C-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/24/2003	0	0	0	3.27	0.6	0	4.1	0.6	3.87	7.97
5/30/2003	648.8	0	22	1.97	0.05	0	3.2	0.05	2.02	5.22
6/30/2003	61.3	0	20	2.88	0	0	3.5	0	2.88	6.38
7/24/2003	178.5	0	17	0.51	0	0	5.4	0	0.51	5.91
8/19/2003	63.7	4	17	3.02	0	0	6.9	0	3.02	9.92
9/30/2003	2	6	6	8.57	0	0	9.7	0	8.57	18.27
10/21/2003	0	2	2	7.22	0	0	10	0	7.22	17.22
11/18/2003	0	0	8	3.75	0.02	0	8.3	0.02	3.77	12.07
12/16/2003	0	0	0	3.42	0	0	6.3	0	3.42	9.72
1/20/2004	0	2	2	0	0.06	0.02	7.3	0.08	0.08	7.38
2/17/2004	1	0	0	3.78	0.08	0	6.3	0.08	3.86	10.16
3/16/2004	32.3	0	0	2.65	0.04	0	4.7	0.7	2.69	7.39

DRAFT

Malibu Study Area
Well C-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/24/2003	200	0	14	0.11	0.61	0	0.57	0.61	0.72	1.29
5/30/2003	2	0	4	0.44	0.07	0	0.85	0.07	0.51	1.36
6/30/2003	6.3	0	0	0.76	0	0	0.88	0	0.76	1.64
7/24/2003	2419.2	7	7	0.22	0	0	0.55	0	0.22	0.77
8/19/2003	1203.3	0	50	0.47	0	0	0.77	0	0.47	1.24
9/30/2003	15.5	0	0	0.44	0	0	0.87	0	0.44	1.31
10/21/2003	0	0	0	0.27	0	0	0.79	0	0.27	1.06
11/18/2003	4	8	30	0.21	0.03	0	0.78	0.03	0.24	1.02
12/16/2003	571.7	0	0	0.3	0	0	1	0	0.3	1.3
1/20/2004	4.1	0	0	0.48	0.02	0.02	0.94	0.04	0.52	1.46
2/17/2004	7.3	0	0	0.61	0.08	0	1.3	0.08	0.69	1.99
3/16/2004	4.1	0	0	0.23	0.03	0	0.84	0.7	0.26	1.1

3-1165

DRAFT

Malibu Study Area
Well MW-5

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/24/2003	0	0	0	0.1	3.52	0	3	3.52	3.62	6.62
5/30/2003	6	0	4	0.07	15.3	0	0.13	15.3	15.37	15.5
6/30/2003	2	0	17	0.03	7.49	0	0.05	7.49	7.52	7.57
7/24/2003	0	0	4	0.39	14.9	0	0.39	14.9	15.29	15.68
8/19/2003	2	0	0	0.02	11.7	0	1.6	11.7	11.72	13.32
9/30/2003	5.2	0	0	0	6.13	0	0.16	6.13	6.13	6.29
10/21/2003	1553.1	0	0	0	6.46	0	2	6.46	6.46	8.46
11/18/2003	4.1	8	23	0	2.39	0	0.16	2.39	2.39	2.55
12/16/2003	0	0	2	0	28.5	0.39	0.19	28.89	28.89	29.08
1/20/2004	0	0	0	0	1.31	0.02	0	1.33	1.33	1.33
2/17/2004	0	0	0	0.12	1.46	0	0.28	1.46	1.58	1.86
3/16/2004	0	0	0	0.02	2.57	0	0.29	0.7	2.59	2.88

3-1166

DRAFT

Malibu Study Area
Well P-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	0	0	0	0.08	6.58	0	0.15	6.58	6.66	6.81
5/29/2003	19.5	0	2	0.21	2.85	0	0	2.85	3.06	3.06
6/26/2003	0	0	4	0.08	5.49	0	0.85	5.49	5.57	6.42
7/21/2003	0	0	2	0.41	3.55	0	0.22	3.55	3.96	4.18
8/18/2003	0	0	4	0.13	7.16	0	0.18	7.16	7.29	7.47
9/29/2003	9.8	0	0	0	2.82	0	0.42	2.82	2.82	3.24
10/20/2003	1	0	2	0	4.07	0	0.1	4.07	4.07	4.17
11/18/2003	1	0	14	0.08	4.99	0	0.74	4.99	5.07	5.81
12/15/2003	1	0	0	0	2.89	0	0.18	2.89	2.89	3.07
1/19/2004	0	0	4	0	4.58	0	0	4.58	4.58	4.58
2/16/2004	0	0	2	0.25	3.53	0	0.61	3.53	3.78	4.39
3/15/2004	0	0	0	0.04	3.75	0	0.11	0.7	3.79	3.9

3-11697

DRAFT

Malibu Study Area
Well P-7

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	3.1	0	23	0	0.68	0	0.26	0.68	0.68	0.94
5/28/2003	66.4	2	240	0.5	0.19	0	0.29	0.19	0.69	0.98
6/27/2003	0	0	0	0.2	0.11	0	0.37	0.11	0.31	0.68
7/24/2003	65.3	0	4	0.23	0	0	65.3	0	0.23	65.53
8/19/2003	547.5	0	0	0.08	0	0	0.27	0	0.08	0.35
9/30/2003	721.5	9	9	0	0	0	0.44	0	0	0.44
10/21/2003	125.4	23	1600	0	0.07	0	0.65	0.07	0.07	0.72
11/18/2003	55.9	50	900	0.04	0.09	0.02	0.35	0.11	0.15	0.5
12/16/2003	3	8	23	0	0.57	0.03	0.23	0.6	0.6	0.83
1/20/2004	12	12	80	0.04	0.5	0.04	0.52	0.54	0.58	1.1
2/17/2004	22.5	2	23	0.02	0.54	0.05	0.24	0.59	0.61	0.85
3/16/2004	7.4	0	30	0.02	0.57	0	0.18	0.7	0.59	0.77

TERA RD

Malibu Study Area
Well P-9

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/23/2003	4.1	0	0	0.88	1.51	0	1.6	1.51	2.39	2.39
5/29/2003	21.3	0	0	0.31	1.83	0	1.3	1.83	2.14	2.14
6/26/2003	4.1	0	0	3.35	0.14	0	3.4	0.14	3.49	3.49
7/21/2003	2	0	2	3	0.71	0	3.2	0.71	3.71	3.71
8/18/2003	17.1	0	4	1.69	0.42	0	3.4	0.42	2.11	2.11
9/29/2003	44.1	0	4	1.56	0.42	0		0.42	1.98	1.98
10/20/2003	13.2	0	2	1.49	0.66	0	1.5	0.66	2.15	2.15
11/17/2003	1	0	6	2.11	0.12	0	5	0.12	2.23	2.23
12/16/2003	8.5	0	0	1.17	1.11	0	2	1.11	2.28	2.28
1/20/2004	13.4	4	8	0.51	2.13	0.1	1	2.23	2.74	2.74
2/17/2004	20.9	0	0	3.09	0.15	0	3.9	0.15	3.24	3.24
3/16/2004	45.7	0	110	0.03	5.12	0.05	3.6	0.7	5.2	5.2

3-1156

EXHIBIT D

Malibu Study Area
Well SMBRP-1

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TkN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TkN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/23/2003	0	7	50	0.78	0.15	0	2.7	0.15	0.93	3.63
5/30/2003	11	0	2	0.52	0.49	0	2	0.49	1.01	3.01
6/27/2003	0	0	0	2.52	0	0	4.9	0	2.52	7.42
7/24/2003	2419.2	0	50	1.72	0.14	0	2.5	0.14	1.86	4.36

3-1175

DRAFT

Malibu Study Area
Well SMBRP-2

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	7200	3000	3000	2.72	0	0	29	0	2.72	31.72
5/30/2003	2419.2	70	300	0.72	0.05	0	14	0.05	0.77	14.77
6/30/2003	2419.2	120	250	1.29	0.11	0	20	0.11	1.4	21.4
7/24/2003	2419.2	4	500	0.56	0	0	6	0	0.56	6.56
8/20/2003	0	0	4	0.57	0	0	10	0	0.57	10.57
9/30/2003	2419.2	0	9	0	0	0	1.1	0	0	1.1
10/21/2003	2419.2	0	0	0	0	0	1.3	0	0	1.3
11/18/2003	1119.8	0	23	0.07	0.14	0	0.9	0.14	0.21	1.11
12/16/2003	1413.6	0	2	0	0.18	0	0.93	0.18	0.18	1.11
1/20/2004	1413.6	0	0	0.25	0.06	0.02	0.81	0.08	0.33	1.14
2/17/2004	435.2	0	0	0.33	0.09	0	0.64	0.09	0.42	1.06
3/16/2004	25.7	0	30	0.17	0.07	0	0.58	0.7	0.24	0.82

3-11-71

FILED

Malibu Study Area
Well SMBRP-3c

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	30.8	0	0	0	2.82	0	0.1	2.82	2.82	2.92
5/30/2003	2419.2	0	0	0.2	2.78	0	0.37	2.78	2.98	3.35
6/27/2003	0	0	0	0.22	0.97	0	0.4	0.97	1.19	1.59
7/24/2003	4.1	0	0	0.24	0	0	0.41	0	0.24	0.65
8/19/2003	7.4	0	0	0.14	0.52	0.25	7.4	0.77	0.91	8.31
9/30/2003	1	0	0	0	0.37	0	0.44	0.37	0.37	0.81
10/21/2003	2	2	1600	0	0.37	0	1.4	0.37	0.37	1.77
11/18/2003	1	0	17	0	0.48	0	0.16	0.48	0.48	0.64
12/16/2003	1	0	0	0	1	0	0.2	1	1	1.2
1/20/2004	1	2	4	0.03	2.31	0.02	0	2.33	2.36	2.36
2/17/2004	1	0	0	0.16	3.79	0	0.38	3.79	3.95	4.33
3/16/2004	0	0	0	0.12	4.27	0	0.18	0.7	4.39	4.57

3-11-12

T F A R D

Malibu Study Area
Well SMBRP-6

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	0	0	13	0	2.02	0	0.36	2.02	2.02	2.38
5/30/2003	16.5	11	26	0.16	0.33	0	1.2	0.33	0.49	1.69
6/27/2003	0	2	2	0.16	0.21	0	1.1	0.21	0.37	1.47
7/24/2003	1	0	2	0.36	0	0	0.44	0	0.36	0.8
8/19/2003	0	0	0	0.05	0.22	0	0.14	0.22	0.27	0.41
9/30/2003	0	4	110	0	0.17	0	0.44	0.17	0.17	0.61
10/21/2003	0	0	900	0	0.27	0	1.3	0.27	0.27	1.57
11/18/2003	2	33	34	0	0.93	0	0.2	0.93	0.93	1.13
12/16/2003	0	0	0	0	1.55	0	0.35	1.55	1.55	1.9
1/20/2004	7.4	0	2	0	4.43	0.03	0	4.46	4.46	4.46
2/17/2004	5.2	0	0	0.05	6.88	0	0.27	6.88	6.93	7.2
3/16/2004	10.7	11	110	0.11	2.74	0	0.3	0.7	2.85	3.15

9-11-73

TABLE

Malibu Study Area
Well SMBRP-7b

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/23/2003	0	0	0	0.69	0.16	0	1.4	0.16	0.85	2.25
5/29/2003	0	0	0	2.29	0.56	0	0.39	0.56	2.85	3.24
6/30/2003	0	0	0	0.74	0	0	1.7	0	0.74	2.44
7/21/2003	29.3	0	0	0.53	0.06	0	1	0.06	0.59	1.59
8/18/2003	2419.2	0	300	0.33	0	0	0.91	0	0.33	1.24
9/30/2003	4.1	2	4	0.35	0.1	0	0.6	0.1	0.45	1.05
10/21/2003	0	0	0	0	0	0	0.43	0	0	0.43
11/18/2003	19.6	4	4	0.18	0	0	0.79	0	0.18	0.97
12/15/2003	0	0	0	0.17	0.03	0	0.59	0.03	0.2	0.79
1/19/2004	0	6	350	0.1	0.07	0	0.13	0.07	0.17	0.3
2/16/2004	0	0	0	0.42	0.03	0	0.49	0.03	0.45	0.94
3/15/2004	691	0	20	0.03	0.02	0	0.67	0.7	0.05	0.72

3-1474

FEARD

Malibu Study Area
Well SMBRP-8

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	2	2	8	0	46.3	0	0.33	46.3	46.3	46.63
5/29/2003	2419.2	2	6	0.22	55.6	0	0	55.6	55.82	55.82
6/30/2003	1	0	0	0.26	11.1	0	0.28	11.1	11.36	11.64
7/21/2003	148.5	0	11	1.44	61.5	0	1.9	61.5	62.94	64.84
8/20/2003	0	0	14	0	63.8	0	0.86	63.8	63.8	64.66
9/30/2003	3	2	300	0.04	43.1	0	0.45	43.1	43.14	43.59
10/21/2003	2419.2	0	0	0	31.6	0	0.53	31.6	31.6	32.13
11/18/2003	8.4	22	23	0	48.1	0	0.9	48.1	48.1	49
12/16/2003	2419.7	0	0	0	2.61	0	0.02	2.61	2.61	2.63
1/20/2004	2419.2	60	170	0	48.4	0.04	0	48.44	48.44	48.44
2/17/2004	5	0	2	0.09	48.6	0.02	0.18	48.62	48.71	48.89
3/16/2004	10.5	0	0	0.02	60.2	0	0.18	0.7	60.22	60.4

3-1175

DRAFT

Malibu Study Area
Well SMBRP-9

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/23/2003	0	0	0	0.01	3.03	0	1.1	3.03	3.04	4.14
5/28/2003	4.1	0	4	0.47	32.1	0	0	32.1	32.57	32.57
6/26/2003	0	0	11	0.4	25.8	0	0.52	25.8	26.2	26.72
7/21/2003	2419.2	240	1600	0.29	21.6	0	0.22	21.6	21.89	22.11
8/18/2003	2419.2	0	500	0.02	18.7	0	0.29	18.7	18.72	19.01
9/29/2003	6.3	0	7	0	13.2	0	0.16	13.2	13.2	13.36
10/20/2003	124.5	0	0	0	31.2	0	0.1	31.2	31.2	31.3
11/17/2003	1	17	500	0.15	22.3	0	0.48	22.3	22.45	22.93
12/15/2003	0	0	0	0	21.9	0	0.48	21.9	21.9	22.38
1/19/2004	14.2	0	0	0	30.8	0	0	30.8	30.8	30.8
2/16/2004	0	0	0	0.09	34.7	0.02	0.11	34.72	34.81	34.92
3/16/2004	10.7	0	0	0.02	38.5	0	0.24	0.7	38.52	38.76

FEARD

Malibu Study Area
Well SMBRP-10c

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/24/2003	0	0	0	0.09	3.41	0	0.35	3.41	3.5	3.85
5/29/2003	157.8	0	2	0.47	1.66	0	1.1	1.66	2.13	3.23
6/26/2003	0	2	4	0.04	1.27	0	1.3	1.27	1.31	2.61
7/21/2003	770.1	2	130	0.44	0.93	0	2.3	0.93	1.37	3.67
8/18/2003	1986.3	0	0	0.11	0.65	0	1	0.65	0.76	1.76
9/29/2003	33.7	0	4	0	0.32	0	2.7	0.32	0.32	3.02
10/20/2003	125.7	2	2	0	0.67	0	2.6	0.67	0.67	3.27
11/17/2003	43.5	0	0	0.06	0.7	0	1.4	0.7	0.76	2.16
12/15/2003	5.2	0	2	0	0.59	0	1.5	0.59	0.59	2.09
1/19/2004	2	0	0	0	1.43	0	0.24	1.43	1.43	1.67
2/16/2004	1	0	0	0.26	1.31	0	1.3	1.31	1.57	2.87
3/15/2004	5.1	0	0	0.05	1.79	0.02	1.3	1.81	1.86	3.16

3-11-77

LEARD

Malibu Study Area
Well SMBRP-11

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	0	0	0	0.04	5.66	0	0.85	5.66	5.7	6.55
5/28/2003	2419.2	0	4	0.3	3.85	0	0.51	3.85	4.15	4.66
6/26/2003	0	0	2	0.03	2.48	0	0.49	2.48	2.51	3
7/21/2003	1203.3	2	110	0.37	1.48	0	0.52	1.48	1.85	2.37
8/18/2003	2419.2	2	240	0.17	1.35	0	0.98	1.35	1.52	2.5
9/29/2003	28.1	4	7	0	0.55	0	0.8	0.55	0.55	1.35
10/20/2003	3	0	0	0	0.45	0	0.16	0.45	0.45	0.61
11/18/2003	0	13	13	0.11	0.09	0	0.38	0.09	0.2	0.58
12/16/2003	7	0	0	0	0.26	0	0.29	0.26	0.26	0.55
1/20/2004	15.3	0	0	0	1.54	0.03	0.2	1.57	1.57	1.77
2/17/2004	5	0	0	0.11	0.25	0	0.28	0.25	0.36	0.64
3/15/2004	2	0	0	0.04	3.43	0	0.11	3.43	3.47	3.58

C-11178

DRAFT

Malibu Study Area
Well SMBRP-12

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	2	2	50	5.14	0	0	13	0	5.14	18.14
5/28/2003	0	4	4	9.29	0	0	12	0	9.29	21.29
6/27/2003	0	0	0	10.2	0	0	12	0	10.2	22.2
7/21/2003	0	0	0	8.6	0.06	0	11	0.06	8.66	19.66
8/18/2003	1	0	0	6.45	0	0	12	0	6.45	18.45
9/29/2003	0	0	0	7.26	0	0	12	0	7.26	19.26
10/20/2003	0	0	0	6.29	0	0	6.5	0	6.29	12.79
11/17/2003	0	0	0	3.66	0.02	0	8.7	0.02	3.68	12.38
12/15/2003	1	2	4	7.19	0.02	0	9.6	0.02	7.21	16.81
1/19/2004	0	2	2	7.82	0.07	0	22	0.07	7.89	29.89
2/16/2004	1	0	0	0	0.03	0	12	0.03	0.03	12.03
3/15/2004	0	0	0	1.01	0	0	12	0	1.01	13.01

DRAFT

Malibu Study Area
Well SMBRP-13

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/22/2003	34.1	0	0	0.16	1	0	0.59	1	1.16	1.75
5/28/2003	54.8	0	2	6.03	0.49	0	0.28	0.49	6.52	6.8
6/27/2003	5	0	0	0.15	0.3	0	0.35	0.3	0.45	0.8
7/21/2003	0	0	0	0.38	0.23	0	0.4	0.23	0.61	1.01
8/18/2003	2	0	8	0.09	0.09	0	0.34	0.09	0.18	0.52
9/29/2003	5.1	0	0	0.03	0.06	0	0.62	0.06	0.09	0.71
10/20/2003	2	0	0	0	0	0	0.15	0	0	0.15
11/17/2003	2	0	2	0.06	0.03	0	0.27	0.03	0.09	0.36
12/15/2003	19.9	0	0	0.14	0.02	0	1.2	0.02	0.16	1.36
1/19/2004	2	0	2	0	0.24	0	0	0.24	0.24	0.24
2/16/2004	26	2	2	0.05	0.42	0	0.4	0.42	0.47	0.87
3/15/2004	7.4	0	2	0.02	0.41	0	1.2	0.41	0.43	1.63

3-1186

DRAFT

Malibu Study Area
Well SMBRP-14

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TkN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/22/2003	21.1	17000	17000	17.4	0	0	25	0	17.4	42.4
5/28/2003	91.4	1600	1600	0.26	0	0	15	0	0.26	15.26
6/27/2003	0	1600	1600	13.1	0	0	16	0	13.1	29.1
7/21/2003	2419.2	900	1600	23.8	0.18	0	26	0.18	23.98	49.98
8/18/2003	16.6	220	1600	8.23	0	0	28	0	8.23	36.23
9/29/2003	8.4	1600	1600	21.1	0.07	0	26	0.07	21.17	47.17
10/20/2003	1	300	1600	20.4	0	0	100	0	20.4	120.4
11/17/2003	5.2	500	1600	15.5	0.03	0.02	33	0.05	15.55	48.55
12/15/2003	2	1600	1600	16.4	0.02	0	31	0.02	16.42	47.42
1/19/2004	22.8	1600	1600	16.2	0.05	0.02	36	0.07	16.27	52.27
3/15/2004	6.3	1600	1600	0.48	0.02	0	22	0.02	0.5	22.5

3-1191

DRAFT

Malibu Study Area
Well SMBRP-15b

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/25/2003	67.6	0	0	0.14	0.91	0	1	0.91	1.05	2.05
5/28/2003	2419.2	0	21	1.21	1.03	0	0.42	1.03	2.24	2.66
6/26/2003	3.1	0	0	0.05	0.94	0	0.28	0.94	0.99	1.27
7/21/2003	0	0	0	0.37	0.94	0	0.24	0.94	1.31	1.55
8/18/2003	2	0	2	0.05	1.31	0	0.18	1.31	1.36	1.54
9/29/2003	0	2	2	0	1.15	0	0.4	1.15	1.15	1.55
10/20/2003	0	0	0	0.18	1.64	0	0.48	1.64	1.82	2.3
11/18/2003	0	0	0	0	1.56	0.03	0.4	1.59	1.59	1.99
12/15/2003	0	0	0	0.02	1.7	0	0.66	1.7	1.72	2.38
1/20/2004	0	0	0	0	1.46	0.05	0	1.51	1.51	1.51
2/17/2004	9.1	0	0	0.09	1.24	0.06	0.2	1.3	1.39	1.59
3/16/2004	2	0	2	0.08	1.05	0.03	0.25	1.08	1.16	1.41

3-1192

DRAFT

Malibu Study Area
Well SMBRP-16

Parameter	Enterococcus	Fecal Coliform	Total Coliform	Ammonia	Nitrate	Nitrite	TKN	Nitrate + Nitrite	Ammonia + Nitrate + Nitrite	Ammonia + Nitrate + Nitrite + TKN
Unit	(MPN/100ml)	(MPN/100ml)	(MPN/100ml)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
MCL		0	0					10	10	
Sample Date										
4/23/2003	33.3	0	0	0.2	2.88	0.49	0.64	3.37	3.57	4.21
5/28/2003	2419.2	0	4	6.08	4.02	0.31	1.2	4.33	10.41	11.61
6/26/2003	29.2	0	0	0.83	2.38	0.19	1.6	2.57	3.4	5
7/21/2003	5.2	0	0	0.52	4.5	0.24	0.56	4.74	5.26	5.82
8/18/2003	2419.2	0	0	0.04	4.58	0	1.1	4.58	4.62	5.72
9/29/2003	42.8	0	0	0	2.77	0.1	1.4	2.87	2.87	4.27
10/20/2003	0	0	0	0	3.66	0	0.73	3.66	3.66	4.39
11/17/2003	3.1	0	2	0.32	3	0.09	1.5	3.09	3.41	4.91
12/15/2003	1	0	0	0.04	4.11	0	1.1	4.11	4.15	5.25
1/19/2004	0	0	0	0.06	4.68	0.06	0.1	4.74	4.8	4.9
2/16/2004	0	0	2	0.04	5	0.03	0.99	5.03	5.07	6.06
3/15/2004	1	0	2	0.03	0	5.12	0.05	0.7	5.15	5.2

3-1183

FEARD

Technical Memorandum #2: Pathogens and Nitrogen in Wastewaters Impair Underlying Groundwater as a Potential Source of Drinking Water

Attachment 2-2

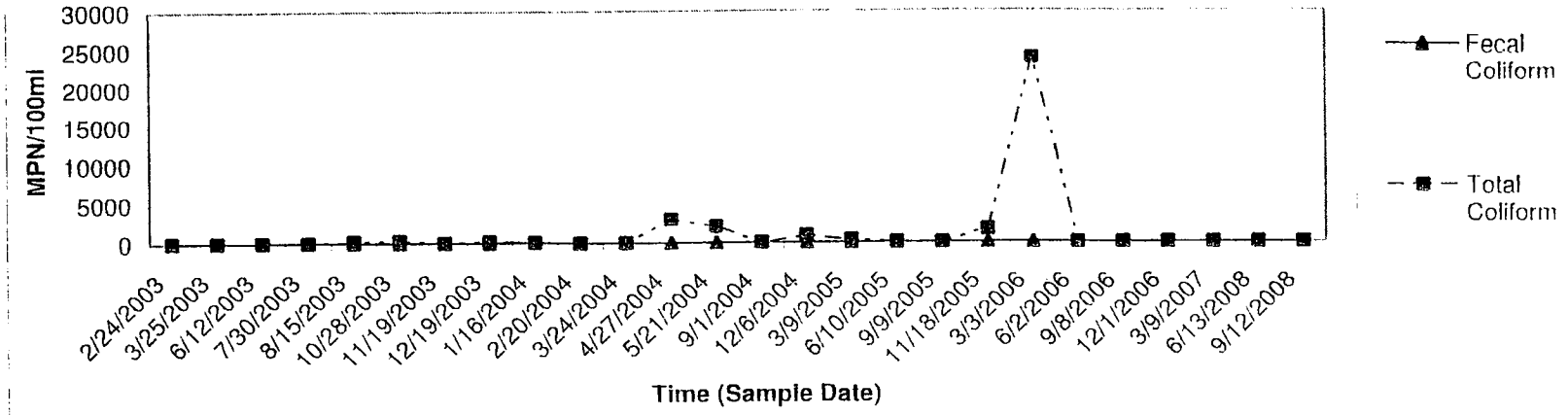
Graphs for 47 Individual Wells

DRAFT

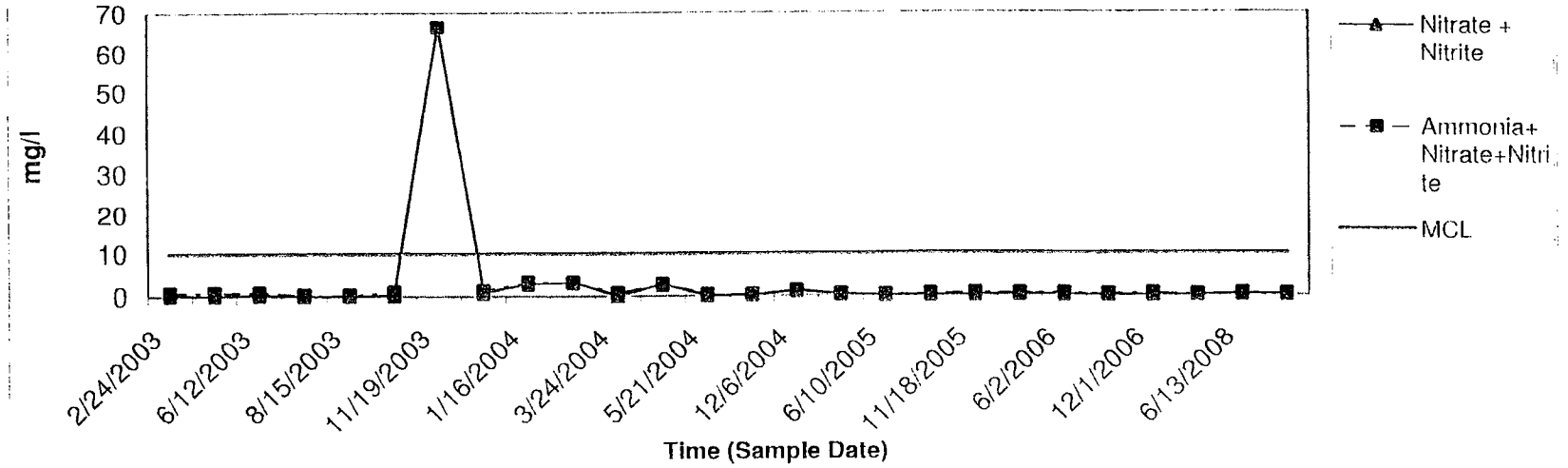
3-1184

Malibu Administrative Center

Well #7b



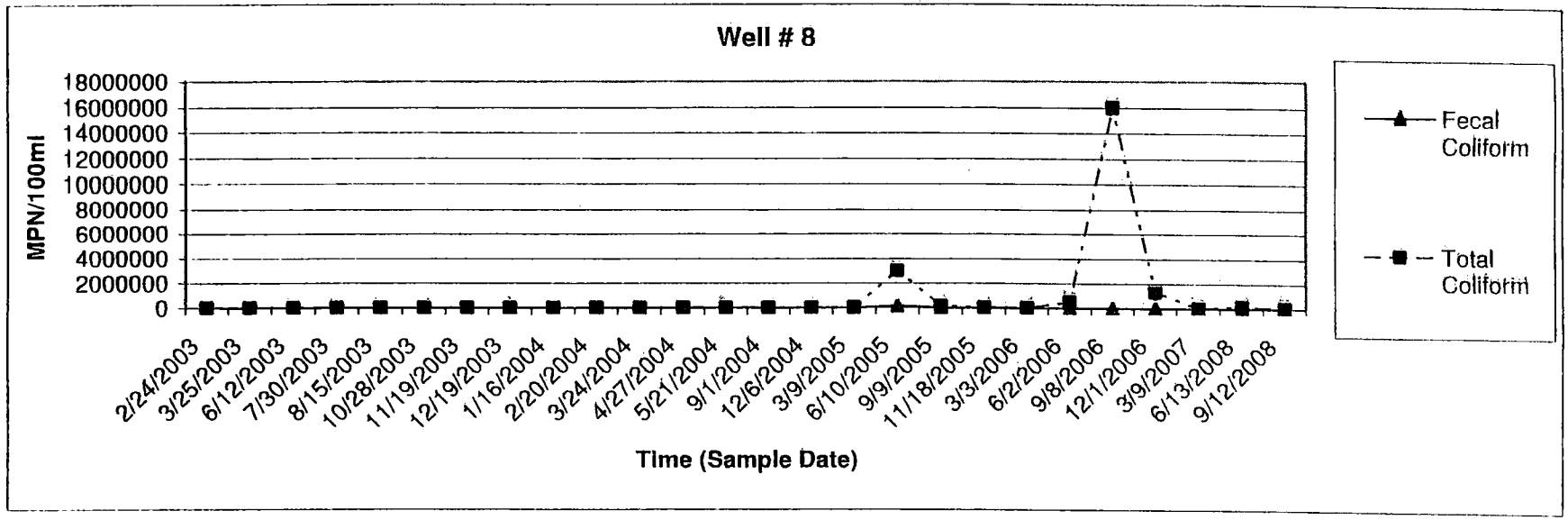
Well #7b

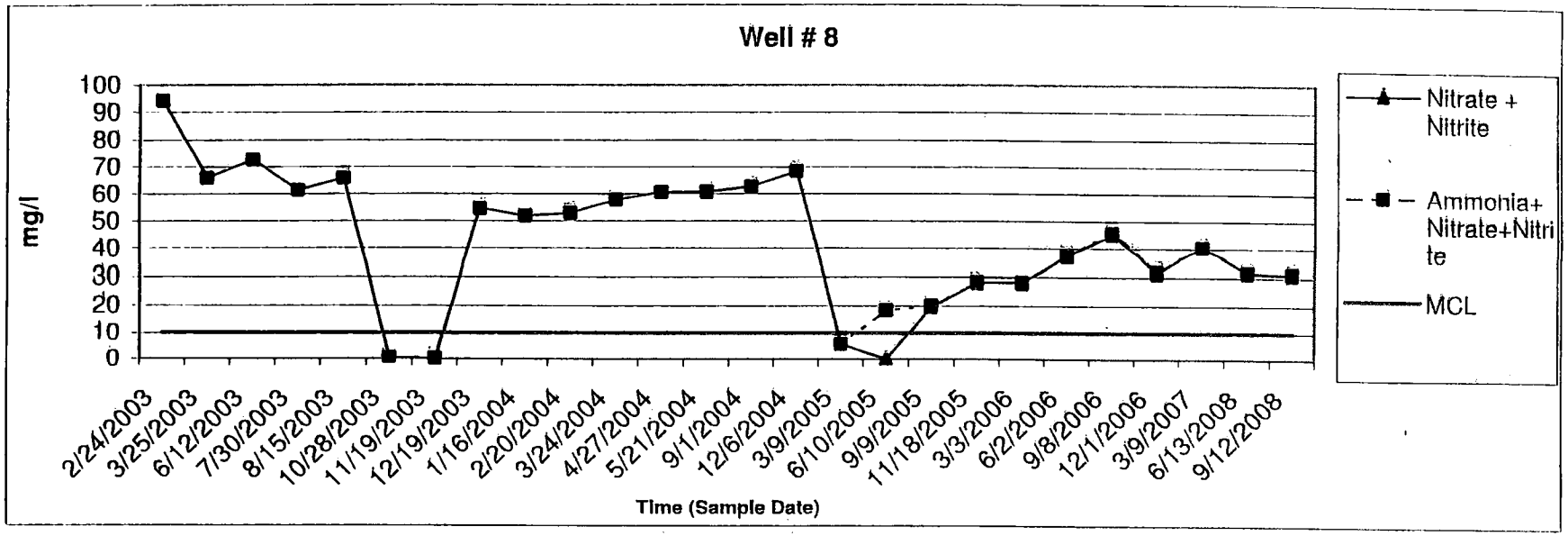


3-1185

T E A R D

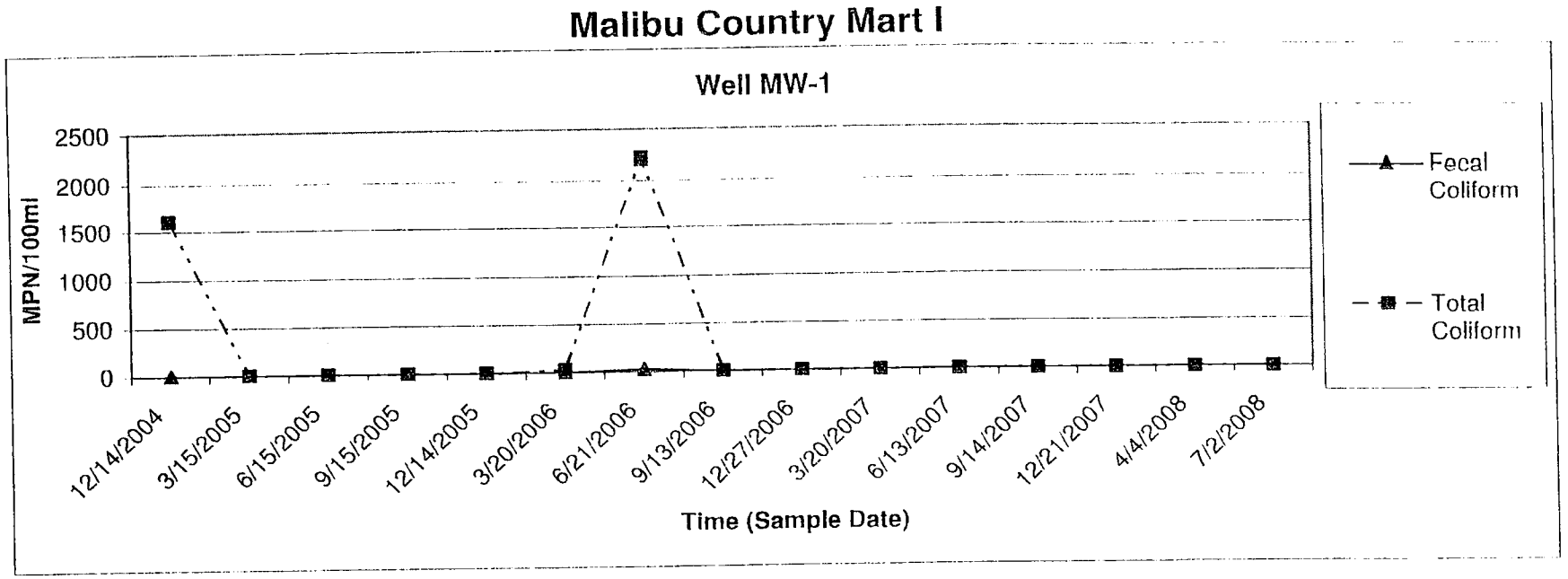
Malibu Administrative Center





9-1165

FILED


Malibu Country Mart I
Well MW-1
MPN/100ml
2500
2000
1500
1000
500
0
12/14/2004
3/15/2005
6/15/2005
9/15/2005
12/14/2005
3/20/2006
6/21/2006
9/13/2006
12/27/2006
3/20/2007
6/13/2007
9/14/2007
12/21/2007
4/4/2008
7/2/2008
Time (Sample Date)
Fecal Coliform
Total Coliform

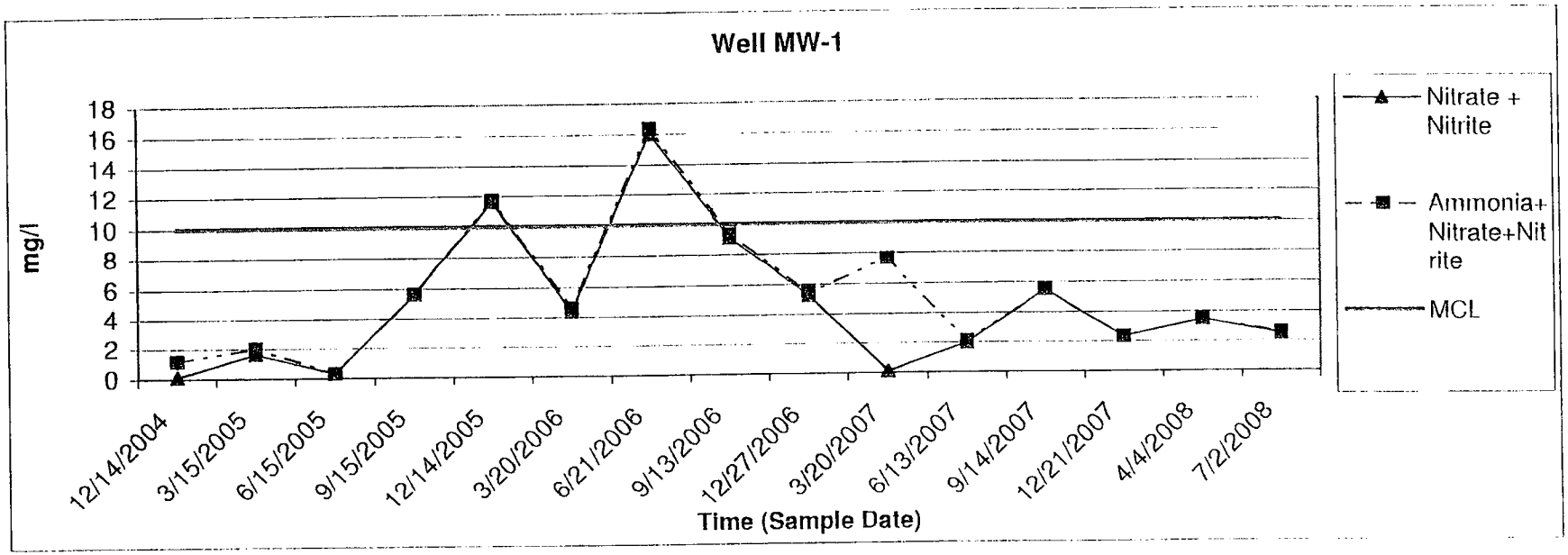
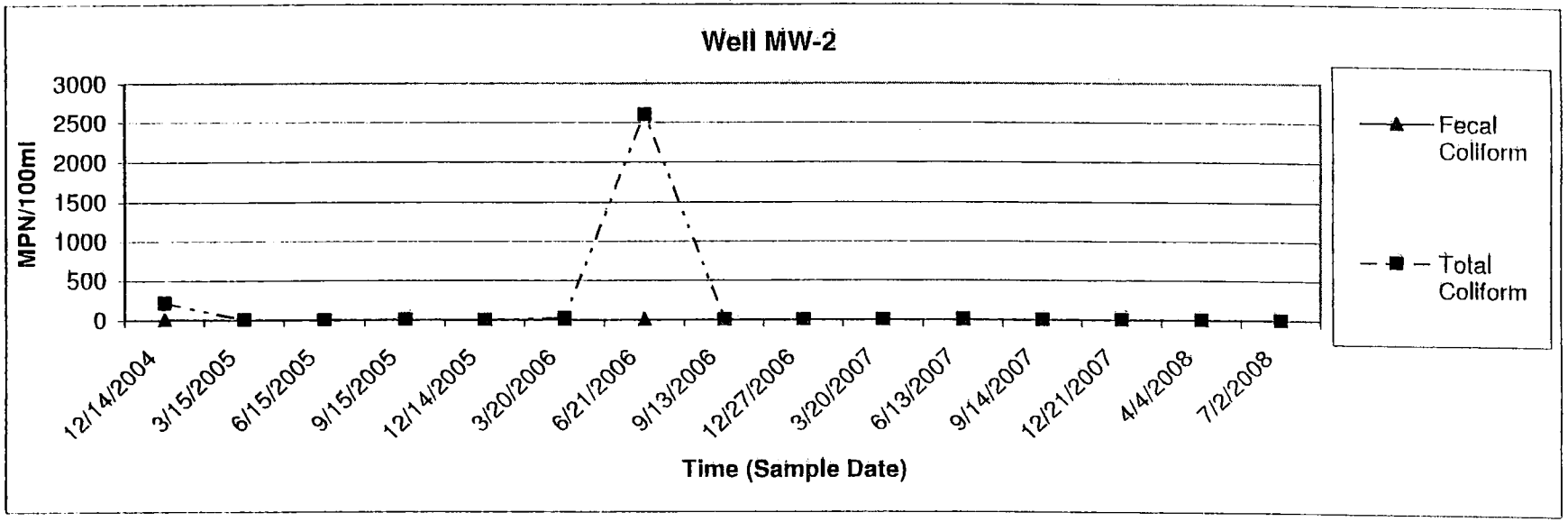
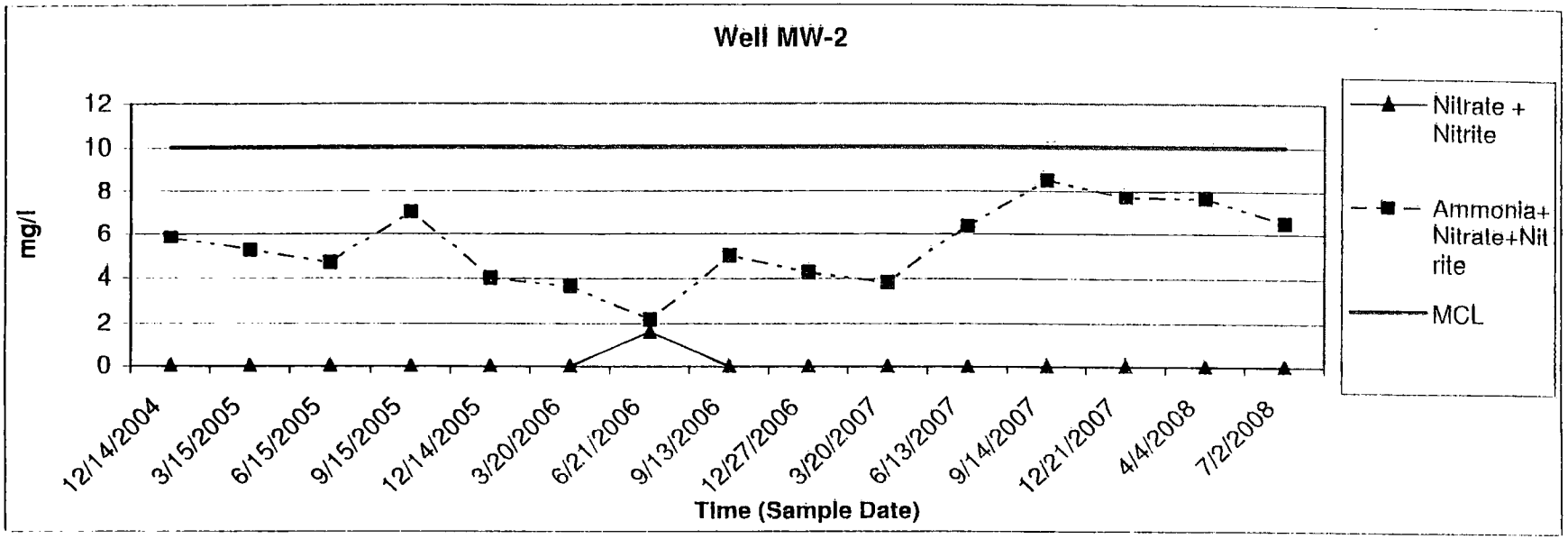

Well MW-1
mg/l
18
16
14
12
10
8
6
4
2
0
12/14/2004
3/15/2005
6/15/2005
9/15/2005
12/14/2005
3/20/2006
6/21/2006
9/13/2006
12/27/2006
3/20/2007
6/13/2007
9/14/2007
12/21/2007
4/4/2008
7/2/2008
Time (Sample Date)
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL

TABLE D

Malibu Country Mart I

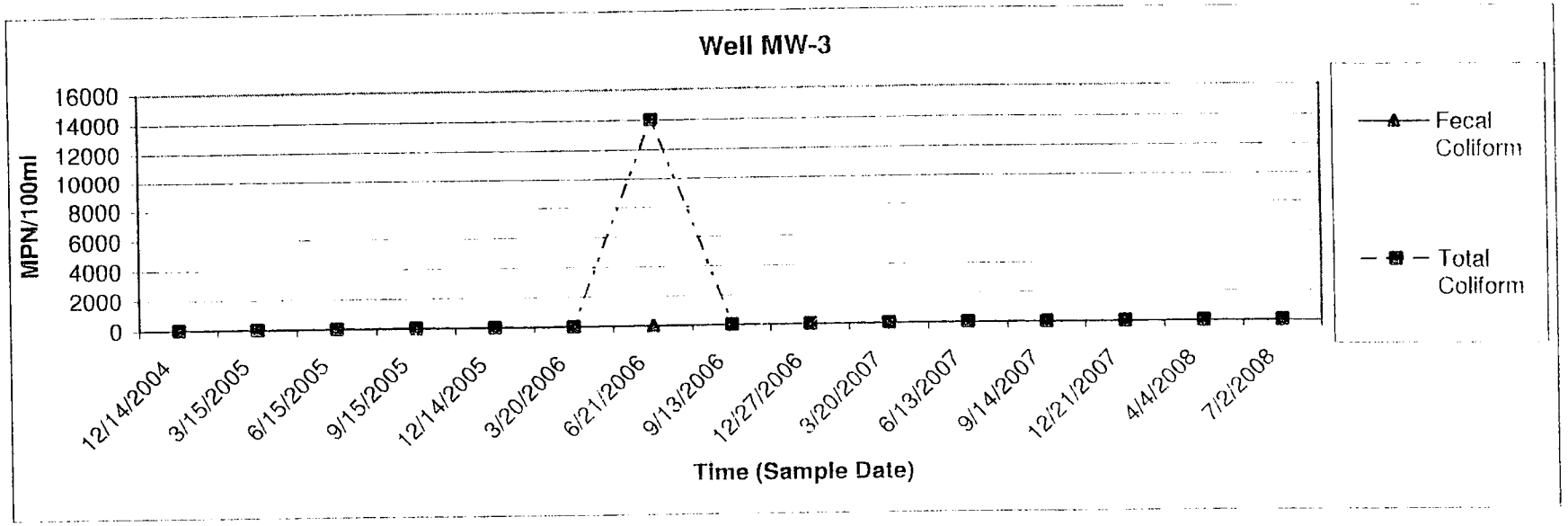


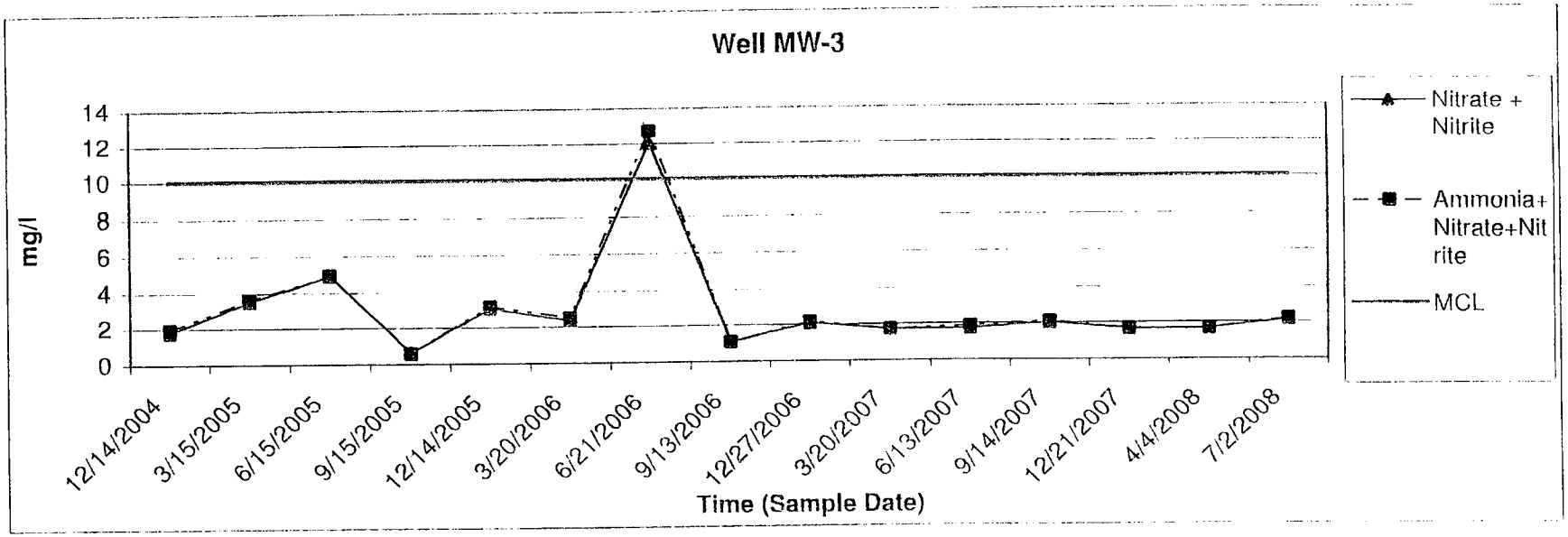


T2-56

LEARD

Malibu Country Mart I



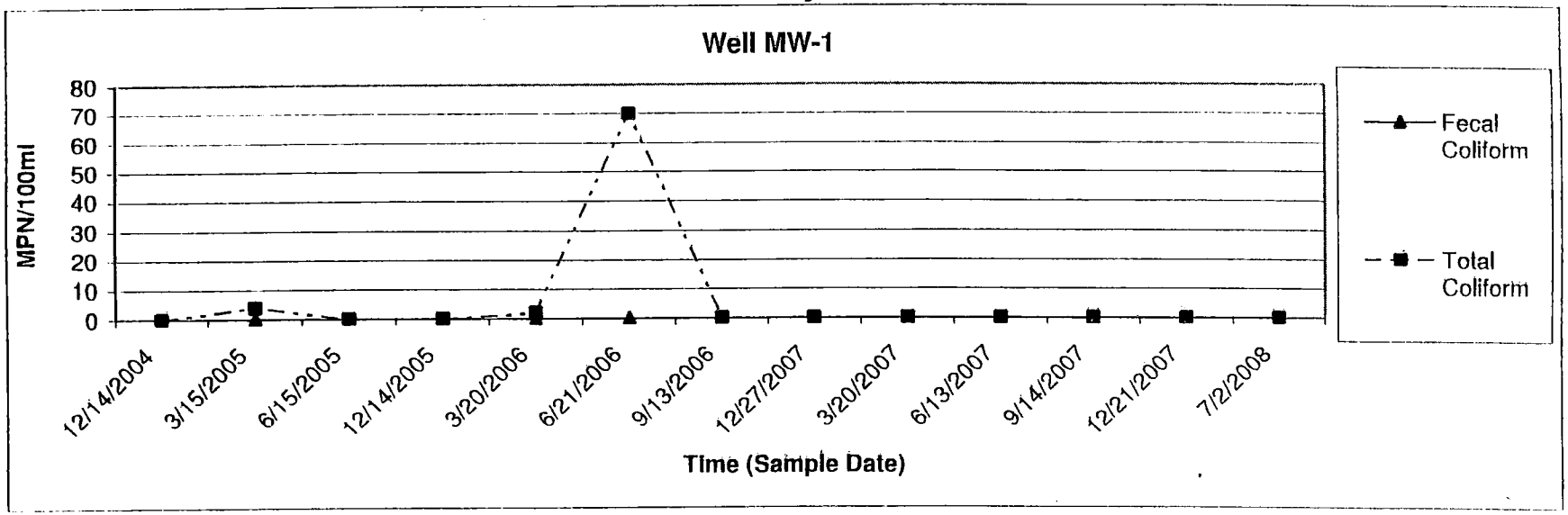


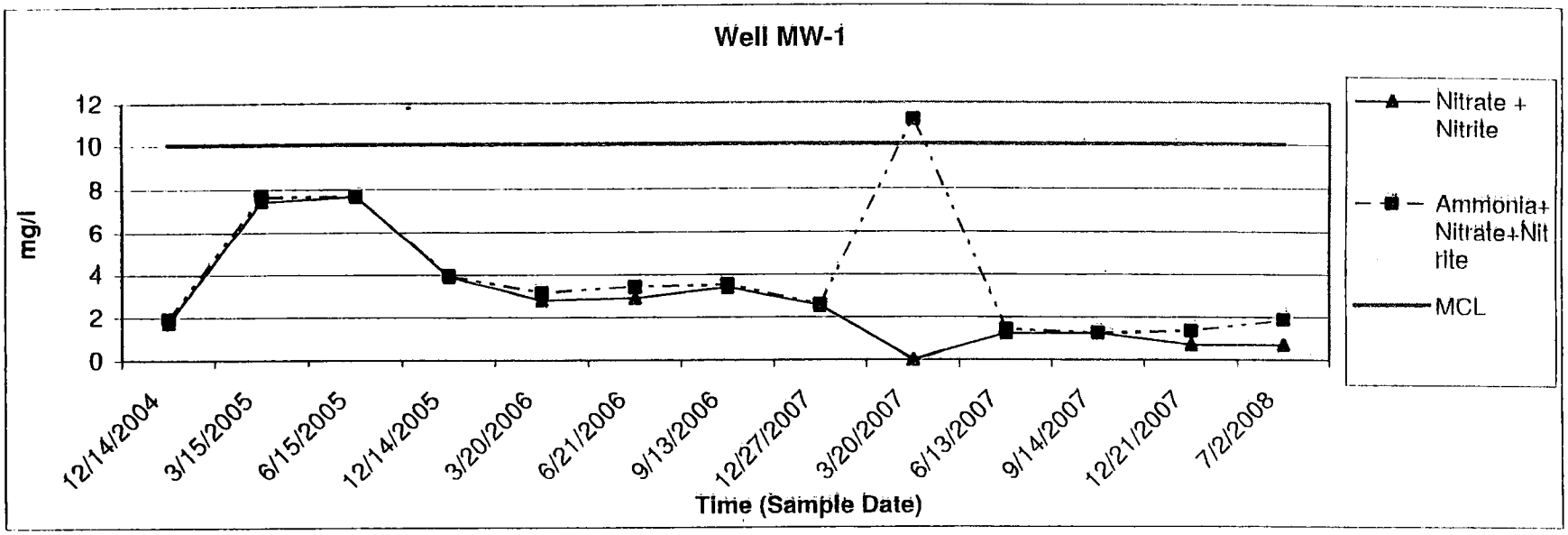
T2-57

SGT-9

LEAD

Malibu Country Mart II

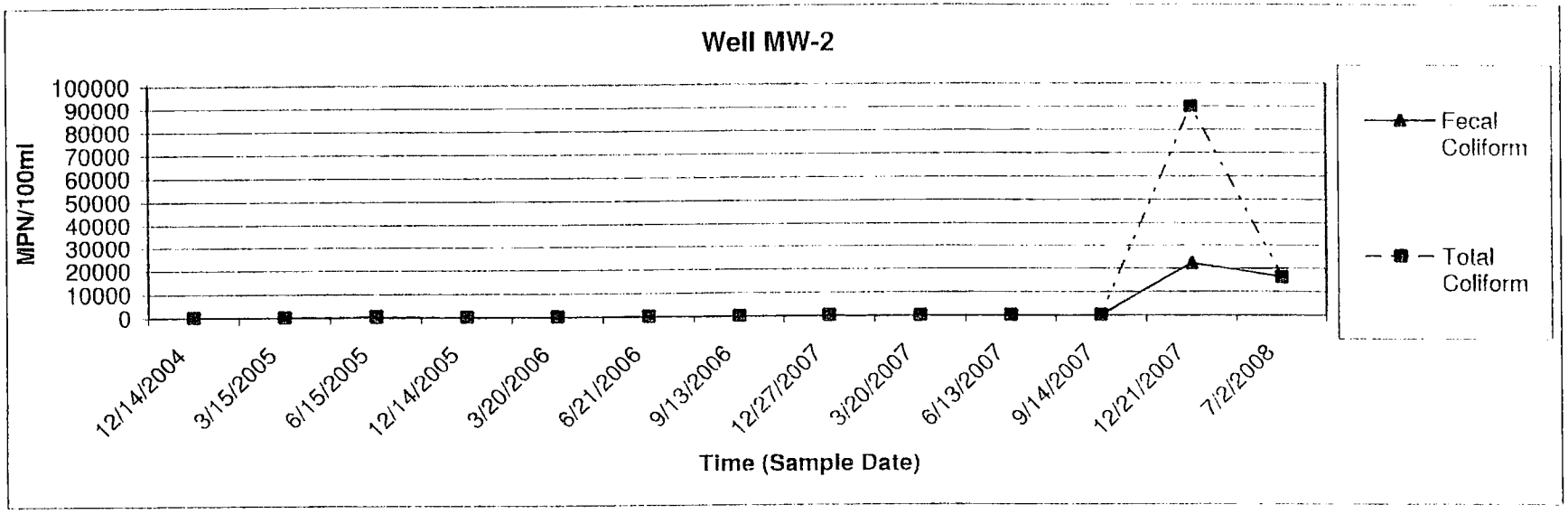


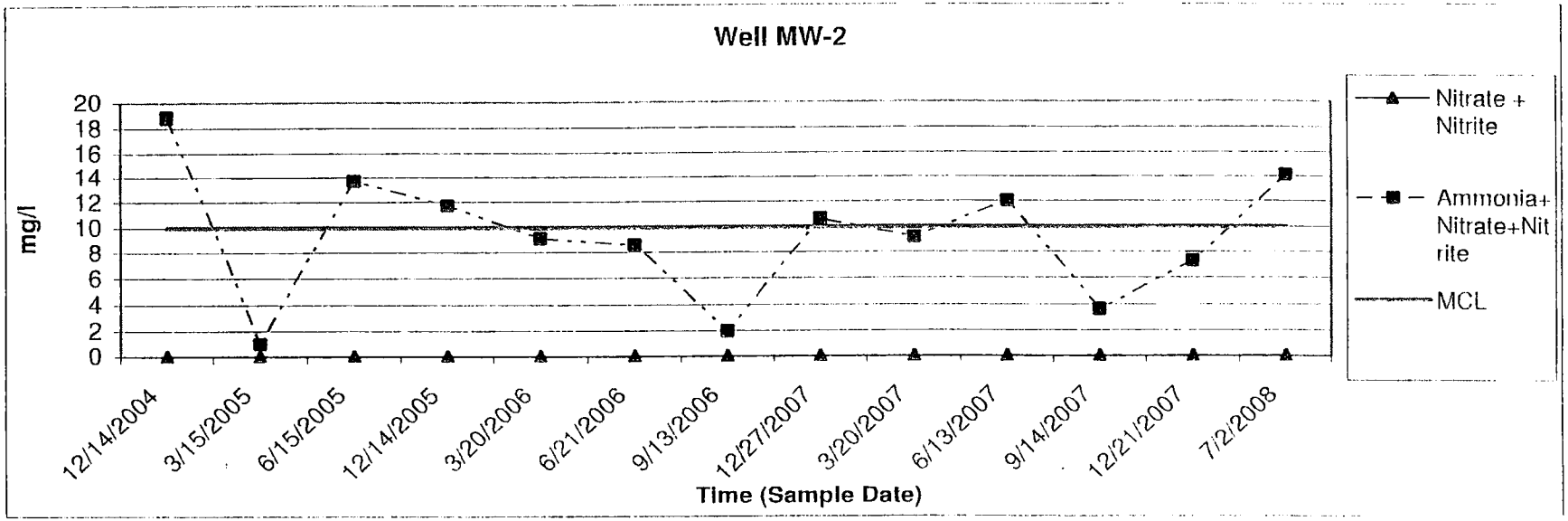


T2-58

DRAFT

Malibu Country Mart II

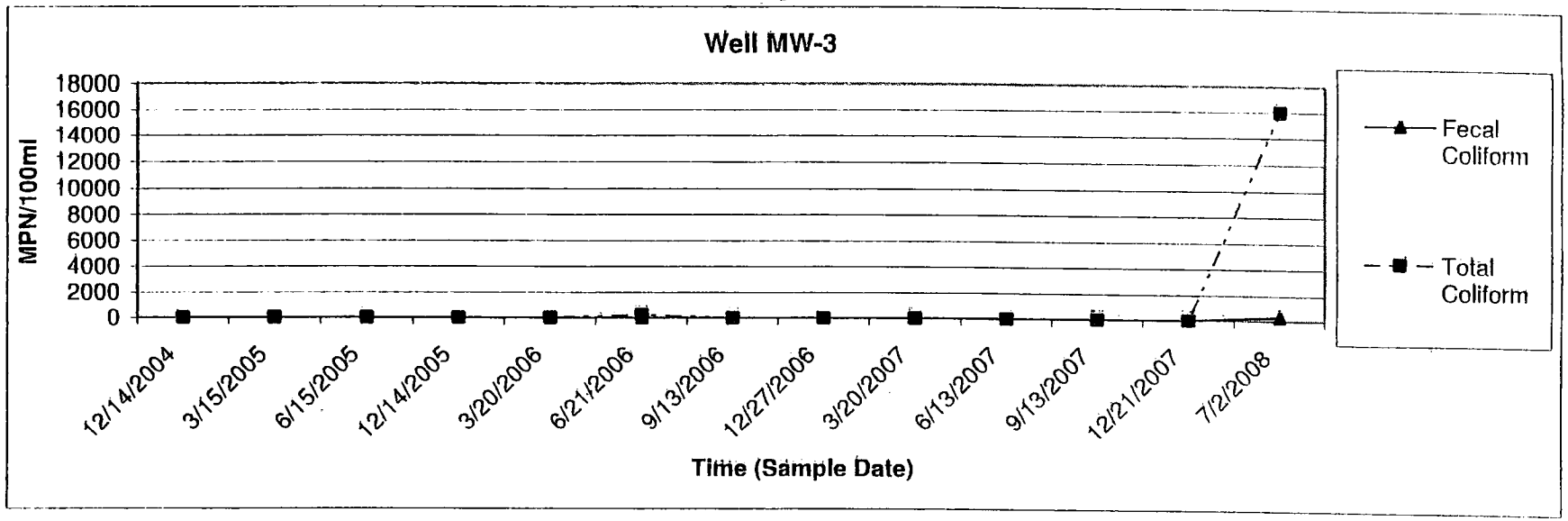


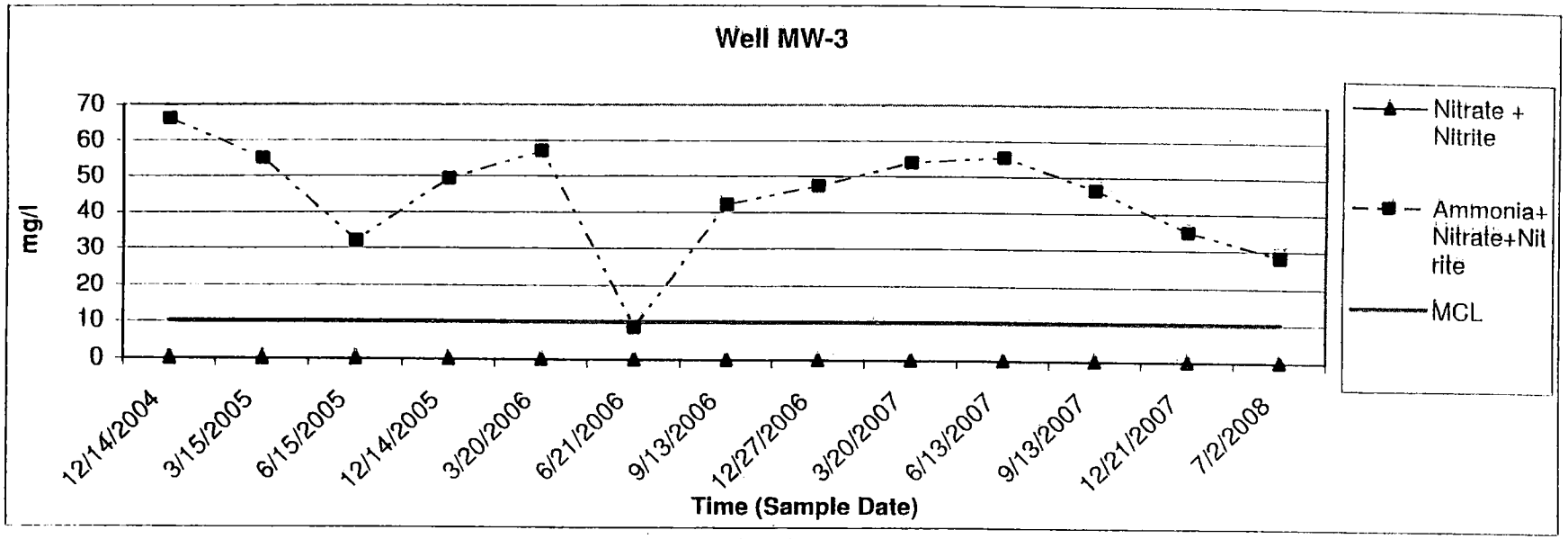


3-1151

LEARD

Malibu Country Mart II

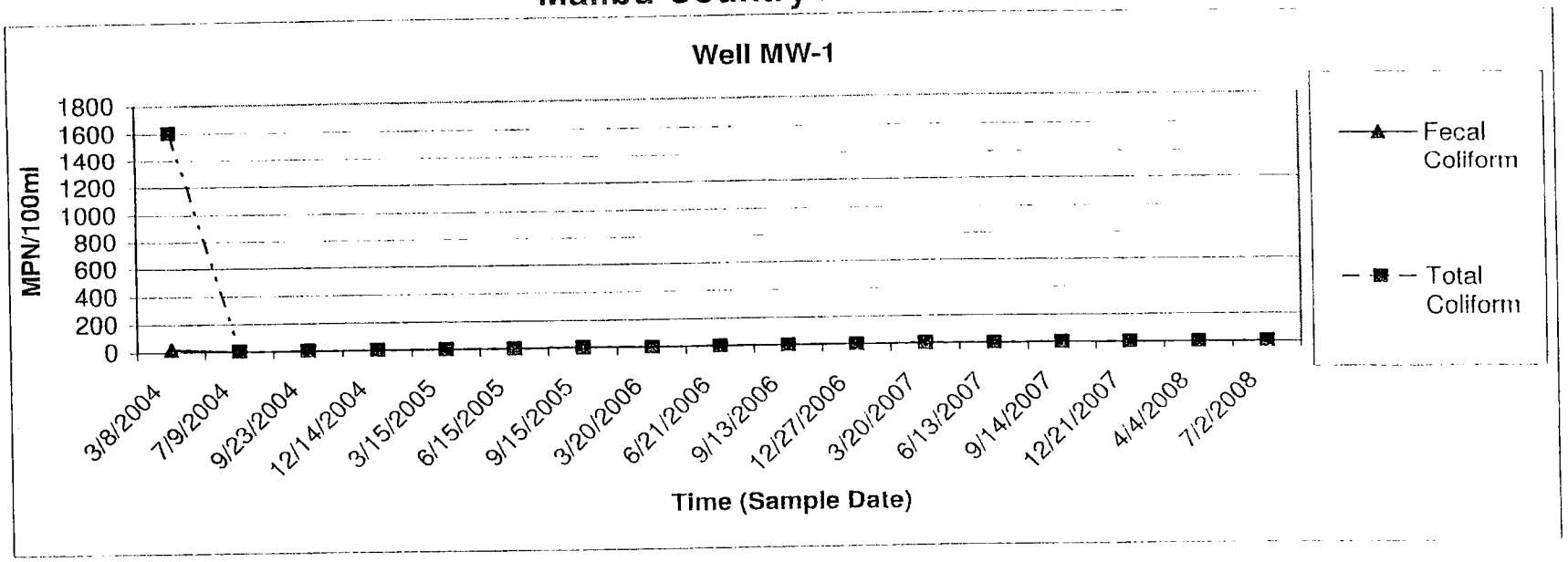


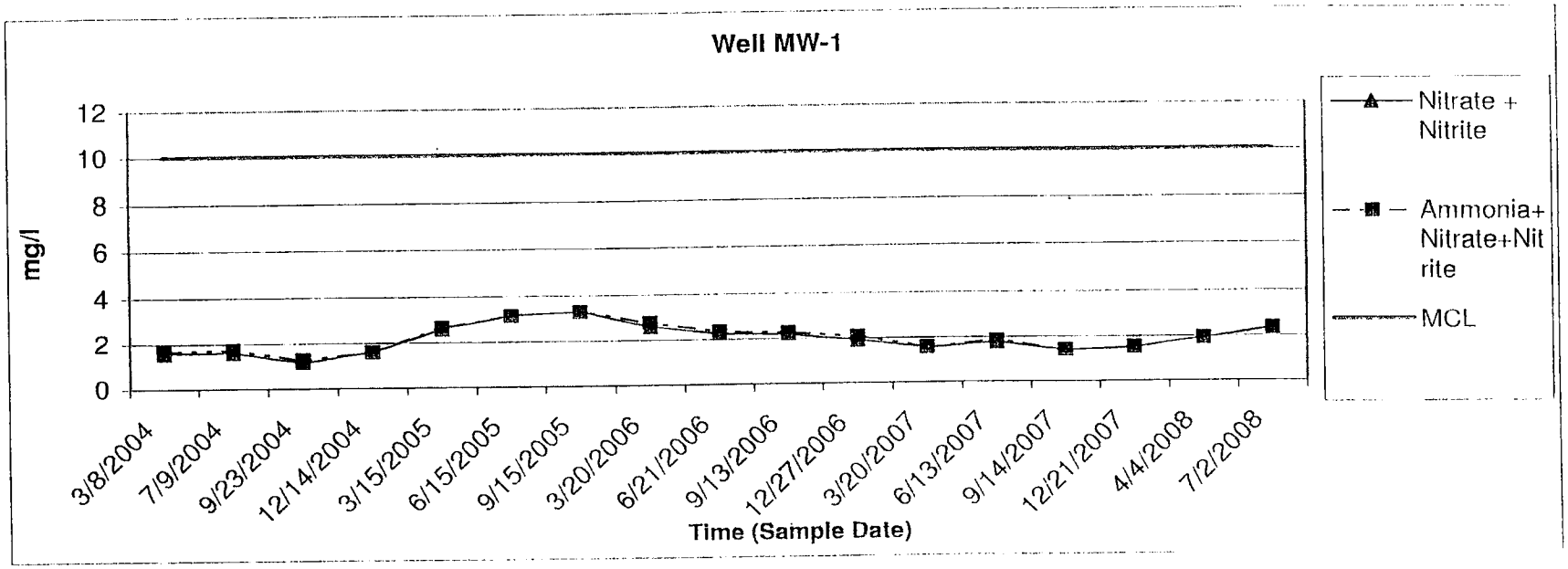


T2-60

LEAD

Malibu Country Mart III

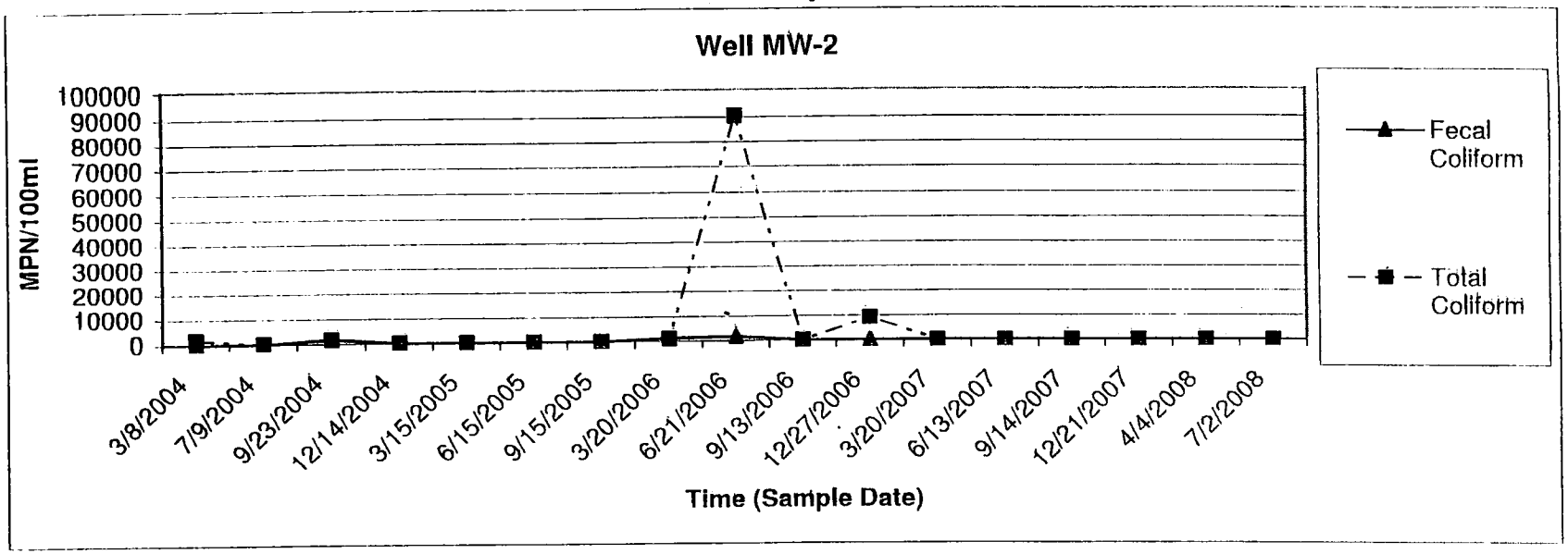


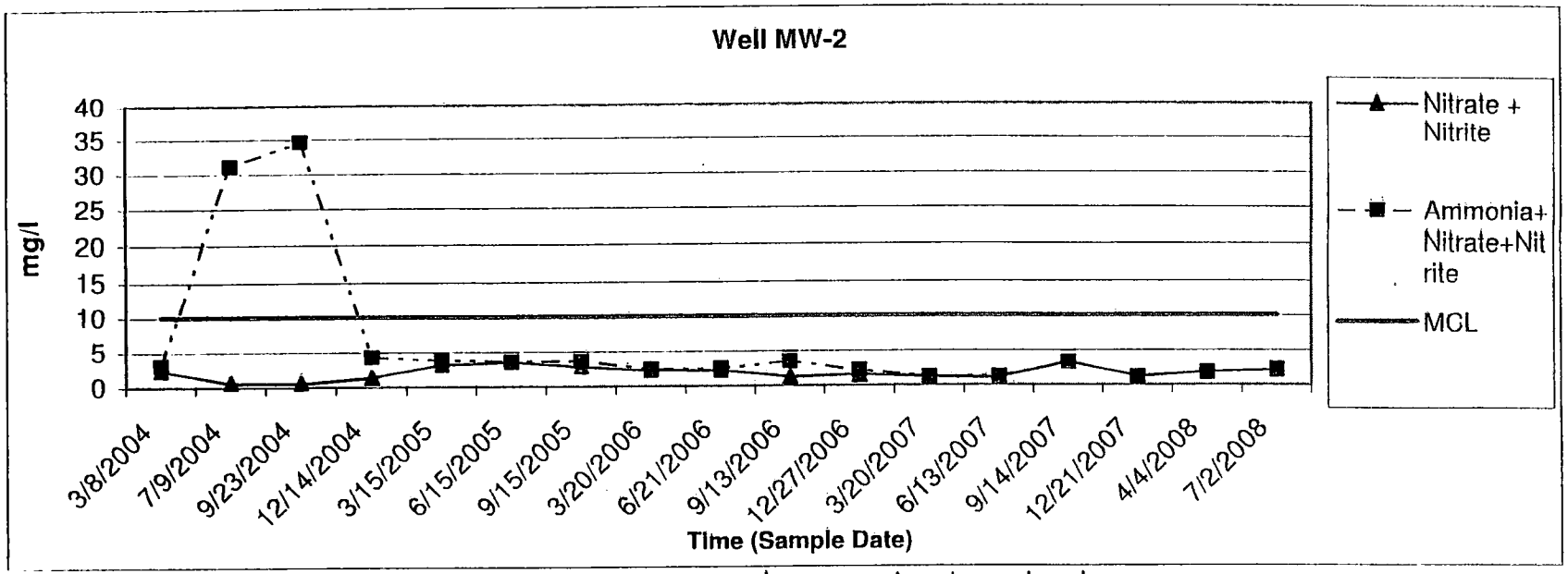


S-1193

LEARD

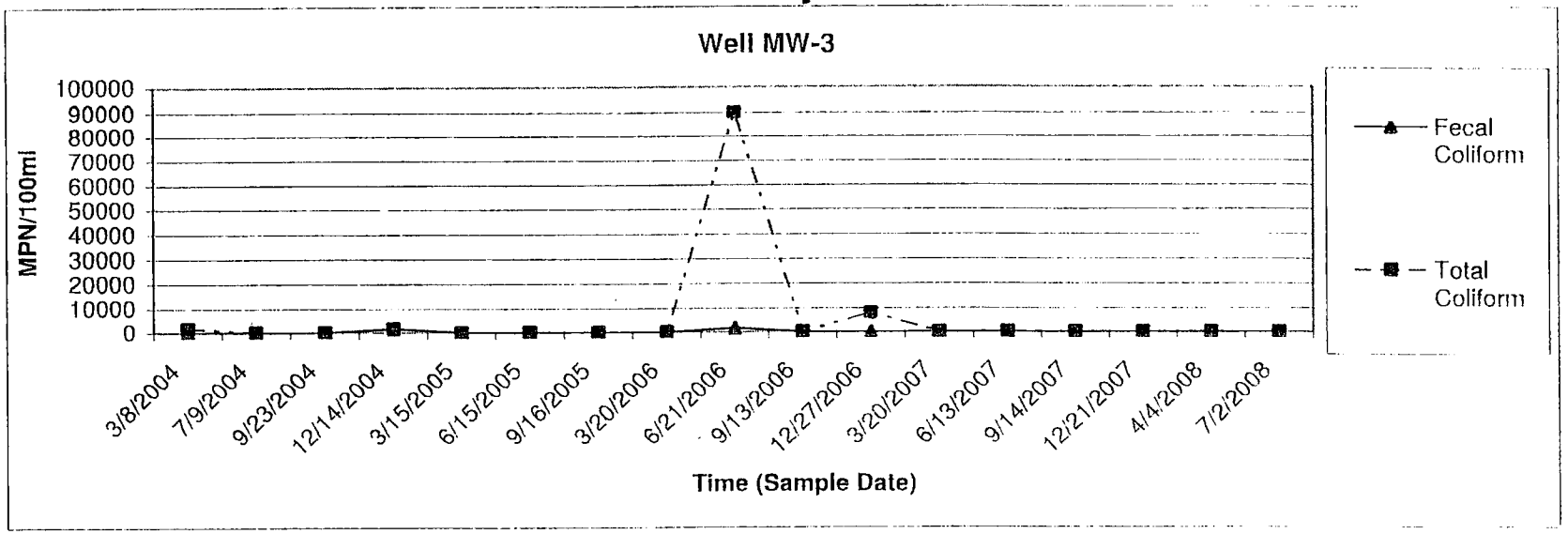
Malibu Country Mart III

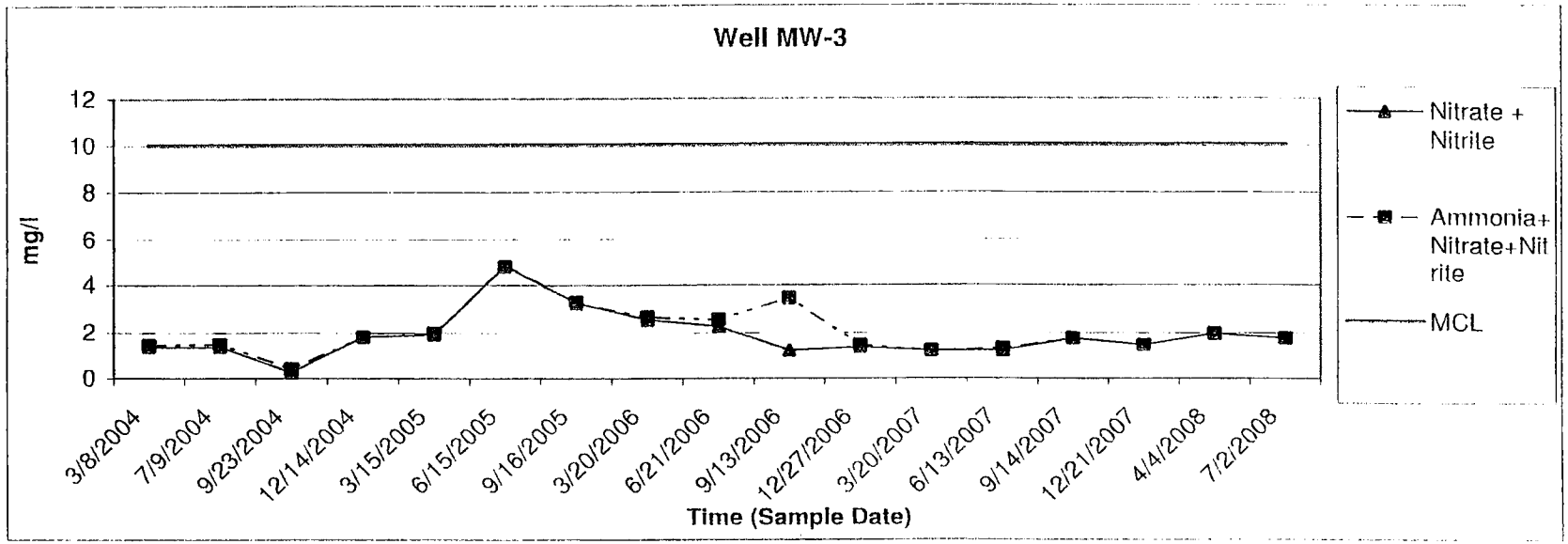




T E A R D

Malibu Country Mart III

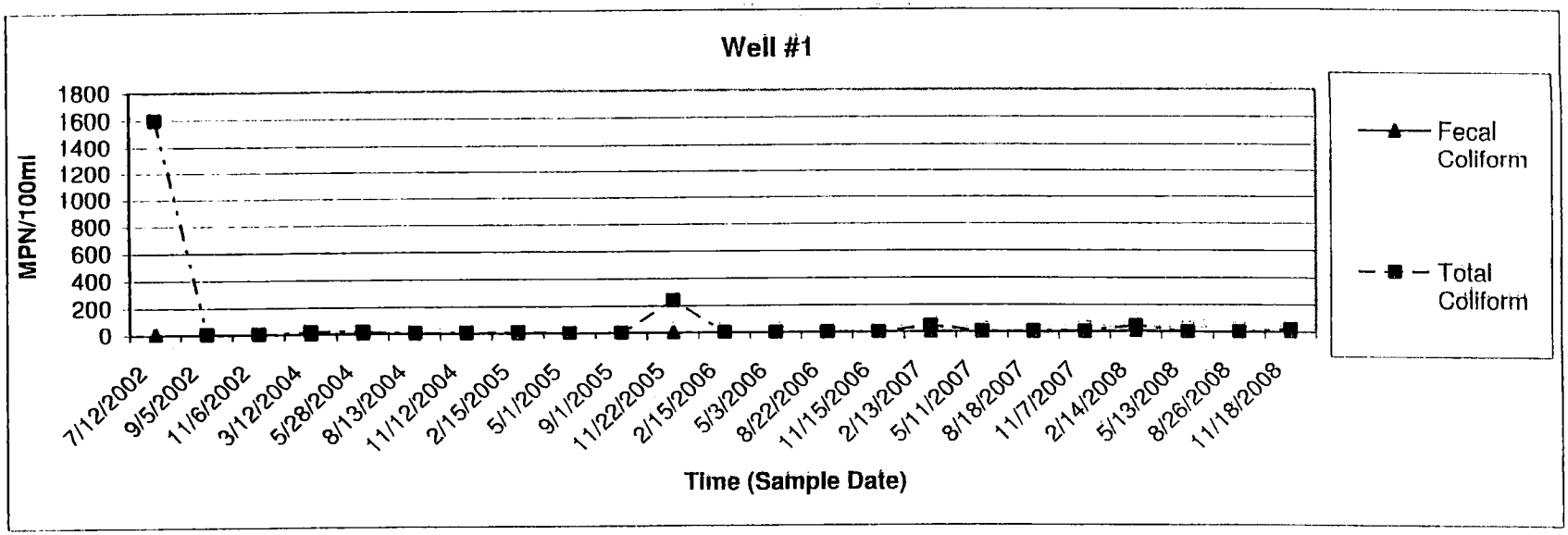


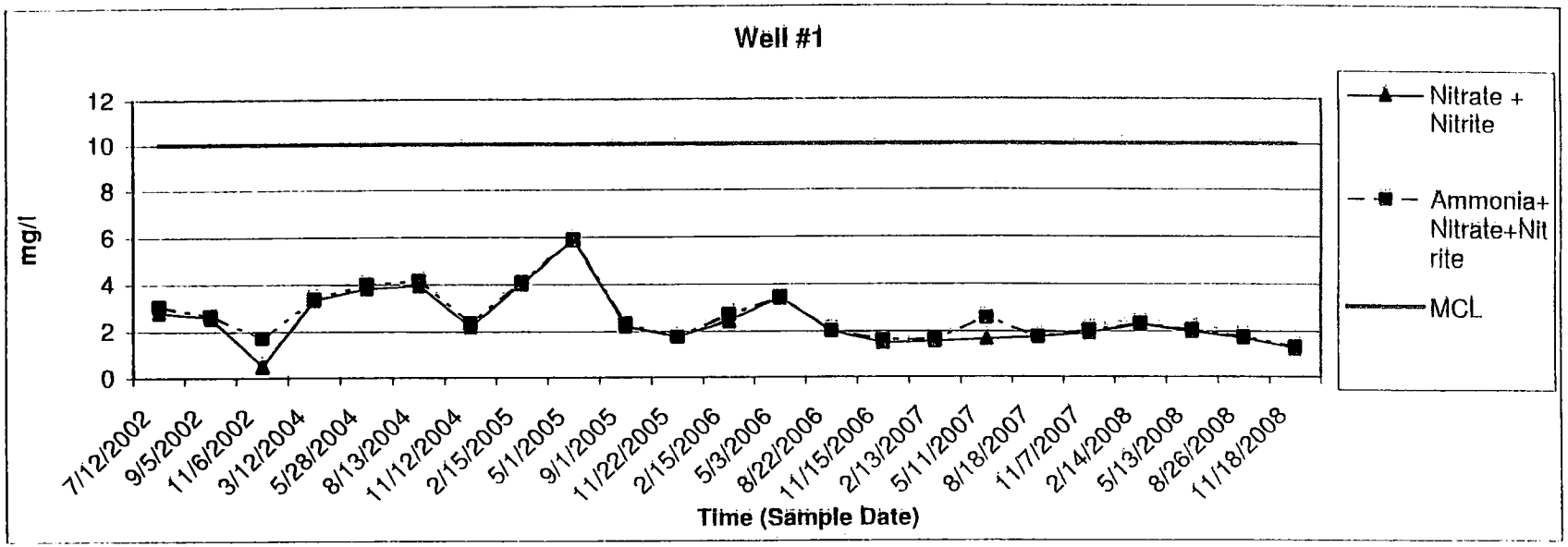


3-1195

DRAFT

Malibu Creek Plaza

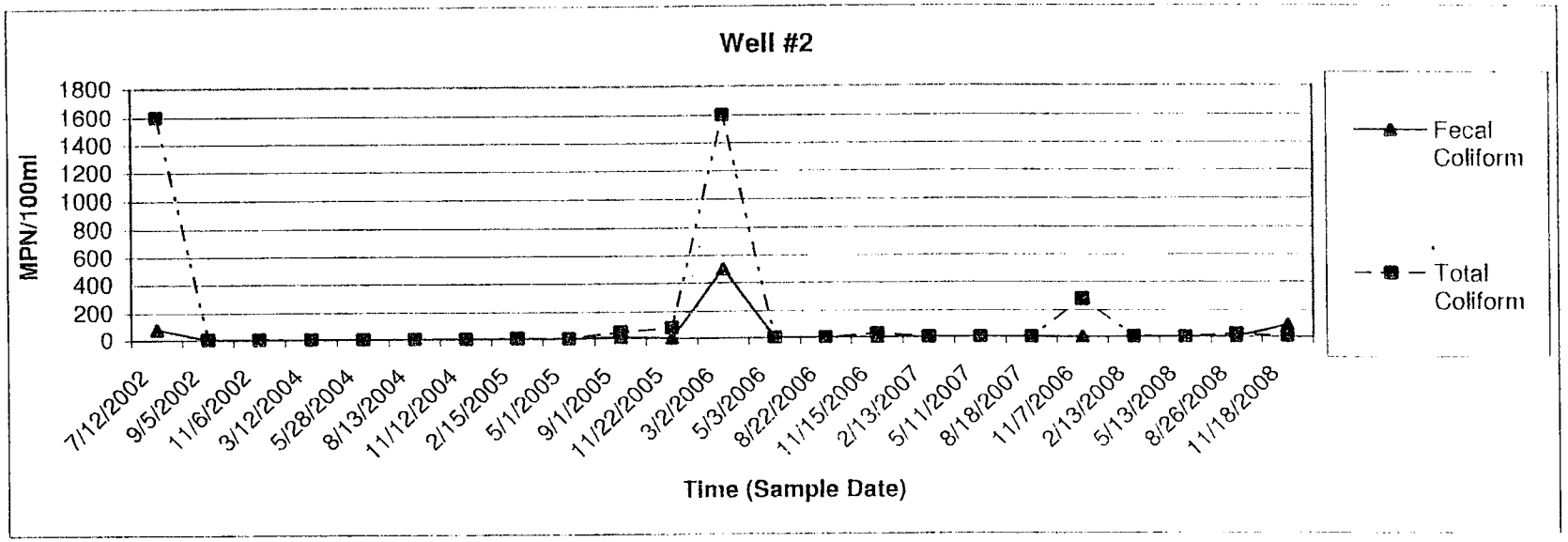




T2-64

T E A R D

Malibu Creek Plaza



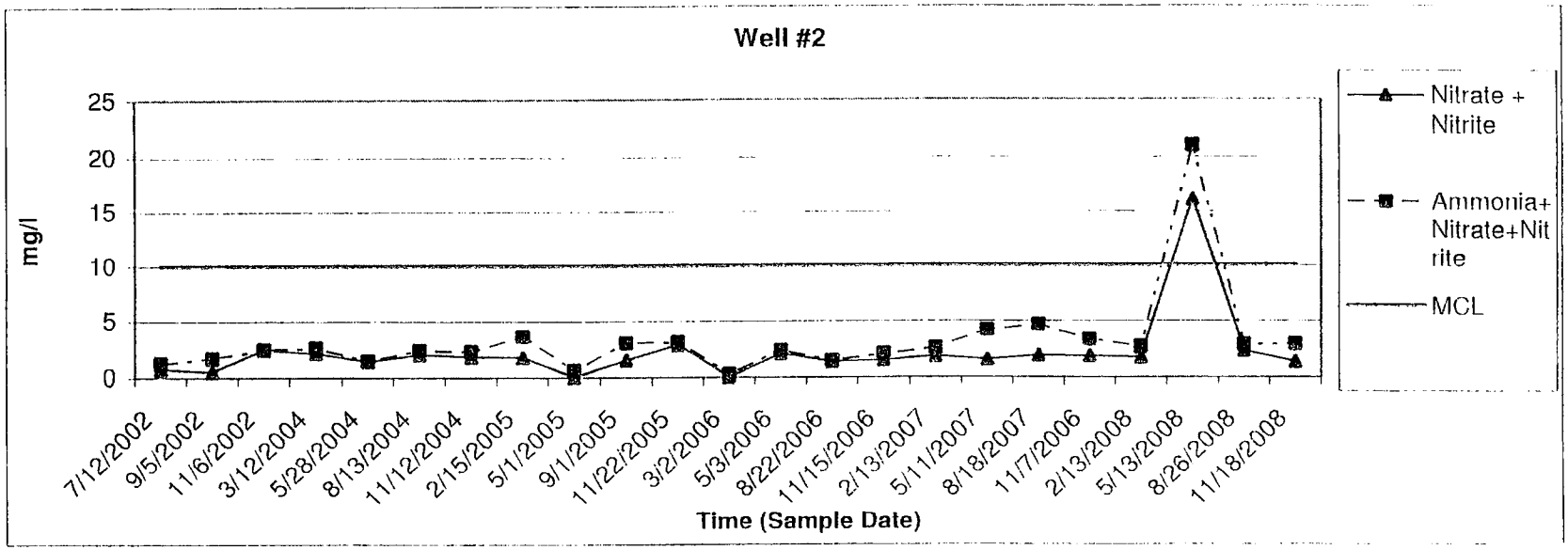
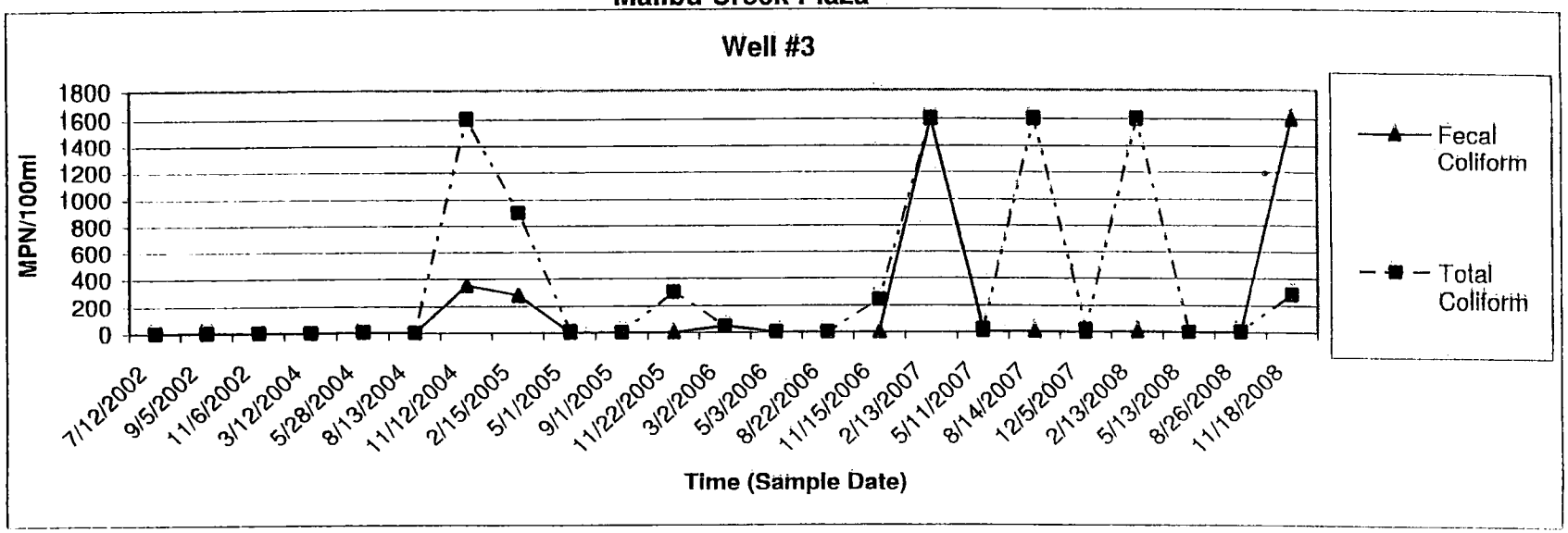
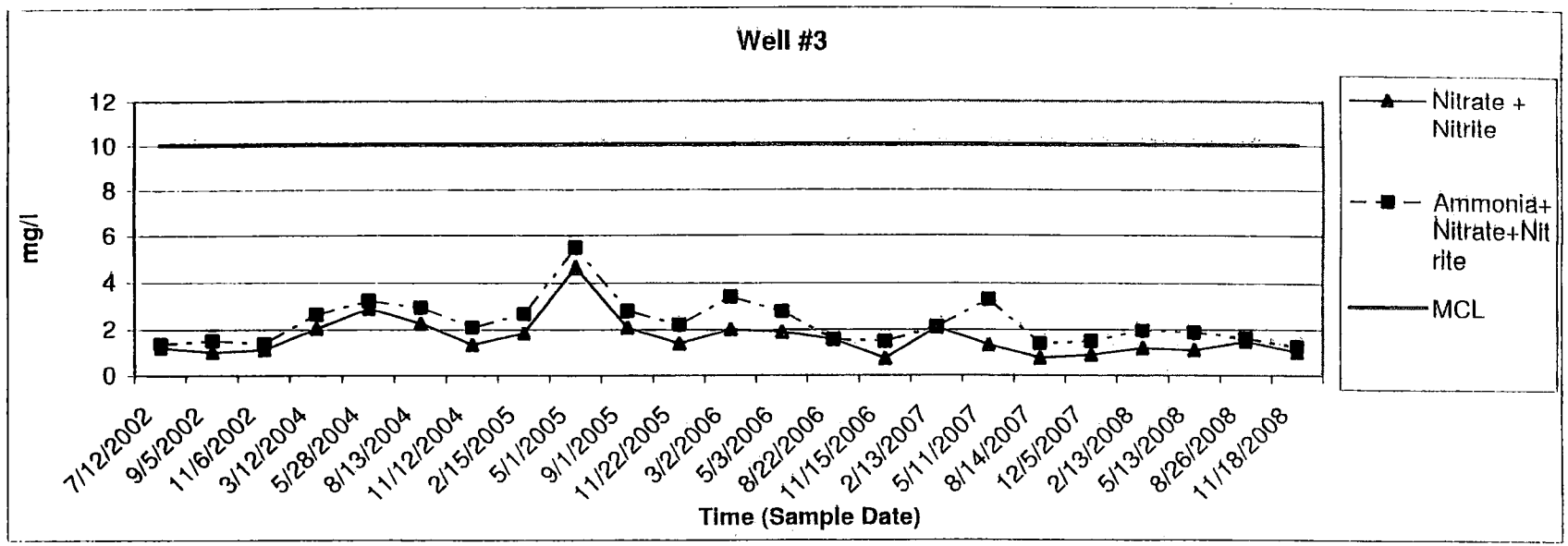


EXHIBIT D

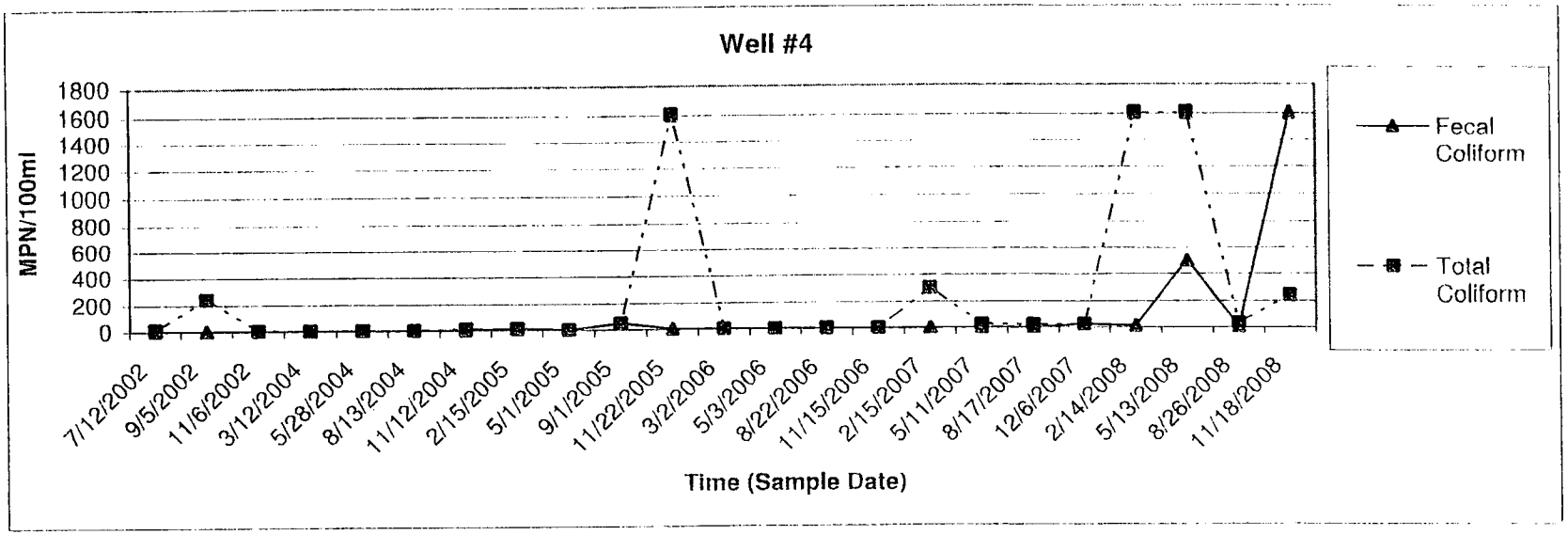
Malibu Creek Plaza

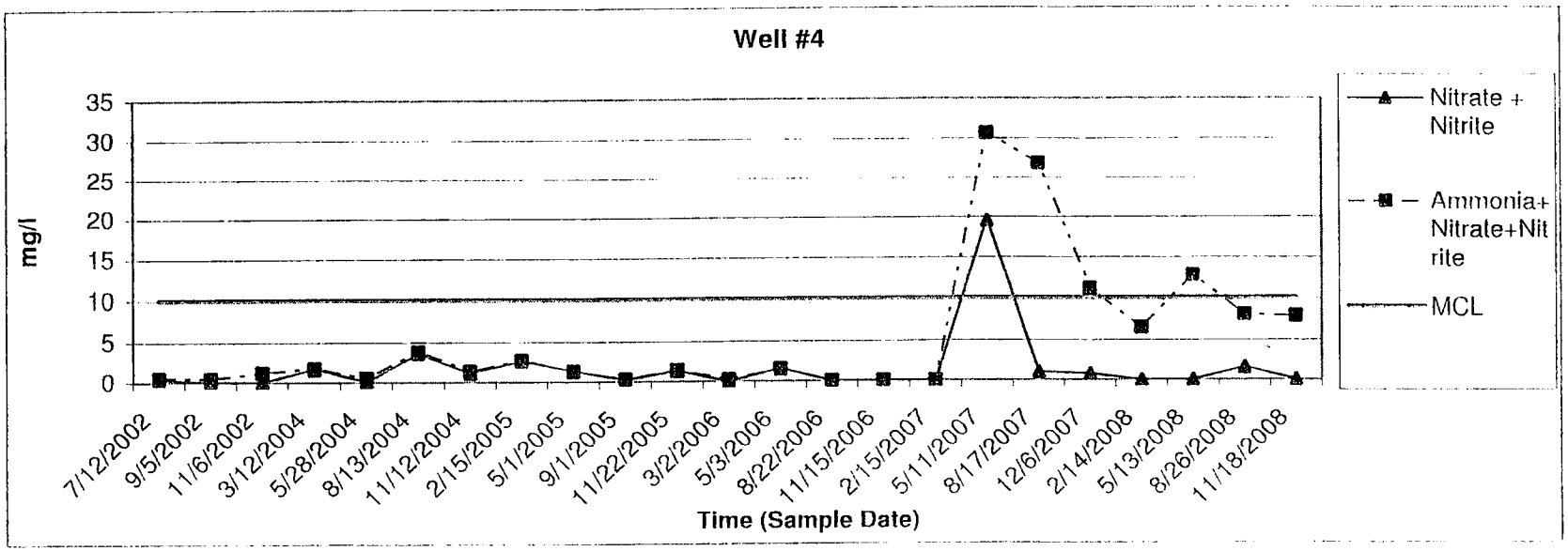




T E A R D

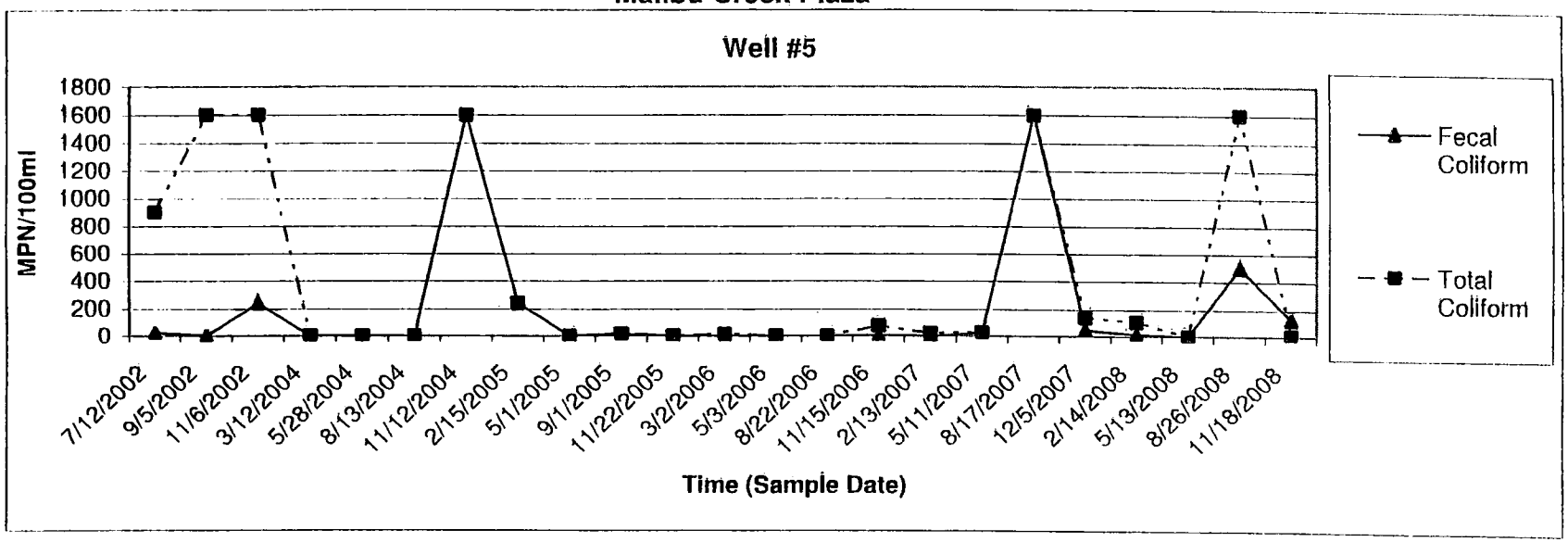
Malibu Creek Plaza

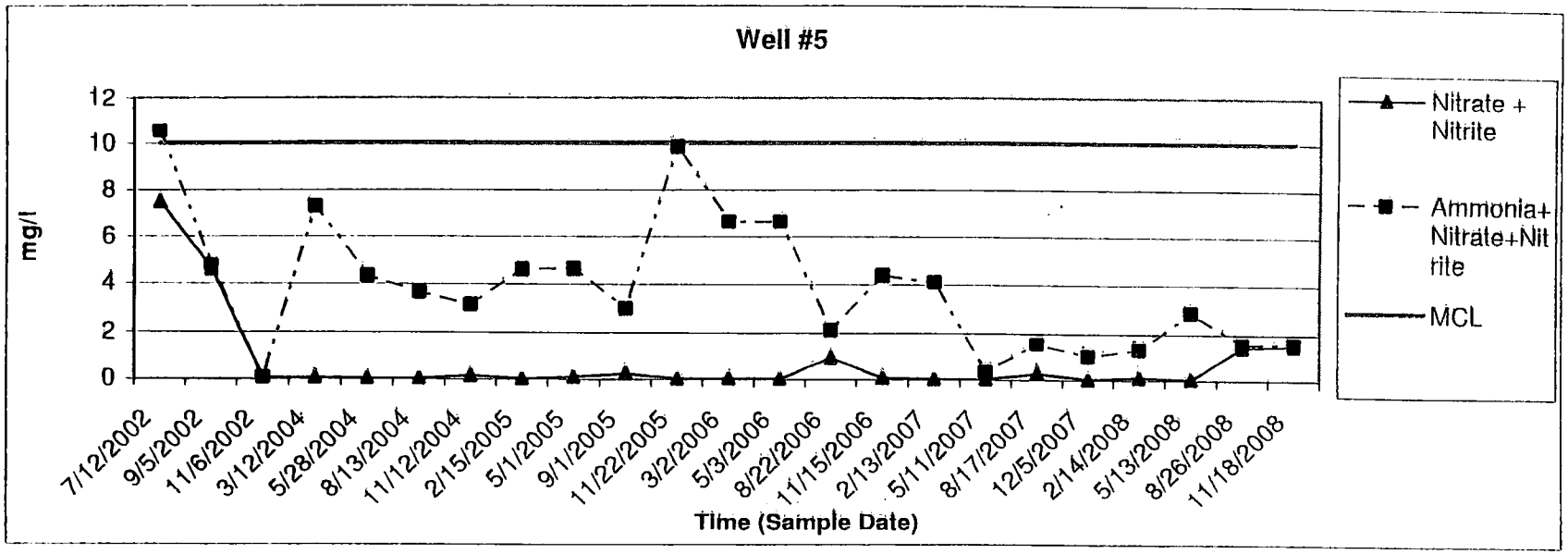




TABLED

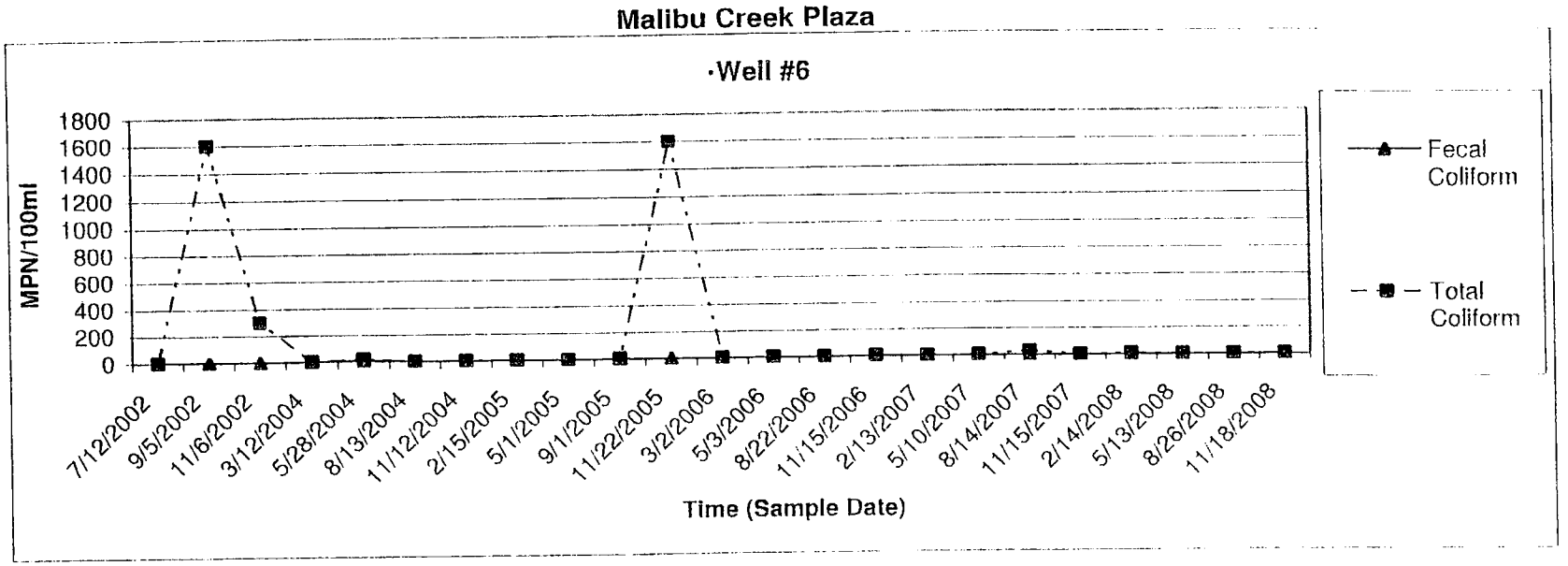
Malibu Creek Plaza

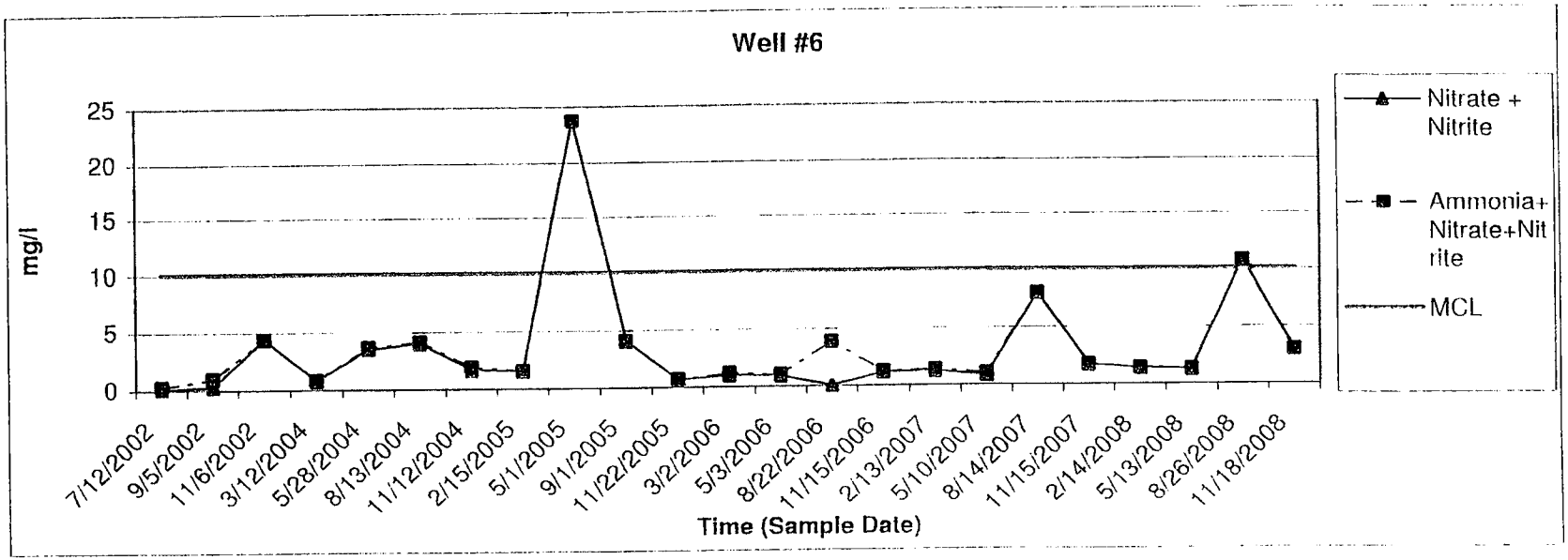




T2-68

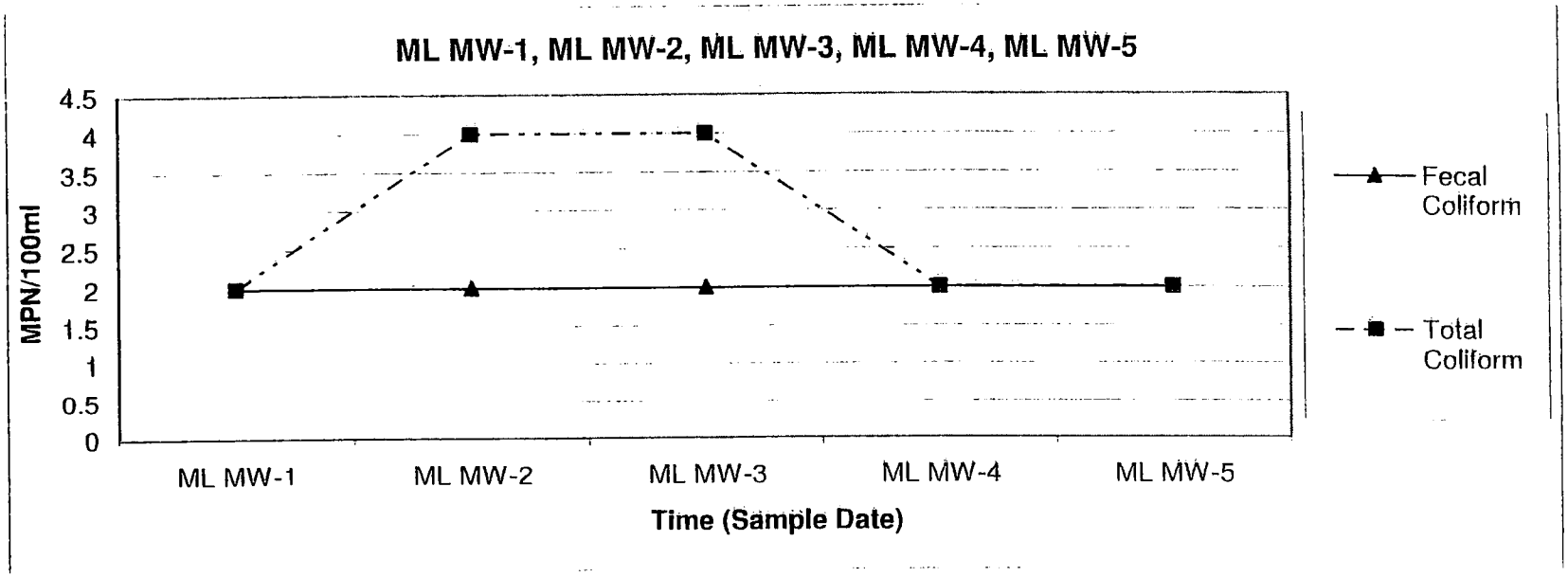
DRAFT

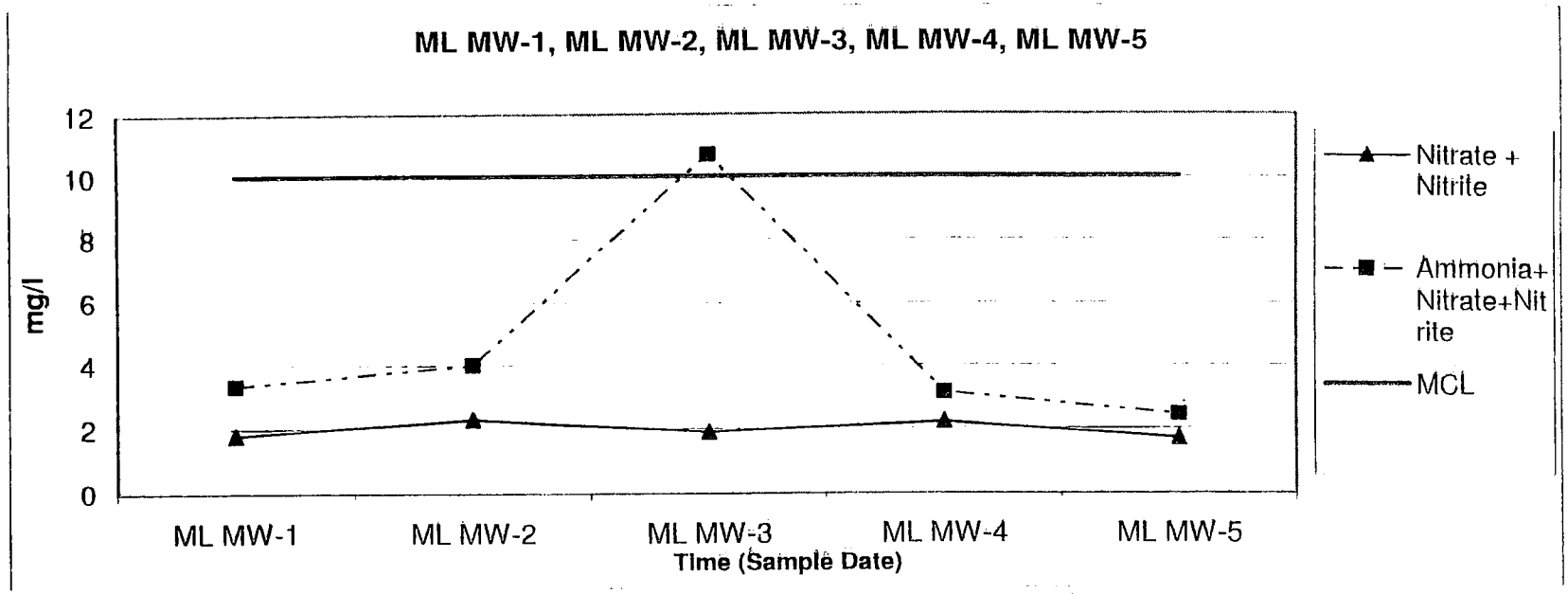

Malibu Creek Plaza
Well #6
MPN/100ml
1800
1600
1400
1200
1000
800
600
400
200
0
7/12/2002
9/5/2002
11/6/2002
3/12/2004
5/28/2004
8/13/2004
11/12/2004
2/15/2005
5/1/2005
9/1/2005
11/22/2005
3/2/2006
5/3/2006
8/22/2006
11/15/2006
2/13/2007
5/10/2007
8/14/2007
11/15/2007
2/14/2008
5/13/2008
8/26/2008
11/18/2008
Time (Sample Date)
Fecal Coliform
Total Coliform


Well #6
mg/l
25
20
15
10
5
0
7/12/2002
9/5/2002
11/6/2002
3/12/2004
5/28/2004
8/13/2004
11/12/2004
2/15/2005
5/1/2005
9/1/2005
11/22/2005
3/2/2006
5/3/2006
8/22/2006
11/15/2006
2/13/2007
5/10/2007
8/14/2007
11/15/2007
2/14/2008
5/13/2008
8/26/2008
11/18/2008
Time (Sample Date)
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL

LEARD

Malibu Lumber

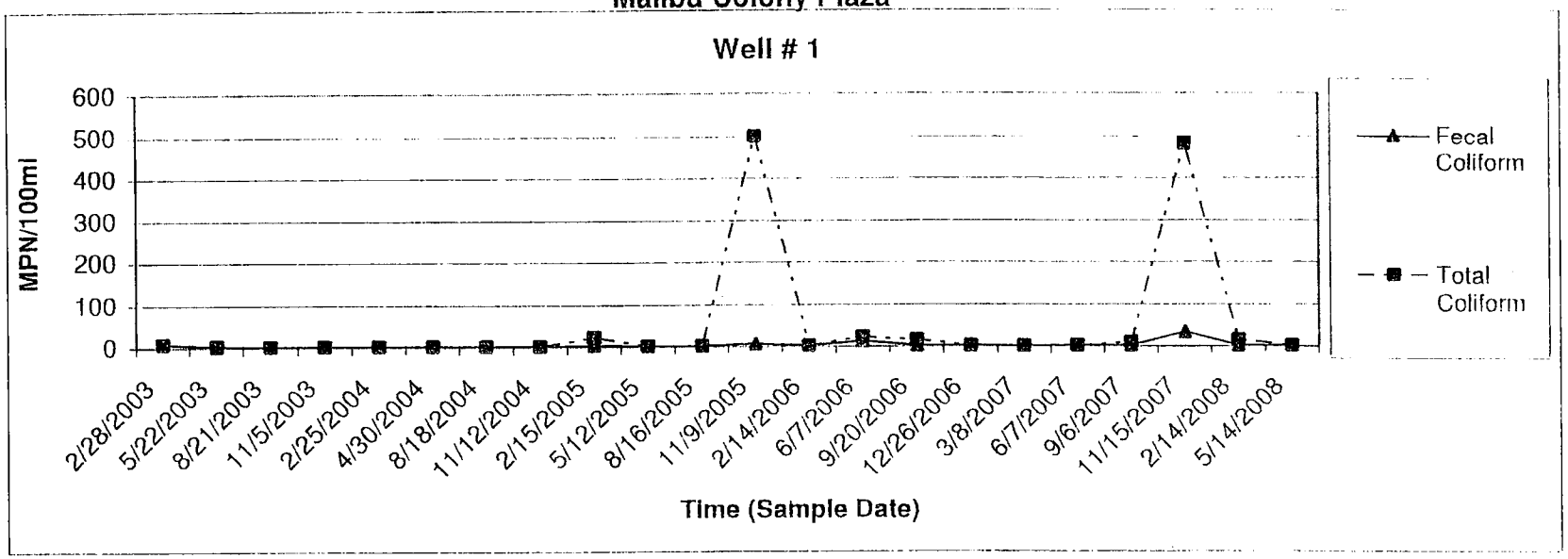




T2-70

FILED

Malibu Colony Plaza



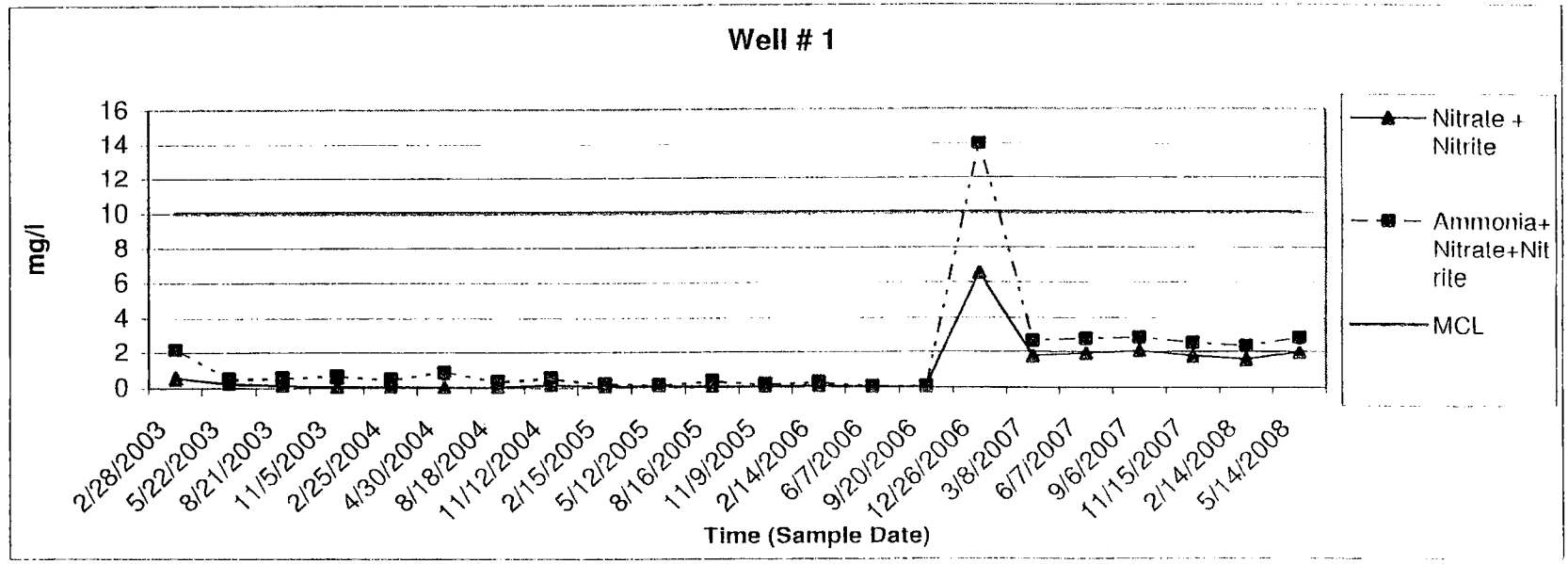
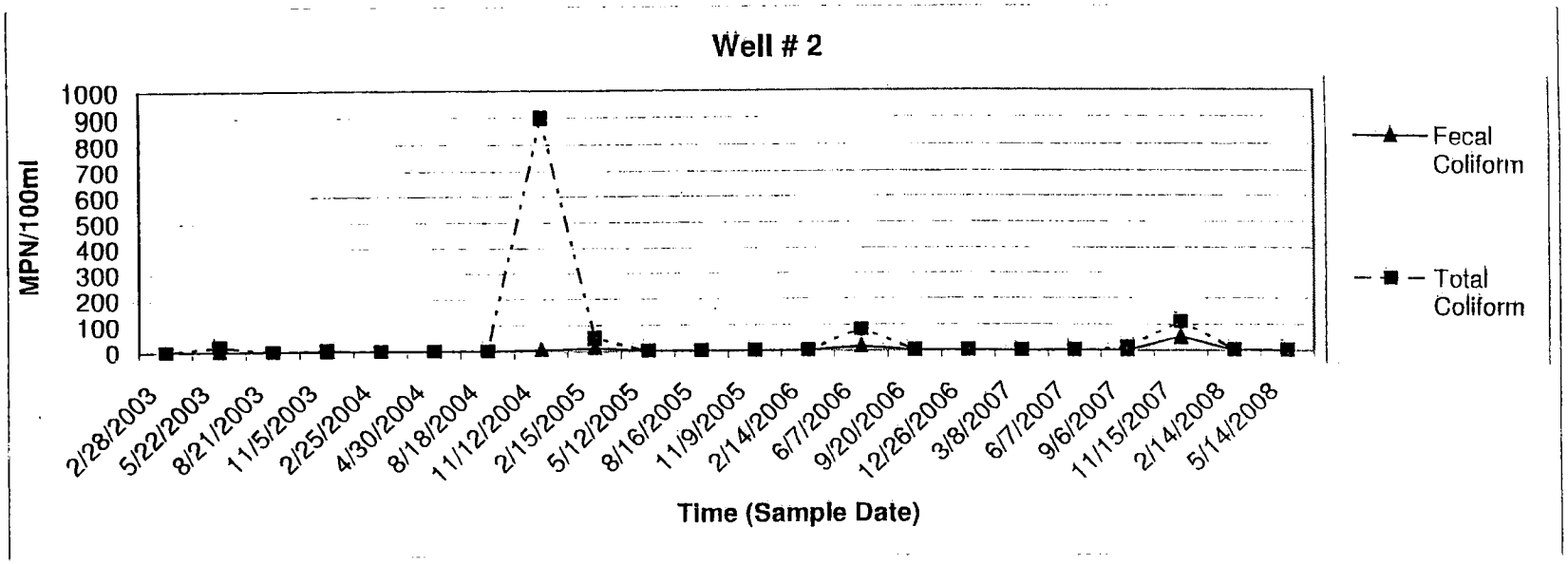
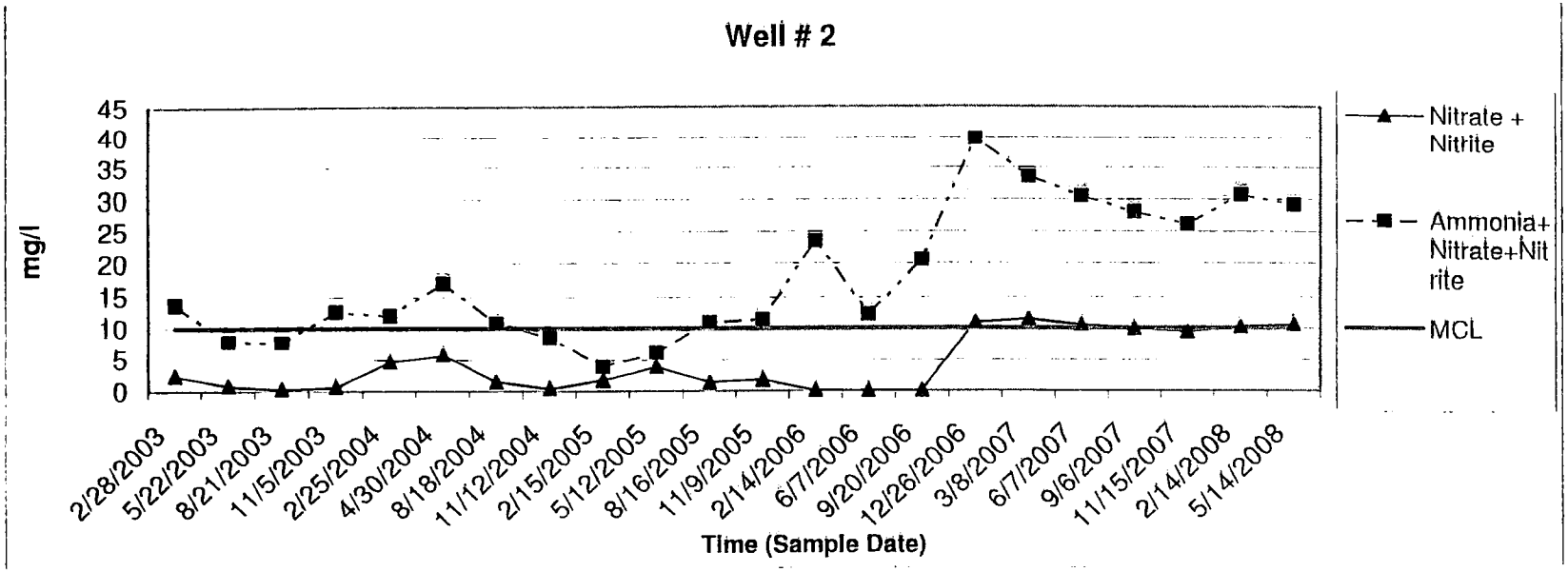


EXHIBIT D

Malibu Colony Plaza



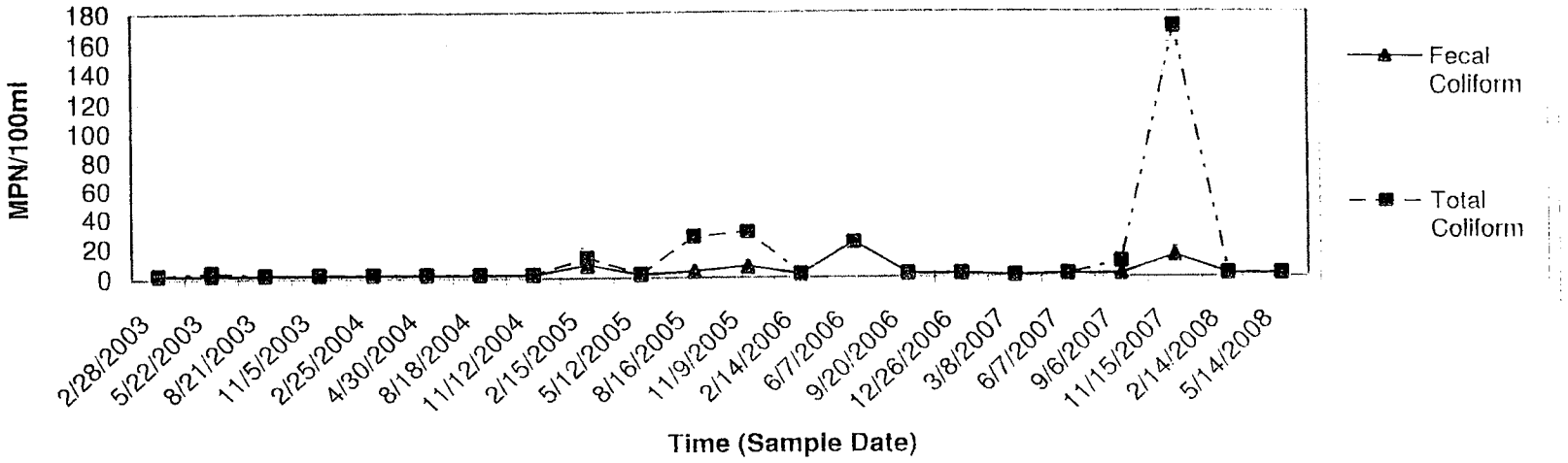


T2-72

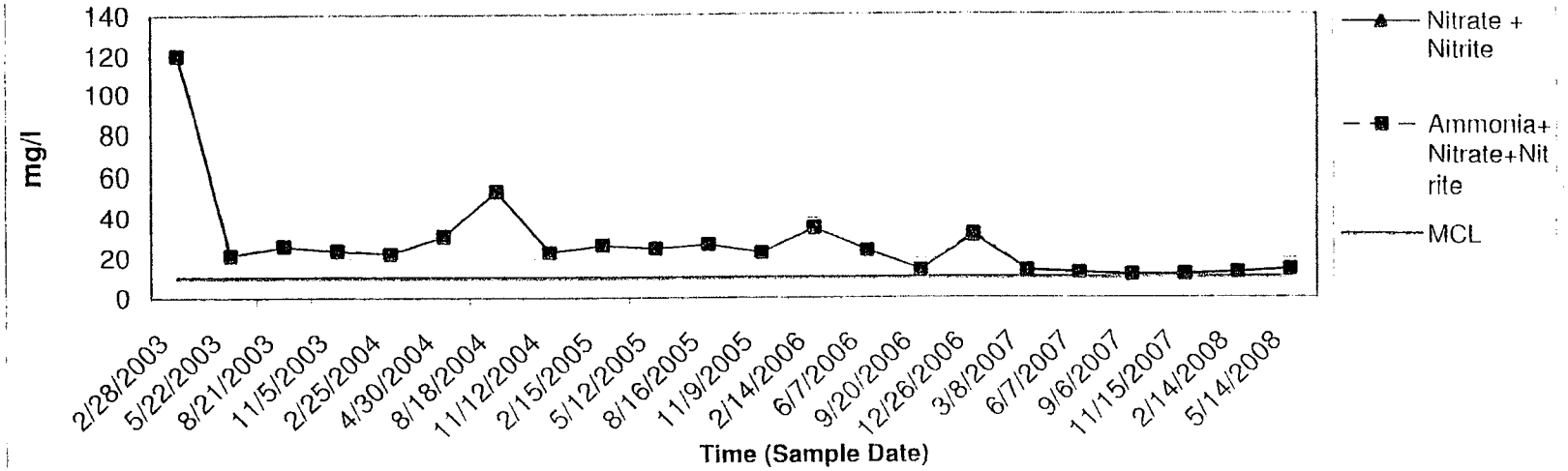
T E A R D

Malibu Colony Plaza

Well # 3

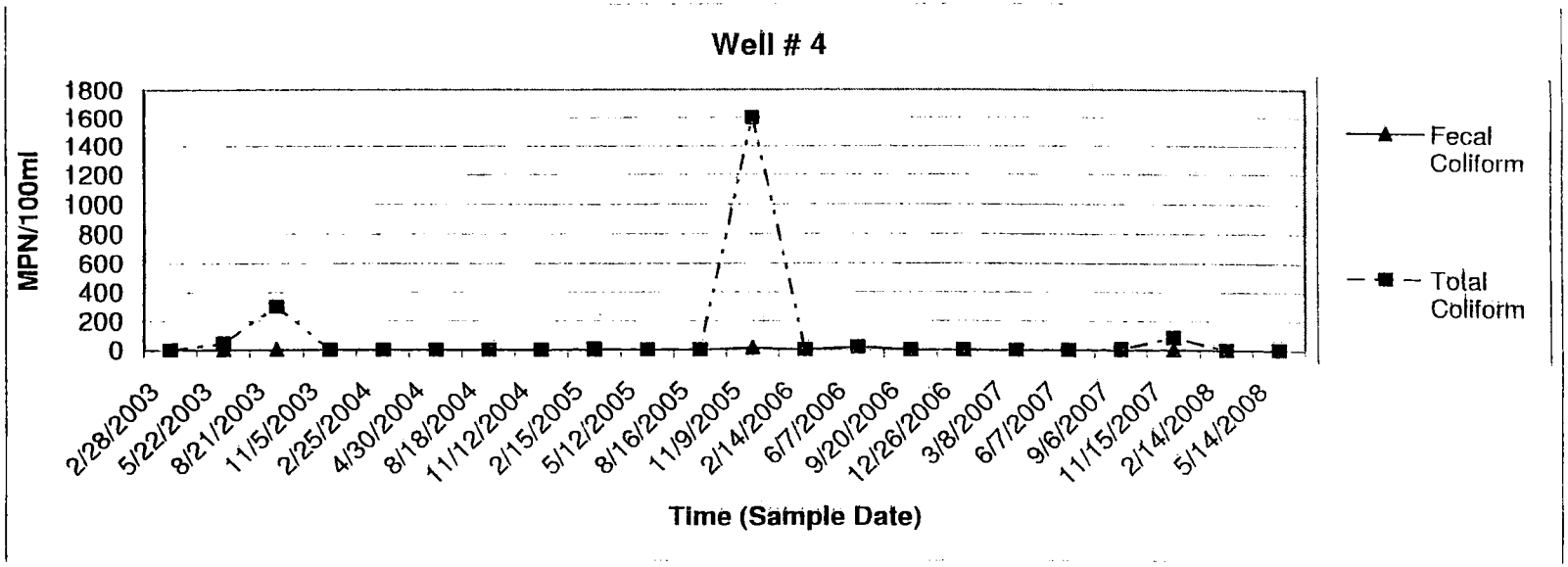


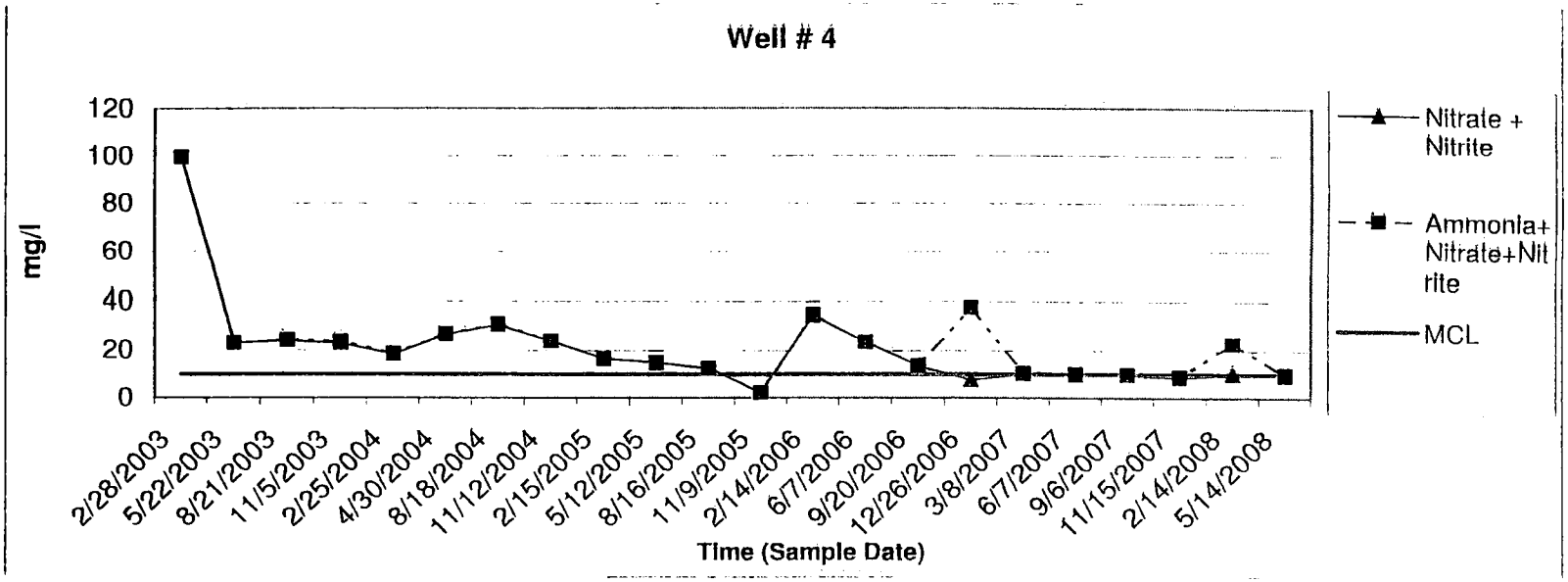
Well # 3



LEARU

Malibu Colony Plaza

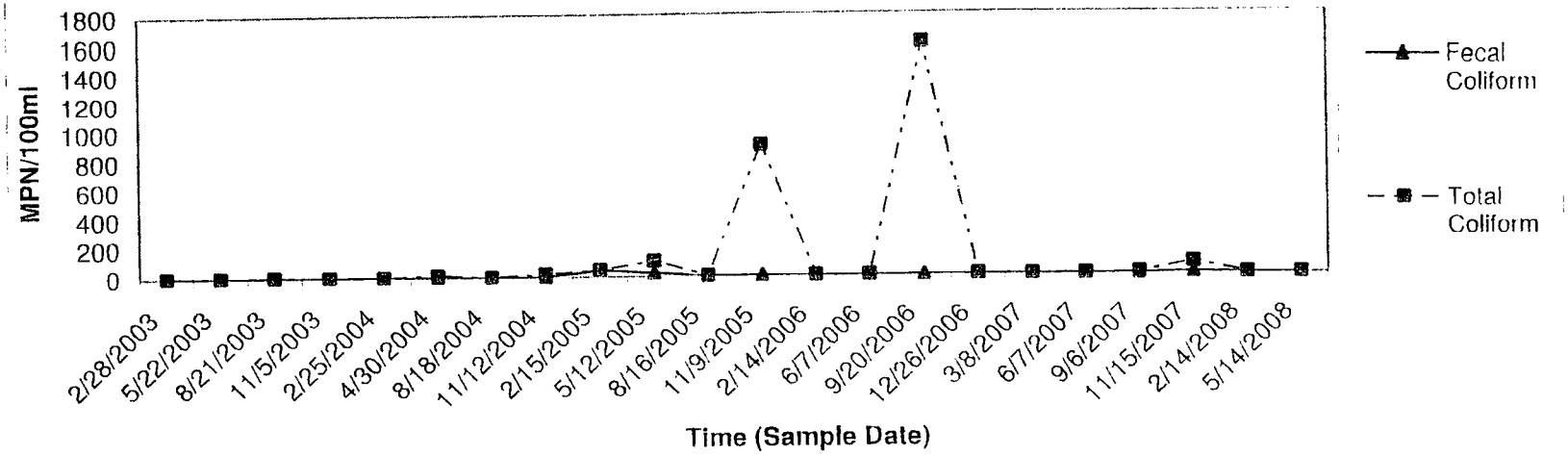




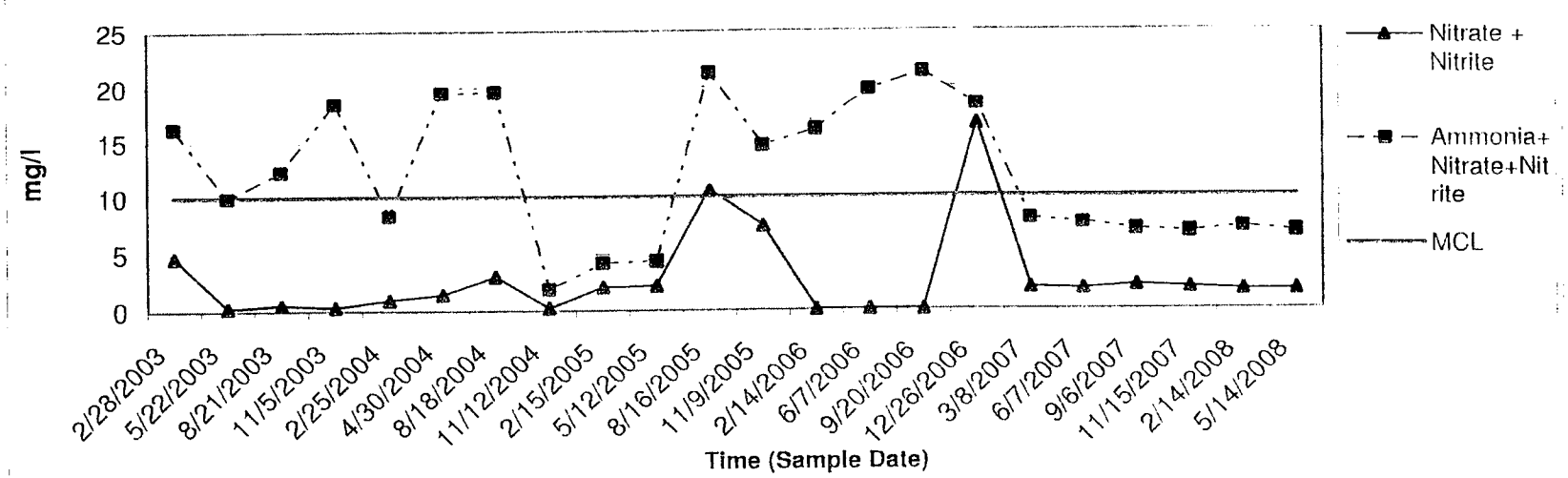
T E A R D

Malibu Colony Plaza

Well # 5

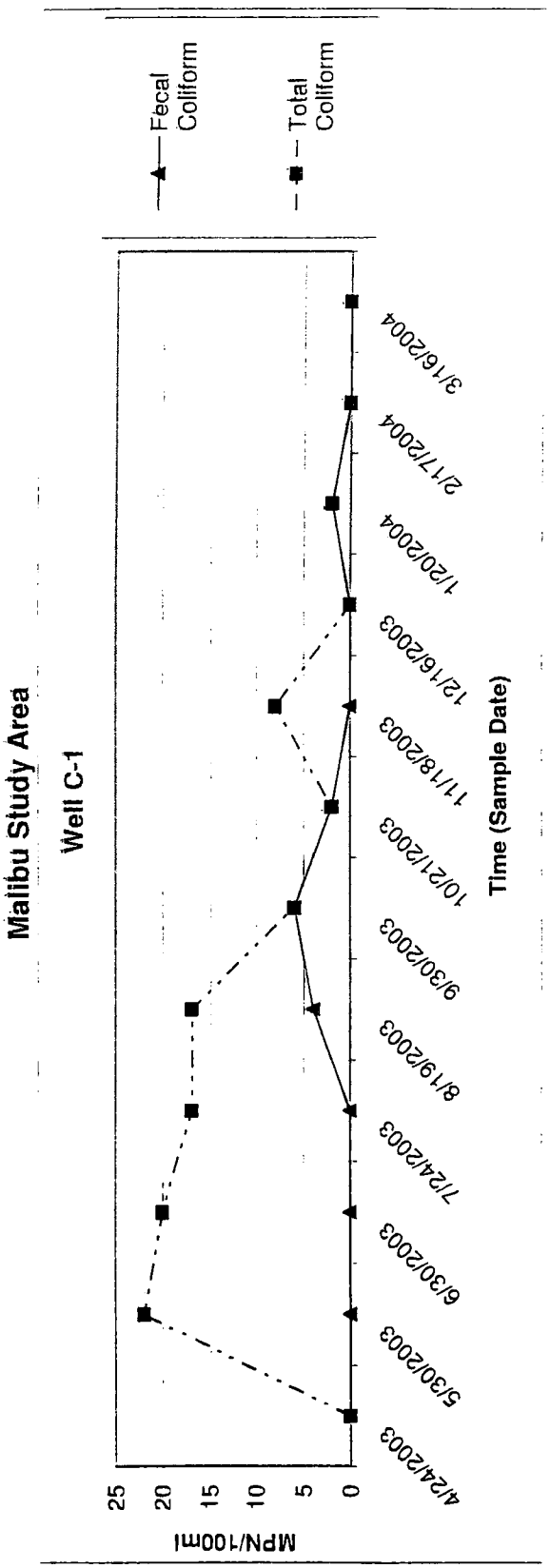


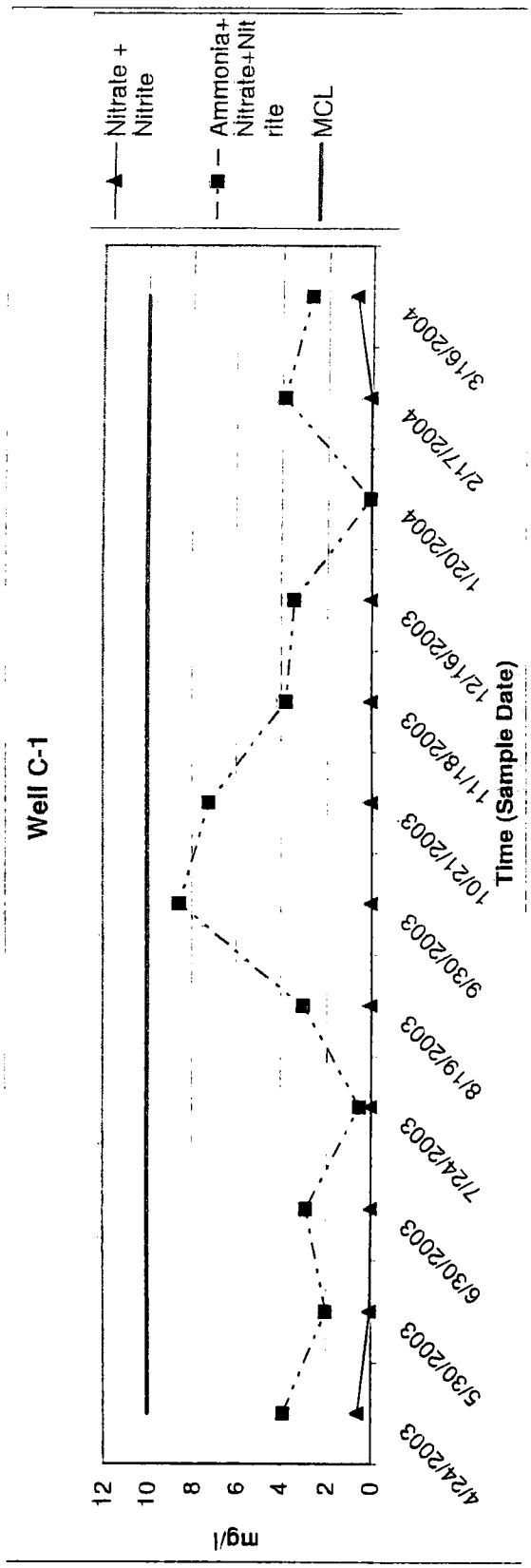
Well # 5



2-1207

FILED

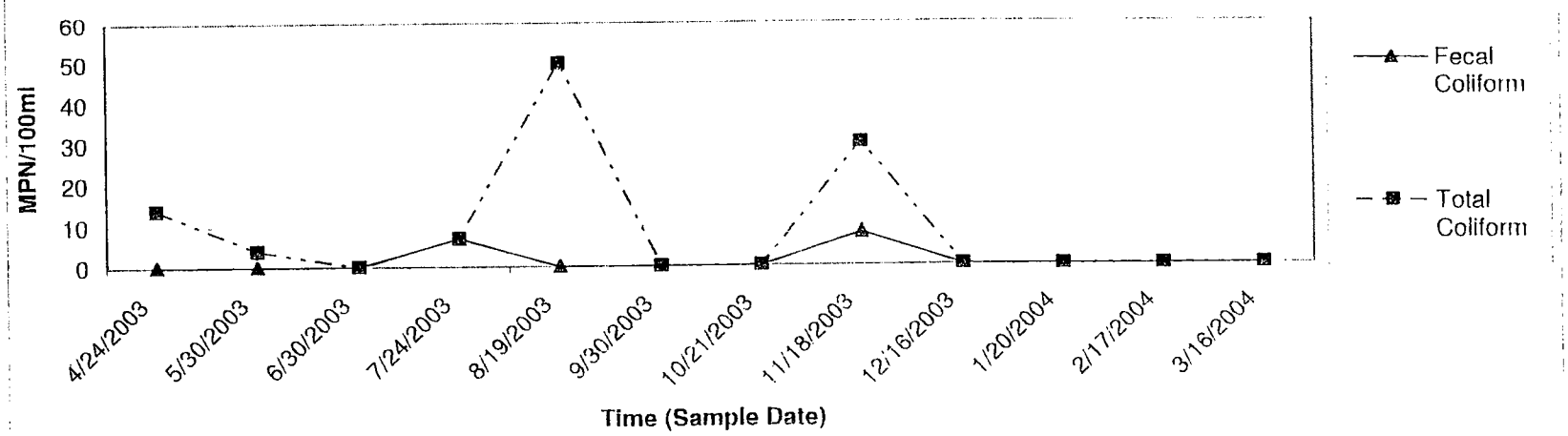

Malibu Study Area
Well C-1
Fecal Coliform
Total Coliform
MPN/100ml
25
20
15
10
5
0
4/24/2003
5/30/2003
6/30/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)


Well C-1
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL
mg/l
12
10
8
6
4
2
0
4/24/2003
5/30/2003
6/30/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)

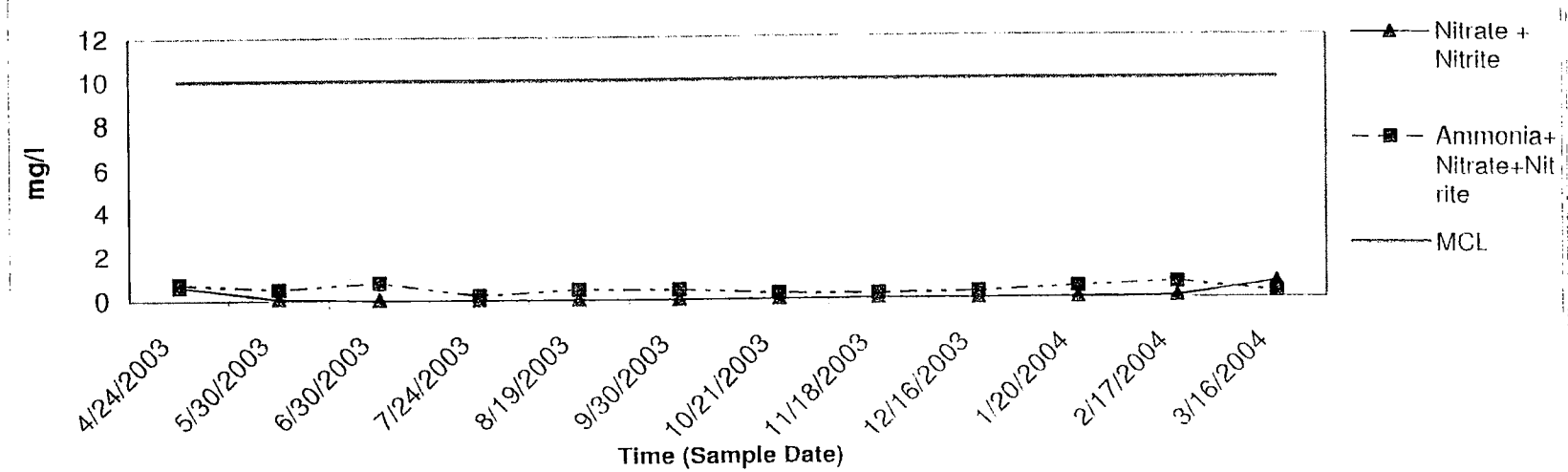
DRAFT

Malibu Study Area

Well C-2



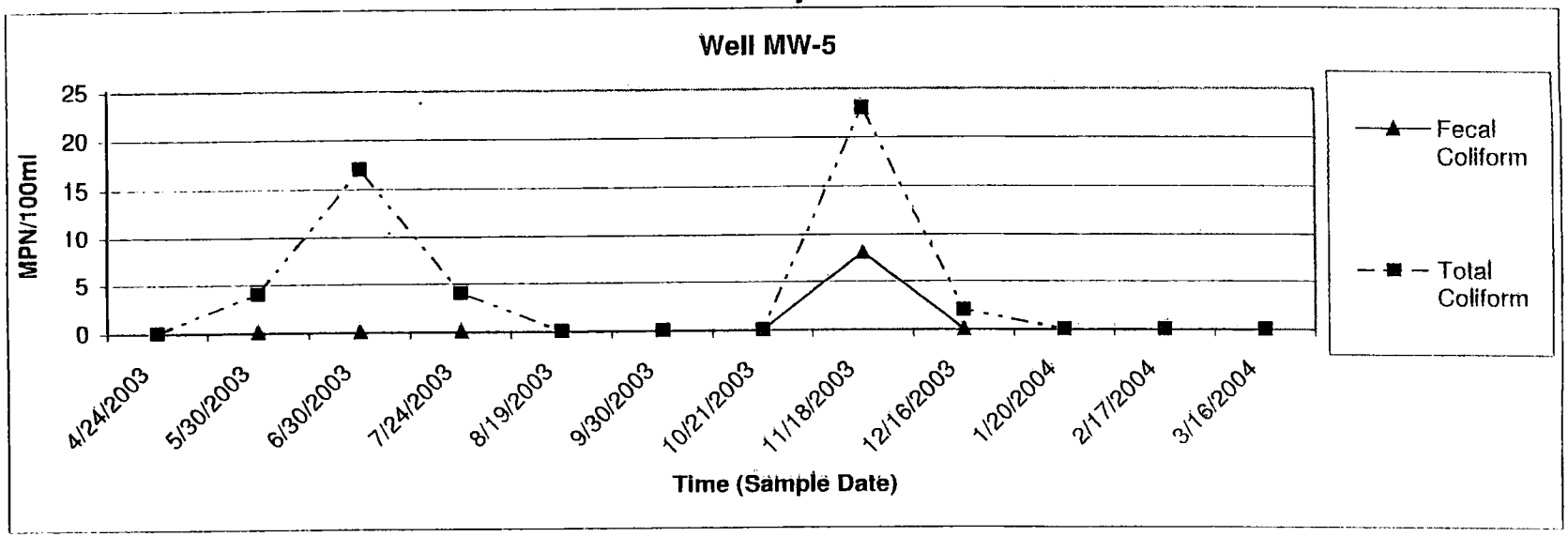
Well C-2

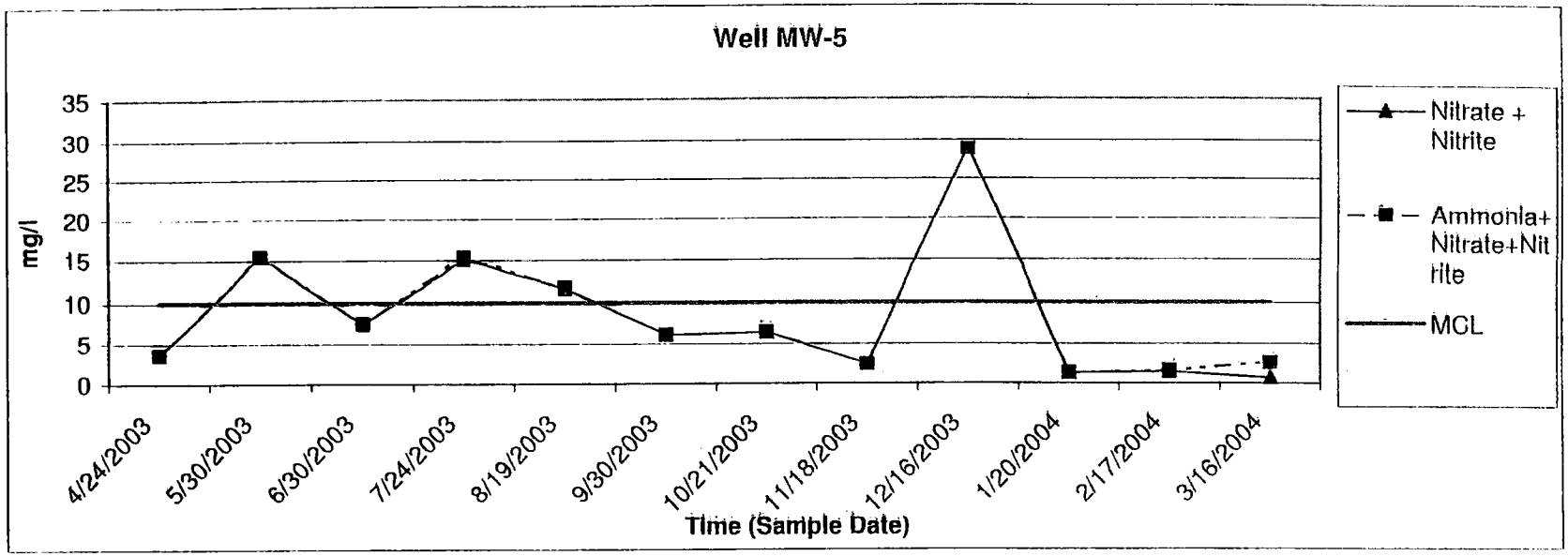


T2-77

FILED

Malibu Study Area

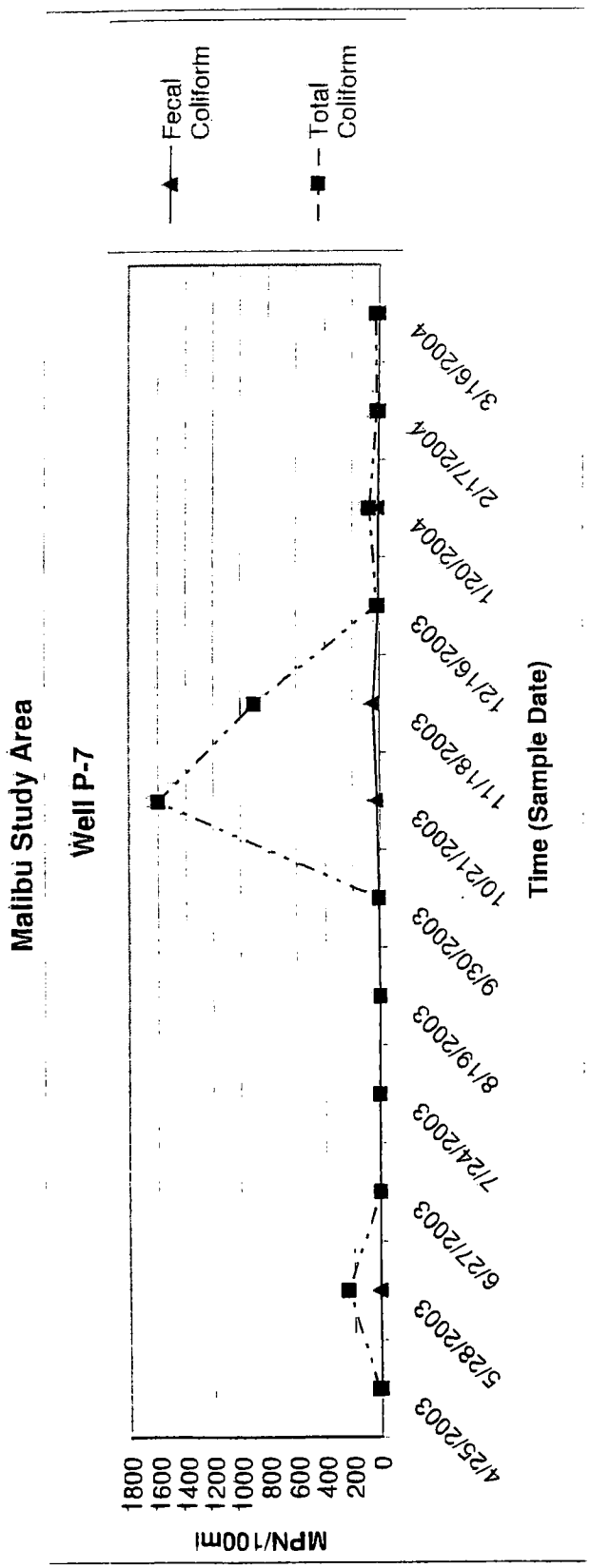


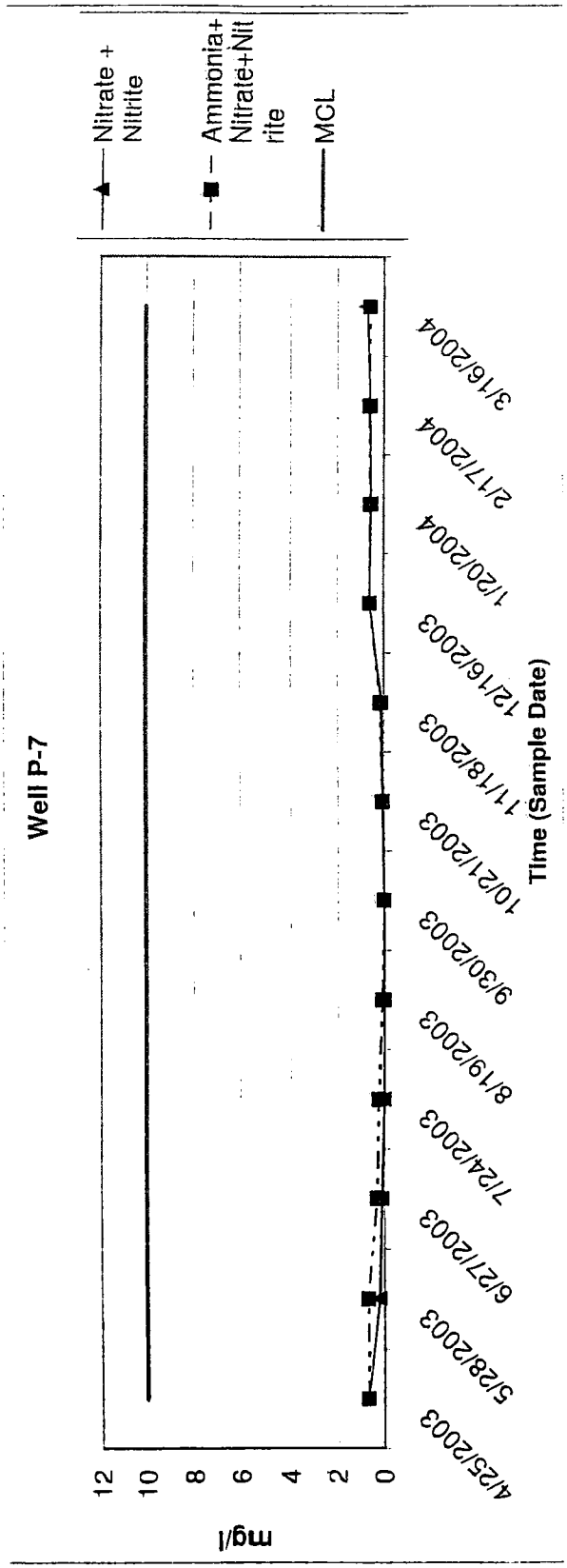


DRAFT

Malibu Study Area
Well P-1
Fecal Coliform
Total Coliform
MPN/100ml
0
2
4
6
8
10
12
14
16
4/25/2003
5/29/2003
6/26/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/18/2003
12/15/2003
1/19/2004
2/16/2004
3/15/2004
Time (Sample Date)
Well P-1
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL
mg/l
0
2
4
6
8
10
12
4/25/2003
5/29/2003
6/26/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/18/2003
12/15/2003
1/19/2004
2/16/2004
3/15/2004
Time (Sample Date)

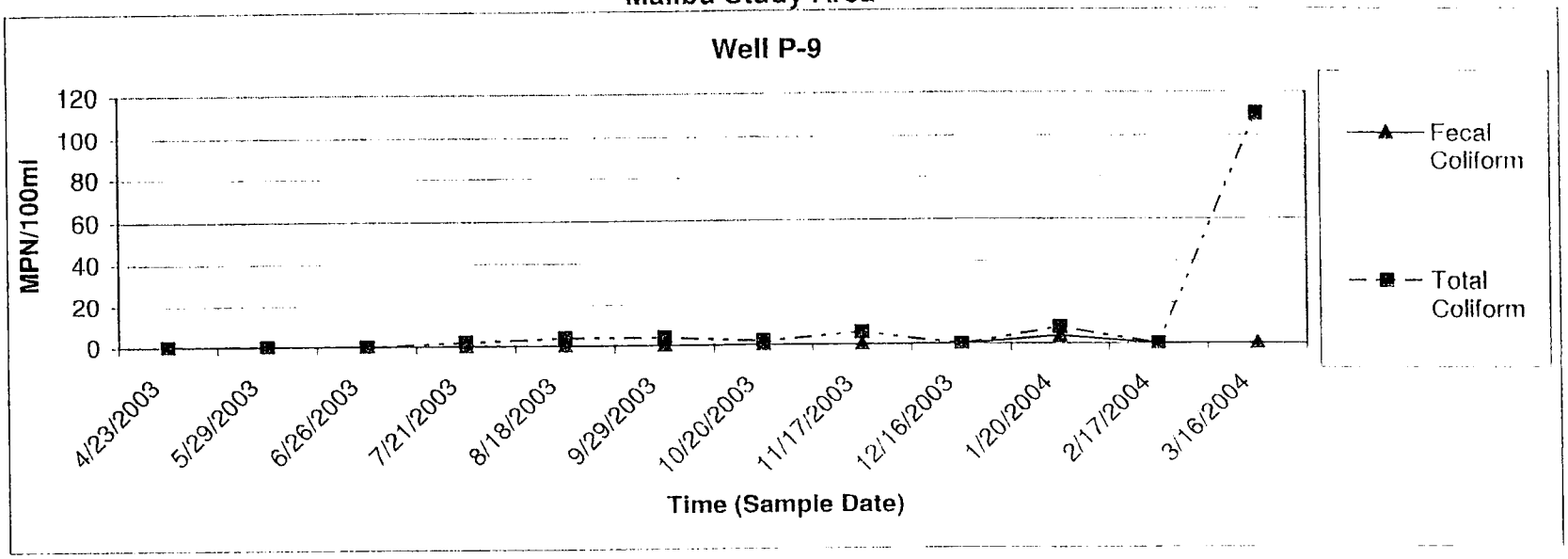
DRAFT


Malibu Study Area
Well P-7
Fecal Coliform
Total Coliform
MPN/100ml
1800
1600
1400
1200
1000
800
600
400
200
0
4/25/2003
5/28/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)


Well P-7
Nitrate + Nitrite
Ammonia+ Nitrate+Nit rite
MCL
mg/l
12
10
8
6
4
2
0
4/25/2003
5/28/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)

DRAFT

Malibu Study Area



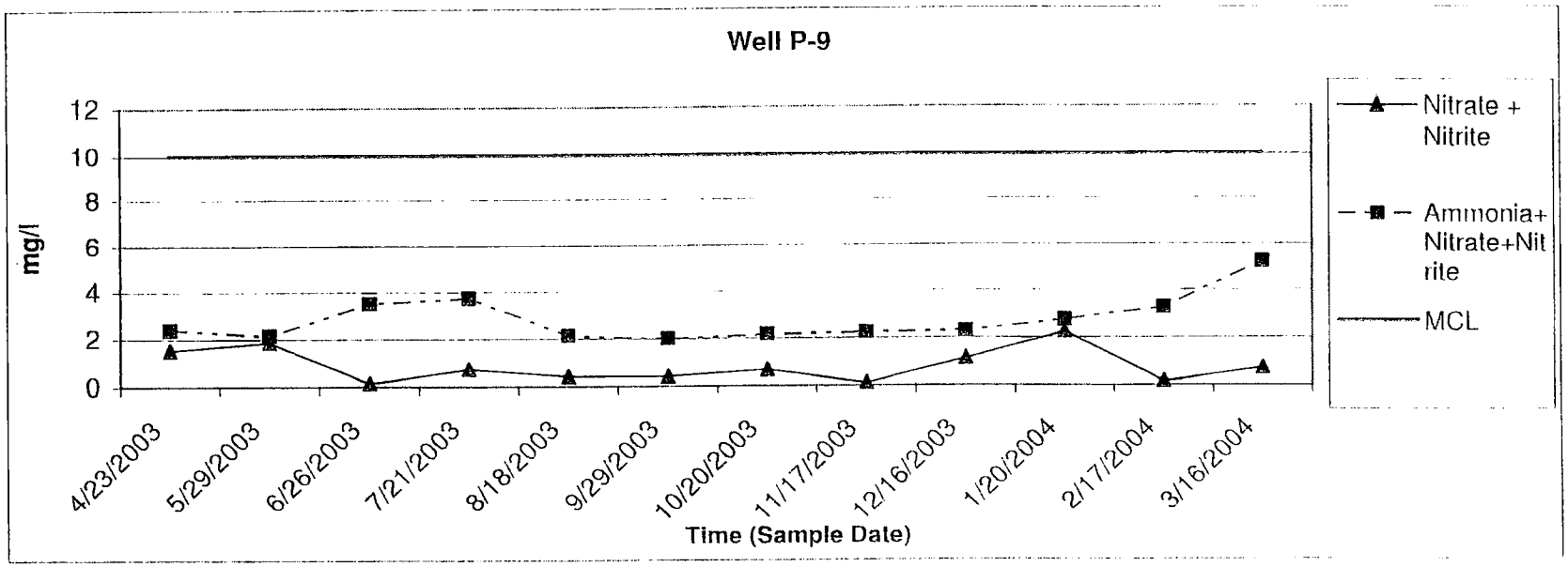
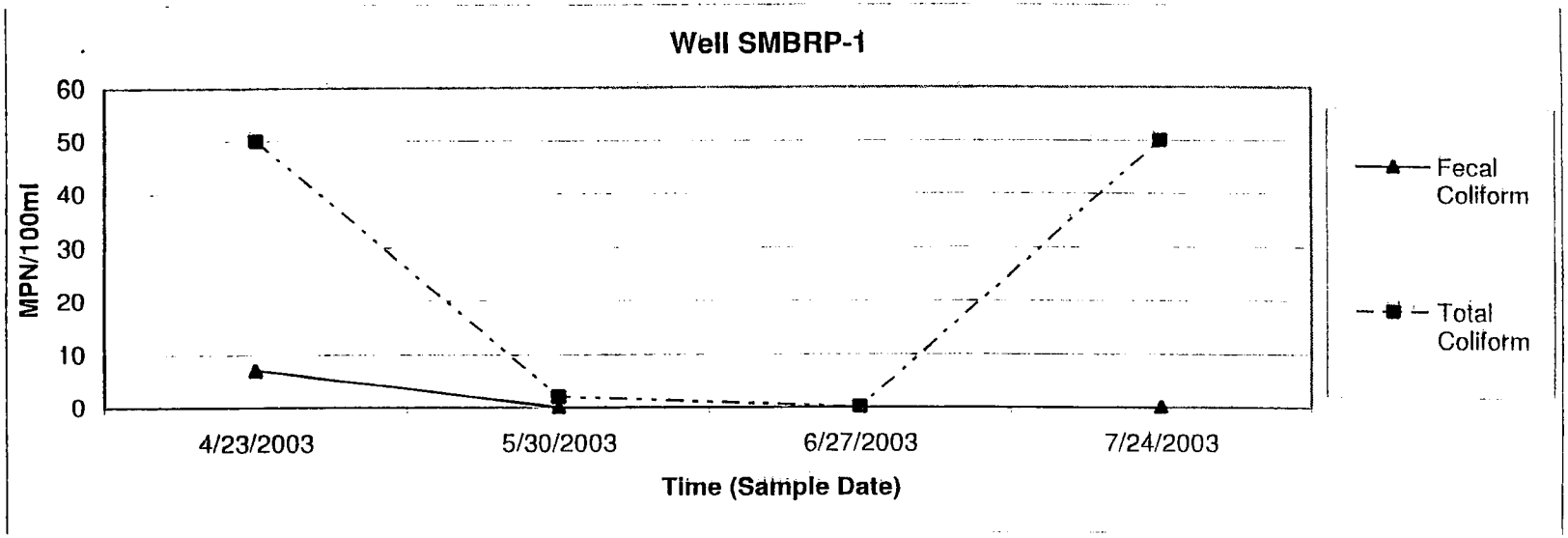
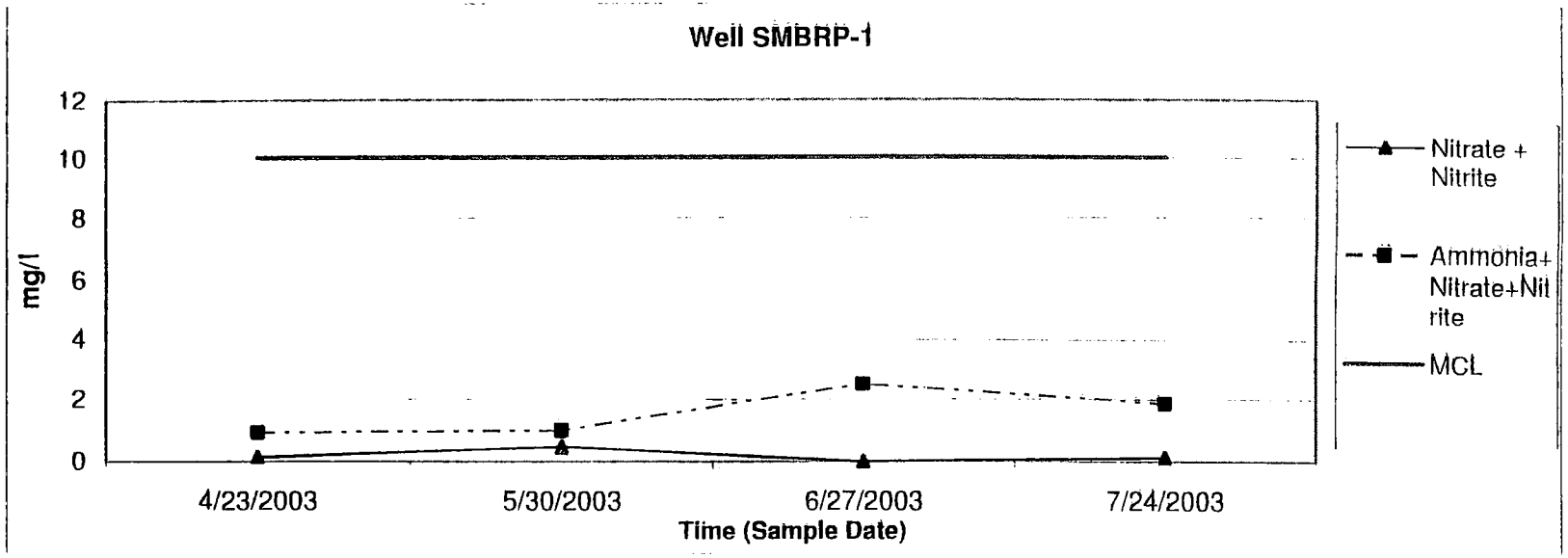


EXHIBIT D

Malibu Study Area

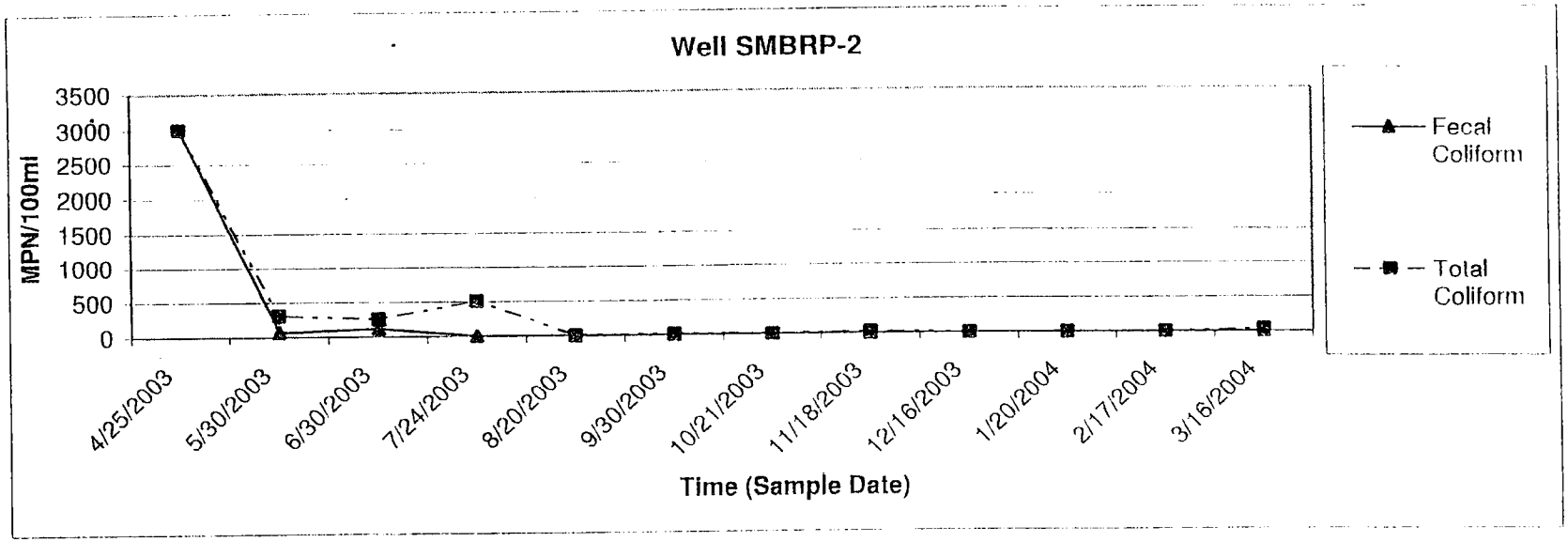


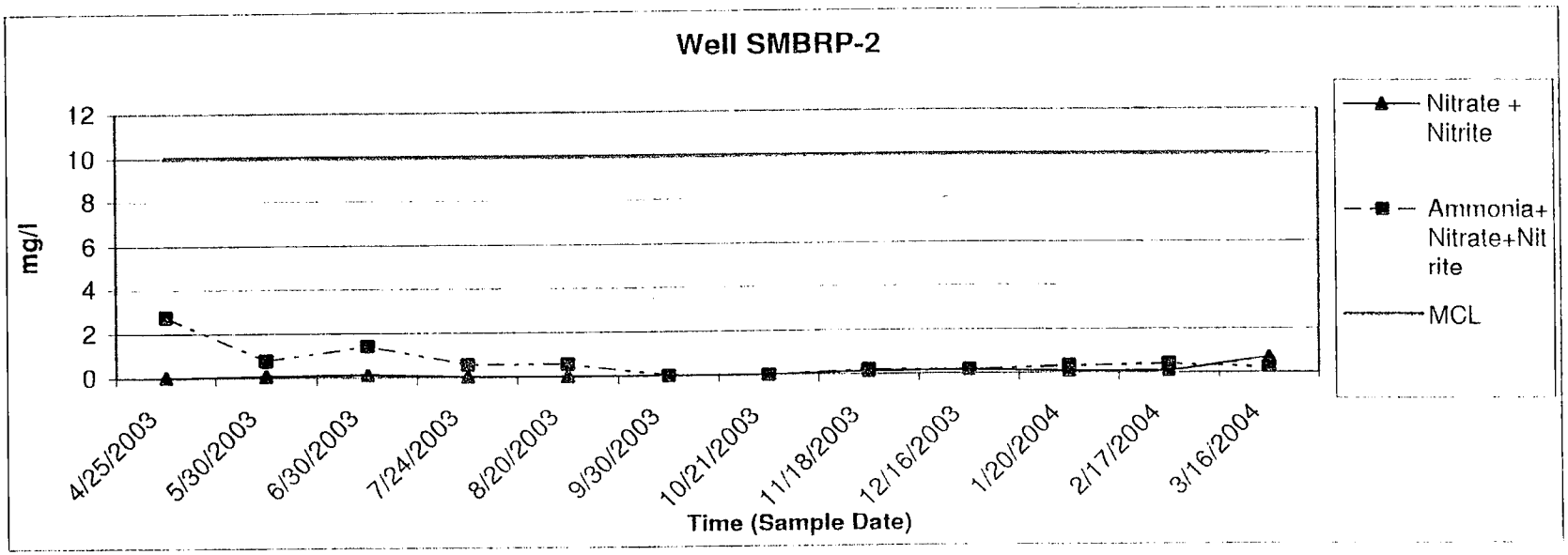


T2-82

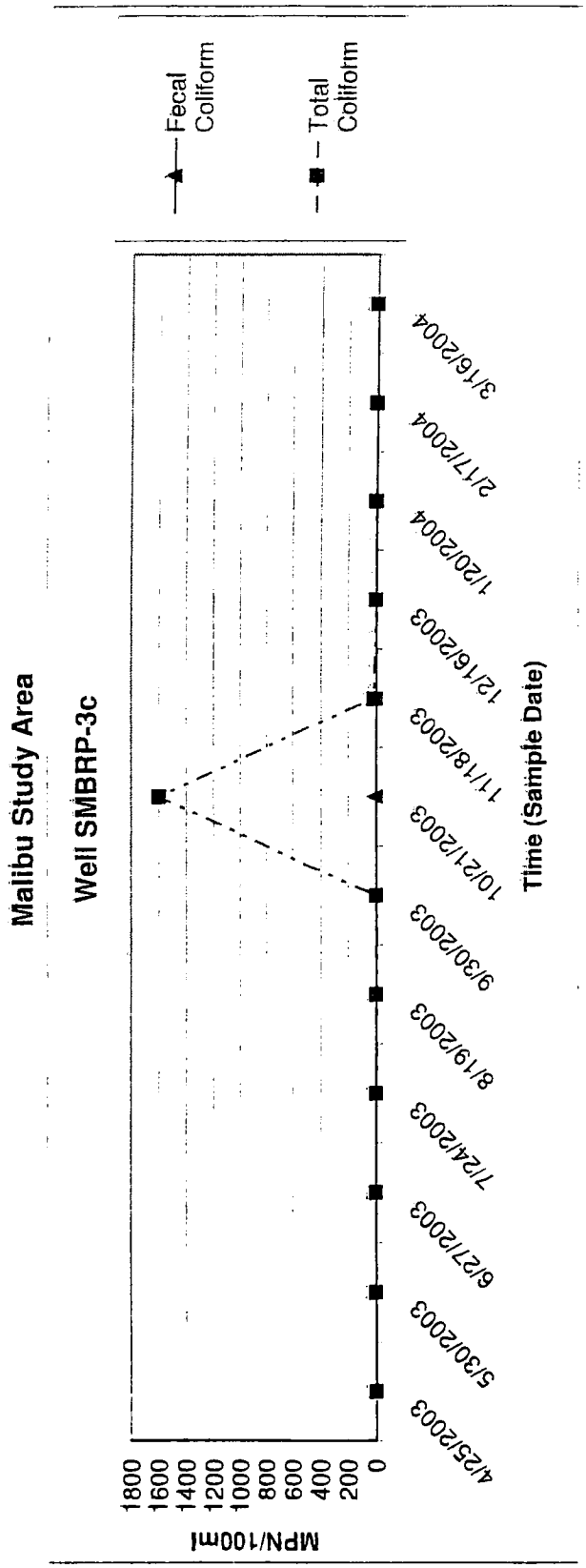
T E A R D

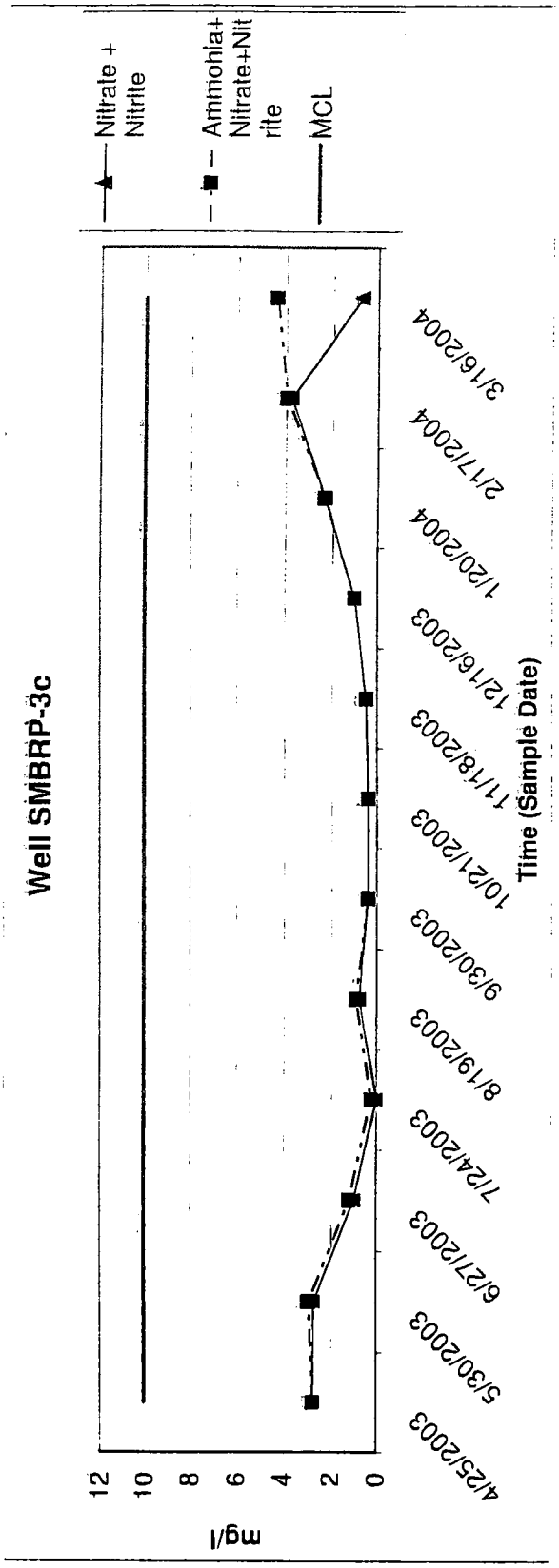
Malibu Study Area



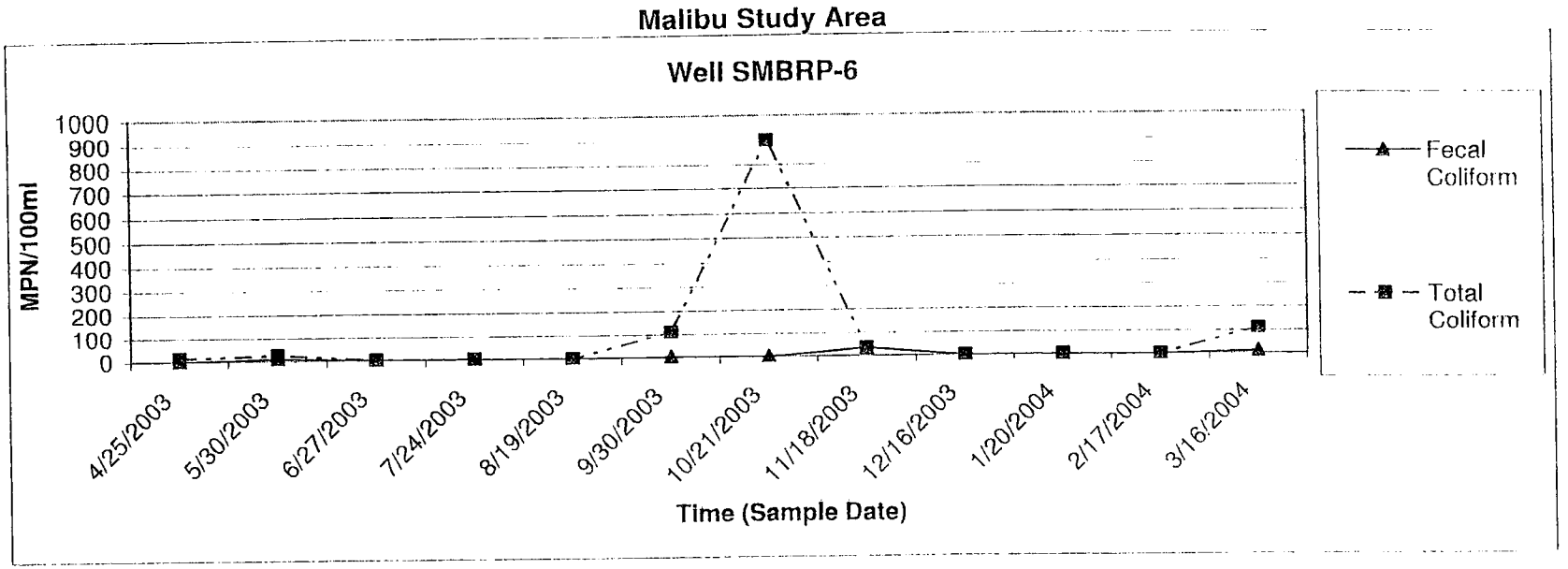


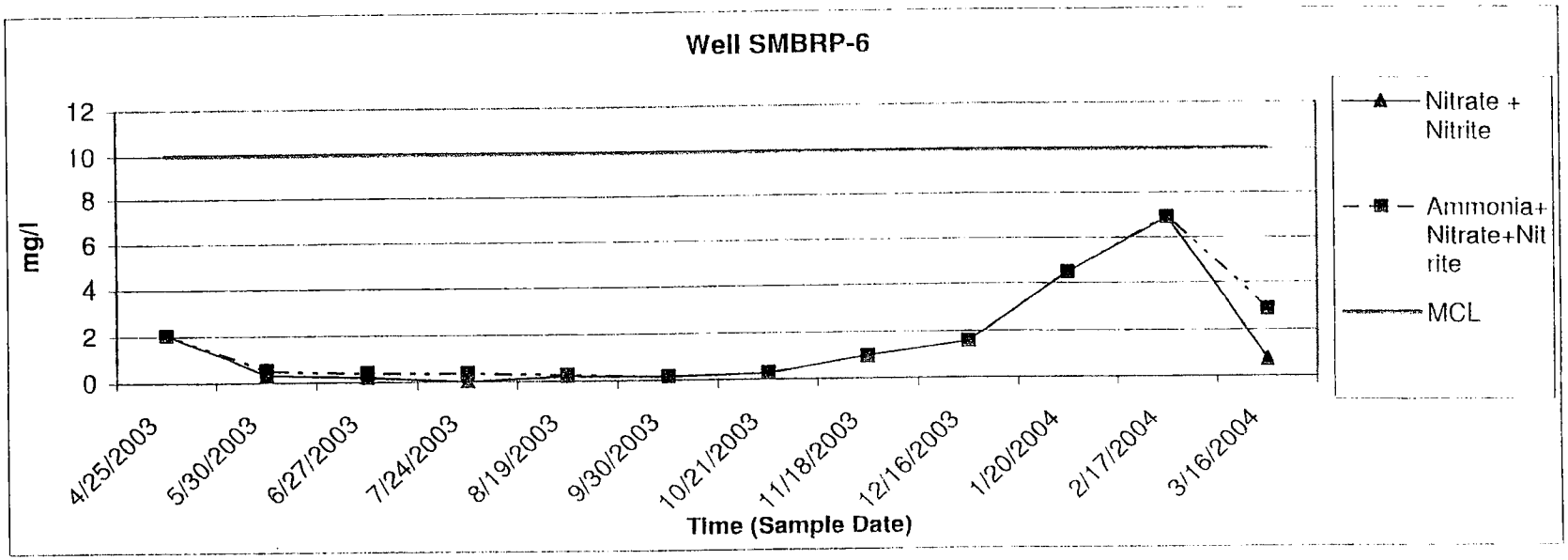
FEARD


Malibu Study Area
Well SMBRP-3c
Fecal Coliform
Total Coliform
MPN/100ml
1800
1600
1400
1200
1000
800
600
400
200
0
4/25/2003
5/30/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)

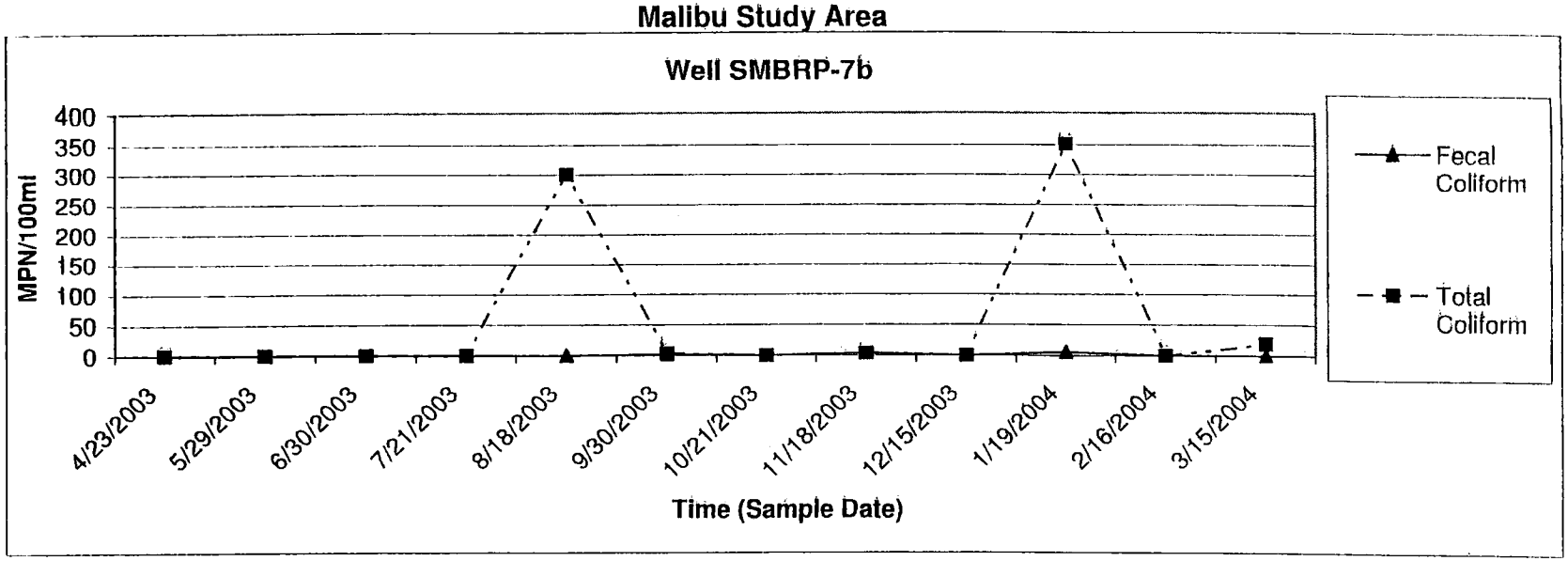

Well SMBRP-3c
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL
mg/l
12
10
8
6
4
2
0
4/25/2003
5/30/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)

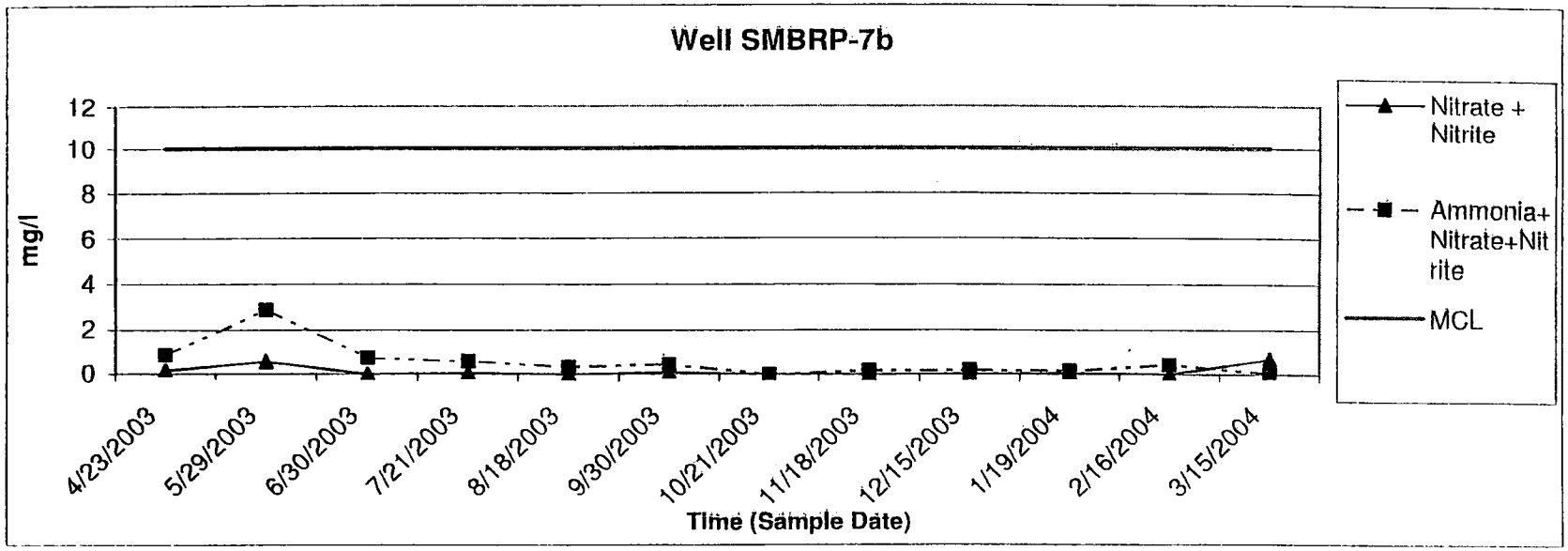
DRAFT


Malibu Study Area
Well SMBRP-6
MPN/100ml
1000
900
800
700
600
500
400
300
200
100
0
4/25/2003
5/30/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)
Fecal Coliform
Total Coliform


Well SMBRP-6
mg/l
12
10
8
6
4
2
0
4/25/2003
5/30/2003
6/27/2003
7/24/2003
8/19/2003
9/30/2003
10/21/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/16/2004
Time (Sample Date)
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL

TABLE


Malibu Study Area
Well SMBRP-7b
MPN/100ml
400
350
300
250
200
150
100
50
0
4/23/2003
5/29/2003
6/30/2003
7/21/2003
8/18/2003
9/30/2003
10/21/2003
11/18/2003
12/15/2003
1/19/2004
2/16/2004
3/15/2004
Time (Sample Date)
Fecal Coliform
Total Coliform

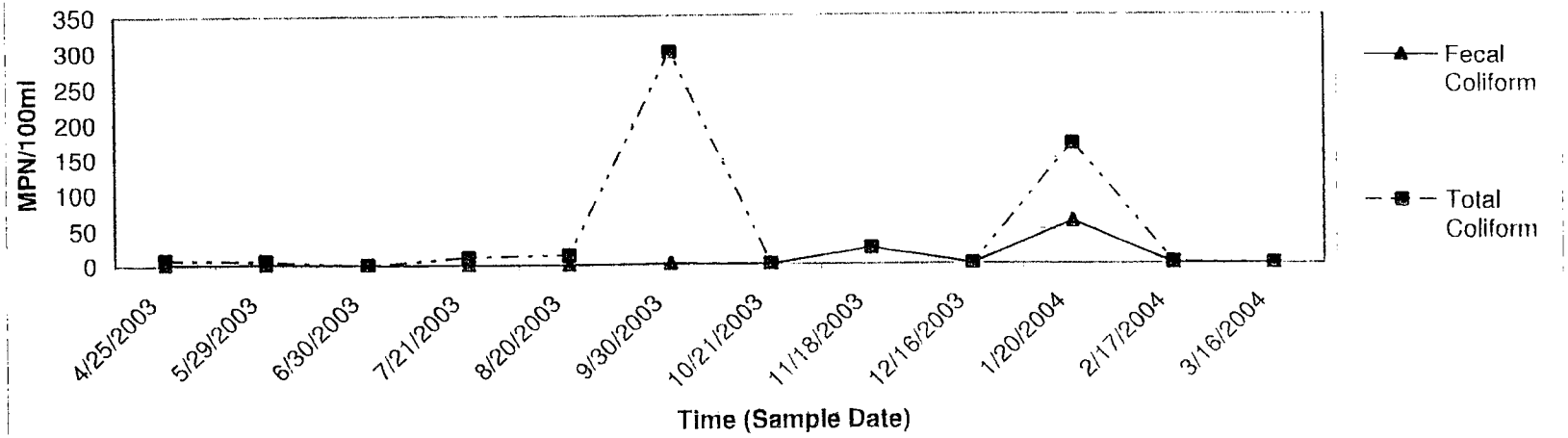

Well SMBRP-7b
mg/l
12
10
8
6
4
2
0
4/23/2003
5/29/2003
6/30/2003
7/21/2003
8/18/2003
9/30/2003
10/21/2003
11/18/2003
12/15/2003
1/19/2004
2/16/2004
3/15/2004
Time (Sample Date)
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL

G-1248

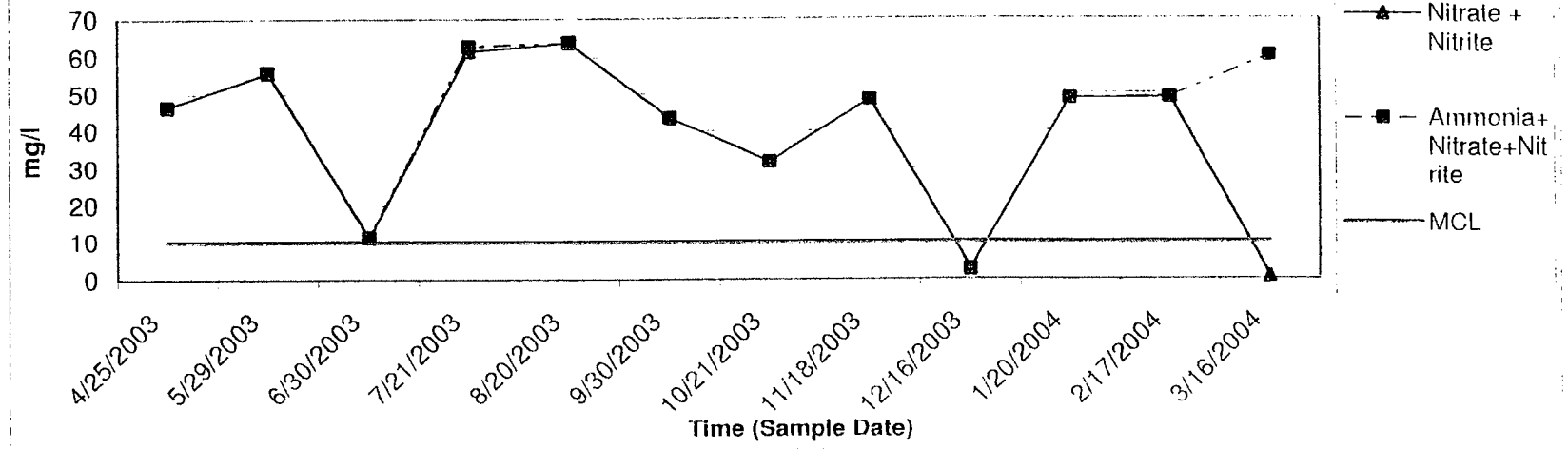
DRAFT

Malibu Study Area

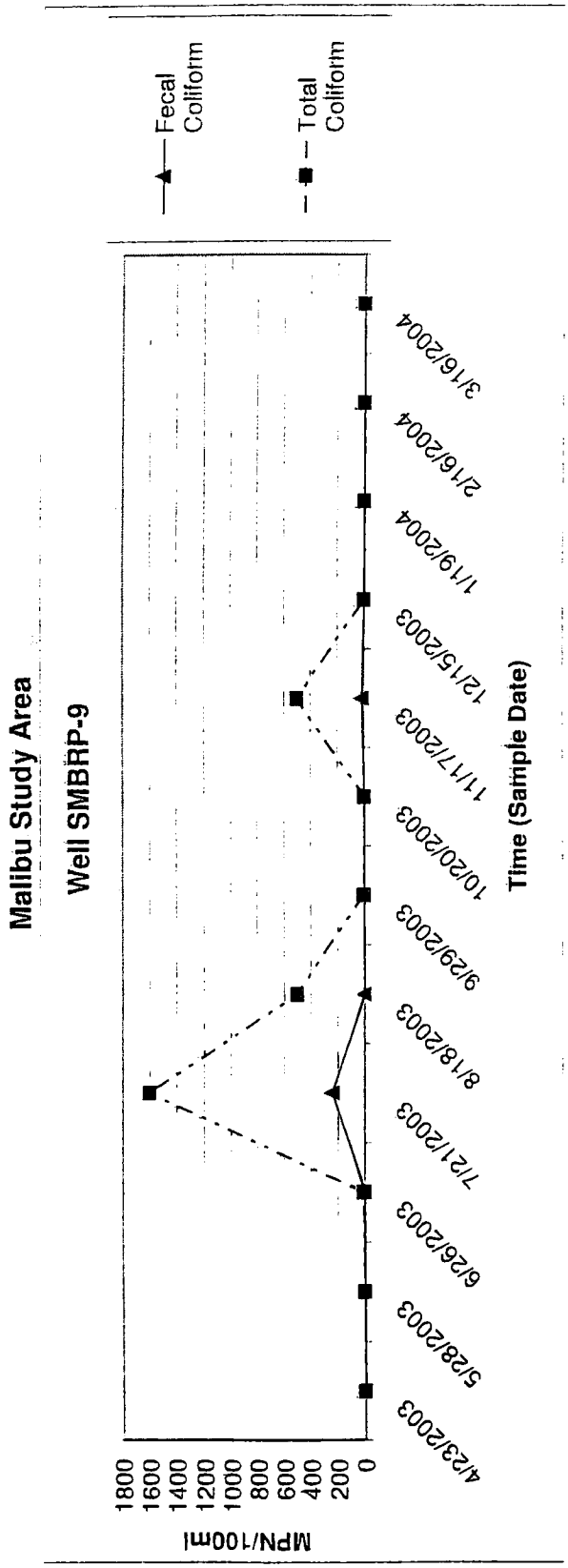
Well SMBRP-8

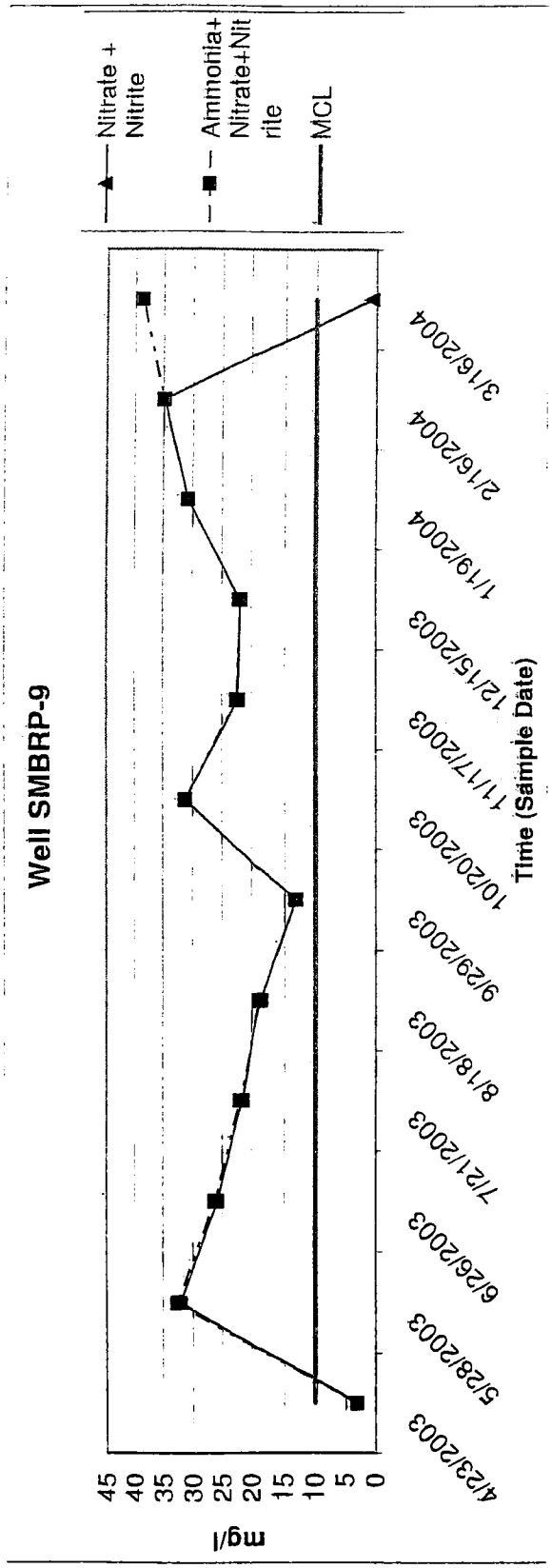


Well SMBRP-8



LEARD

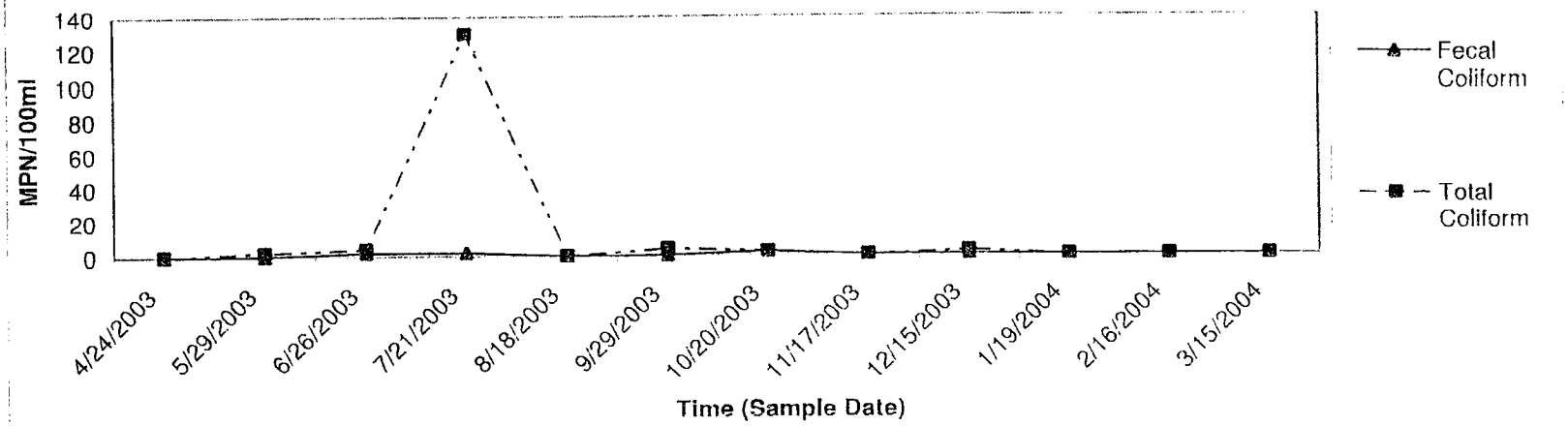

Malibu Study Area
Well SMBRP-9
Fecal Coliform
Total Coliform
MPN/100ml
1800
1600
1400
1200
1000
800
600
400
200
0
4/23/2003
5/28/2003
6/26/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/17/2003
12/15/2003
1/19/2004
2/16/2004
3/16/2004
Time (Sample Date)


Well SMBRP-9
Nitrate + Nitrite
Ammonia+ Nitrate+Nit rite
MCL
mg/l
45
40
35
30
25
20
15
10
5
0
4/23/2003
5/28/2003
6/26/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/17/2003
12/15/2003
1/19/2004
2/16/2004
3/16/2004
Time (Sample Date)

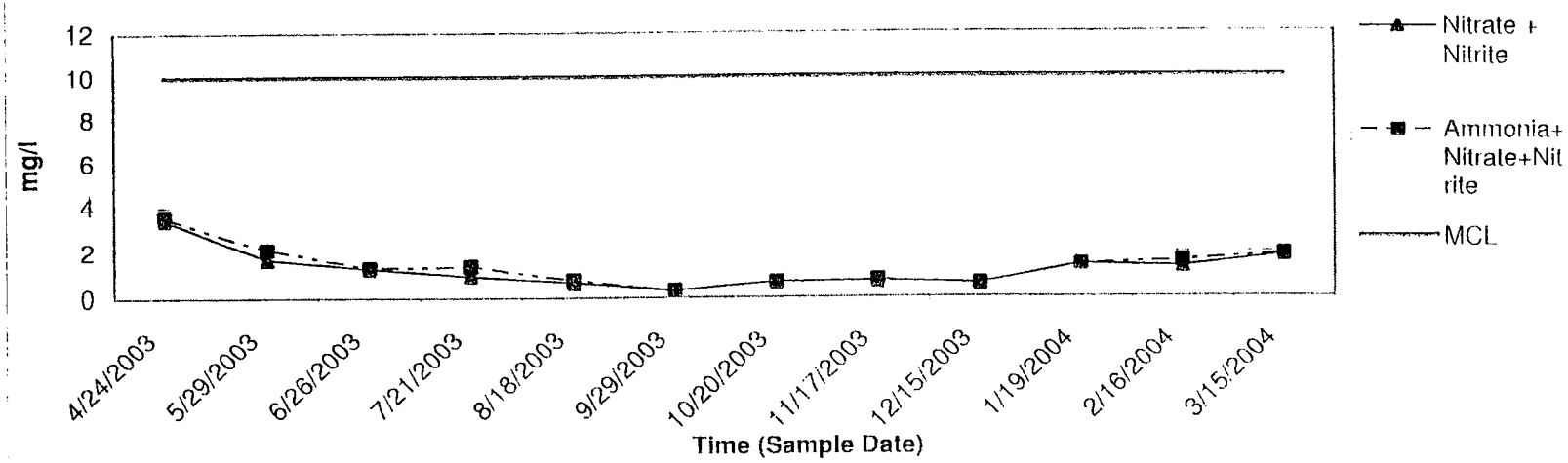
DRAFT

Malibu Study Area

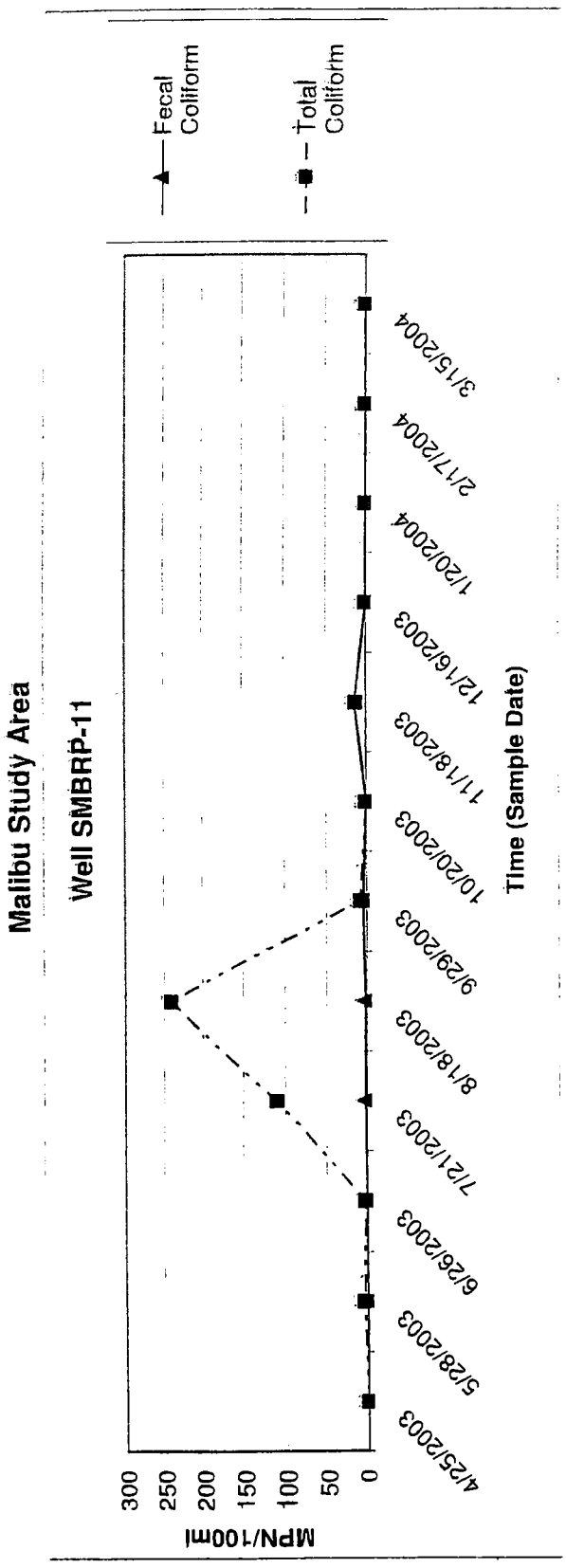
Well SMBRP-10c

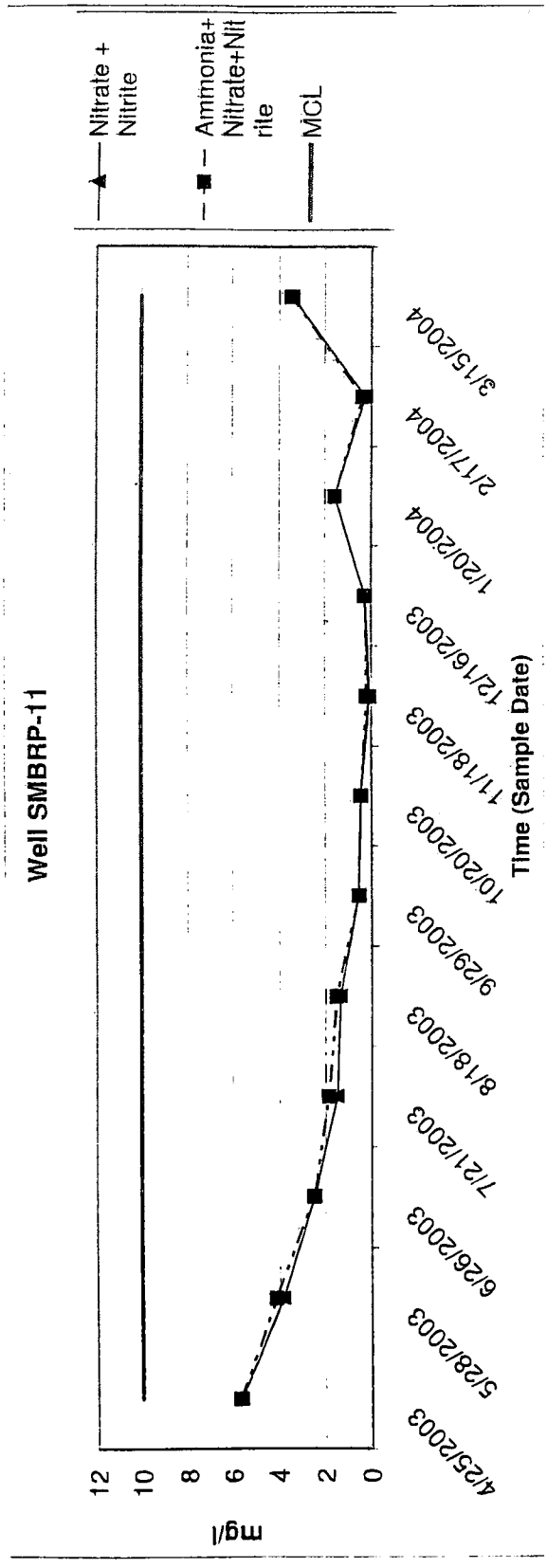


Well SMBRP-10c



LEARD

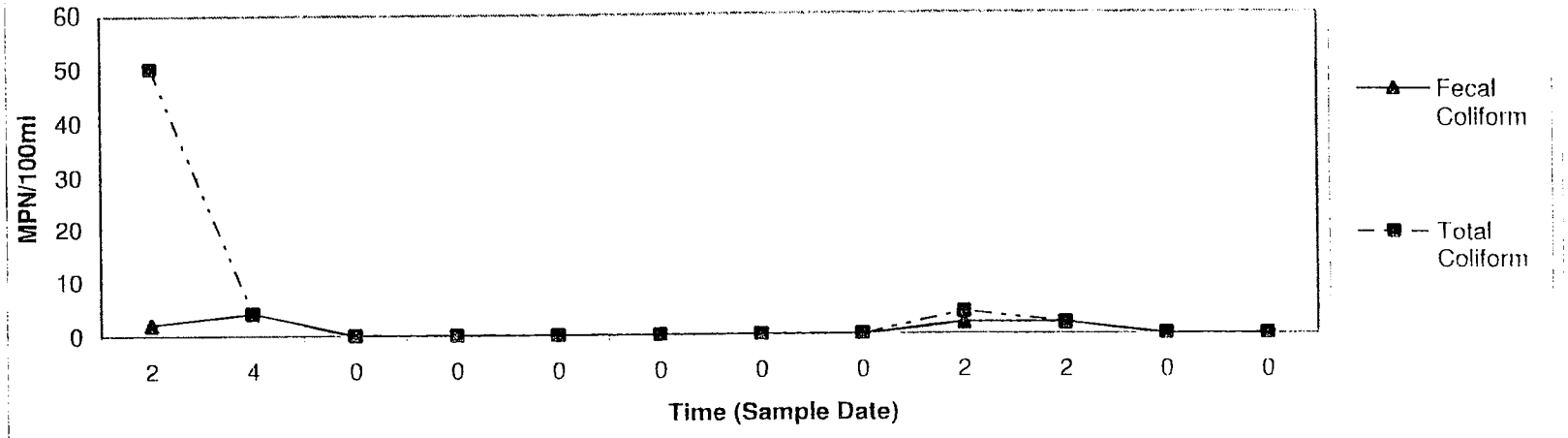

Malibu Study Area
Well SMBRP-11
Fecal Coliform
Total Coliform
MPN/100ml
300
250
200
150
100
50
0
4/25/2003
5/28/2003
6/26/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/15/2004
Time (Sample Date)


Well SMBRP-11
Nitrate + Nitrite
Ammonia+ Nitrate+Nitrite
MCL
mg/l
12
10
8
6
4
2
0
4/25/2003
5/28/2003
6/26/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/18/2003
12/16/2003
1/20/2004
2/17/2004
3/15/2004
Time (Sample Date)

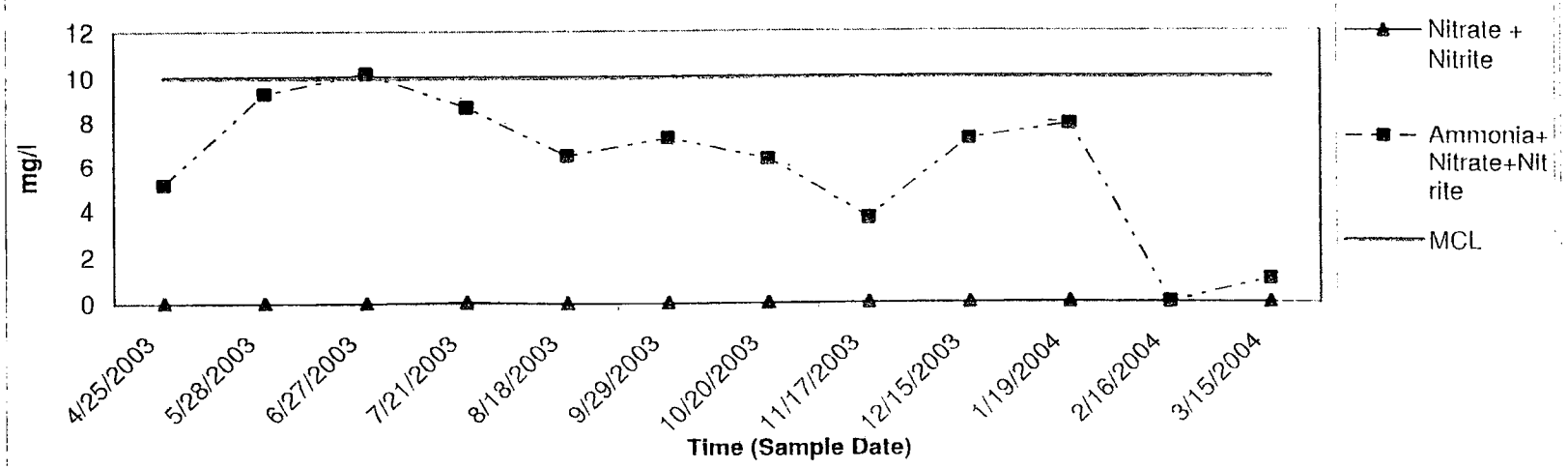
DRAFT

Malibu Study Area

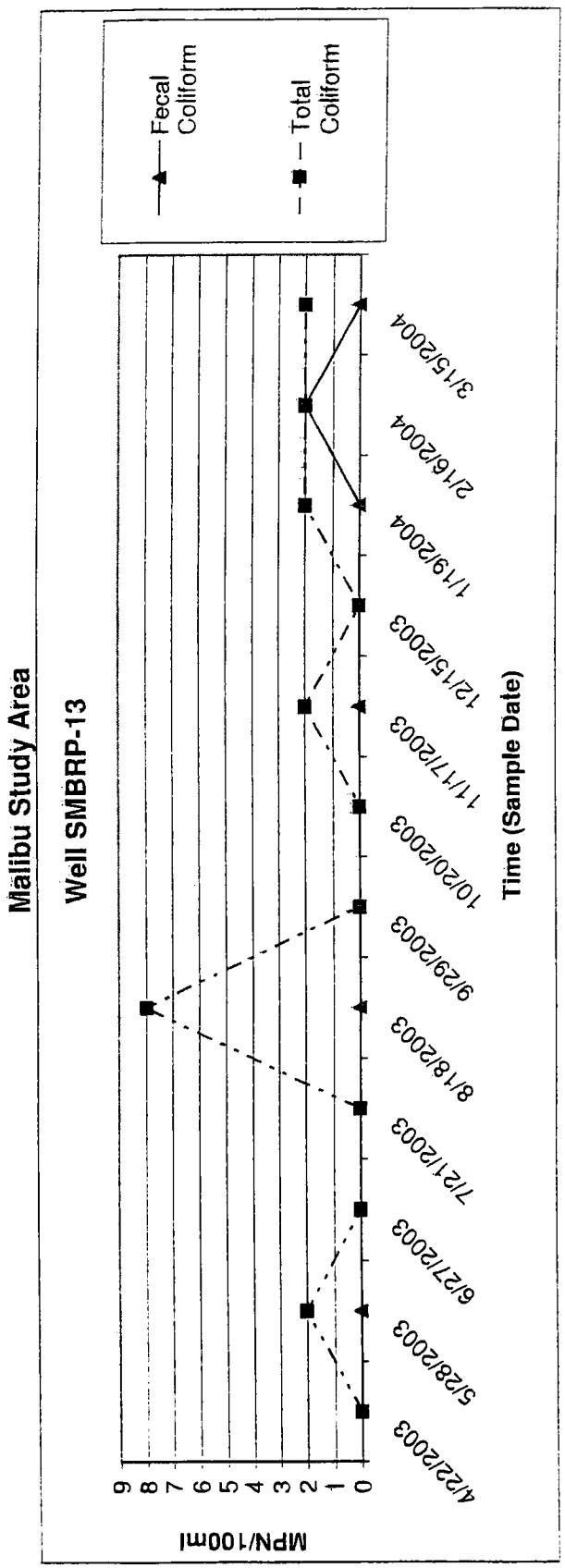
Well SMBRP-12

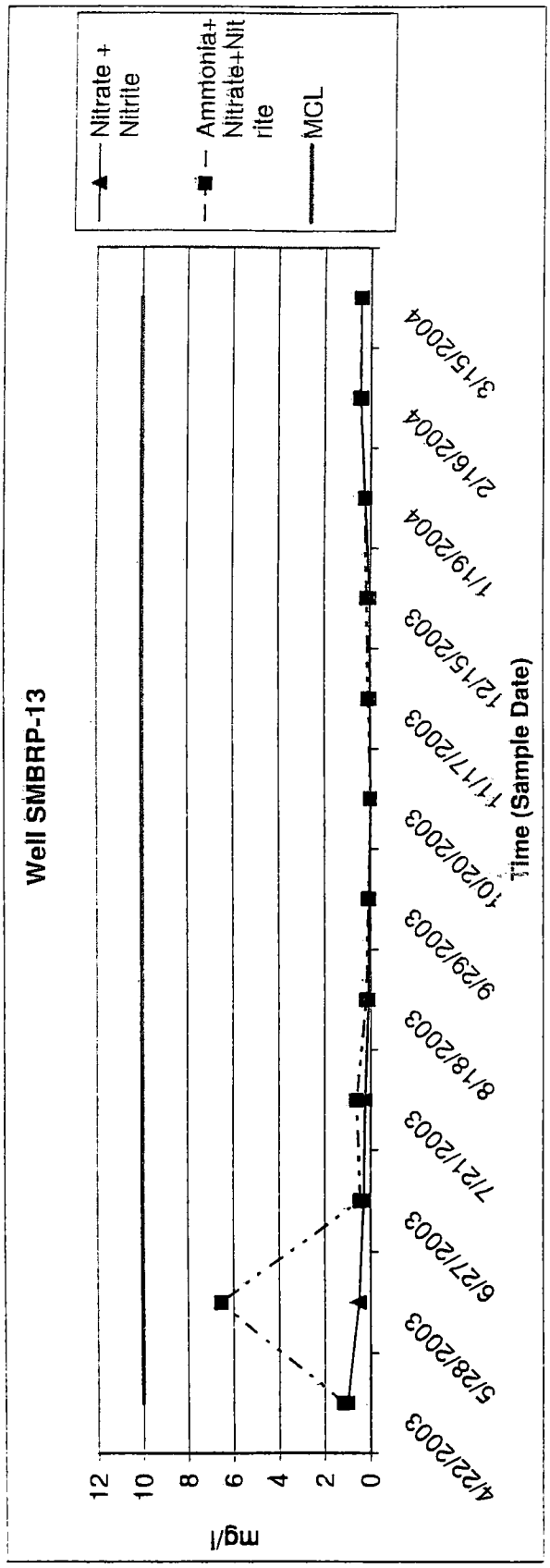


Well SMBRP-12



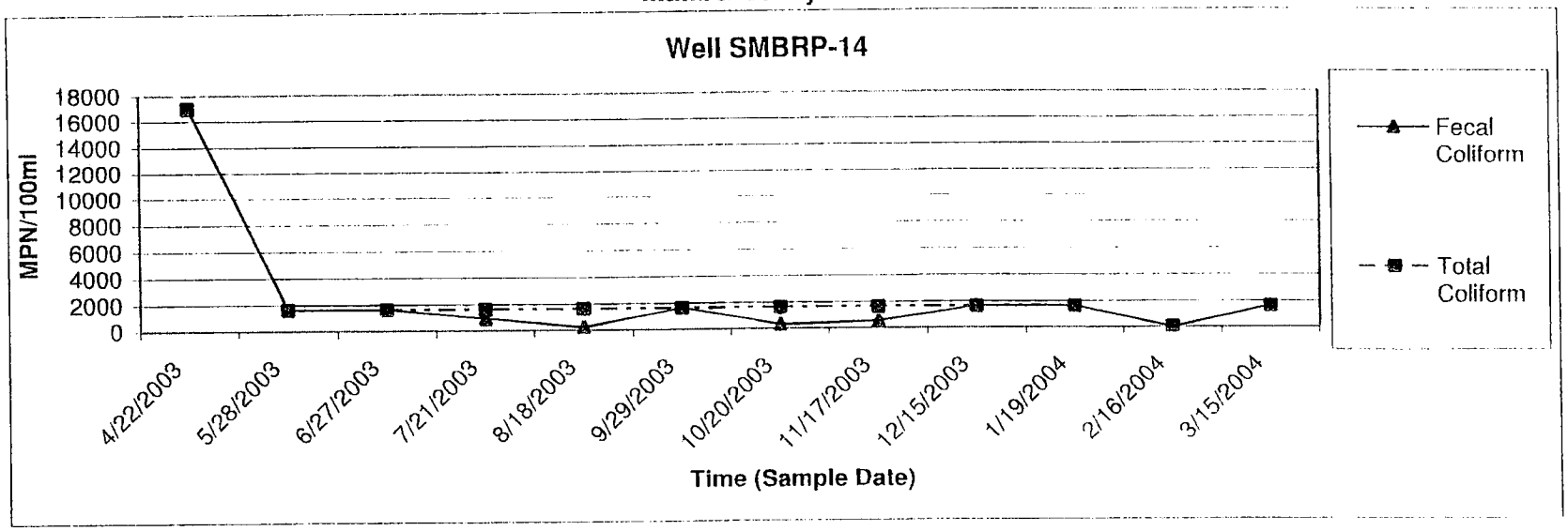
DRAFT

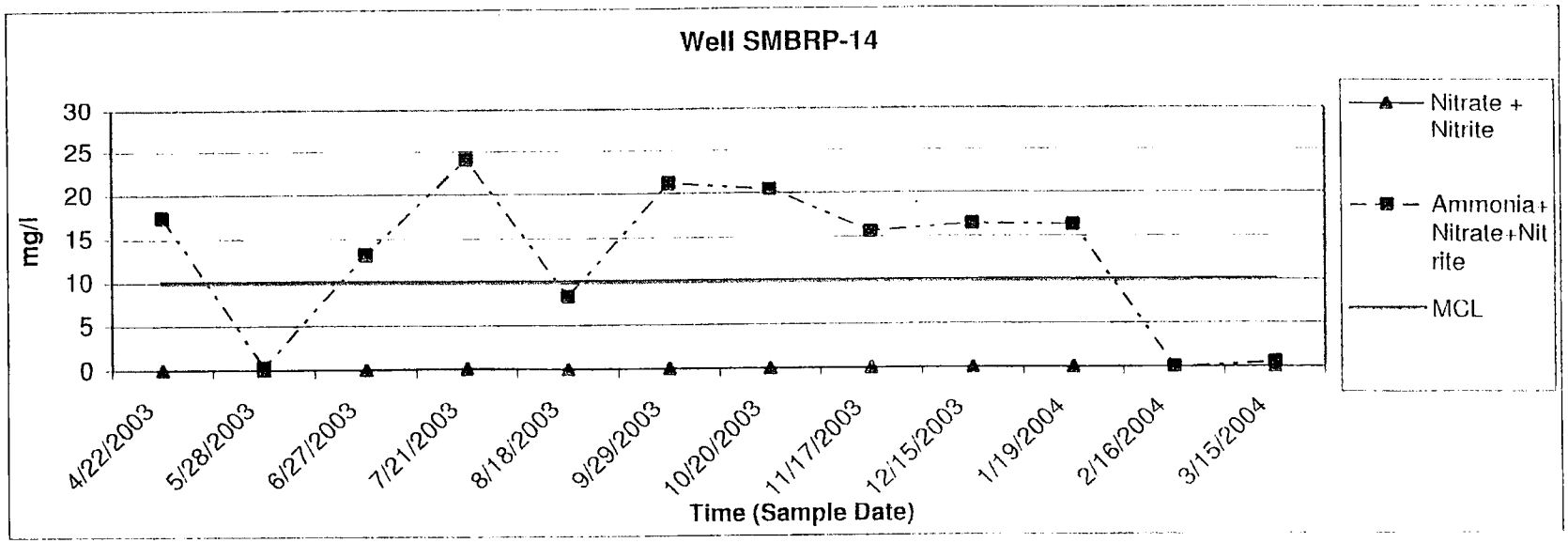

Malibu Study Area
Well SMBRP-13
Fecal Coliform
Total Coliform
MPN/100ml
Time (Sample Date)
0
1
2
3
4
5
6
7
8
9
4/22/2003
5/28/2003
6/27/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/17/2003
12/15/2003
1/19/2004
2/16/2004
3/15/2004


Well SMBRP-13
Nitrate + Nitrite
Ammonia+ Nitrate+Nit rite
MGL
mg/l
Time (Sample Date)
0
2
4
6
8
10
12
4/22/2003
5/28/2003
6/27/2003
7/21/2003
8/18/2003
9/29/2003
10/20/2003
11/17/2003
12/15/2003
1/19/2004
2/16/2004
3/15/2004

DRAFT

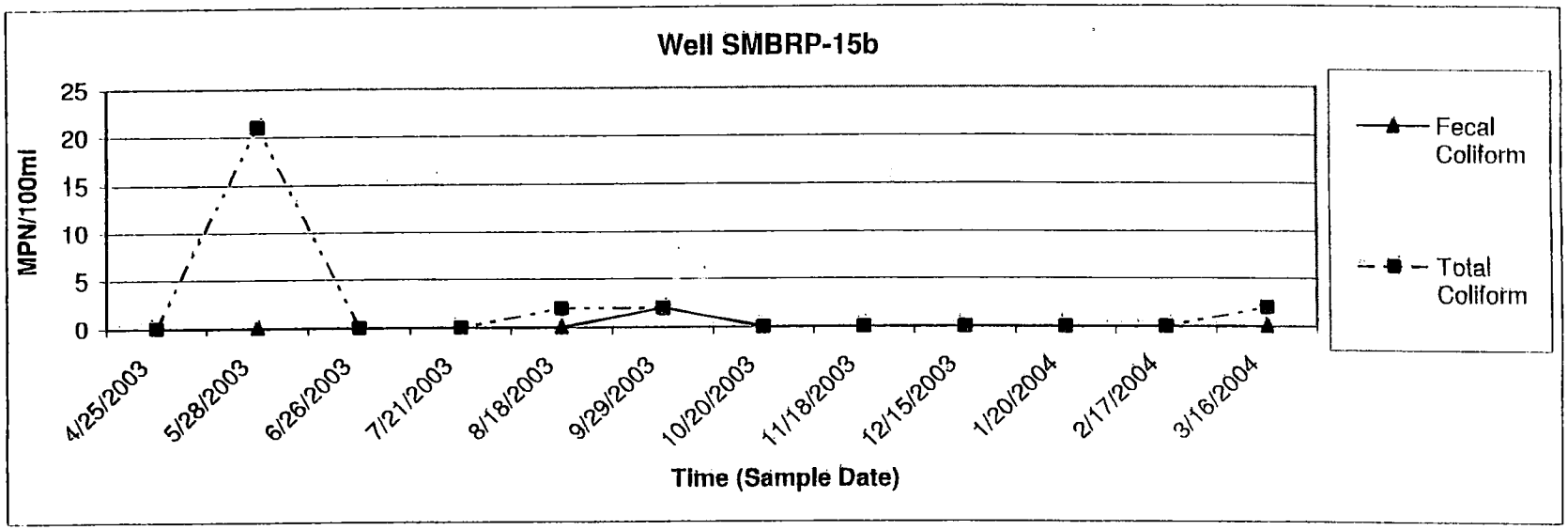
Malibu Study Area

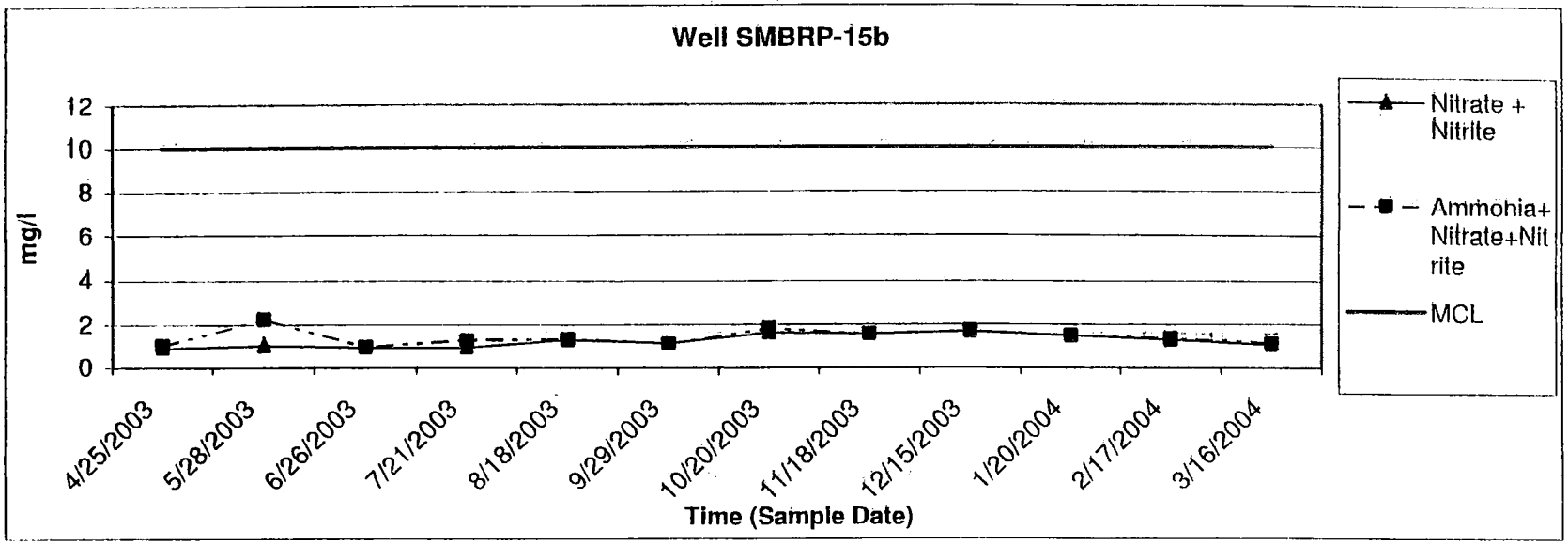




T E A R D

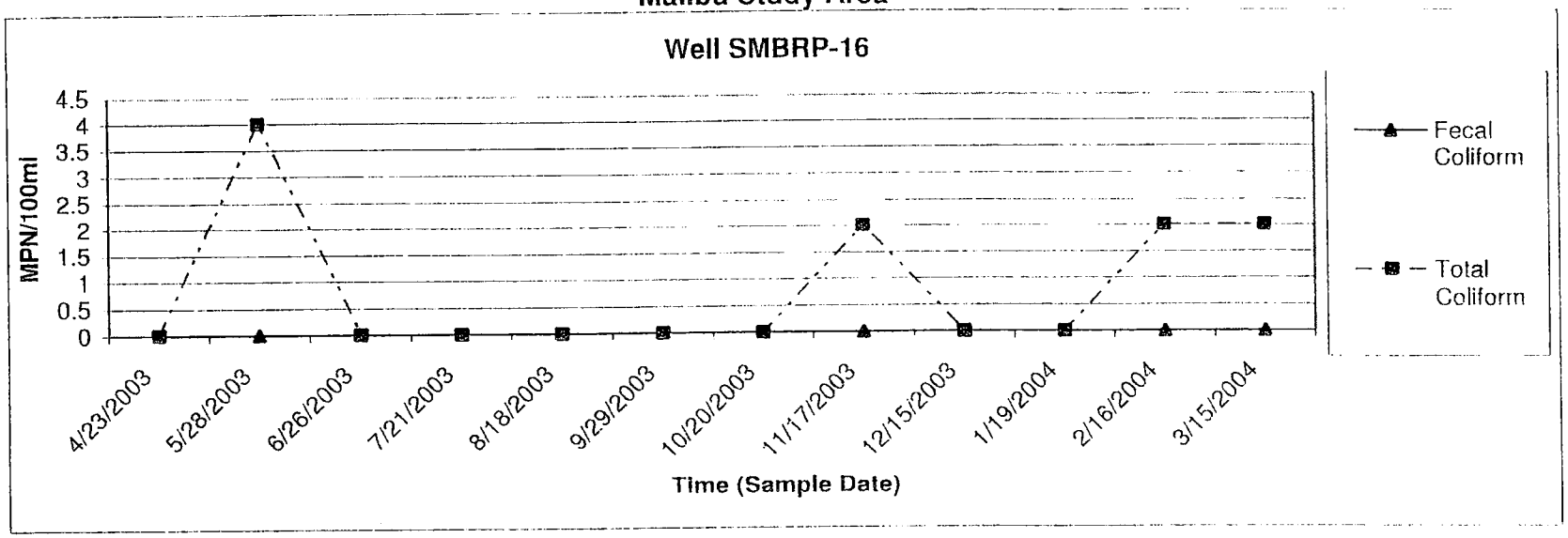
Malibu Study Area

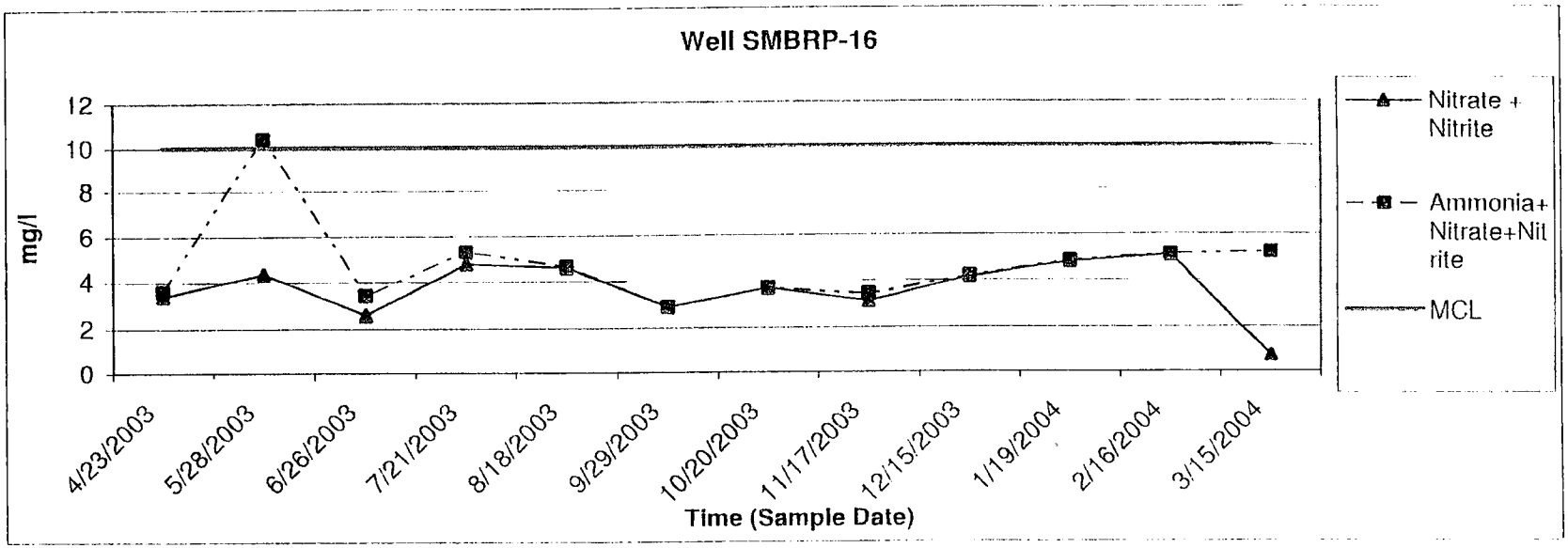




T E A R D

Malibu Study Area





FIGURE

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit on Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

Technical Memorandum #3:

Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment for Water Contact Recreation

D

R

A

F

T

By
Elizabeth Erickson*, Registered Geologist
Groundwater Permitting Unit

* *The author would like to thank Regional Board staff, Joe Luera and interns Albert Chu, Shentong Lu, Shannon Liou, Justin Tang, Tessa Nielsen, Holly MacGillivray, Thomas Palmieri, Ryan Thatcher and Yifei Tong for their assistance in preparing map, tables and graphs.*

Technical Memorandum #3: *Pathogens in Wastewaters that are in Hydraulic Connection with Beaches are a Significant Source of Impairment for Water Contact Recreation*

By
Elizabeth Erickson, Registered Geologist
Groundwater Permitting Unit

1. Purpose

The purpose of the study is (a) to measure the discharge of enterococcus, a fecal-indicator-bacteria for human pathogens, from septic systems (Onsite Wastewater Disposal Systems or OWDS) in the Malibu Civic Center onto adjacent surface waters and beaches, and (b) to determine human health impacts of septic system wastewater disposal on beach users.

2. Study Design and Data

The study design is (a) to examine the distribution of bacteria in groundwater beneath the Malibu Civic Center area, (b) to use beach studies to determine likely fate and transport paths and (c) to use epidemiology studies to estimate health impacts.

Fecal-indicator-bacteria are identified in septic discharge, in leachfields/seepage pits, in groundwater, in streams and beaches and, through rainfall records and frequency distributions, related to groundwater discharge. Onsite Wastewater Disposal System performance data from reporting permitted commercial facilities, groundwater monitoring data and beach monitoring data at the Malibu Civic Center are studied for the presence of enterococcus bacteria, which can originate in the human gut, have been used as indicators of human pathogens, and are the basis of a marine recreational criteria for the protection of human health.

The Los Angeles Regional Water Quality Control Board (Regional Board) was tasked with permitting about 40 commercial facilities in the study area after the year 2000 when the State Water Resource Control Board (SWRCB) eliminated waivers for septic systems. Twenty one permitted facilities were transferred to the City of Malibu for oversight under Memorandum of Understanding signed in 2004. Twenty permitted commercial facilities are under Regional Board's oversight. Notices of Violation (NOV) were issued in the spring of 2009 to 20 facilities for non-compliance with WDR and Time Schedule Orders including failure to submit monitoring reports. Of the permitted septic systems which provided monitoring information, four provided end-of-pipe measures and ten submitted groundwater monitoring results. End-of-pipe discharge reports from permitted systems describe effluent as it enters the leachfield/seepage pit. Enterococcus densities were also examined in groundwater monitoring wells surrounding the leachfields which receive septic system effluent.

The City of Malibu measures groundwater quality periodically throughout the Malibu Valley basin which receives the effluent from the septic systems in the Civic Center. The ground water monitoring of 20 wells in the Malibu Civic Center area was completed by the City of Malibu in 2004 and summarized by Stone Environmental, Inc. (Stone) in 2004, but water level and water quality monitoring information collected since that date has not been submitted to the Regional Board and is not included in this analysis.

DRAFT

State and local agencies and nonprofit organizations measure enterococcus in the surface waters and on the beaches adjacent to the Malibu Civic Center area and these records were examined. As an example, beach data was collected as part of the Coordinated Shoreline Monitoring Plan for Santa Monica Bay beaches and the result of a multi-jurisdictional collaborative effort, involving representatives from (a) municipalities and public agencies responsible for the implementation of the Santa Monica Bay Beaches Bacteria Total Maximum Daily Loads (TMDLs), (b) the Regional Board, and (c) the environmental advocacy groups. The "Santa Monica Bay Beaches Bacteria Total Maximum Daily Load Coordinated Site Monitoring Plan, April 7, 2004" (CSMP) went into effect on April 28, 2004 and can be found at http://ladpw.org/wmd/npdes/beachplan.cfm . All sampling procedures are standardized, including morning sampling in ankle-deep water at fixed points with testing in State certified laboratories.

The CSMP monitoring sites were selected to sample the wave wash of 55 miles of shoreline encircling Santa Monica Bay. The sites include major drains that have measurable flow to the beach at the wave wash during the wet weather and beaches that are used for wading and swimming. Each subwatershed was represented by at least one sampling site. Where a storm drain of freshwater outlet is absent, the midpoint of the beach is used. Based on observations of the Santa Monica Bay Restoration Commission staff and Regional Board staff, only the monitoring sites at Santa Monica Canyon and Ballona Creek have flow to the beach wave wash during dry weather throughout August, September, October and November of each sample year.

Among the beach monitoring information collected, the study focused on records for June through August in 2005, May through October in 2006, April through October in 2007, and May through October in 2008, on a total of 58 beaches, 36 of which receive freshwater drainage (with MS-4 stormwater permits) and 22 of which do not. The beaches stretch from El Pescador Beach in the northwest to Redondo Beach in the southeast. Winter data was not evaluated as septic discharge through groundwater to the beach is anticipated to be smaller in contrast to stormwater bacteria discharge to the beaches after rain events.

The sample sites were sorted according to characteristics, such as watershed size, land-use, fecal-indicator-bacteria concentrations, septic system presence, wave strength and beach visitor population. A full array of site characteristics were found to be represented: sewage or septic system waste treatments, adjacent groundwater levels of enterococcus levels above 1 MPN/100mL, watershed sizes ranging from 813 acres to 81,980 acres, urban acres ranging from 128 acres to 68,700 acres, and wave action identified from surf web-sites ranging from none to persistent. Some beaches had adjacent lagoons, tidally influenced pools, stormwater containments and low flow diversions.

Two epidemiology studies, one by the U.S. Environmental Protection Agency (EPA) used in the development of the existing marine recreational swimming criteria based on enterococcus densities, and a recent study from Wisconsin (Borchardt, 2003) correlating health impacts on children to septic system density, were used to estimate the human health effects of a septic system disposal for the Malibu Civic Center

Attachment 3-1 contains a discussion of the statistical analysis completed as part of this study. Attachment 3-2 contains an expanded reference list.

D R A F T

Groundwater Discharge

This study examines correlations between bacteria distributions in groundwater basin, surface waters and on many beaches with different characteristics. A different study design would be necessary to confirm causation. For the purposes of this study, groundwater discharge is defined as any flow which passes through the beach face or subsurface to enter the wave zone. It may be comprised of varying volumes of (a) stormwater or urban runoff which has entered the groundwater upgradient from the beach and discharges at the beach, (b) septic effluent which enters the groundwater as a discrete plume or with mixing and discharges at the beach, (c) groundwater which has resided for longer than a season in the aquifer and discharges at the beach. In every beach studied, except Ballona Creek and Santa Monica Canyon beaches, freshwater entering the wave zone must pass through the sand of the beach face during some of the summer months.

When septic beaches are compared with sewered beaches during dry weather, septic beaches may receive groundwater discharge of septic effluent, urban flows, and groundwater, while sewered beaches are limited to a mix of urban and groundwater flows.

Peer Review

A peer review of a portion of this work was conducted between June 8, 2009, and the public release of this document. An early technical review resulted in recommendations from the reviewers (a) to enhance the confidence of the conclusions using statistics, (b) to recommend additional studies to confirm and extend the results shown here, and (c) to emphasize the complexity of the subsurface hydraulic and microbiological environment between septic discharge and the ocean which have limited a simple characterization of a relationship between human illness from marine recreational swimming and coastal septic use. In response to these comments, additional statistical results were completed and the qualitative conclusions were made on human health risks. The external technical reviewers were Dr. Mark Gold (Heal the Bay), Mr. Steve Weisberg and Dr. John Griffith (Southern California Coastal Water Research Project or SCCWRP), Dr. Alexandria Boehm (Stanford University) and Dr. John Izbicki (US Geological Survey), all of whom have completed research on pathogens on beaches.

Dr. C.Y. Jeng (Department of Toxic Substances Control) provided helpful discussions on statistics.

Integration with Ongoing Studies

An epidemiology study of Surfrider Beach by SCCWRP is planned for the summer of 2009. Groundwater assessment is planned for a seven-day period in July 2009 by Dr. John Izbicki. While providing critical and important information, these two studies are limited in their ability to deny a causal relationship between septic systems and bacteria because (a) groundwater and epidemiology are not examined over an extended period of time and (b) groundwater identification of bacteria transport is repeatedly confounded by time, tide and effluent pathway dependent variations (Boehm et. al., 2004). Descriptions of the ongoing studies are available from the Regional Board.

DRAFT

3. Results

Bacteria in Groundwater

Enterococcus bacteria are found being discharged from OWDS, in the adjacent leachfields/seepage pits, throughout the groundwater basin, and in the subsurface adjacent to Malibu Creek, Lagoon and the Civic Center Beaches.

End-of-pipe bacteria measurements were reported for four permitted sites in the Malibu Civic Center. Half of the measures show enterococcus bacteria concentrations larger than or equal to total or fecal coliform measures[1]. The data show the typical wide variation in measures of water samples examined for this study.

All four reporting sites had disinfection so the end-of-pipe measures show events which are present during the failure of chlorine, ultraviolet or ozone treatment. Technical memorandum #1 quantifies the frequency of these failures as does the permit violations notices discussed above.

Table 1: End-of-Pipe Effluent Bacteria Densities MPN/100mL reported for permitted Malibu Civic Center Commercial Facilities with Disinfection. Highlighted measures are enterococcus values in human waste which exceed fecal and/or total bacteria counts or are above 35 Most Probable Number (MPN)/100 mL (geometric mean standard for beneficial use of body contract recreation (REC-1)).

Site	Total	Fecal	Enterococcus
Malibu Creek Preservation	1,600	350	46
	1,600	140	110
Malibu Beach Inn	Not measured	2	2
	Not measured	2	2
Malibu Colony Plaza	105	2	2
	4,000	2	2
	1,600	1,600	2,419
	1,600	1,600	2,419
Fire Station 88	1,600	1,600	2,419
	9,000	Not available	90,000
	24,000	24,000	24,000
	30,000	2,400	50,000
	240,000	Not available	240,000
	300,000	50,000	1,600,000

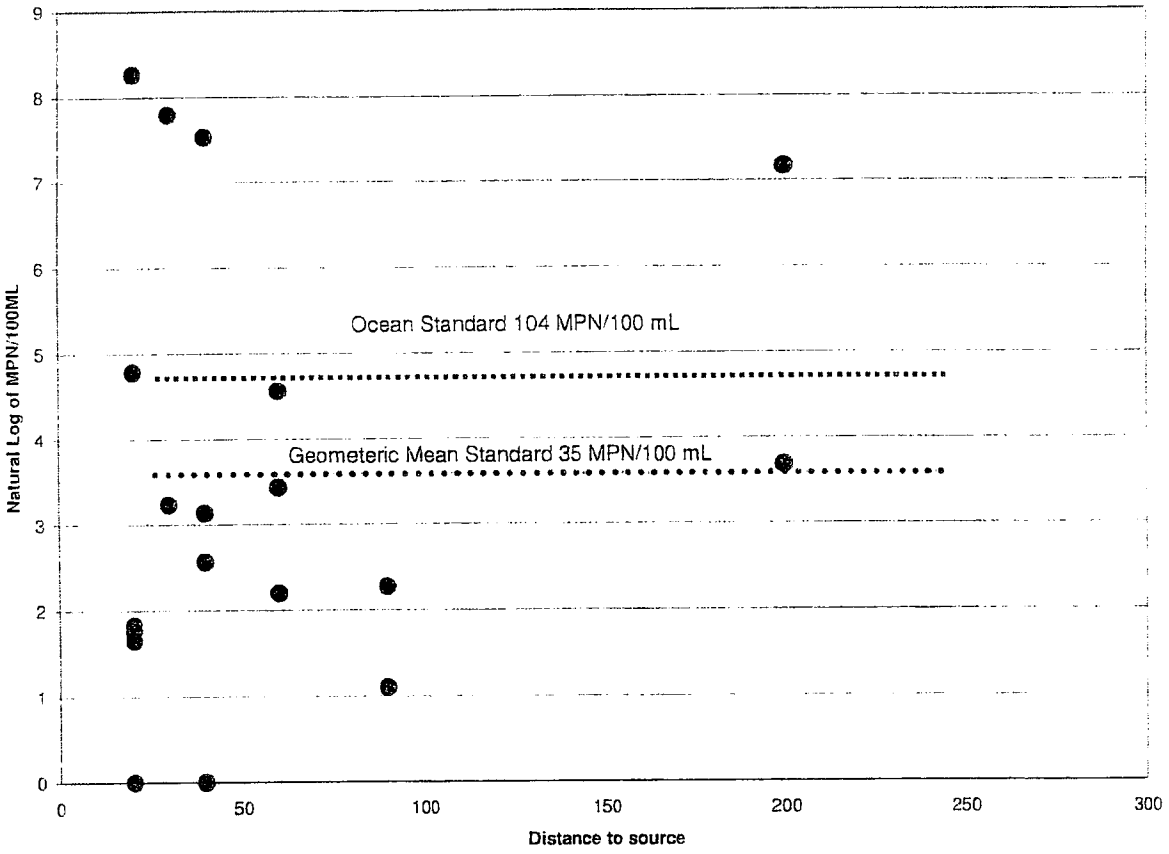
[1] All bacteria measures, even from the same waste stream, are highly variable. Enterococcus bacteria in end-of-pipe measures correlate with fecal (R^2 = .88) and total (R^2=.84) bacteria in those same samples.

3-1232

DRAFT

An examination of maximum enterococcus densities in groundwater monitoring wells adjacent to nine permitted Advanced Onsite Wastewater Disposal Systems in the Malibu Civic Center found that the groundwater bacteria densities are present at elevated levels and decrease from 10,000,000 MPN/mL to zero with distance from the subsurface discharge point to the monitoring well (Figure 1).

Figure 1: Natural Log of Enterococcus in Groundwater Wells versus distance from the end-of-pipe in feet in the Malibu Civic Center (outliers at 200 feet distance are attributed to bacteria transport through fractures to the Malibu Administration Center, possibly from residential septic systems)



Elevated bacteria levels were found throughout the Malibu Valley groundwater basin which underlies the Malibu Civic Center area as reported in 2004 by Stone Environmental in "Final Report- Risk Assessment of Decentralized Wastewater Disposal Systems in High Priority Areas in the City of Malibu CA."(Figures 2a. 2b and 3). Large densities are seen adjacent to the receiving waters. Fifteen out of 20 wells in Stone 2004 Study and 16 out of 27 permit monitoring wells contained maximum enterococcus exceeding water quality objective of 104 MPN/100ml for beneficial use of REC-1, i.e., 31 out 47 wells (76% wells) have exceedance.

DRAFT

Figure 2a: Chart of Maximum Enterococcus MPN/100 mL for 20 groundwater wells in the Civic Center area from Stone 2004 Study (well locations are shown in Figure 3).

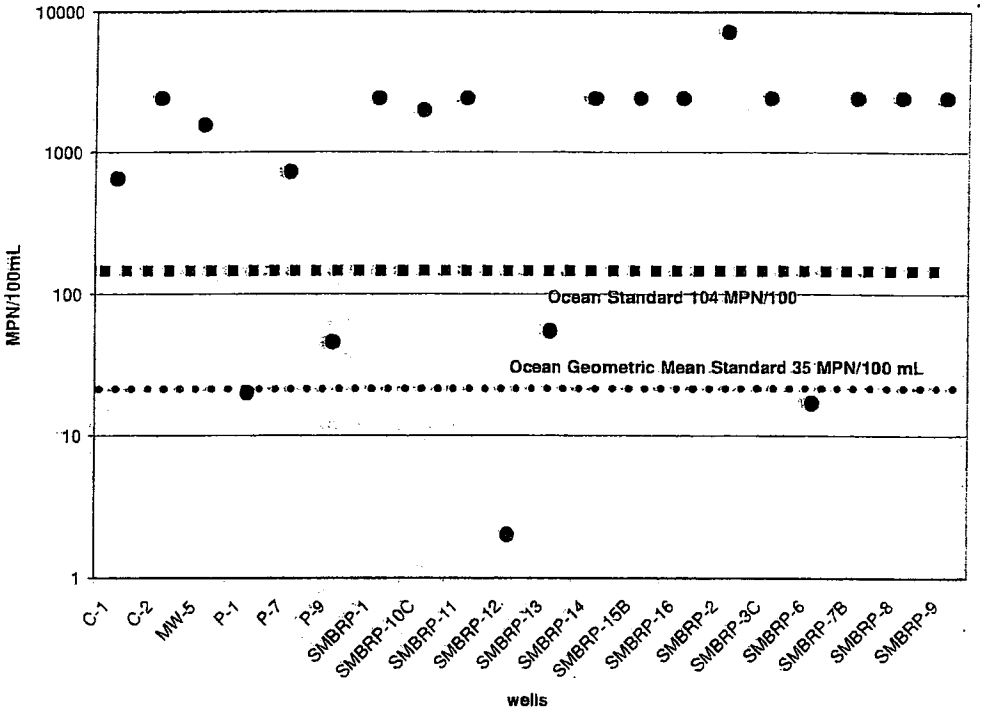
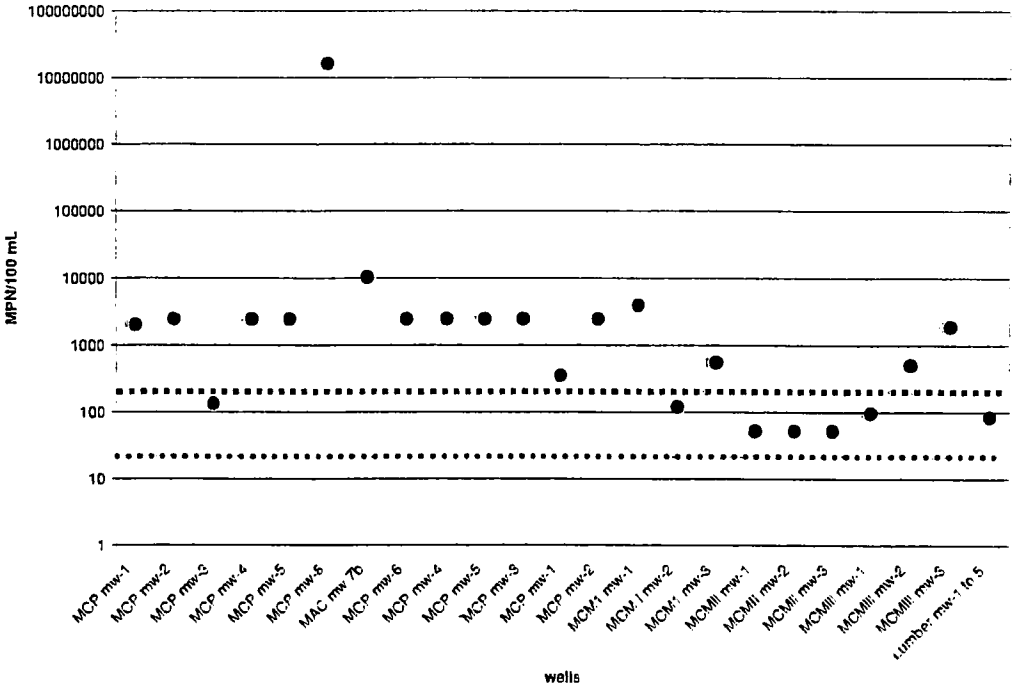
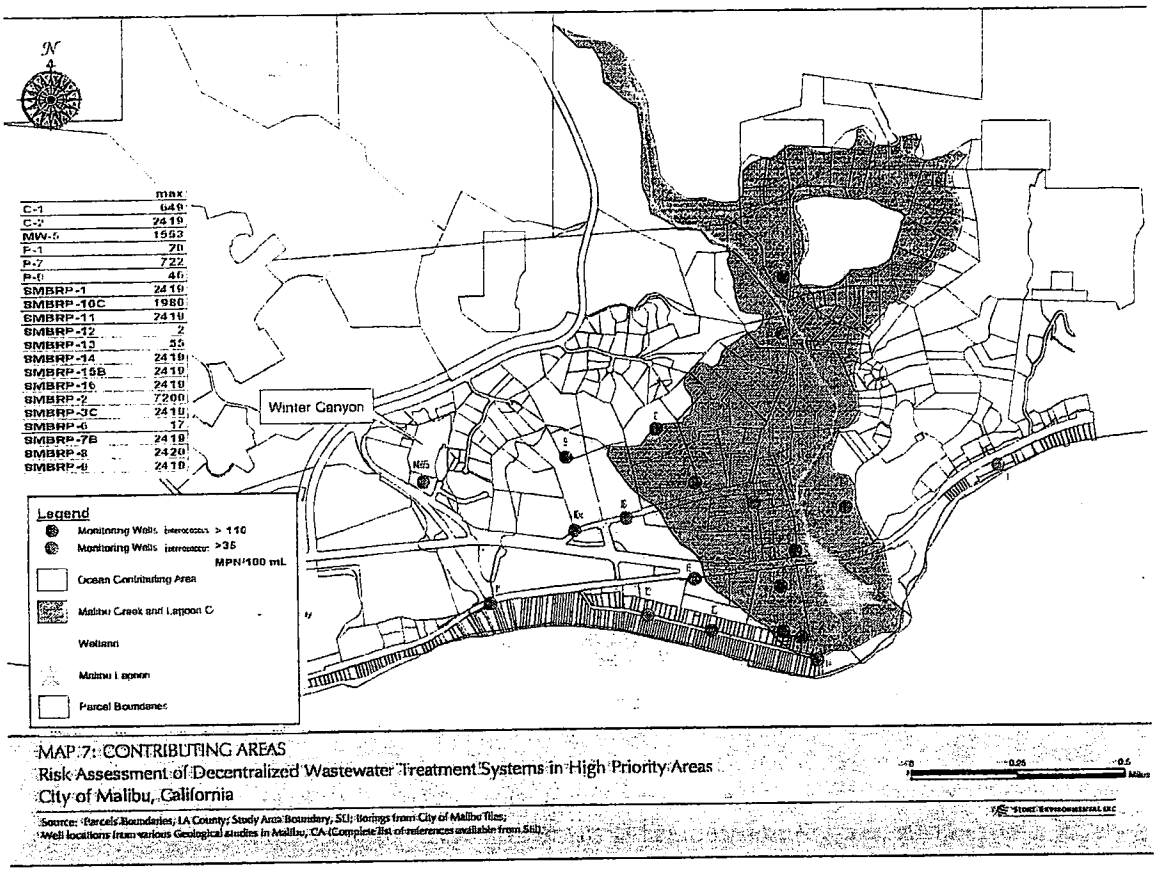


Figure 2b: Chart of Maximum Enterococcus MPN/100 mL for 27 permit monitoring wells in the Civic Center area (well locations are shown in Figure 1 of Technical memorandum #2).



DRAFT

Figure 3 after Stone 2004 shows the <u>maximum</u> enterococcus measures in wells in the Civic Center area. (Densities above 104 MPN/100 mL are the darkest spots).

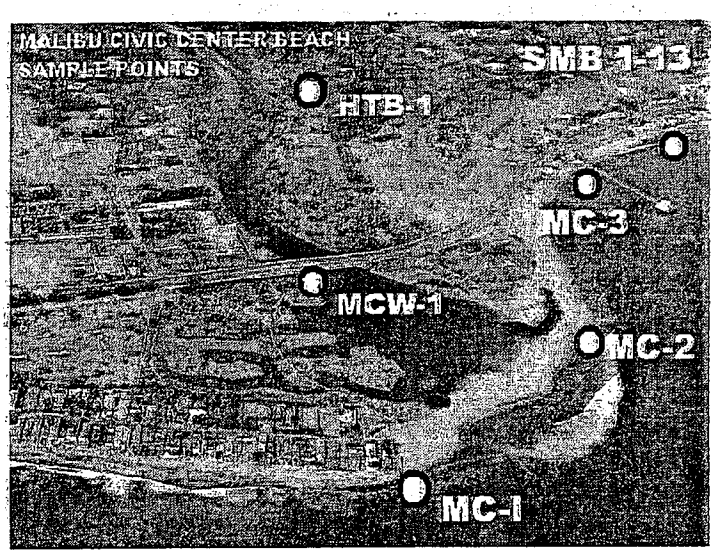


Bacteria in Surface Water

Summer levels of the fecal-indicator-bacteria enterococcus are not as high in the water entering Malibu Lagoon from the Malibu Creek watershed (see Figure 4), as they are downstream of the Malibu Civic Center area. The contrast can be seen in Figure 5 showing enterococcus at Lower Malibu Creek sampling station HTB-1 and Lagoon sampling station MCW-1. Some bacteria in surface water flows in the Malibu Civic Center may enter the surface water with summer groundwater discharge from the Malibu Civic Center area and result in higher enterococcus in the Lagoon. Further, the bacteria in the lagoon surface water must enter the groundwater beneath Surfrider Beach again before discharging into the wave zone at MC-2 as seen on the Figure 4 below.

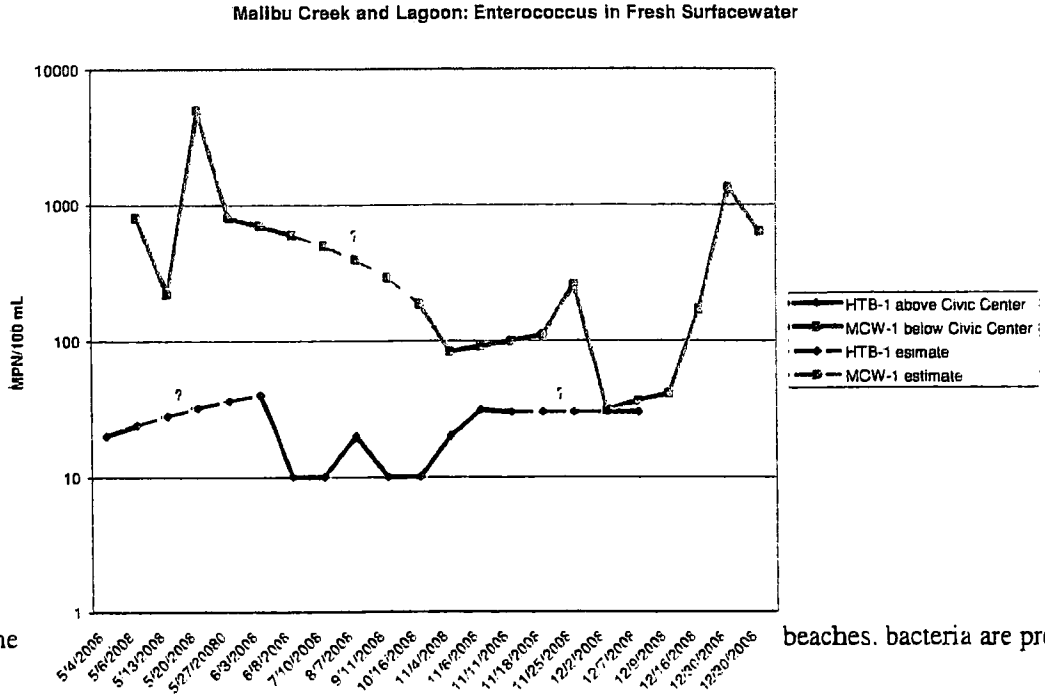
DRAFT

Figure 4: Malibu Civic Center Surface water and Beach Sampling Points. (HTB-1 where surface water from Malibu Creek watershed enters the lagoon, MCW-1 where Malibu Creek enters Malibu Lagoon after receiving groundwater discharge from the Malibu Civic Center. Also see are beach sampling points MC-1 at the Beach adjacent to Malibu Colony, MC-2 at the breach point of Malibu Lagoon on Surfrider Beach, MC-3 at the beach adjacent to Malibu Pier and SMB-1-13 at Carbon Canyon Beach where Sweetwater Canyon discharges.)



The Malibu Creek and Lagoon TMDL also evaluated the bacteria levels in surface water and set loads for total bacteria which are less than the loads measured in 2004.

Figure 5: Enterococcus in Surface water at Malibu Civic Center



On the beaches. bacteria are present

DRAFT

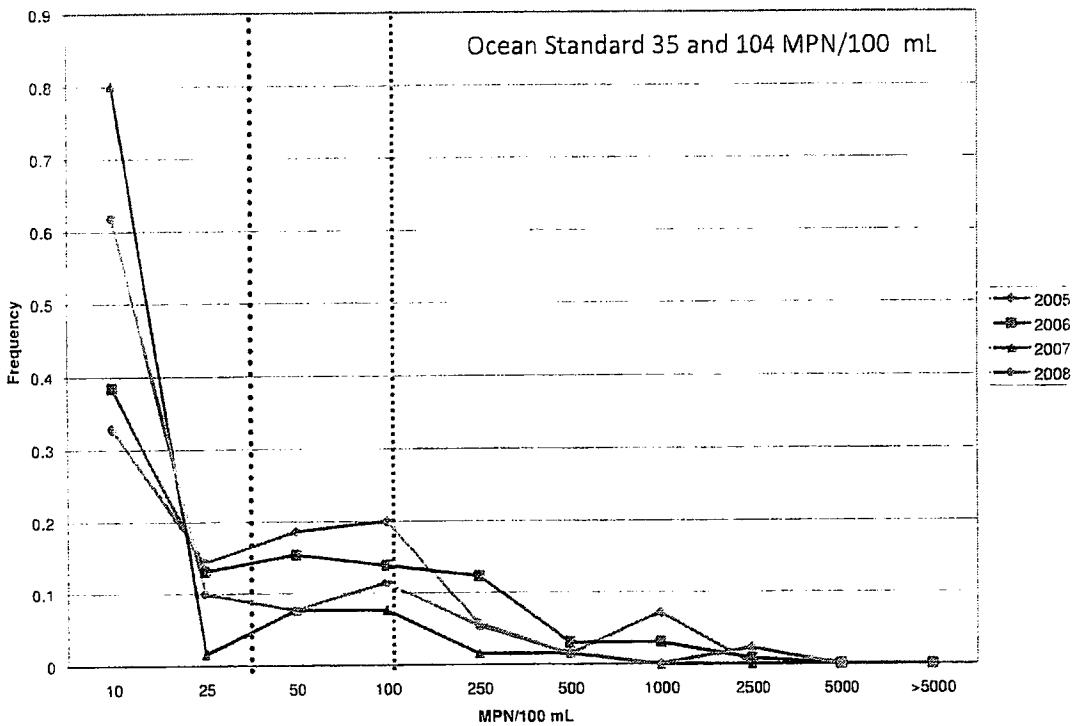
at levels above water quality objectives at Malibu Colony (MC-1), Surfrider Beach (MC-2), and Malibu Pier (MC-3). The pollution on beaches has been quantified in the 2003 303(d) list, Heal the Bay's beach quality grades, and the Regional Board's Santa Monica Bay Bacteria TMDLs. Further, the Regional Board issued a Notice of Violation (NOV) for bacteria at the Malibu Civic Center beaches in March 2008. It identified violations of the waste discharge requirements established in Board Order No. 01-182, as amended by Order No. R4-2006-0074 and Order No. R4-2007-0042, Board directions which constitute the Los Angeles MS-4 Permit controlling urban runoff and stormwater discharge. The NOV identified 493 days and 836 instances in the City of Malibu during the summer of 2007 when water contact recreation objectives were exceeded. Of these exceedances, seventy single sample violations occurred adjacent to the Malibu Civic Center.

Enterococcus on Malibu Civic Center Beaches and all Santa Monica Bay Beaches

The enterococcus measures recorded on beaches at the Malibu Civic Center area over the summers 2005 to 2008 were sorted by interval frequency and plotted against the percentage of the total number of measurements. The method was chosen to minimize the impact of varying sample sizes and simplify large variations in the measures.

The Civic Center beaches were found to have enterococcus frequency distributions with correlation coefficients which demonstrate that the distribution of bacteria frequencies is consistent at a beach, and not a function of external events such as swimmer shedding, the inappropriate disposal of a diaper or beach use by a homeless person.

Figure 6. Surfrider Beach MC-2 Enterococcus Interval Frequency for May-October Summer Single Measures (Correlation coefficients of the frequency distribution ranges from .82 to .99: see discussion in Attachment 3-1)



DRAFT

Figure 7. Malibu Colony MC-1 Enterococcus Interval Frequency for May-October Summer Single Measures

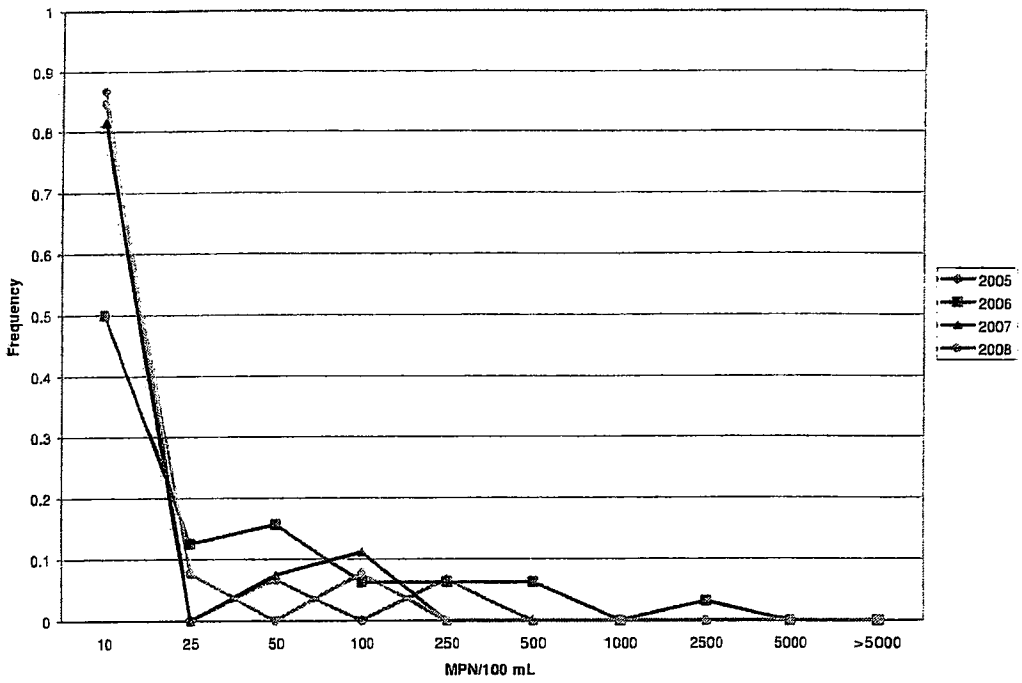
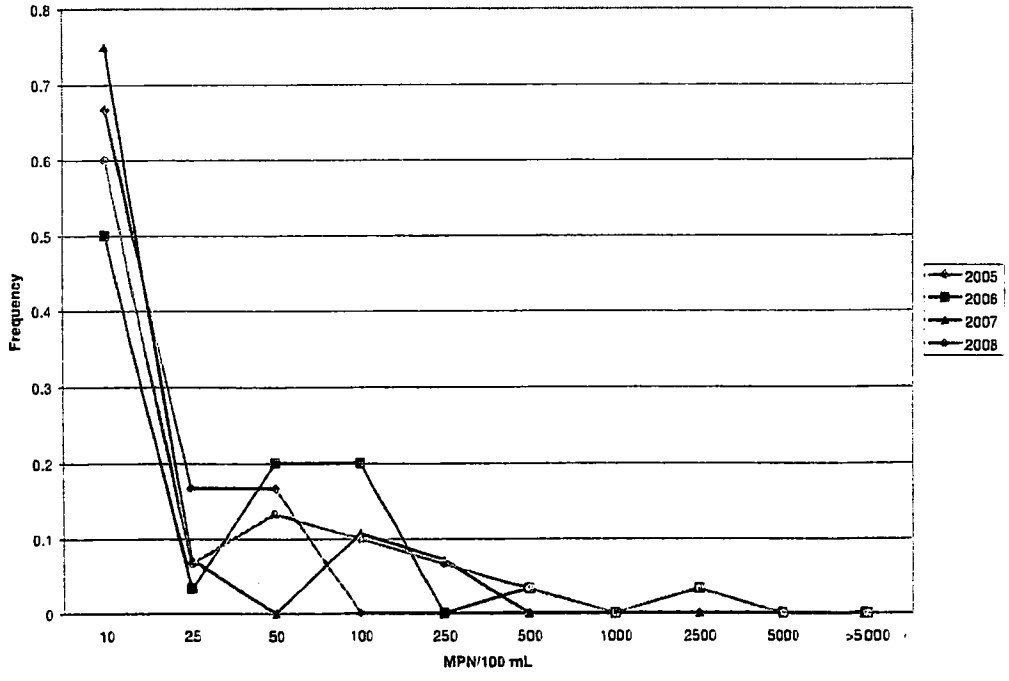


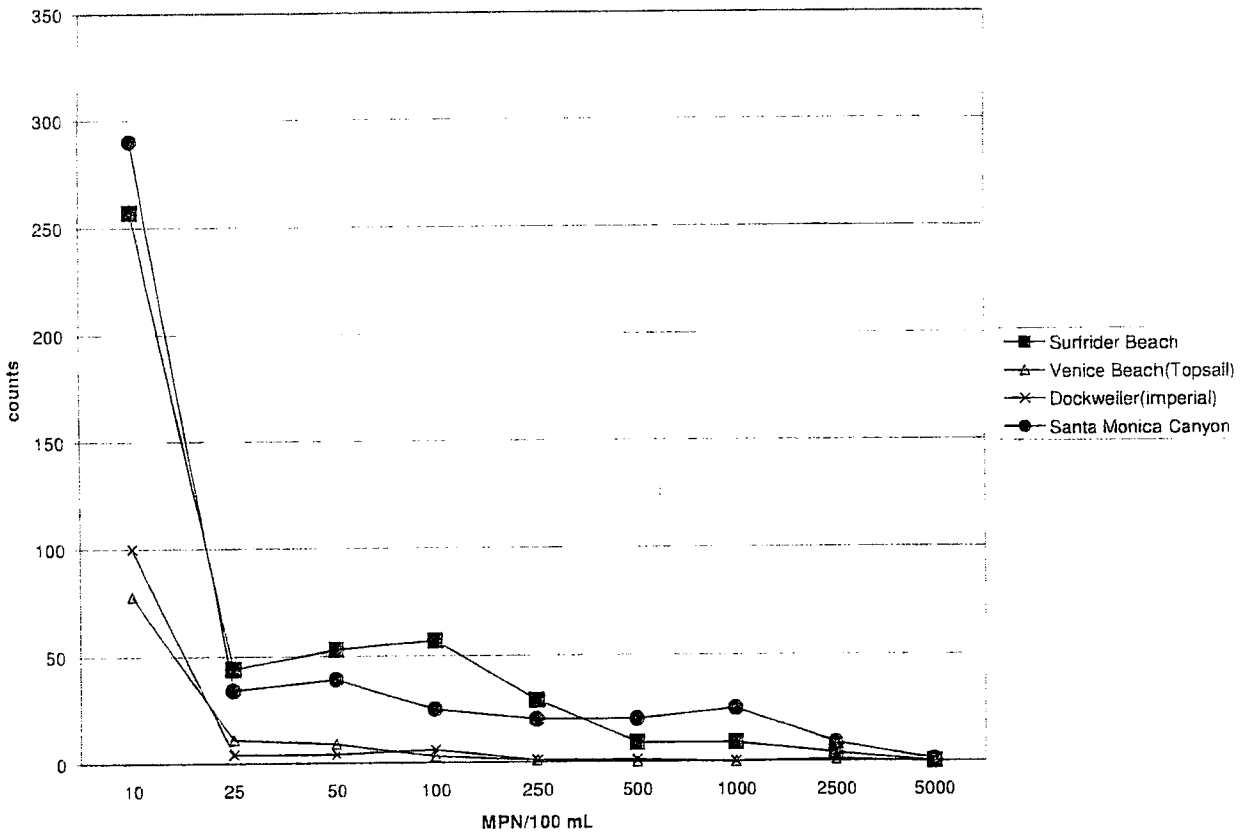
Figure 8. Malibu Pier MC-3 Enterococcus Interval Frequency for May-October Single Measures



DRAFT

The enterococcus interval frequency distribution at the Malibu Civic Center beaches (septic beaches) are both similar and distinct from those found for other individual beaches, as in this comparison of the septic Surfrider Beach and Santa Monica Canyon. Venice Beach at Topsail and Dockweiler Beach at Imperial, all of which are sewered. All four beaches are near to a freshwater discharge point for a large watershed area and have heavy public use. In this particular graph, values below 10 MPN/100 mL were not included and counts are displayed instead of frequency.

Figure 9. Surfrider, Santa Monica Canyon, Venice and Dockweiler Beaches Enterococcus Interval Counts for May-October Summer Single Measures for 2005-2008 without values <10 MPN/100mL



DRAFT

The Malibu Civic Center beaches were found to have enterococcus frequency distributions similar to those for all Santa Monica Bay Beaches in that they had the most measures at 10 MPN/100 mL and some additional measures above 1,000 MPN/100 mL. Figures 10-13 and Tables 4-7 of all Santa Monica Bay beaches for 2005 through 2008 show that these general characteristics are present for all the studied beaches.

Figure 10..34 Santa Monica Bay Beaches 2005 (All MS-4 beaches without direct ocean discharge to waves) Enterococcus Interval Frequency for June-August Single Measures

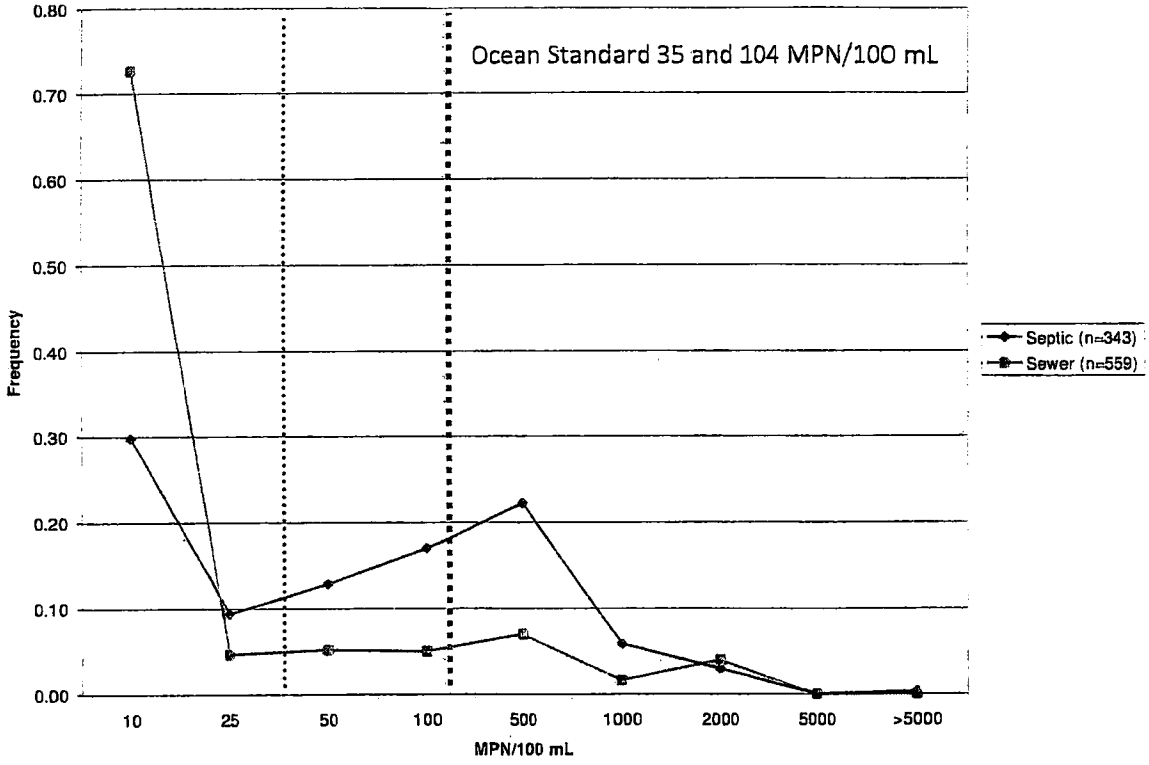


Table 4: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2005.

In MPN/100mL	all beaches in 2005			
Enterococcus	Septic (n=466)	% total days reported at septic sites	Sewer (n=859)	% total days reported at sewer sites
Days above 35	206	44%	207	24%
Days above 104	108	23%	126	15%

3-1240

DRAFT

Figure 11. 34 Santa Monica Bay Beaches 2006 (All MS-4 beaches without direct ocean discharge to waves) Interococcus Interval Frequency for May-October Single Measures

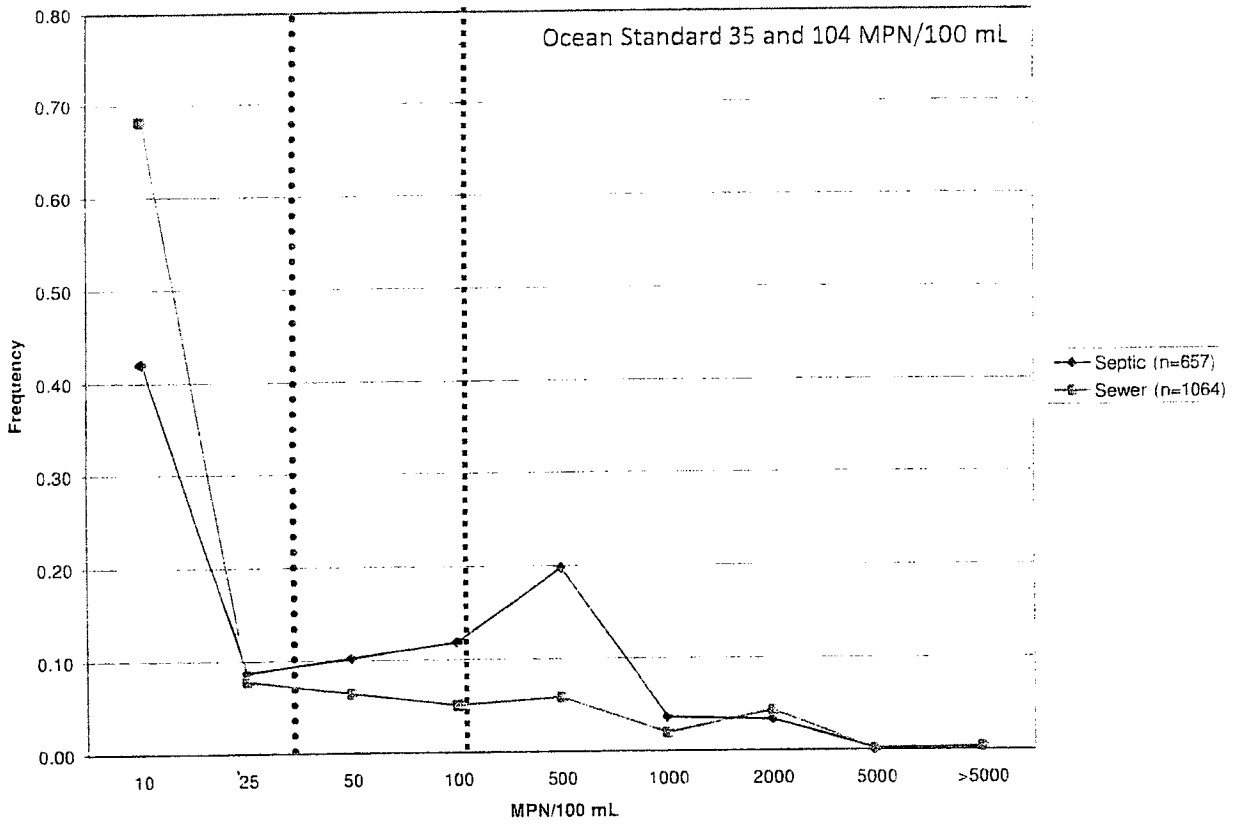
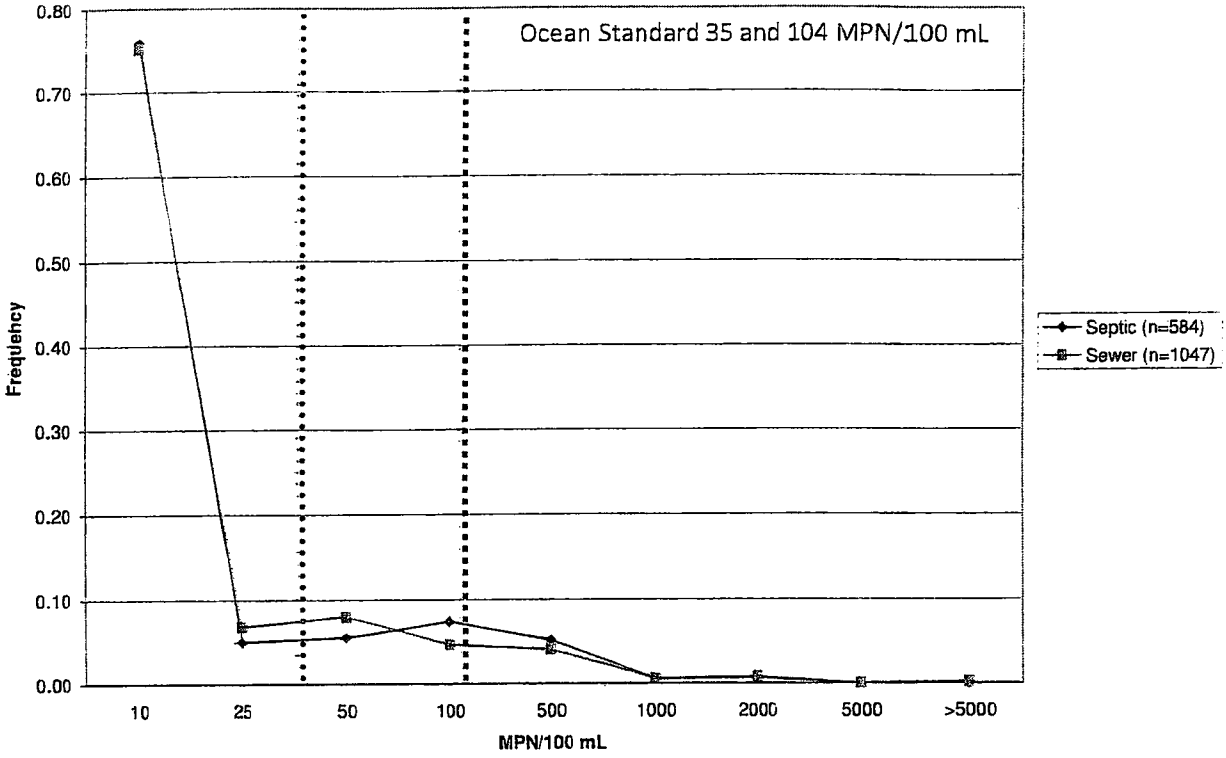


Table 5: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2006. Sewered beaches were tested about one and a half times as often, in this year, as septic beaches, yet more days were recorded when enterococcus densities on septic beaches were higher than the Ocean single sample and geometric mean objectives.

In MPN/100mL	all beaches in 2006			
Enterococcus	Septic (n=903)	% total days reported at septic sites	Sewer (n=1669)	% total days reported at sewer sites
Days above 35	326	36%	295	18%
Days above 104	183	20%	156	9%

DRAFT

Figure 12. 34 Santa Monica Bay Beaches 2007 (All MS-4 beaches without direct ocean discharge to waves) Enterococcus Interval Frequency for May-October Single Measures



DRAFT

Table 6: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2007. Sewered beaches were tested about twice as often, in this year, as septic beaches, and both had the same frequency of exceedances.

In MPN/100mL	all beaches in 2007			
Enterococcus	Septic (n=816)	% total days reported at septic sites	Sewer (n=1705)	% total days reported at sewer sites
Days above 35	106	13%	215	13%
Days above 104	38	5%	79	5%

Figure 13. 34 Santa Monica Bay Beaches 2008 (All MS-4 beaches without direct ocean discharge to waves) Enterococcus Interval Frequency for May-October Single Measures

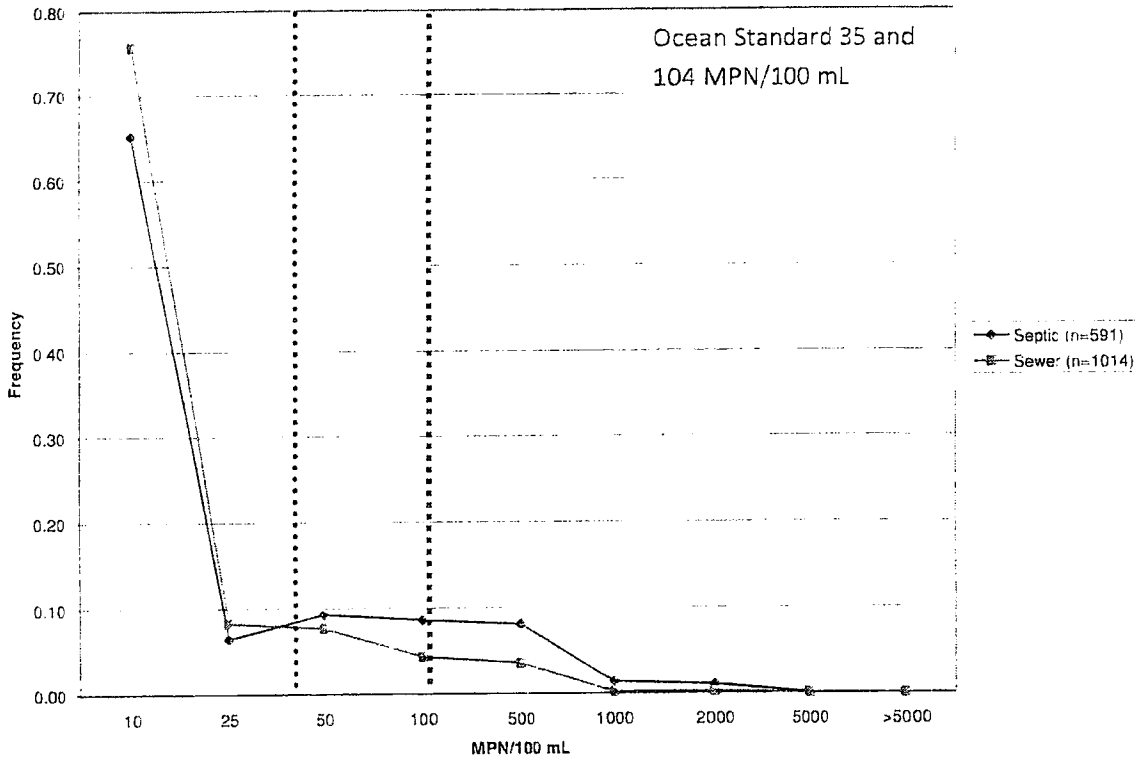


Table 7: Relative Number of Exceedances for 58 Septic and Sewered Beaches in 2008.

In MPN/100mL	all beaches in 2008			
Enterococcus	Septic (n=813)	% total days reported at septic sites	Sewer (n=1644)	% total days reported at sewer sites
Days above 35	145	18%	176	11%
Days above 104	59	7%	54	3%

This general comparison between Civic Center Beaches and all Santa Monica Bay beaches is consistent with the hypothesis that the mechanism(s) supplying enterococcus bacteria to beaches during the summer months does not operate uniformly every year. Further, the mechanism which supplies enterococcus bacteria to the beaches at levels of 10 MPN/100 mL, and to a lesser extent at levels above 1,000 MPN. must operate on all beaches regardless of the year or the method of waste treatment in the adjacent area.

Statistic analysis is performed for the same data sets of 2005-2008 using Gehan Test (a non-parametric Statistical Program) from USEPA ProUCL Statistical Program. All results confirmed hypothesis that

DRAFT

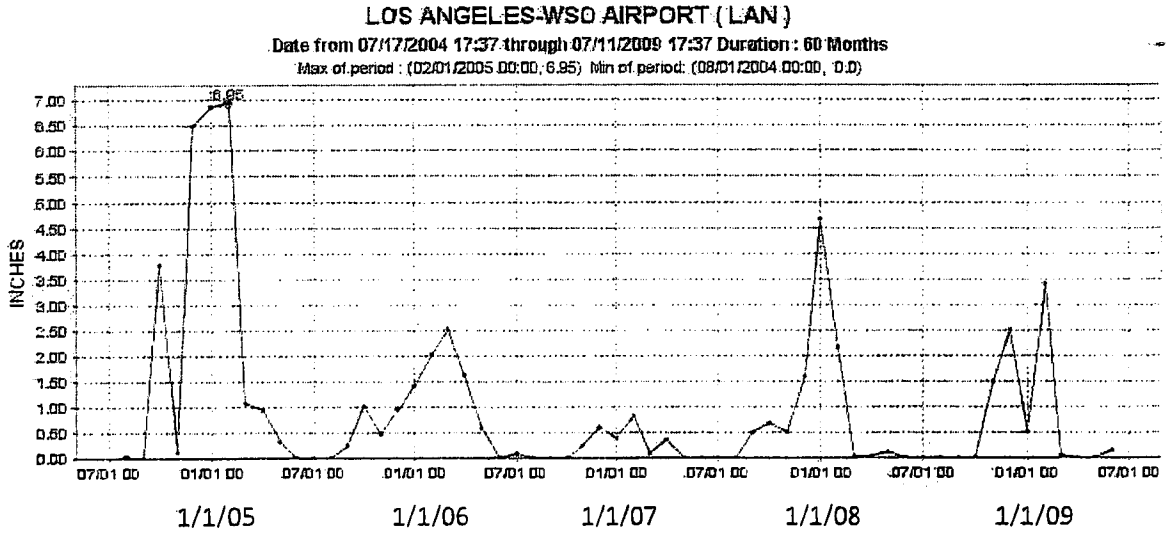
enterococcus concentrations at septic beaches are greater than sewered beaches with 95% confidence level except 2007 data. Gehan Test results are included in Attachment 3-1. *Rainfall and Bacteria*

Examination of all Santa Monica Bay beaches over four years provides evidence that bacteria are transported by groundwater to the beach face. Because bacteria must be transported by the groundwater between the septic systems and surface receiving waters and groundwater gradients increase after rain, a correlation between the number of enterococcus measures per site and the rainfall is expected at beaches where groundwater movement of the bacteria takes place.

Rainfall and Enterococcus

The highest monthly volume of rain fell in 2005 (wet year), among the years evaluated here, when 6.95 inches were recorded. The lowest was reported in 2007 (dry year) when less than one inch was recorded. However, the average annual rain fall in this area is 12 inches per year, significantly larger than the rain received in this study's "wet" year of 2005. Rain gauge reports from Los Angeles International Airport reported by the Department of Water Resources confirm annual variations in precipitation by year and are shown in Figure 14.

Figure 14. Rain gauge information for Los Angeles International Airport (elev.100 feet)



Septic beaches are more distinct from sewered beaches in summers preceeded by rainy winters. The relative frequency of bacteria densities above 35 MPN/100mL on the beaches during the summer are seen to decrease between 2005 and 2007 in Tables 4 through 6. The rainfall also decreases during this period as shown in Figure 14.

Non parametric statistical tools were applied to the enterococcus beach data sets using Gehan Test from EPA's ProUCL statistical program. Using Form 1 Test, the Null Hypothesis is "Septic Beach

DRAFT

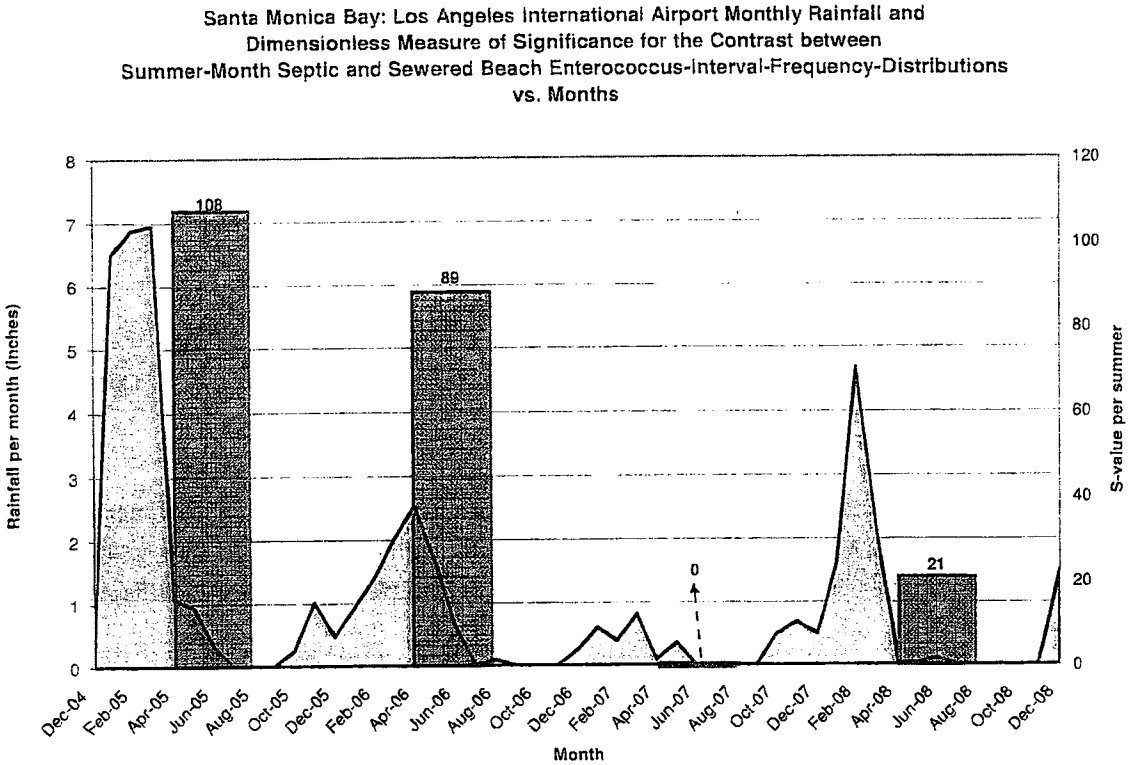
Mean/Median Less Than or Equal to Sewer Beach Mean/Median;" and the Alternative Hypothesis is "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median". The result of the Gehan Test for 2005, 2006 and 2008 shows that the Null Hypothesis is rejected by a low P-value with an alpha value of 0.05 (a confidence level of 95%), which rejects the Null Hypothesis and supports the Alternative Hypothesis "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median".

The statistical assessment of the 2007 enterococcus data is not consistent with the statistical results for 2005, 2006, and 2008. The same results were also obtained with an alpha value of 0.01 (a confidence level of 99%): enterococcus concentrations at septic beaches are higher than concentrations at sewered beaches statistically. Form 2 Test is also performed using the Gehan Test to verify the above conclusions.

The "Substantial Difference" (S) is used to estimate the difference in enterococcus concentration between septic and sewered beaches and is shown in Figure 15. The rainfall was low in 2007, as is the S value. The S increases as the winter rains increase in 2008.

Because septic or sewered beach have no stormwater discharge for June to September, these observations document a supply and transport mechansim. Ground water discharge with elevated enterococcocus densities after wet winters is affecting septic beaches to a greater extent than is occuring on sewered beaches. In the summer of 2008, the frequency of enterococcus densities above 35 MPN/100mL does not increase to the 2006 summer levels, despite increasing rainfall in the winter of 2007-2008, nor does the S value increase to 2006 levels. This observation is attributed to short term rain events in February 2008 when discharge was via stormwater and not groundwater recharge..

Figure 15.



3-1245

DRAFT

* For a discussion of the S value see Appenidx 1 on statistics.

The number of violations of the Ocean Plan enterococcus objectives, as reported in the 2008 Notice of Violation sent to MS-4 Stormwater dischargers based on the Santa Monica Bay Dry Weather Bacteria Total Maximum Daily Loads, is higher at Civic Center Beach than at beaches with shared physical characteristics. The exception is Santa Monica Pier. It had fewer geometric mean enterococcus exceedances than Malibu Pier and even single sample enterococcus is less likely to be a human-fecal-indicator as summarized in Table 8. In general, septic beaches have higher exceedance of water quality objectives than sewered beaches when similar individual beach data sets are compared.

Table 8: Failure to meet Ocean Standards at Civic Center Beaches and paired beaches

Fecal Indicator Bacteria Violations for Civic Center Beach	Paired Beach	Single Total	Single Fecal	Single Enter	30 day Mean Enter	Objective not achieved	Total Days objective not achieved
Surfrider (MC-2)		7	25	9	8	132	62
	Santa Monica Canyon(2-7)	0	1	8	0	10	10
	Venice beach Topsail (2-9)	0	0	0	0	0	0
	Dockweiler Imperial (2-13)	1	0	0	0	1	1
Malibu Colony (MC-1)		0	1	0	13	19	14
	Will Rogers east of Sunset (2-3)			3	3		
	Santa Monica Beach at strand (3-9)			0	0		
	Hermosa Beach at 26th (5-4)			1	1		
Malibu Pier (MC-3)		0	0	3	16	20	19
	Santa Monica Pier (3-3)	4	96	15	13	424	236
	Redondo Beach Pier (6-2)			2	2		
	Hermosa Beach Pier (5-5)			1	1		

D R A F T

A specific measure of the human health risk with enterococcus density is based on an epidemiology study (Cabelli, V.J. 1983 EPA health criteria for enterococcus density in marine recreational waters) which correlates fecal-indicator-bacteria enterococcus, a bacteria species found in the human gut, and increased rates of gastrointestinal illness (flu symptoms) among swimmers who immersed their heads. Some of the beaches studied had identifiable sources of treated or untreated human waste entering the marine environment in the vicinity of the beaches, and some did not. All had urban runoff, storm flow and human visitors during the study period.

The swimming-associated gastroenteritis examined in the study is acute, is of short duration and children have the highest attack rates. The symptoms quantified were fever, vomiting, diarrhea, stomachache, and nausea. EPA proposed human rotavirus and/or the parvo-like viruses as etiologic agents. The researchers find "..the etiologic agent(s) for the observed GI [Gastrointestinal] symptomatology is present in sewage in large numbers, that it is highly infective and/or that it survives sewage treatment, disinfection, and/or transport better than the indicator [enterococcus] (page 44)."

EPA counted the immersed-head swimming and non-swimming populations, their highly credible gastrointestinal illness rates and the enterococcus density in the chest-depth water. They found a linear relationship between the swimming associated rate for gastrointestinal symptoms for 1,000 people and enterococcus bacteria density, a relationship depicted for frequency interval in Table 9.

Table 9. Enterococcus Densities and Illnesses among Swimmers

1983 EPA Health Effects Criteria for Marine Recreational Waters (Figure 9, page 43)						
MPN/100 mL	10	50	100	250	500	1,000
Number of illnesses per 1,000 swimmers	9	23	30	40	46	53

Where enterococcus densities are measured and EPA's other assumptions apply, the risk of illnesses per 1,000 swimmers can be estimated using this relationship. If the interval frequencies of enterococcus densities are calculated for a beach over a summer, then that interval frequency (F) at the Santa Monica Bay beaches times the number of illnesses corresponding to the average MPN/100 mL of the interval (N), from the EPA study quantifies the risk (R) as estimated in the number of illnesses in 100 summer days if 1,000 swimmers swim each day.

F (Frequency for range of MPN/100mL) **X** **N** (Number of illness for average MPN/100ML) = **R** (Risk or number of illnesses).

EPA's criteria have been applied to enterococcus bacteria delivered in stormwater flow across a beach into the Santa Monica Bay, similar to the river influent cases in New York. It has also been applied where no surface flow exists between the influent drain or river and the beach monitoring site, like the case in

DRAFT

Boston Harbor, where increased enterococcus densities are related to transport of bacteria from the Ocean or through the beach subsurface.

Since the EPA criteria were developed, some authors (Yamahara, 2008) have questioned its application where an ocean outfall of untreated or partially treated sewage is not present. The EPA study is used here because the illness rates were also based on beaches with no identifiable source of human sewage.

Human viruses, have been found in Malibu Lagoon and Ballona Creek as described in Dr. Mark Gold's 1994 thesis. The source of the viruses are identified as urban flows/stormwater and septic discharge. An elevated risk that enterococcus bacteria indicate human fecal pathogens and viruses could be inferred to exist at beaches adjacent to septic systems, receiving surface flows which discharge directly into the wave wash, and adjacent to discharging ground water in which human enterococcus is identified and attributed to septic discharge. Table 10 below is based on 2006 data and combines the EPA risk as defined solely by enterococcus frequencies and illnesses among swimmers and an estimated additional risk factor that the enterococcus measured on the beach is associated with human fecal pathogens or human viruses. Selected beaches are ranked by the presence of (a) year-round overland flow across the beach of storm/urban flow like Ballona Creek where human viruses were identified , (b) septic systems within 300 feet of the tributary channel or the beach like Malibu Lagoon where the viruses were found, or (c) groundwater concentrations of enterococcus above 1 MPN/ 100 mL within 300 feet of the tributary or channel adjacent and related to leach field discharge of human waste. A ranking of 'High' means that all of these factors are present, a ranking of "Moderate" means that two of these factors are present, and a ranking of "Low" means that one of these factors is present. "None" means that none of these factors are present.

The beaches adjacent to the Malibu Civic Center show the highest combined risk based on possible illness related to enterococcus levels and an increased likelihood of the presence of human fecal pathogens and viruses.

D R A F T

Table 10: Combined Measures of Risk for Human Health- individual Santa Monica Beaches (2006).

Site	1983 EPA health risk (Additional illnesses)	Additional risk factors for human enterococcus*	
SMB 1-12	43	High	Marie Canyon Stormdrain on Puerco Beach
SMB 1-07	27	High	Ramirez Canyon at Paradise Cove Pier
SMB MC-02	22	High	Breach of Malibu Lagoon/Malibu Beach
SMB MC-03	20	High	Malibu Pier on Carbon Beach
SMB MC-01	19	High	Malibu Point on Malibu State beach
SMB 1-10	24	Mod	Solstice Creek at Dan Blocker Beach
SMB 1-18	21	Mod	Topanga Canyon on Topanga State Beach
SMB 2-07	17	Mod	Santa Monica Canyon ##
SMB BC-01	13	Mod	Ballona Creek##
SMB 1-08	27	Low	Escondido Creek
SMB 1-09	19	Low	Latigo Canyon
SMB 3-03	18	None	Santa Monica Pier Stormdrain/Beach##
SMB 5-02	17	None	28th Street Drain. Manhattan Beach##
SMB 3-04	12	None	Pico-Kenter Storm Drain##

*risk factors are (a) groundwater enterococcus levels above 1 MPN/100mL, (b) adjacent septic systems, and (c) surface flow across the beach face. ## sewered beaches. Enterococcus levels were not found to correlate with increasing watershed size among MS-4 beaches and were not found to correlate with other possible sources of human enterococcus such as beach attendance or with possible elevated rates of enterococcus preservation such as low wave strength (Yamahara 2007).

Risk at Septic Beaches compared to Risk at Sewered Beaches

A comparison of estimated illness risk for 13 septic and 21 sewered beaches[2], using only the EPA criteria and the MS-4 interval frequency curves for the wettest summer of 2005 results in a risk of 22 illnesses among swimmers for all septic beaches and a risk of 16 swimmer illnesses for all sewered beaches for 100 days with 1000 swimmers at all beaches or 10,000 swimmers at all Santa Monica Bay beaches over 10 days.

For 2006, 22 illness are predicted for 13 septic beaches for every 1000 summer swimmers and 16 for 21 sewered beaches for every 1000 swimmers. While the illness risk for 2007 is the same, the risk of illness in the wet year of 2008 is 15 for septic beaches and 13 for sewered beaches.

This risk calculation assumes that human viruses are equally likely to be indicated by enterococcus at all beaches. More human illnesses are expected at septic beaches because the supply of human fecal material is larger, as described above based on 2005 to 2008 data.

Waste Discharge Treatment and Human Health Risk

About 300 Malibu Colony residences can be counted from aerial photo interpretations after 1955 on US Geological Survey topographic maps at a beach bar with 6,000 feet of ocean front. The width of the developed area of the Colony is estimated at 500 feet for a total area of 3,000,000 square feet. Because 43,560 square feet constitutes an acre, the septic density for Malibu Colony is about 4 septic systems per acre.

Septic systems have been shown to discharge to the surface in the vicinity of the leachfields/seepage pits and this process has been linked to increased illness in children. As a result, increased septic system density is also related to an elevated human health risk. In M.A. Borchardt et.al., "Septic System Density and Infectious Diarrhea in a Defined Population of Children" in May 2003 (*Environmental Health Perspectives* Vol. 111, No. 5), an 8% increase in the risk of viral diarrhea illness was associated with an additional septic holding tank per 640 acres and a 20% increase in bacterial diarrhea was related to an additional septic holding tank in 40 acres. For reference, the density of septic systems in Malibu Colony is much higher, about 4 per acre. The author states "consumption of well water was not a likely transmission route of bacterial infection from nearby septic systems in this study, because bacterial pathogens were not isolated from the wells of case households, although contamination may have been sporadic."

[2] For the purposes of this study, the following site definitions were made: MS-4 Septic (13)1-06, 1-07, 1-08, 1-09, 1-10, 1-11, 1-12, 1-13, 1-18, 4-01, MC-01, MC-02,MC-03; MS-4 Sewer (21) 2-01, 2-02, 2-06, 2-07, 2-10, 2-11, 2-13, 2-15, 3-01, 3-02, 3-03, 3-04, 3-05, 3-06, 3-07, 3-08, 5-02, 5-03,6-01,6-05,BC-01; Non MS-4 Septic (9)1-01,1-02,1-03,1-04,1-05,1-14,1-15,1-16,1-17; Non MS-4 Sewer (15) 2-03,2-04,2-05,2-08,2-09,2-12,2-14,3-09,5-05,5-04,5-05,6-02,6-03,6-04,6-06

DRAFT

In contrast, a high level of effectiveness of sewage treatment in centralized treatment plants has been developed through best management practices (Allen 1949), the National Pollution Discharge Elimination System and the State of California's Title 22 regulation. State and Federal regulations now require that when treated sewage is discharged in large quantities (above 50,000) gallons per day, viruses must be 99.9% deactivated by ultra violet or chlorine disinfection before possible human contact is allowed. Even advanced onsite wastewater disposal systems in the Malibu Civic Center area have high failure rate of disinfection as shown in Table 1.

4. Discussion of Historic and Recent Studies

Historic Studies relating Malibu Civic Center Septic Systems to Human Health Risk and Beach Pathogens

Existing technical studies (summarized in Table 11) link septic systems at the Malibu Civic Center area to beach bacteria and are discussed below:

On February 5, 1970, Los Angeles County Health (now California Department of Public Health or CADPH) provided a letter to the Regional Board stating that serious potential hazards to human health were expected to result from septic systems. CADPH has repeatedly closed Surfrider Beach at the Malibu Civic Center due to high bacteria concentrations.

On July 8, 1987, Los Angles County Public Works held a public meeting to discuss a Draft Environmental Impact Report for a centralized waste water treatment plant and sewer for Malibu to address human health risk caused by septic system pathogens. The City of Malibu subsequently incorporated and a group of citizens brought a lawsuit to block the formation of assessment districts. The legal settlement required the new City of Malibu to provide sufficient oversight of onsite waste water treatment facilities such that they would meet Regional Board requirements.

The 1994 Ph.D. thesis of Dr. Mark Gold "What are the health risks of swimming in the Santa Monica Bay?" identified human viruses in Malibu Lagoon and identified a source of the contamination as adjacent septic systems.

On December 12, 2002, the Regional Board adopted a Resolution amending the Santa Monica Beach bacteria TMDL to the Basin Plan. The staff report found that bacteria loads from septic systems contribute to beach pathogens.

On August 30, 2004, the Stone report found that bacteria in the groundwater may enter receiving water where septic systems are found within 6 month groundwater travel time of the Ocean or Malibu Creek.

The September 17, 2004, Memorandum of Understanding between the City of Malibu and the Regional Board stated that "ordinances shall be drafted by staff, and recommended for adoption within the six-month-time-of-travel zone, as identified in the Risk Assessment Report (Stone), to provide advanced treatment and disinfection. The six-month time-of-travel zone shall include all areas contributing to Malibu Creek and Lagoon, and beaches between Sweetwater Canyon outfall and Winter Canyon outfall. OWTS located outside of the six-month-travel-time zone that cannot demonstrate compliance through inspection or that are identified as impacting groundwater by any other means shall provide adequate vertical separation and/or advanced treatment with disinfection." As of the date of this document, the City

D R A F T

of Malibu has not provided documentation that systems within the six-month-time-of-travel zone have been upgraded to prevent bacteria discharge to the subsurface or include disinfection, nor has an ordinance to this effect been passed by the City of Malibu.

On Dec. 13, 2004, the Regional Board adopted a Resolution amending the Malibu Creek and Lagoon Bacteria TMDL to the basin plan. The staff report references a surface water model prepared by Tetra Tech which quantifies bacteria loads provided by septic systems in the Malibu Civic Center.

Numerous studies have been completed to describe the ecosystem, hydrology, land use, possible mechanisms of waste water treatment, and costs to support of policy decisions about bacteria and human health risk in the Malibu Civic Center (Ambrose et. al. 2008; Bing Yen and Associates, 2001; Crawford Multari and Clark Associates, 1997, 2006, 2007; Ensitu Engineering, 2008; Gold, 1994; Jones and Stokes, 2008; REGIONAL BOARD, 1972, 1998, 1990, 2002, 2004b, 2008, 2008b; Lucero, 2008; Warshall, 1992; Questa, 2003; RMC, 2008; SMBRP, 1999, 2001; UCLA, 2000; URS Greiner, 1999; EPA, 2003; Stone, 2004a, 2004b, 2004c; Trim, 1994; Thorsen, 2008; and Van Beveren, 2008a, 2008b, 2008c).

Table 11: Historic Findings of Human Health Risk related to Malibu Septic System Use.

Date	Source	Summary
Feb 5, 1970	LA County Flood letter to Regional Board	Future septic systems will pollute groundwater in Malibu Creek with nutrients
Feb 5, 1970	LA County Health (now CA DPH) to Regional Board	Serious potential hazard to health from septic systems
Feb 11, 1970	CA DWR to Regional Board	Malibu Valley needs an area wide Water Quality plan
Apr. 8, 1970	Public Hearing SWRCB	Discontinue septics, continue Regional Board surveillance
Jan. 21, 1971	CA DPH Status Ocean and streams in Malibu	Local ocean and freshwater bacteria exceed shell fish collection in areas of development
Mar. 12, 1971	Regional Board EO to LA County Supervisors	Sewer for Malibu must be provided
May 31, 1972	Regional Board Resolution 72-4	Waste Discharge Requirements only allowed if a timetable is established to provide future connections to LA County sewer
Apr. 10, 1985	CA DPH to LA County Supervisors	Staff report and recommendation to authorize Sewer districts
July 8, 1987-Nov. 30 1988	LA Public Works Public Meeting and Malibu Citizens Committee public meetings	Draft Environmental Impact Report for Sewer, discussion of Malibu incorporating, discuss alternatives for centralized system with wetland treatment
Jan. 18, 1989	LA County Supervisors hearing	STEP WWTP system construction approved

DRAFT

1992	Warshall et. al. report finalized	Septic systems in Malibu described. Pathogen removal quantified. Author states that systems require extensive management and recommends centralized system in some areas like Civic center
1994	Thesis Dr. Mark Gold	Three studies between 1990 and 1992 show high fecal-indicator-bacteria frequencies at ankle-depth wave wash and human viruses in runoff from three storm drains in Santa Monica Bay.
Dec. 14, 1998	Regional Board Resolution 98-023	Directs Report of Waste Discharge for all septics and ACL to City of Malibu
Aug 12, 1999	Regional Board Resolution 99-13	El Rio Septic staff report: Poorly maintained septics linked to nitrogen contamination in groundwater
1999	Dames and Moore study	Salt tracer, no pathogens found in wells within 200 feet, but tidal reversal confound results
1999	URS Greiner study	Salt Tracer found at 20 feet in wells, but pathogens not seen in short period test.
Dec. 12, 2002	Regional Board Resolution	Santa Monica Bay bacteria Total Maximum Daily Load: beach pathogens attributed to loads from septic systems
March 21, 2003	EPA Malibu Creek Nutrient TMDL	Total Maximum Daily Load sets loads and numeric targets for total Nitrogen
2003	Questa study	Groundwater discharge to receiving water, quantified including volume from septic system discharge.
Aug 30, 2004	Stone study	Bacteria may enter receiving water where septic systems are found within 6 month travel time
Dec. 13, 2004	Regional Board Resolution	Malibu Creek and Lagoon TMDL: Tetra Tech surface water model sets loads for bacteria from septic systems
March 2006	Richard Viergutz, M.S. Thesis	Discharge of sewage-polluted groundwater into Malibu Creek and Lagoon resulting from groundwater surface interactions

Recent Studies relating Septic Systems to Beach pathogens

Research completed over the last ten years has expanded the understanding of beach bacteria sources and mechanisms of transport. For example, it has been demonstrated that the fecal-indicator-bacteria enterococcus is present on all California beaches, a contamination that is related to both human and non-human sources (Yamahara, 2007) and can be associated with septic system effluent (Boehm et. al., 2004; De Sieyes et. al , 2008). Enterococcus can be transported, stored and, under some conditions, grown in the beach environment. Groundwater transport of bacteria occurs and has been related to nitrogen levels from onsite wastewater treatment systems.

In 2003, Mark Borchardt and others reported in Environmental Health Perspectives, Vol. 111, No. 5 that the density of septic systems correlated with increased rates of infectious diarrhea in children in central Wisconsin. Fecal enterococcus bacteria were one of the indicators used to denote the presence of human pathogens. Borchardt found that viral diarrhea increased by 8% for every additional holding tank in 640 acres and bacterial diarrhea increase by 22% for every additional holding tank in 40 acres. While household wells were sampled for bacterial, risks relate to surface contact with pathogens near septic systems.

D R A F T

In 2004, Alexandria Boehm and others reported in Environmental Science and Technology Vol. 38. No. 13 that groundwater discharge of microbial pollution moved from a shallow beach aquifer on to the beach face at Huntington Beach. While fecal-indicator-bacteria were found in only one groundwater sample, column studies show that the transport of enterococcus is not inhibited by sand collected in the field. In addition, radon isotopes characteristic of groundwater linked 38% of the enterococcus variation to groundwater discharge.

In 2007, Kevin Yamahara and others reported in Environmental Science and Technology, Vol. 41, No. 12, that 91% of sampled California coastal beaches had enterococcus. The presence of a source, such as a river, wave shelter and surrounding anthropogenic land use correlated with a significant portion of the population variation. An enterococcus gene study identified a human fecal source in a nearby storm drain.

In 2008, Nicholas De Sieyes and others reported in the Journal of Limnology and Oceanography Vol. 53, No. 4, that fresh nutrient-rich groundwater discharges in fortnightly pulsing into the ocean across a beach. While fecal indicator bacteria and human gene analysis found in monitoring wells were attributed to pollution from adjacent septic systems, the concentrations of these pathogens did not increase with nutrients.

In 2009, Kevin Yamahara and others reported in Applied and Environmental Microbiology, Vol. 75. No. 6, that enterococcus bacteria, related to human enteric disease from swimming in marine waters, can replicate in beach sand with repeated wetting.

In 2009, the American Association for the Advancement of Science summarized studies on Methicillin Resistant Staphylococcus Aureus bacteria (MSRB) found in ocean water and on beaches in Florida in 2009. The bacterial infections are resistant to anti-biotics and are more commonly found in hospitals, but are now known to be transmitted to the beach through contact with infected individuals and, according to one report, through municipal effluent. The ability of the bacteria to travel via sewage has not been quantified.

Other studies have been completed within the last twenty years to characterize pathogen sources and the mechanisms of transport since 1970 when concerns about a human health impact were first discussed for the Malibu Civic Center Area (Bloch, A.B. et. al., 1990; Boehm, A et.al., 2004; Borchardt, M.A. et. al., 2003; Chu A.K. and Sander, B.F., 2008; Cuyk. S.V. et. al. 2004., De Sieyes, N.R., Yamahara, K.M., Layton, B.A., Joyce, E.H., & Boehm, A.B. 2008; Goyal, S.M., & Gerba, C.P. August 1979; Ground Water Monitoring and Assessment Program. May 1999; Noble, R.T. & Fuhrman, J.A.,1996;Schaub. S.A., & Sorber, C.A. May 1977; Schijven, J.F. & Hassanizadeh, S.M. 2002; Stramer, S.L., & Cliver, D.O. 1984;Tiefenthaler, L.L, Stein, E.D., & Lyon, G.S. January 2008; United States Environmental Protection Agency. August 2002;Vaughn, J.M., Landry E.F., Baranosky, L.J., Beckwith, C.A., Dahl, M.C., & Delihas, N.C. July 1978;Yates, M.V., Gerba, C.P., & Kelley, L.M. April 1985;Yates, M.V., Yates, S.R., Warrick, A.W., & Gerba C.P. September 1986;Yamahara, K.M., Layton, B.A., Santoro, A.E., & Boehm, A.B. 2007;Yamahara, K.M., Walters, S.P., & Boehm, A.B. January 6, 2009)

These studies have shown that the beach is a more complex microbiological environment than was previously understood. Familiar fecal-indicator-bacteria like enterococcus have been found in animal and bird (Boehm et. al., 2004: De Sieyes et. al , 2008) feces. Enterococcus has been grown in the laboratory setting from unseeded ocean water samples (Yamahara, 2009) and found in a freshwater environment free

DRAFT

from human impact (Tiefenthaler, 2008). Enterococcus has also been shown to persist for later discharge in the beach sand and occur in higher concentrations in organic beach debris (San Diego Regional Board-Newport Bay Total Maximum Daily Loads; Yamahara, 2007).

Anthropogenic enterococcus has been identified in marine water in sheltered urban beaches (Yamahara, 2007) and in nitrogen-rich water (De Sieyes, 2008; Boehm, 2004) attributed to septic discharge from septic systems through the groundwater into the Ocean. Radon rich water associated with groundwater discharge has been related to groundwater discharge of enterococcus on a beach in an urban setting (Boehm et. al., 2004; De Sieyes et. al , 2008).

Recent work also shows that the beach is a more complex hydrologic environment than the steady state condition than had been previously modeled (Stone 2005 Malibu Risk Assessment). Tidal and seasonal (neap and spring) freshwater transport rates have both been reported as higher (Boehm et. al., 2004; De Sieyes et. al , 2008) while ground transport rates during low tide are reported to be higher (Izbicki, 2009). Bacteria have been shown to move unimpeded through field sand samples (Yamahara, 2007). Other workers used sand column studies to show bacteria and virus retention and remobilization was related to the movement of organic material. Sand filtration studies for sewage treatment plants describe 'breakthrough' or bacterial transport for both small (viruses) and large particles (bacteria) in the dynamic condition of 'backwashing' or sand re-packing which takes place in a sand filter and on a beach.

Studies of groundwater do not report bacteria in concentrations consistent with the bacteria measurements taken on the adjacent beach (Boehm, 2004; De Sieyes, 2008). Hydrological mounding beneath the septic areas may affect water table gradients otherwise dependent on tides and freshwater subsurface movement and may result in unpredicted flow paths and either limit or enhance septic discharge (Izbicki, 2009). Similarly, bacteria and viruses have recently been shown to adhere and remain viable in organic material (Yamahara, 2007; Azadpour-Keeley, 2003; Noble, 1996; Schaub, 1997, Schijven, 2002; Stramer, 1984) until remobilized. Other mechanisms which may result in the preservation of enterococcus include elevated nitrogen and/or oxygen levels (Vaughn, 2008; Azadpour-Keeley, 2003; Yates, 1985, 1986) in the subsurface or on the beach face. Further, the subsurface septic plumes have been found to stay intact during subsurface movement (Groundwater Monitoring and Assessment Program: Baxter, Minnesota, 1999).

Possible Sources and Transport Mechanisms for Bacteria in the Malibu Civic Center.

Figure 15 shows the Malibu Civic Center with planned development (Questa, 2003), and the line of the cross section shown in Figure 16. The cross section shows possible paths of transport for the bacteria discharged into septic leachfields/seepage pits to Malibu Creek, Malibu Lagoon and the ocean. Note in the cross section that bacteria leaving septic systems in Malibu Colony or adjacent to Legacy Park have the shortest travel times and fewest opportunities for subsurface physical detention, chemical attack or biological predation.

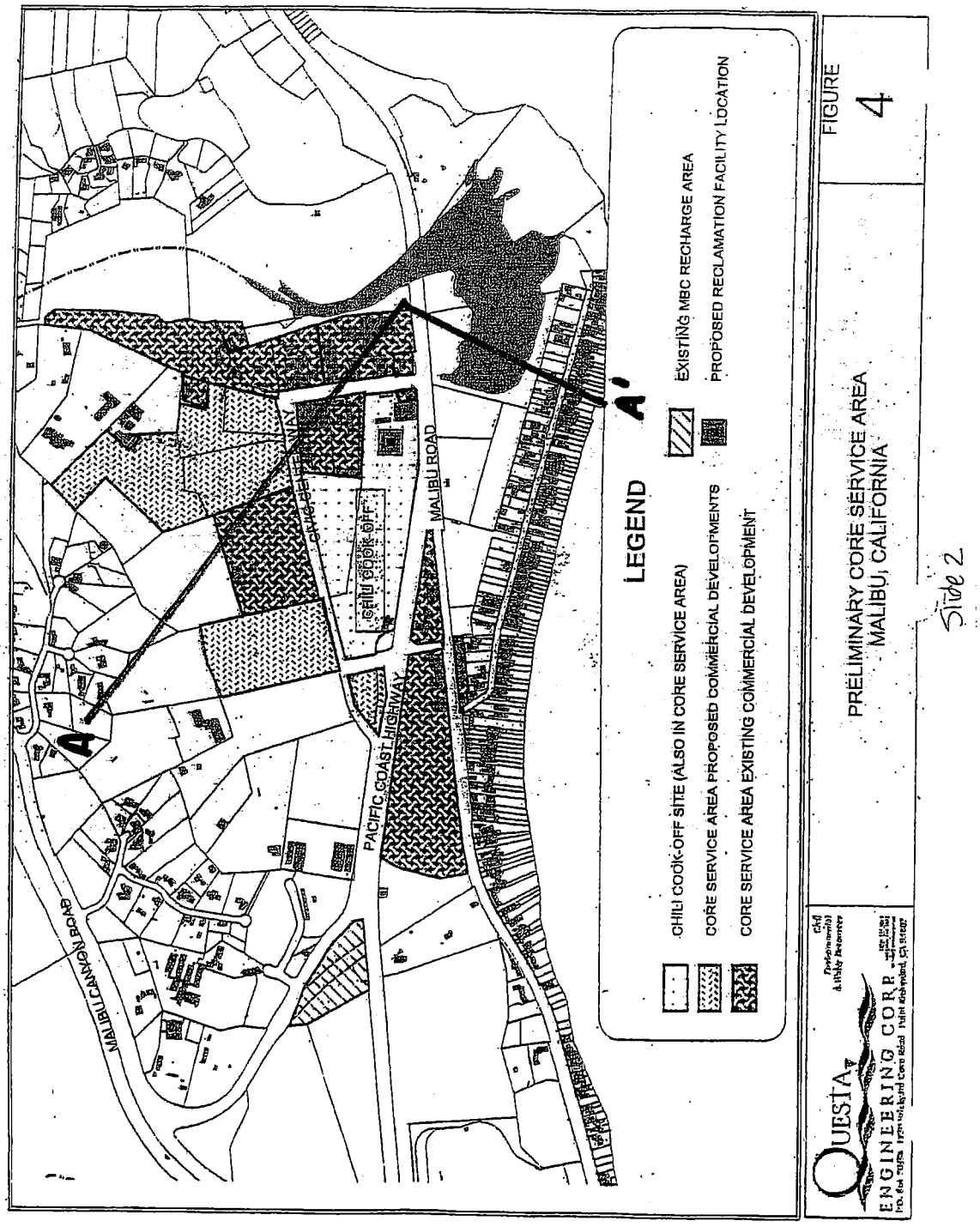
The movement of bacteria from the Civic Center area north of Pacific Coast Highway via subsurface transport to Surfrider Beach under summer conditions would require preservation or growth of enterococcus and movement through the beach barrier with remobilization in marine water (see Figure 16 [cross section]). Human fecal enterococcus must survive physical, chemical and biological destruction in the subsurface before their discharge. enterococcus from higher elevations within the watershed must

D R A F T

travel further and both light and distance are known to cause de-activation of both viruses and bacteria (Azadpour-Keeley. 2003;Yates, 1985, 1986).

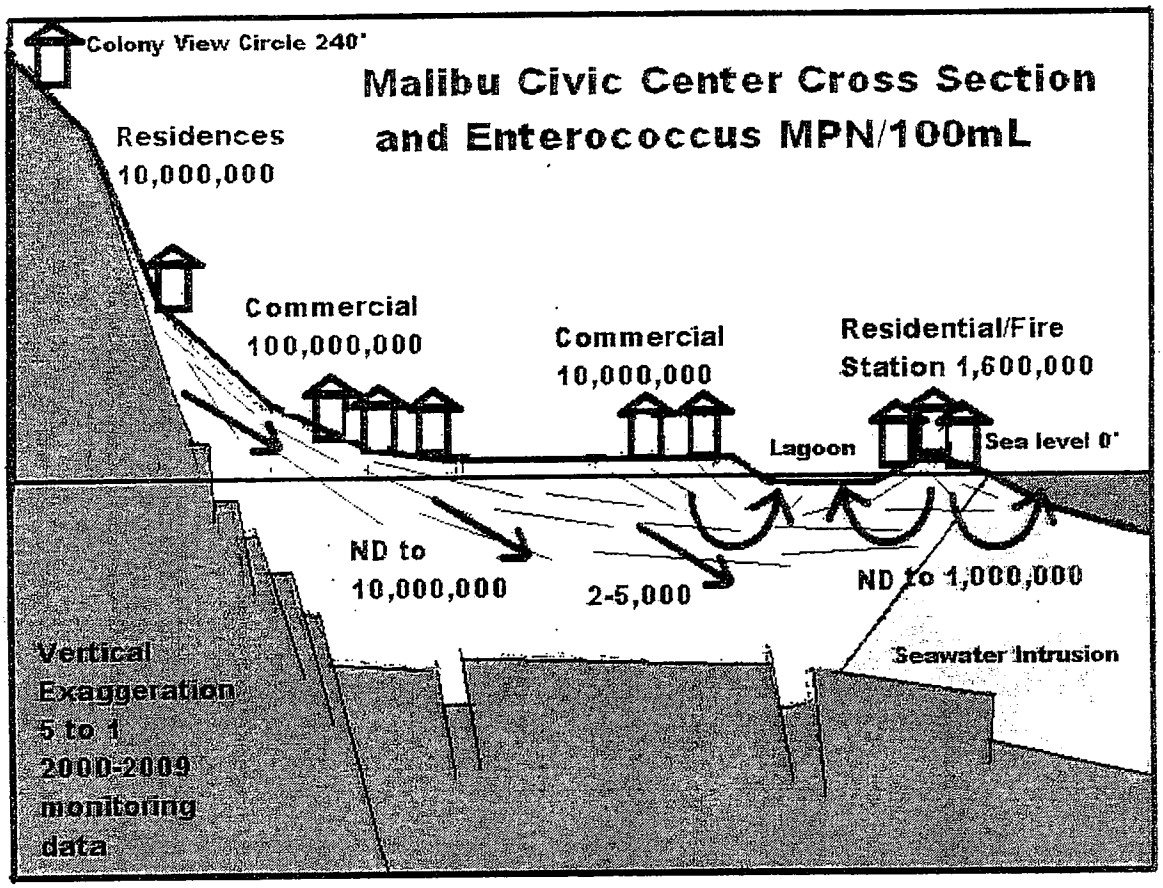
DRAFT

Figure 16. Planned development in the Malibu Civic Center from Questa 2003 and cross section line



DRAFT

Figure 17. Cross Section A to A' showing facility and groundwater bacteria and flow paths



5. Conclusion

Malibu Creek, Lagoon, and nearby beaches are popular not only within the local community but as a destination for visitors as well. In the Basin Plan, the Regional Board has designated these waters for both water contact recreation (e.g. swimming) and non-contact water recreation (e.g. sunbathing, aesthetic enjoyment), and set standards at levels that will protect human health.

As determined by the Regional Board and US Environmental Protection Agency, surface waters in the Malibu Creek Civic Center area are impaired for water contact recreation, and consistently have failed to meet standards set to protect ingestion of waters by swimmers and surfers. Repeated failures to meet standards set to protect public health has resulted in a 'beach bummer' reputation for Surfrider Beach.

To examine the hydraulic connection of discharges from OWDSs through groundwater to nearby surface waters, staff evaluated more than 8,000 samples of wastewater effluent, underlying or nearby groundwater, and surface waters. Staff determined that pathogens from wastewaters migrate to surface waters and that, consistent with data supporting the designations of impairments, the levels of pathogens do not meet standards

DRAFT

protective of human health. Staff also determined that risks of infectious disease from water contact recreation were elevated at beaches in the Malibu Civic Center area versus comparable beaches with sewers.

Staff also reviewed numerous previous studies, and found conclusions from these other studies to be consistent with staff's determination of impairment to the beneficial use of water contact recreation.

D
R
A
F
T

ATTACHMENT 3-1: STATISTICS

Statistical Significance

The application of statistical tools to the beach bacteria data sets revealed that standard tests have a high potential to produce misleading results. Additional statistical tests were used to confirm a significant difference between enterococcus interval frequency distributions for septic and sewered beaches in 2005, 2006 and 2007 for non-MS-4 beaches not including beaches with direct discharge to beach wave wash.

The examination of enterococcus on beaches requires the manipulation of very large data sets. As an example, 7,081 measures were collected from beaches receiving MS-4 discharge in the summers of 2005 through 2008. The measures were not all normally distributed and were dominated by densities at or below 10 Most Probable Number (MPN)/100 mL (considered to be non-detect), with the presence of occasional measures above 24,000 MPN/100mL. The majority of the bacteria measures in the beach data sets had low and high enterococcus densities which together constitute a log normal distribution, but with interval frequencies between 50 and 1,000 MPN/100 mL which were not consistent with a log normal distribution.

Statistics which rely on normal distributions may produce false positive measures of significance for the beach bacteria populations. Many single beach samples assembled through weekly sampling over 4 summers did not have sufficiently large populations to allow statistical assessment with such tests. For example, an attempt to compare Surfrider and Manhattan (40th Street) beaches during the summer of 2007 was not successful because of the distribution of the measures for Manhattan Beach (9 measures below 10 MPN/100 mL, one of 24,000 MPN/100mL and 5 of 10 MPN/100mL). The resulting sample distribution was not normally distributed nor was the natural log of the sample distribution normally distributed. A comparison of the data with the larger sample at Surfrider Beach varied with the interval to which the statistical test was applied.

Where data sets are large, normal distributions can be created through repeated sampling. However, the largest data sets also had very large measurements and many small measurements, suggesting that populations were not the result of sample bias. As an example, annual populations for all sewered and septic beaches which had high correlation coefficients for large and small intervals, but not for the interval between 50 and 1,000 MPN/100 mL.

If normality was assumed and Student's t-tests and Correlation Coefficient were applied, the results were repeatedly inconsistent. Some data sets which Student's t-test showed to have intervals from different populations were also found to have high Correlation Coefficients. Where a correlation was suspected and the data sets were plotted, the typical result was that a single very high or numerous very low values produced a large correlation coefficient (R^2) erroneously indicating that the correlation is good. Where the sample sets were distinct, did not correlate, and were suspected to be samples from different populations, the Student t-test (p) or the Student's t-test of the natural log (ln p) were measured. Small measures of p or ln p indicated that some populations were distinct with values above .05 considered significant (less than 1 chance in 20) .The typical result was that a Student t-test finding that the populations to be distinct was highly dependent on the size of the sample (and the number of values below 25 MPN/100mL) or the presence of a few measures above 1000 MPN/100 mL.

DRAFT

The statistic package Minitab was used to apply the Chi-square test. When the chi square correlation was made on truncated populations of all beaches with some values below 10 MPN/100 ML removed, the results ($p<.05$) indicated that septic and sewered beaches did not belong to the same population. However, the removal of about half of the population was of concern.

Non parametric statistical tools were applied to the same data sets. When all septic and sewered beaches for the year 2005 - 2008 were contrasted using the non-parametric Quartile Hypothesis Test, the Wilcoxon-Mann-Whitney (WMW)Test and Gehan Test from EPA's ProUCL statistical program, the Quartile Test results recommend using the WMW Test. However, the WMW Test is only applicable for data set with less than 40% non-detect level of 10 MPN/100mL. Therefore, the Gehan Test is the most appropriate Test for this study. The Gehan test looks at all intervals and emphasizes the mean/median interval. The results are summarized in Tables 1 through 4.

The Null Hypothesis is termed "Septic Beach Mean/Median Less Than or Equal to Sewer Beach Mean/Median;" and the Alternative Hypothesis is "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median" using Gehan Form 1 Test.

The result of the Gehan Test for 2005, 2006 and 2008 shows that the Null Hypothesis is rejected by a low P-value with an alpha value of 0.05 (a confidence level of 95%) , which rejects the Null Hypothesis and supports the Alternative Hypothesis "Septic Beach Mean/Median Greater Than Sewer Beach Mean/Median". The 2007 data is not consistent with the results of 2005, 2006, and 2008 due to low groundwater discharge to beaches after dry winter. The same results were also obtained with an alpha value of 0.01 (a confidence level of 99%) that enterococcus concentration at septic beaches is higher than concentration at sewered beaches statistically.

D R A F T

Table 1 - 2005 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	358	754
Number of Non-Detect Data	113	482
Number of Detect Data	245	272
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	31.56%	63.93%
Minimum Detected	20	20
Maximum Detected	9208	4200
Mean of Detected Data	261.7	368.9
Median of Detected Data	87	99
SD of Detected Data	661.3	591.3

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	9.461
Critical z (0.95)	1.645
P-Value	1.52E-21

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

DRAFT

Table 2 - 2006 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	685	1377
Number of Non-Detect Data	293	921
Number of Detect Data	392	456
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	42.77%	66.88%
Minimum Detected	20	20
Maximum Detected	24192	48010
Mean of Detected Data	324.9	532.3
Median of Detected Data	86.5	42
SD of Detected Data	1320	2701

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	11.74
Critical z (0.95)	1.645
P-Value	4.17E-32

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

DRAFT

Table 3 - 2007 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	731	1364
Number of Non-Detect Data	574	1023
Number of Detect Data	157	341
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	78.52%	75.00%
Minimum Detected	10	20
Maximum Detected	2000	24192
Mean of Detected Data	127.5	260
Median of Detected Data	52	41
SD of Detected Data	281	1713

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	-1.226
Critical z (0.95)	1.645
P-Value	0.89

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site <= Background
P-Value >= alpha (0.05)

DRAFT

Table 4 - 2008 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Less Than or Equal to Background Mean/Median (Form 1)
Alternative Hypothesis	Site or AOC Mean/Median Greater Than Background Mean/Median

Area of Concern Data: septic
Background Data: sewered

Raw Statistics

	Site	Background
Number of Valid Data	734	1315
Number of Non-Detect Data	514	979
Number of Detect Data	220	336
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	70.03%	74.45%
Minimum Detected	20	20
Maximum Detected	2000	2000
Mean of Detected Data	146.8	90.55
Median of Detected Data	53	31
SD of Detected Data	290.3	226.3

Site vs Background Gehan Test

H0: Mean/Median of Site or AOC <= Mean/Median of background

Gehan z Test	
Value	3.45
Critical z (0.95)	1.645
P-Value	2.81E-04

Conclusion with Alpha = 0.05
Reject H0, Conclude Site > Background
P-Value < alpha (0.05)

D R A F T

An additional measurement of significance using the Gehan test can be achieved by adding an investigation value (i.e. enterococcus concentration) to the mean/median before assessing the Null hypothesis to demonstrate the magnitude of difference using Gehan Form 2 Test. The larger this value, called substantial difference, S, the greater the difference between the populations, i.e., the greater an S, the greater an enterococcus concentration for septic beaches versus sewered beaches. Definitions from EPA's ProUCl program are detailed follow.

> Δ (delta): The true difference between the mean concentration of X in one sample and the mean of X in a second sample. Delta is an unknown parameter which describes the true state of nature. Hypotheses about its value are evaluated using statistical hypothesis tests. In principle, we can select any specific value for Δ and then test if the observed difference is as large as Δ or not with a given confidence and power.
>
> S (substantial difference): A difference in mean concentrations that is sufficiently large to warrant additional interest based on health or ecological information. S is the investigation level. If Δ exceeds S, the difference in concentrations is judged to be sufficiently large to be of concern, for the purpose of the analysis. A hypothesis test uses measurements from the site and from background to determine if Δ exceeds S.

In the study cases, the S value was calculated to determine the significance of the contrast between sewered and septic beaches for the summers of 2005, 2006, 2007 and 2008. The resulting S values show that septic beaches were most distinct from sewered beaches in 2005 after wet winter and not distinct in 2007 after dry winter. A substantial difference exists between septic and sewered beaches for every year except 2007.

Year	2005	2006	2007	2008
S value MPN/100 mL	108	89	0	21

The Gehan calculation with S factor calculation for the 2005 - 2008 are shown in Tables 5 - 8.

DRAFT

Table 5 – 2005 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	108
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	358	754
Number of Non-Detect Data	113	482
Number of Detect Data	245	272
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	31.56%	63.93%
Minimum Detected	20	20
Maximum Detected	9208	4200
Mean of Detected Data	261.7	368.9
Median of Detected Data	87	99
SD of Detected Data	661.3	591.3

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 108

Gehan z Test Value	-1.631
Critical z (0.95)	-1.645
P-Value	0.0514

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 108.00
P-Value >= alpha (0.05)

DRAFT

Table 6 – 2006 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	89
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	685	1377
Number of Non-Detect Data	293	921
Number of Detect Data	392	456
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	42.77%	66.88%
Minimum Detected	20	20
Maximum Detected	24192	48010
Mean of Detected Data	324.9	532.3
Median of Detected Data	86.5	42
SD of Detected Data	1320	2701

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 89

Gehan z Test Value	-1.353
Critical z (0.95)	-1.645
P-Value	0.088

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 89.00
P-Value >= alpha (0.05)

DRAFT

Table 7 – 2007 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options

From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	0
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference, S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference, S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	731	1364
Number of Non-Detect Data	574	1023
Number of Detect Data	157	341
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	78.52%	75.00%
Minimum Detected	10	20
Maximum Detected	2000	24192
Mean of Detected Data	127.5	260
Median of Detected Data	52	41
SD of Detected Data	281	1713

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 0

Gehan z Test Value	-1.226
Critical z (0.95)	-1.645
P-Value	0.11

Conclusion with Alpha = 0.05
Do Not Reject H0, Conclude Site >= Background + 0.00
P-Value >= alpha (0.05)

DRAFT

Table 8 – 2008 Gehan Site vs Background Comparison Hypothesis Test for Data Sets with Non-Detects

User Selected Options	
From File	WorkSheet.wst
Full Precision	OFF
Confidence Coefficient	95%
Substantial Difference	21
Selected Null Hypothesis	Site or AOC Mean/Median Greater Than or Equal to Background Mean/Median plus a Substantial Difference. S (Form 2)
Alternative Hypothesis	Site or AOC Mean/Median Less Than Background Mean/Median plus a Substantial Difference. S

Area of Concern Data: septic beaches
Background Data: sewered beaches

Raw Statistics

	Site	Background
Number of Valid Data	734	1315
Number of Non-Detect Data	514	979
Number of Detect Data	220	336
Minimum Non-Detect	10	10
Maximum Non-Detect	10	10
Percent Non detects	70.03%	74.45%
Minimum Detected	20	20
Maximum Detected	2000	2000
Mean of Detected Data	146.8	90.55
Median of Detected Data	53	31
SD of Detected Data	290.3	226.3

Site vs Background Gehan Test

H0: Mu of Site or AOC >= Mu of background 21

Gehan z Test Value	-0.305
Critical z (0.95)	-1.645
P-Value	0.38

Conclusion with Alpha = 0.05
Do Not Reject H0. Conclude Site >= Background + 21.00
P-Value >= alpha (0.05)

DRAFT

ATTACHEMENT 3-2: REFERENCES

Ambrose, Richard. May 14, 2008. Ecological Goals. Malibu Legacy Park Project prepared by Richard F. Ambrose in association with RMC Water and Environment

Allen, L.A., Brooks, E., Williams, & I.L. November 1949. Effect of Treatment at the Sewage Works on the Numbers and Types of Bacteria in Sewage. Prepared for The Journal of Hygiene by L.A. Allen, E. Brooks, & I.L. Williams.

Azadpour-Keeley, A., Faulkner, B.R., & Chen, J.S. April 2003. Movement and Longevity of Viruses in the Subsurface. Prepared for United States Environment Protection Agency by A. Azadpour-Keeley, B.R. Faulkner, and J.S Chen

Bales, R.C., Gerba, C.P., Grondin, G.H., & Jensen, S.L. 1989. Bacteriophage Transport in Sandy Soil and Fractured Tuff. Prepared for Applied and Environmental Microbiology by R.C. Bales, C.P. Gerba, G.H. Grondin, & S.L. Jensen.

Bing Yen & Associates, Inc. January 5, 2001. Report of Malibu Civic Center Groundwater Evaluation. Prepared for City of Malibu by Bing Yen & Associates, Camarillo CA.

Bloch, A.B., Stramer, S.L., Smith, D., Margolis, H.S., Fields, H.A., McKinley, T.W. Gerba, C.P., Maynard, J.E., & Sikes, R.K. April 1990. Recovery of Hepatitis A Virus from Water Supply Responsible for a Common Source Outbreak of Hepatitis A. Prepared for American Journal of Public Health by A.B. Bloch, S.L. Stramer, D. Smith, H.S. Margolis, H.A. Fields, T.W. McKinley, C.P, Gerba, J.E. Maynard, & R.K. Sikes.

Boehm, A.B., Shellenbarger, G.G., & Paytan, A. 2004. Groundwater Discharge: Potential Association with Fecal Indicator Bacteria in the Surf Zone. Prepared for Environmental Science & Technology by A.B Boehm, G.G. Shellenbarger, & A. Paytan.

Borchardt, M.A., Bertz, P.D., Spencer, S.K.,& Battigelli, D.A. 2003. Incidence of Enteric Viruses in Groundwater from Household Wells in Wisconsin. Prepared for Applied and Environmental Microbiology by M.A. Borchardt, P.D. Bertz, S.K. Spencer, & D.A. Battigelli.

Borchardt, M.A., Chyou, P.H., DeVries, E.O., & Belongia, E.A. May 2003. Septic System Density and Infectious Diarrhea in a Defined Population of Children. Prepared for Environmental Health Perspectives by M.A. Borchardt, P.H. Chyou, E.O. DeVries,& E.A. Belongia.

Cabelli, V.J. August 1983. Health Effects Criteria for Marine Recreational Waters. Prepared for Health Effect Research Laboratory Office of Research and Development by V.J. Cabelli.

CDM. August 10, 2006. Technical Memorandum Task 10, TMDL Implementation Analysis.

CDM. February 27, 2007. Integrated Total Maximum Daily Load Implementation Plan for the Malibu Creek Watershed. Prepared for Los Angeles County Department of Public Works by CDM, Irvine CA.

D R A F T

Chu. A.K.. & Sanders. B.F. August 2008. Data Requirements for Load Estimation in Well-Mixed Tidal Channels. Prepared for Journal of Environmental Engineering by A.K. Chu. & B.F Sanders.

City of Malibu. November 5. 2002. Ordinance No. 242. City Council of the City of Malibu.

City of Marco Island. City of Marco Island Position Paper Septic Tank Replacement Program. Prepared by the City of Malibu for the City of Malibu.

Crawford. Multari & Clark Associates. July 1997. Draft. City of Malibu. Civic Center Specific Plan. Prepared for City of Malibu by Crawford. Multari & Clark Associates, San Luis Obispo CA.

Cuyk. S.V.. Siergrist. R.L.. Lowe. K.. & Harvey. R.W. 2004. Vadose Zone Processes and Chemical Transport. Prepared for Journal of Environmental Quality by S.V Cuyk. R.L. Siergrist. K. Lowe. & R.W. Harvey.

De Sieyes. N.R.. Yamahara. K.M.. Layton. B.A.. Joyce, E.H.. & Boehm. A.B. 2008. Submarine Discharge of Nutrient-Enriched Fresh Groundwater at Stinson Beach. California is enhanced during Neap Tides. Prepared for Limnol Oceanography by N.R. de Sieyes. K.M. Yamahara. B.A. Layton, E.H. Joyce. & A.B. Boehm.

Ensitu Engineering Inc. June 30. 2008. Advanced Onsite Wastewater Treatment System Design. California Department of Health Services Engineering Report. Prepared for Malibu Lumber by Ensitu Engineering Inc. Morro Bay CA.

Ensitu Engineering Inc. August 13, 2008. Malibu Lumber Wastewater Flow Calculations Commercial Development without Restaurant Use. Letter addressed to Brett Thornton. prepared by Ensitu Engineering, Morro Bay CA.

Ensitu Engineering Inc. 2008. Advanced Onsite Wastewater Treatment System Design, City of Malibu Engineering Report. Prepared for Malibu Lumber by Ensitu Engineering Inc.. Morro Bay CA.

Gold, M.A. 1994. What are the health risks of swimming in the Santa Monica Bay?: An examination of the issues surrounding the public health debate. Prepared for University of California. Los Angeles by M.A. Gold.

Goyal. S.M., & Gerba, C.P. August 1979. Comparative Adsorption of Human Enteroviruses. Simian Rotavirus. and Select Bacteriophages to Soils. Prepared for Applied and Environmental Microbiology by S.M. Goyal. & C.P. Gerba.

Gronewold, A.D.,& Wolpert, R.L. April 7, 2008. Modeling the Relationship between Most Probable Number (MPN) and Colony – Forming Unit (CFU) Estimates of Fecal Coliform Concentration. Elsevier.

Ground Water Monitoring and Assessment Program. May 1999. Effect of Septic Systems on Ground Water Quality – Baxter. Minnesota. Prepared for Ground Water Monitoring and Assessment Program by Ground Water Monitoring and Assessment Program

DRAFT

James, Kirsten. November 19, 2008. Comments on Tentative Waste Discharge Requirements, Water Reclamation Requirements and Monitoring and Reporting Program for Malibu Lumber. Heal The Bay, Santa Monica CA.

Jones & Stokes. 2008. Malibu Legacy Park Project, Draft Environmental Impact Report. Prepared for City of Malibu by Jones & Stokes, Los Angeles CA.

REGIONAL BOARD. 1972. Resolution No. 72-4, Policy Statement Relative to Sewage Disposal in the Malibu Area. California Regional Water Quality Control Board, Los Angeles Region.

LARWCB. December 14, 1998. Resolution No. 98-023 Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 1990. Regional Water Quality Control Board's Interim Policy on the Use of Septic Tanks. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2002. Santa Monica Bay Beaches Wet Weather Bacteria TMDL, Item #5 Regional Board Workshop, June 27, 2002. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2004b. Total Maximum Daily Loads for Bacteria, Malibu Creek Watershed. California Regional Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2008. 520th Regular Board Meeting, Item 16, Consideration of Termination of Memorandum of Understanding for Onsite Wastewater Treatment Systems for the City of Malibu. California Water Quality Control Board, Los Angeles Region.

REGIONAL BOARD. 2008b. 521st Regular Board Meeting, Item 18, Revised Order, Waste Discharge Requirements/Water Reclamation Requirements and Monitoring and Reporting Program for City of Malibu's Malibu Lumber at City of Santa Monica's Legacy Park. California Regional Water Quality Control Board, Los Angeles Region.

Lucero, Gene. 2008. Submittal of Comments to Tentative Waste Discharge Requirements and Water Reclamation Requirements for Malibu Lumber LLC. Latham & Watkins, LLP.

National Center for Environment Research. 2003. Final Report: Fate for Pathogens in Storm Water Runoff. Prepared for National Center for Environment Research by National Center for Environment Research.

Nicosia, L.A., Rose, J.B., Stark, L., & Stewart, M.T. 2001. Ground Water Quality. Prepared for Journal of Environment Quality by L.A Nicosia, J.B Rose, L. Stark, and M.T. Stewart.

Noble, R.T. & Fuhrman, J.A. October 25, 1996. Virus Decay and Its Causes in Coastal Waters. Prepared for Applied and Environmental Microbiology by R.T. Noble, & J.A. Fuhrman.

Office of Water. October 2006. Occurrence and Monitoring Document for the Final Ground Water Rule. Prepared for Office of Water by the Office of Water.

DRAFT

Peter Warshall & Associates and Philip Williams & Associates. 1992. Malibu Wastewater Management Study. A Human Ecology of the New City. Prepared for City of Malibu by Philip Williams and Associates. San Francisco CA and Peter Warshall & Associates. Tucson AZ.

Pradhan. S.. Hoover. M.T.. Clark. G.H.. Gumpertz. M.. Wollum. A.G.. Cobb. C.. & Strock. J. February 2008. Septic Tank Additive Impacts on Microbial Populations. Prepared for Journal of Environmental Health by S. Pradhan. M.T. Hoover. G.H. Clark. M. Gumpertz. A.G. Wollum. C. Cobb. & J. Strock

Questa Engineering Corporation. July 7. 2003. Preliminary Conceptual Plan for Wastewater Reclamation in the Civic Center Area. Malibu. California. Prepared for City of Malibu by Questa Engineering. Santa Barbara CA.

RMC Water and Environment. August 15. 2008. Irrigation of Legacy Park with Treated Effluent from Lumber Yard Development. Technical Memorandum prepared by RMC Water and Environment.

RMC Water and Environment. May 14. 2008. Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon. Prepared by RMC Water and Environment for City of Malibu. Legacy Park.

Rong. Y. November 3. 1997. Pitfalls in Statistics for Environmental Sampling Evaluation. Prepared for Environmental Geosciences by Yue Rong.

Santa Monica Bay Restoration Project. 1999. Malibu Creek Watershed Restoration Activities Draft. Malibu Creek Watershed Executive Advisory Council. .

Santa Monica Bay Restoration Project. January 2001. Improving Septic System Management in the Santa Monica Bay Watershed. Santa Monica Bay Restoration Project. Septic System Task Force.

Schaub. S.A.. & Sorber. C.A. May 1977. Virus and Bacteria Removal from Wastewater by Rapid Infiltration Through Soil. Prepared for Applied and Environmental Microbiology by S.A. Schaub. & C.A. Sorber.

Schijven. J.F. & Hassanizadeh. S.M. 2002. Virus Removal by Soil Passage at Field Scale and Groundwater Protection of Sandy Aquifers. Prepared for Water Science and Technology by J.F Schijven & S.M Hassanizadeh .

Stone Environmental. Inc. 2004. Final Report- Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu CA. Prepared for Santa Monica Bay Restoration Commission by Stone Environmental, Montpelier VT.

Stone Environmental. Inc. April 9. 2004. IWIMS Design Document, City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates. Inc by Stone Environmental. Montpelier VT.

Stone Environmental. Inc. May 6. 2004. IWIMS Design Document. City of Malibu Clean Beaches Initiative. Prepared for S. Groner Associates. Inc by Stone Environmental. Montpelier VT.

Stramer. S.L.. & Cliver. D.O. 1984. Septage Treatments to Reduce the Numbers of Bacteria and Polioviruses. Prepared for Applied and Environmental Microbiology by S.L. Stramer.& D.O. Cliver.

DRAFT

Tiefenthaler, L.L, Stein, E.D., & Lyon, G.S. January 2008. Fecal Indicator Bacteria Levels During Dry Weather form Southern California Reference Streams. Prepared for Southern California Coastal Water Research Project by L.L. Tiefenthaler, E.D. Stein, & G.S. Lyon.

Tim, Heather. November 1994. Review of Monitoring and Response Protocol for the Malibu Creek Watershed. Santa Monica Bay Restoration Project.

Thorsen, Jim. 2008. Letter in Response to the Los Angeles Regional Water Quality Control Board's Letter Regarding Notification of Incomplete Application for Waste Discharge Requirements for Malibu Lumber. City of Malibu, CA.

United States Environmental Protection Agency. January 2001. Linkage between Water Quality Targets and Pollutant Sources. Prepared for United States Environmental Protection Agency by United States Protection Agency.

United States Environmental Protection Agency. August 2002. Predicting Attenuation of Viruses During Percolation in Soils. Prepared for United States Environmental Protection Agency by United States Protection Agency.

University of California, Los Angeles. May 200. Lower Malibu Creek and Lagoon Resource Enhancement and Management. Final Report to the California State Coastal Conservancy by UCLA.

URS Greiner Woodward Clyde. 1999. Final Report, Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems. Prepared for City of Malibu by URS Greiner Woodward Clyde, Santa Ana CA.

US Environmental Protection Agency. January 10, 2003. Total Maximum Daily Loads for Nutrient, Malibu Creek Watershed, Public Review Draft. US Environmental Protection Agency, Region 9.

Van Beveren & Butelo Inc. 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared for Malibu Lumber, LLC by Van Beveren & Butelo Inc

Van Beveren & Butelo Inc. February 20, 2008. Supporting Geology/Soils Report Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. June 27, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. August 11, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Van Beveren & Butelo Inc. October 13, 2008. Response to Comments by the City of Malibu Proposed Legacy Park Discharge Area. Prepared by Van Beveren & Butelo Inc for Malibu Lumber LLC.

Vaughn, J.M., Landry E.F., Baranosky, L.J., Beckwith, C.A., Dahl, M.C., & Delihas, N.C. July 1978. Survey of Human Virus Occurrence in Wastewater-Recharged Groundwater on Long Island. Prepared for Applied and Environmental Microbiology by J.M. Vaughn, E.F. Landry, L.J. Baranosky, C.A. Beckwith, M.C. Dahl, & N.C. Delihas.

D R A F T

Viergutz. Richard. 2006. Discharge of Sewage-Polluted Groundwater into Malibu Creek and Lagoon Resulting from Groundwater Surface Interactions: MS Thesis. California State University. Los Angeles

Yates. M.V.. Gerba. C.P.. & Kelley. L.M. April 1985. Virus Persistence in Groundwater. Prepared for Applied and Environmental Microbiology by M.V. Yates. C.P. Gerba. & L.M. Kelley.

Yates. M.V., Yates. S.R.. Warrick. A.W.. & Gerba C.P. September 1986. Use of Geostatistics to Predict Virus Decay Rates for Determination of Septic Tank Setback Distances. Prepared for Applied and Environmental Microbiology by M.V. Yates. S.R. Yates. A.W. Warrick. and C.P. Gerba.

Yamahara. K.M.. Layton. B.A.. Santoro. A.E.. & Boehm. A.B. 2007. Beach Sands along the California Coast are Diffuse Sources of Fecal Bacteria to Coastal Waters. Prepared for Environmental Sciences & Technology by K.M. Yamahara. B.A. Layton. A.E Santoro. & A.B. Boehm.

Yamahara. K.M., Walters. S.P.. & Boehm. A.B. January 6. 2009. Growth of Enterococci in Unaltered. Unseeded Beach Sands Subjected to Tidal Wetting. Prepared for Applied and Environmental Microbiology by K.M. Yamahara. S.P Walters. & A.B. Boehm.

DRAFT

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an
Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

to Prohibit Onsite Wastewater Disposal Systems
in the Malibu Civic Center Area

D
R
A
F
T

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway*, P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

* *The authors would like to thank Regional Board staff, Joe Luera and intern Gina Ho for their assistance in preparing map and tables.*

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

by
Toni Callaway, P.G., Engineering Geologist
Orlando Gonzalez, Water Resources Control Engineer
Groundwater Permitting Unit
and
C.P. Lai, Ph.D., P.E., Water Resources Control Engineer
TMDL Unit

D R A F T

1. Purpose

Aquatic life in Malibu Lagoon is impaired by eutrophication resulting from excessive nitrogen loads. One of the sources of nitrogen loading is from discharges of wastewaters through on-site wastewater disposal systems (OWDSs) in the Malibu Civic Center area.

The purpose of this evaluation was to quantify cumulative nitrogen loads from OWDSs to Malibu Lagoon and compare the result with targets established through the TMDL for restoration of Malibu Lagoon.

2. Method

a. Malibu Civic Center Area Description and Data Collection

The City of Malibu does not provide regional sewage collection or treatment. Most wastewater generated in Malibu is treated by onsite wastewater disposal systems (OWDS) is the terminology used to describe wastewater discharged from both septic and advanced treatment systems. The Malibu Civic Center area for this evaluation corresponds to the lower two miles of the Malibu Creek watershed, which discharges to the Malibu Lagoon and the ocean, and was divided into 5 sectors as shown in Map 1. The Malibu Civic Center area includes the Malibu Valley, Winter Canyon, and the surrounding hills and the beaches located immediately north and south of the Lagoon.

The main commercial area in the Malibu Valley has historically been referred to as the Malibu Civic Center area. Both Los Angeles County and the City of Malibu have administrative offices there. Commercial development is concentrated along Pacific Coast Highway, Malibu Road, and Cross Creek Road adjacent to Malibu Creek just above the Malibu Lagoon.

Malibu Civic Center area has high groundwater and is also subject to flooding and tidal fluctuations. Shallow groundwater located in the Cross Creek area closest to Malibu Lagoon

3-1277

rises and drops in response to daily tides (Figure 1) and provides direct evidence of communication with Malibu Lagoon and the ocean.

Each Waste Discharge Requirements (WDR) includes a monitoring and reporting program that requires quarterly submission of self-monitoring data. These data include mass loading from wastewater discharged at commercial properties located in the Malibu Civic Center area. The subsequent evaluation of such data incorporates information from monitoring reports submitted to the Regional Board from the 4th quarter 2004 to the 2nd quarter 2009. The time interval for data inclusion is post release of the Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", in 2004 (2004 Stone Report).

This evaluation of nitrogen loading from the subsurface discharge of sewage incorporates information from Regional Board records. WDRs have been issued to most of the larger commercial dischargers in the area; and for these sites, a Monitoring and Reporting Program (MRP) is issued with every permit. For smaller businesses and private residents, we have used inventory listed in 2004 Stone Report.

Staff identified all of the commercial and residential properties located in the Malibu Civic Center area. The inventory consists of 349 residential properties and 38 commercial properties. When it was available, real data on wastewater volumes and total nitrogen (TN) concentrations from self-monitoring reports were used for this evaluation. When actual data were not available, conservation assumptions, based on information from published literature, were used to calculate nitrogen mass loading from all wastewater discharged in the Malibu Civic Center area. Results from the summation of the wastewater TN load are used to model attenuation of the nitrogen load as it moves from the point of discharge to groundwater and from groundwater as it flows to the Lagoon.

Commercial Sites - Several sources were used for the inventory of commercial properties located in the Malibu Civic Center area. The Regional Board's databases for permitted and un-permitted commercial facilities were the primary sources of information (Table 1). Other sources of information were the 2004 Stone Report, the City of Malibu, and the (2002) Malibu Survey by S. Groner & Associates. Wastewater discharge volumes from commercial properties located in the Malibu Civic Center area were extracted from the self- monitoring reports submitted for those facilities which are permitted. For the un-permitted commercial properties, additional information regarding business activities, population served, and the OWTS was utilized to estimate discharge volumes and wastewater strength.

Residential Sites – An inventory of residential properties located in the Malibu Civic Center area was listed in the 2004 Stone Report and used for its assessment of nitrogen loads contributed by residential properties in the Malibu Civic Center area[1]. This inventory was originally extracted from the City of Malibu Assessor's data of 2002. Information is posted in the Assessor's web-page by Assessor Identification Number (AIN). The number of bedrooms

[1] Stone Environmental. Inc.. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu. California." 2004.

DRAFT

and bathrooms at each residence was used to estimate the wastewater discharge volume for each home. Calculations for the total nitrogen load discharged at residential property in the Malibu Civic Center area used the estimated wastewater discharge volumes. The residential property inventory sorted by sector location is listed in Table 2.

Geographic Sectors – Earlier evaluations approached the assessment of nitrogen loading by estimating the percentage of the groundwater flow from the entire lower Malibu Creek watershed, which discharges to the Lagoon versus the Pacific Ocean. Staff evaluation of nitrogen loading to the Lagoon used a different approach. All sectors of the entire watershed do not have an equal flow contribution to impairment of the Lagoon. Therefore, we divided the Malibu Civic Center area into geographic sectors to evaluate groundwater flow and nitrogen load contribution to evaluate impairment of the Lagoon from OWDS discharges. Initially, the area surrounding Malibu Lagoon was divided into five geographic sectors on the basis of surface topography (Map 1). Surface geographic features marking boundaries for the sectors are the gently sloping Valley floor, Malibu Creek, Pacific Coast Highway (PCH), and the Pacific Ocean. After considering flow gradients, subsurface hydrologic, and geologic conditions, two of the sectors were further divided on the basis of estimated flow contribution to the Lagoon. Each sector has a unique flow contribution to the Lagoon.

b. Total Nitrogen Loading from Onsite Wastewater Treatment Systems

Slightly different approaches had to be taken to calculate total nitrogen loads from wastewater discharged at commercial and residential sites. Because the Regional Board issues permits or WDRs for wastewater discharges from commercial sites, there has been much more information on file for commercial properties. Historically, permitting of residential wastewater discharges has been delegated to local agencies.

i. Commercial Wastewater

We calculated the nitrogen loading from the commercial facilities dividing the commercial facilities into three groups. One group includes permitted facilities with advanced wastewater treatment, effluent volume limits, and discharge volume limits. At these permitted facilities, a Discharger is required to measure wastewater volumes, total nitrogen concentrations at "end of pipe," and submit this information to the Regional Board per the MRP issued with the WDR. Staff was able to use actual data from these sites to calculate the nitrogen loads. The second group includes smaller permitted commercial facilities where monitoring of wastewater discharge volume is required, but not effluent monitoring, because these facilities discharge domestic-type wastewater. In these cases, staff estimated nitrogen loading by using the provided flow information and published information on total nitrogen concentrations for domestic wastewater from similar types of businesses. The third group includes all un-permitted commercial facilities. In these cases, staff conducted drive-by inspections and collected information from several other sources regarding the OWTS, the business activity, and the population served in order to estimate wastewater flow, nitrogen concentration, and nitrogen loading from these commercial sites. A list of commercial facility is provided (See Table 1).

DRAFT

General Characterization of Wastewater Strength

Biological Oxygen Demand (BOD) - The 5-day BOD (BOD_5, 5-day, 20°C) value is considered the best single strength measure of wastewater and/or polluted surface water containing degradable wastes. Thereafter, in this technical memorandum the term BOD refers to BOD_5, 5-day, 20°C. BOD includes both carbonaceous and nitrogenous loading. The strength of wastewater is commonly expressed in terms of BOD, suspended solids, and chemical oxygen demand (COD). COD is commonly used to measure the amount of oxygen consumed under specific conditions in the oxidation of organic and inorganic material in both sewage and industrial waste. Both BOD and COD greatly impact the amount of dissolved oxygen in receiving water and determine the waste assimilative capacity of that surface water, an example being the Malibu Lagoon.

There are several chemical, physical, and biological parameters which provide information on water quality and organic pollution. These parameters are total and fecal coliform density, pH, nitrite, nitrate, Kjeldahl nitrogen which includes, ammonia nitrogen, and organic nitrogen, phosphates, chlorides, turbidity, suspended solids, temperature, grease fats and oils. BOD is commonly used for the characterization of domestic wastewater and the sizing and design of wastewater treatment systems. In this study, BOD is used to estimate total nitrogen when total nitrogen data is unavailable.

Total Nitrogen Concentration Milligrams per Liter (mg/L) - Total nitrogen concentration in milligrams per liter (mg/L) measured at "end of pipe" (e.o.p.) was used for load calculations when this information was available. Staff also used previous analyses of samples taken directly from the septic tanks. There is considerable information in Regional Board files on the septic tank composition for commercial sites in the Malibu Civic Center area.

Where neither e.o.p nor septic tank effluent analyses was available, staff based the estimation of total nitrogen on typical total nitrogen (TN) concentrations seen in the published literature on domestic wastewater composition. BOD values for commercial wastewater are more widely available than total nitrogen values and total nitrogen can be estimated as a proportion of BOD. Most wastewater engineering textbooks have tables showing the concentration of various elements in typical untreated domestic wastewater. Review of this information yields a percentage proportion or TN/BOD ratio[2] of 21% between total nitrogen (TN) and BOD. Another widely used textbook on wastewater engineering shows TN/BOD ratios ranging from 18% to 21%.[3] An average TN/BOD ratio of 20% was used to estimate the total nitrogen load at selected commercial sites.

In the nitrogen load spreadsheet, either a total nitrogen value from "end of pipe" or an estimated total nitrogen value derived from the TN/BOD ratio in the above tables was used for the nitrogen load spreadsheet, where no "end of pipe" total nitrogen value was available.

D R A F T

[2] Table 4-14, on page 181 in Crites and Tchobanoglous, "Small and Decentralized Wastewater Management Systems." 1998.
[3] Table 3-16, page 109, Metcalf & Eddy, Inc. "Wastewater Engineering Treatment, Disposal and Reuse," 3rd Edition. 1991.

3-1280

Assumptions Made for Commercial Nitrogen Loading Calculations

Most of the larger commercial wastewater discharges have been permitted. There are 38 commercial sites located in the Malibu Civic Center area, 25 of which have been permitted. Total nitrogen concentrations measured at "end of pipe" and wastewater discharges volumes are available and were used for nitrogen loading calculations for these sites. When wastewater effluent analysis was not available, estimation of the total nitrogen load (TN) was based on published information for similar businesses or typical nitrogen concentrations for domestic wastewater. The total nitrogen load spreadsheet developed as Table 2 has two key assumptions: 1) BOD value based on the type of business, and 2) a total nitrogen load based on the average TN/BOD ratio found in the above popular wastewater textbooks. The volume of wastewater discharged is known for most commercial properties in the Malibu Civic Center area, but an estimate of wastewater volume had to be made for 10 of the smaller unpermitted commercial sites. Basic assumptions are listed below:

TN/BOD Ratio - Most of the larger commercial discharges in the Malibu Civic Center area, such as Malibu Colony Plaza, Malibu Creek Plaza, and the three Malibu Country Mart shopping centers, were permitted by the Regional Water Quality Control Board, and as a result we have analysis of septic tank samples, or "end of pipe" effluent where advanced OWTS have been installed. For shopping centers with a high proportion of restaurants and stand alone restaurants, we chose a very high BOD of 800 mg/L and a TN of 160 mg/L, but the septic tanks at the Malibu Country Mart shopping centers have to be pumped each week, and frequent pumping reduces both septic tank solids and the BOD and TN values, so ½ of the TN value was used.

For commercial dischargers such as small offices where we have no data, we choose a low BOD of 220 mg/L, and estimated the TN to be 40 mg/L.

For wastewater generated commercial facilities, such as schools, mid-range to high-range effluent strength and nitrogen concentrations were assumed. Depending on soil profile and groundwater separation, estimated total nitrogen was reduced to values ranging from 75 mg/L to 45 mg/L for these sites.

Flow Rate - For the purpose of calculating nutrient load due to wastewater discharges from OWDS, we have used actual flow data from monitoring reports for commercial facilities permitted by the Regional Water Quality Control Board. As stated previously, the septic discharge volume or flows for residential and smaller un-permitted commercial properties were estimated. For the residential properties, the flow estimate was based on the number of bathrooms.

Some of the smaller commercial properties remain unpermitted because the City of Malibu agreed to assume responsibility for any non-food preparation commercial properties discharging less than 2,000 gpd. For most of the smaller unpermitted commercial properties under the jurisdiction of the City of Malibu. Regional Board staff assumed a

DRAFT

flow of 400 gpd. Many of the smaller commercial properties were not included in previous Malibu inventories and surveys.

2001 Tetra Tech[4] and 2003 U.S. Environmental Protection Agency [5] studies on Total Mass Daily Loads generated in the Malibu Civic Center area used total commercial wastewater flow of 75,000 gallons per day (gpd). Since 2001, the inventory on commercial properties located in the City of Malibu has increased. Current total wastewater volume generated by the commercial properties located in the Malibu Civic Center area is 128,469 gpd. This reflects a greater than 100% increase in the wastewater discharge volume estimated for commercial properties in the Malibu Civic Center area made by in earlier nitrogen loading studies, e.g. 2004 Stone Report, 2005 Questa Report, and 2001 Tetra Tech Report.

The Regional Board staff estimate of the wastewater discharge volume associated with residential OWDS located in the Malibu Civic Center area is 126,300 gpd. This volume was, virtually identical to the residential volume in the 2004 Stone Report. Our estimation of the commercial wastewater discharge volume is greater than commercial discharge volume estimate of 62,166 gpd in the 2004 Stone Report. This Regional Board staff assessment of total nitrogen load does not include non-septic or OWDS nitrogen load contributions.[6]

D R A F T

Formula Used for Calculation of Commercial Nitrogen Loading

Calculations of nitrogen loading from commercial properties were made with the equation shown below.[7]

Equation (4-4):

Mass Load, lb/d = (concentration, mg/L)(flow rate Mgal/d) [(8.345* lb/Mgal x mg/L)]

The above formula has two variables, including: 1) concentration of total nitrogen (TN) in milligrams per liter (mg/L), and 2) flow rate in million gallons per day (Mgal/d). (8.345* is a unit conversion factor)

For the permitted commercial properties, staff used reported average wastewater discharge volumes and total nitrogen values compiled from quarterly monitoring reports for the loading calculations. This evaluation includes more "end of pipe" nitrogen concentrations for our total nitrogen load calculations. Using reported or estimated using wastewater discharge volumes and total nitrogen concentrations. wastewater flow was multiplied by the nitrogen concentration to obtain the nitrogen loading rate.

---

[4] Tetra Tech, Inc., 2001. "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board. dated May 22, 2001.
[5] U.S. Environmental Protection Agency, 2003, "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.
[6] HRL industrial wastewater nitrogen load of .31 lbs/d; TN load from use of treated wastewater for landscape irrigation on Pepperdine University Campus: TN load carried by Malibu Creek from upper watershed; and the TN load from the Malibu Colony private golf course.
[7] Page 196, Crites and Tchobanoglous. "Small and Decentralized Wastewater Management Systems." 1998.

For unpermitted commercial facilities, flow and nitrogen concentration in the wastewater discharge for each business was estimated based on the information searched about the business activities and number of people working or type of business.

ii. Residential Wastewater

A different approach was needed to determine nitrogen mass loading from residential areas. Both discharge volume and nitrogen concentration of the residential domestic wastewater had to be estimated. Wastewater flow was based on the total number of houses and the bedrooms and bathrooms in each house. Residential property located in the Malibu Civic Center area was listed by Assessor Identification Number (AIN) from 2004 Stone Report. With AIN numbers, staff found the address and the number of rooms and baths for each residence posted on the County Assessor's web-page.

Staff assigned houses per their address into the five sectors. Addresses were viewed with aerial photo location guides to insure their section location. Once houses were grouped by sector, the total flow from each sector was calculated by multiplying the total number of homes by 100 gpd produced per bathroom. The next step was to estimate the nitrogen concentration in the domestic wastewater. Staff consulted published literature on wastewater to estimate the nitrogen load. The research indicated that typical untreated domestic wastewater has a range of total nitrogen concentrations. Review of standard engineering literature found nitrogen concentrations of 20 mg/L, 40 mg/L and 85 mg/L, defining domestic wastewater strength[1] as weak, medium or strong. Staff chose a nitrogen concentration of 45 mg/L for calculating the nitrogen load from residential sites. The residential property inventory was sorted by sector location is listed in Table 2.

Assumptions for Residential Flow and Total Nitrogen Concentration

Assumptions made to determine the flow and nitrogen loading from each residence in the absence of wastewater meter and sampling and analytic data of each discharge are listed below.

100 Gallons per Day per Bathroom - Regional Board staff estimated the flow by making the assumption that at least there is one user per bathroom (personal private bathroom) at home with a total water use per person of 100 gallons per day. The 100 gallons per person is widely used number for design and estimation purpose of wastewater flow[8].

45 mg/L for Domestic Wastewater - The nitrogen level in the domestic wastewater depends on the wastewater strength or organic load type discharged to OWDS. Waste strength is determined by considering food preparation practices, type of food prepared and consumed (e.g. high protein foods have higher nitrogen content), the use of garbage disposal units, left-over food handling and disposal practices, etc. The sewage generated by affluent neighborhoods has higher strength, measured by BOD and higher total nitrogen

[8] Table 2-9, page 27, Metcalf & Eddy, Inc., "Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991

3-1283

DRAFT

concentrations. Domestic wastewater with levels of TN as high as 80 mg/L, are associated with residential affluence. Considering affluence and other factors, Regional Board staff selected a septic tank influent value of 60 mg/L of nitrogen, a concentration exactly mid-range of nitrogen concentration values assigned to untreated domestic wastewater, which ranges between low (20 mg/L) medium (40 mg/L) and high (85 mg/L) strength.

Another source of nitrogen reduction occurs within a septic tank, especially when the septic tank is oversized for the wastewater volume and the retention time is several days. This nitrogen load reduction is called "in-tank denitrification" and it can reduce a large percentage of total nitrogen from the effluent. Also, ammonia nitrogen can be incorporated into microbial or plant biomass in the septic tank systems as well as in the subsurface effluent disposal zone given certain environmental conditions. In general, this is not considered a major mechanism for nitrogen removal from septic tanks, but the total nitrogen concentration in residential effluent in the Malibu Civic Center area was further reduced from 60 mg/L to 45 mg/L before calculating the total nitrogen load from residential OWTS. The value of 45 mg/L TN concentration reflects OWDS treatment and removal. Table 14-7[9], indicates that the total nitrogen concentration in the septic tank effluent ranges from 25 mg/L to 60 mg/L. A nitrogen concentration of 45 mg/L for OWDS treated wastewater is mid-range of typical domestic wastewater strengths.

D R A F T

Formula Used for Calculation of Residential Nitrogen Loading

The same basic formula is used to calculate mass load of nitrogen from residential wastewater, but with no data or metering of the discharge volume, residential flow volume was estimated using, the number of bathrooms is multiplied by 100 gpd. Flow volume is converted to million gallons per day by multiplying (10^{-6}). Nitrogen load is calculated by multiplying flow volume by the effluent nitrogen concentration of 45mg/L and unit conversion values. The conversion factor of 8.345 is the result of carrying the conversion for the different units to pounds per day of nitrogen. The formula shown below shows the complete calculations described:

$$\frac{No.\ of}{Bathrooms} \times 100\,gpd \times 3.7854\frac{L}{gal} \times \frac{Total}{Nitrogen}\frac{mg}{L} \times 2.205x10^{-6}\frac{lb}{mg} = Nitrogen\frac{lb}{day}$$

iii. Summary of Total Nitrogen Loading from Commercial and Residential Sites

Staff's inventory of commercial wastewater flows in the Malibu Civic Center area consists of 25 permitted sites and 13 unpermitted sites. The total wastewater discharge volume released from these commercial properties is 128, 469 gallons per day (gpd). The total nitrogen load carried to groundwater by these wastewater discharges is 42.53 lbs/day or 15,422 lbs/year.

[9] Table 14-7. page 1040. Metcalf & Eddy. Inc.. "Wastewater Engineering Treatment. Disposal and Reuse". revised by Tchobanoglous. G. and Burton. F.. McGraw-Hill, 3rd Edition. 1991

Total residential flow is 126,300 gpd and the total nitrogen load from residential sites is 47.429 lbs/day or 17,311 lbs/year.

Total nitrogen loading from commercial and residential wastewater is summarized in Table 1. Total flow of 255,000 gpd and total nitrogen loading of 89.7 lbs/day are used for both spreadsheet and numerical models to estimate the mass loading to Malibu Lagoon.

c. Modeling to Estimate Nitrogen Load to Malibu Lagoon

i. Numerical Model

Using an updated total nitrogen release of 89.7 lbs/d in the numerical fate and transport model, the estimation of wastewater derived nitrogen load transported by groundwater flow to the Lagoon is 28.7 lbs/day. When the estimated total nitrogen load is greater, the numerical model indicates load to the Lagoon is greater. Details of the numerical modeling approach to estimate mass loading to the Lagoon, using updated total nitrogen load, and older load assessments were prepared by Dr. C.P. Lai, and are appended to this Technical Memorandum #4 as Attachment 4-1.

ii. Spreadsheet Model by Flow Reduction via Geographic Sectors and Soil Reduction

Flow Reduction Factor

Flow portioning reduces the TN load reaching the Lagoon. Factors governing flow contribution include: wastewater discharge locations, surface topography, and groundwater contours, which control the direction of groundwater flow. Different proportions of the total wastewater discharged in each reach the Lagoon.

Sector I - consists of the Winter Canyon drainage and the bedrock highlands that extend above the western side of the Malibu Valley. Sector 1 corresponds to the Winter Canyon and West Alluvium areas described in the 2004 Stone Report. Exclusive of Pepperdine University, there are nine commercial wastewater discharges located in this sector. The wastewater discharged from the commercial facilities in Sector 1 is a mixture of treated and untreated wastewater and the total discharge volume is 51,737 gpd. There are 61 homes in Sector 1, discharging an estimated 17, 800 gpd of wastewater.

The highland area is bisected by Malibu Canyon Road and includes 61 homes and a portion of the Pepperdine University campus. Winter Canyon is not eroded to the depth of the Malibu Valley and thickness of the alluvium is less. Sector I is subdivided into two sub-sectors with significant differences in contribution to the Lagoon. The greatest volume of wastewater from Sector I is discharged in the Winter Canyon drainage, but the Winter Canyon flow is assumed to have a relatively low contribution (1%) to Malibu Lagoon. Most of the wastewater discharged in Winter Canyon is assumed to discharge to Malibu Beach.

DRAFT

Section I is divided into the Winter Canyon drainage and drainage from highland area southeast toward Malibu Valley. The division is based on topography. Wastewater in this sub-sector is discharged from mostly single family homes, private schools, nurseries, and the HRL facility. Flow is directed by topography southeast to the western edge of Malibu Valley and east toward Malibu Creek Canyon.

Regional Board staff assumed that the maximum contribution to the Lagoon from this sub-sector is 45% of the total flow. The fractured bedrock highlands outside of the Winter Canyon drainage have a thin veneer of soil. It has been assumed in some previous studies that all wastewater from septic discharges to this highland area flows into the alluvial sediments on the west-side of Malibu Valley. Where flow through the relatively impermeable alluvium is slow and travel times to the Lagoon of 30 years to 50 years. A portion of the wastewater flow from this highland sub-sector does enter the alluvium, as evidenced by the relatively high nitrogen concentrations and high bacteria found in the monitoring wells located near the Valley walls (e.g. monitoring wells located at the Mira Mar Properties on Stuart Ranch Road and behind the County Administration Center on Civic Center Way). Monitoring wells used for the Stone risk assessment study were all located in the alluvium of the Malibu Valley and none of the groundwater table contours extend to the bedrock highlands, which represent over 50% of the Malibu Civic Center area.

Groundwater takes the path of least resistance. It can be logically assumed that some portion of the septic wastewater will percolate down into the fractured bedrock, until it reaches the water table. Low permeability sediments are not recharged at high rates; flow is restricted. There should be sufficient hydrostatic head for groundwater flow through the highly fractured bedrock underlying the Valley. Unconfined, this groundwater will rise to potentiometric surface.

Malibu Water Company records and geologic reports[10] indicate that the deep and shallow alluvial aquifers in the Malibu Valley are recharged by groundwater in the fractured bedrock exposed in the surrounding highlands. All unconfined groundwater in the Malibu Civic Center area rises to the same potentiometric surface, a surface that slopes from the bedrock highlands to sea level. Groundwater in the bedrock highlands derived from rainfall, infiltration from septic discharges, and irrigation preferentially would not flow into relatively impermeable alluvial layers of silt and clay when high permeability sands, gravels, and fractured bedrock underlying the Malibu Valley provide a relative super highway for groundwater flow. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. Wells and borings adjacent to Malibu Creek have found very high permeability sands and gravels. There are no confining layers in this relatively coarse alluvium. These sediments have high conductivities and travel times of 400 feet a day (ft/d).

DRAFT

[10] Old records for the Malibu Water Company, owned and operated by the Adamson Family, are kept in storage at Mariposa Land Company, LLC. offices on Cross Creek Rd.

[11] Stone Environmental, Inc. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", 2004.

Sector II – Sector II consists of area along the west side of Malibu Creek including the residential area surrounding Serra Retreat and the surrounding highlands, which drain to this area. In the Stone Environmental report, Sector II corresponds to the Malibu Tributary, Serra Retreat, North Alluvium, and East Alluvium areas. There is only one commercial facility located in Sector II; that is Serra Retreat with a relatively low wastewater discharge of 720 gpd. There are 83 homes located in this sector with an estimated wastewater discharge volume of 31,100 gpd.

Percolate from septic systems following topography flows toward Malibu Creek. Most of Malibu Water Company's water supply wells were located in this area. It was implied in previous nitrogen load studies that flow from the wastewater discharged into the thin alluvium draped over the bedrock highlands in this sector was confined to this thin soil layer until it reaches the alluvial sediments in the Valley. Alluvium adjacent to Malibu Creek on the east-side of Malibu Valley has very high conductivities, 400 ft/d, and travel times of less than one year for the alluvium in this area of the Malibu Valley were estimated in the (2004) Stone report[11]. Regional Board staff estimated that as much as 95% of the total wastewater flow from this sector reaches the Lagoon.

Sector III – Sector III consists of the relatively flat, gently sloping floor of Malibu Valley located north of Pacific Coast Highway. Sector III is generally described as the Malibu Civic Center area and most of the commercial development is located here. Many of these commercial facilities are located close to Malibu Creek and the Lagoon where the alluvial sediments have high conductivity. Travel time to Malibu Creek and the Lagoon for wastewater discharged in this area can be less than one day. Staff estimates 95% of the wastewater flow from this area reaches Malibu Creek and Lagoon. An exception to this high percentage of total flow is the wastewater discharged from two commercial properties located near the western edge of Malibu Valley. The (2004) Stone report found travel times to the Lagoon from this area can be as much as 50 years[11]. The Racquet Club and Miramar Properties are located in this area. It is estimated that only 20% of the wastewater discharged at these two sites reaches the Lagoon.

Only two homes with an estimated wastewater of 800 gpd are located in Sector III. There are 16 commercial facilities located in Sector III. An estimated 49,438 gpd, consisting of wastewater from both septic and advanced wastewater treatment systems, is discharged in Sector III.

Sector IV – Sector IV consists of commercial facilities located south of Pacific Coast Highway along Malibu Road and 180 homes located in Malibu Colony and Amarillo Beach. All of the wastewater generated at Malibu Colony Plaza, which encompasses all of the commercial facilities located between Malibu Road and Pacific Coast Highway, is pumped under Pacific Coast Highway to Winter Canyon for treatment and disposal and assigned to Sector 1. Most of the wastewater from commercial development in this sector is collected and treated in Winter Canyon. Only five commercial properties located in Sector IV are not connected to the Malibu Colony Plaza wastewater collection system. The collective, wastewater discharge from these commercial properties is only 2,140 gpd.

DRAFT

There are 180 homes located in Sector IV. Wastewater, from the five commercial properties and most of the homes (107), discharges directly to the ocean and beaches north of Malibu Lagoon. A portion of the nutrient and bacteria load discharged to the beach can be transported with sediments toward the Lagoon by the prevailing long-shore movement of northwest to southeast. Once transported toward the Lagoon, it can enter the Lagoon through tidal inflow. The U.S. Environmental Protection Agency estimated that tidal inflow contributed only 1% of the nutrient load in Malibu Lagoon. Staff estimates that 1% of the 42,040 gpd of wastewater discharged in the main area of Sector IV could reach the Lagoon, but acknowledges the proportion could be much smaller.

There are alluvial sediments, estuary sediments, and beach sand beneath Sector IV. Both high and low permeability are found in this mixture of sand, silt and clay. Generally, nutrient removal by soil bacterial action would be high, but it is not because there is little separation between septic discharges and groundwater. Much of this coastal area has little elevation above sea level.

Sector IV has a sub-sector located near the Lagoon and subject to Lagoon tidal fluctuations. A collective wastewater flow of 25,700 gpd from 73 homes is assigned to the near Lagoon sub-sector. It is estimated that nearly 45% of the 25,700 gpd of the wastewater discharged in this sub-sector reaches the Lagoon.

Sector V – Sector V consists of a narrow coastal corridor located south of Malibu Lagoon and adjacent to Pacific Coast Highway and the Pacific Ocean. Sector V is smallest section and contributes little groundwater flow to the Malibu Lagoon. The topography of the area directs groundwater flow to the ocean. This area is described as the East Shore in the 2004 Stone Report. Bacteria and nitrogen from wastewater discharged directly to the ocean pollute the public beaches in this sector. Nitrogen and bacteria discharged to the beaches south of the Lagoon can be transported toward the Lagoon during short intervals when there is a southern swell, usually in the summer and early fall months when storm center highs are located to the south off the coast of Baja California. At such times, coastal long shore transport can reverse direction.

There are nine commercial facilities and 23 homes located in Sector V. The commercial wastewater discharge volume is estimated at 23,674 gpd. Three of the commercial facilities have advanced OWTS and thus, this volume is a mixture of septic and more treated wastewater. The estimated residential wastewater discharge volume from the 23 homes located in Sector V is 10,800 gpd.

Staff estimates a very small proportion of the wastewater discharged in Sector V, approximately 1% of the total flow, has a chance of being transported northward toward the Lagoon where it could be carried by tidal inflow.

DRAFT

Soil Treatment Reduction Factor

Soil Nitrogen Load Reduction Factor for Commercial Sites - Given sufficient separation between the point of wastewater effluent discharge and groundwater, soil bacteria can remove significant amounts of nitrogen. This soil bacteria activity is called "soil treatment". Another factor that influences the removal of nitrogen in the wastewater disposal zone is the soil composition and permeability. This characteristic of the soil is the reason that most permitting agencies require soil percolation testing. If the percolation is too fast (e.g. clean, coarse grained, uniform sand), wastewater flow through the near surface oxygenated zone does not allow time for nitrogen removal by soil bacteria. If the percolation rate is too slow (e.g. very fine soils with high clay content), subsurface disposal of wastewater may not be possible. Table 3 contains information on the depth to groundwater and soil type was utilized to estimate total nitrogen load reduction factors by "soil treatment" ranged from 0% to 20%.

No Soil Treatment Factor for Residential Sites - Permitting of OWDS for residential property is delegated to local agencies, and we do not have information on site-specific conditions needed to make an estimate a "soil treatment" or load reduction factor. Therefore, a nitrogen load reduction factor could not be applied to the nitrogen load estimated for residences located in the Malibu Civic Center area. It is known that many of the Malibu Colony residences lack adequate separation from groundwater. In addition, many residences in the highland sectors of the Malibu Civic Center area use seepage pits rather than leachfields for wastewater disposal. Nitrogen load reduction factors for soil bacteria activity are not applicable where seepage pits are used for wastewater disposal. Filtration of wastewater discharged into seepage pits located in soil or permeable bedrock will remove some bacteria load, but the nitrogen load carried in solution, is not removed by filtration.

Detail calculations for flow reduction and soil treatment reduction are summarized in Table 3.

3. Results

Using staff's loading factors for the numerical fate and transport model, staff estimates that wastewaters transport 29 lb/day into Malibu Lagoon. This model also indicates that loads are increasing. Details of this numerical modeling approach are in the Mass Loading Estimate prepared by Dr. C.P. Lai that is appended to Technical Memorandum #4 as Attachment 4-1.

Also, using the same load factors applied to the 'spreadsheet' model, which characterized the wastewater transport into five hydrogeologic sectors, staff estimates that wastewaters transport 36 lb/day into Malibu Lagoon.

Staff's estimates of 29 lb/day to 36 lb/day from the numerical and 'spreadsheet' models are above two of the estimates (17 lb/day to 20 lb/day) prepared by the third parties in previous studies and slightly overlap the estimate by the other third party (32 lb/day). Among the factors accounting for the range in estimates between staff's estimates and third-party estimates are:

DRAFT

- Commercial Flows: The third-party models used significantly lower assumptions of commercial wastewater flows.
- Residential Concentrations: Two of the three third-party models assumed that residential wastewaters have nitrogen concentrations that are about one-half of what staff assumed.
- Nitrogen concentration of commercial wastewater: The average nitrogen concentration of commercial wastewater discharges has decreased. Since 2004, 15 additional OWTS have been installed at commercial properties in the Malibu Civic Center area.

The ranges in estimates of nitrogen loads to the Lagoon and key factors are shown in the following Table 4:

	Third-Party Estimates			Staff Estimates	
	Stone (2004) Model	**Questa (2005) Model**	**Tetra Tech (2002)**	**Staff Numeric Model**	**Staff Spreadsheet Model**
Commercial Flow Rate (gal/day)	62,166	100,000	75,000	128, 469	128, 469
Commercial Concentration (mg/L)	50.0	50.0	59.2	3-110	3-110
Commercial Load (lb/day)	26	42	37	42.3	42.3
Residential Flow Rate (gal/day)	126,121	126,121	54,800	126,300	126,300
Residential Concentration (mg/L)	20.0	20.0	59.2	45	45
Residential Load (lb/day)	21	21	27	47.4	47.4
Ratio of Mass loading	36%	32%	50%	32%	38%
Gross Load released from OWDSs	47	63	64	89.7	89.7
Net Load to Malibu Lagoon	17	20	32	29	36

DRAFT

Regardless of differing assumptions and models used in the estimates, all estimates – including those prepared by staff as well as past estimates prepared by third parties – indicate that nitrogen loads from OWDSs are significantly above the waste load allocation of 6 lb/day established in a TMDL[12] adopted by the US EPA on March 21, 2003.

4. Conclusion

Staff has determined that OWDSs in the Malibu Civic Center area cumulatively release nitrogen at rates that contribute to eutrophication and impair aquatic life in Malibu Lagoon. This conclusion is supported by staff's estimates ranging from 29 lb/day to 36 lb/day as well as third-party estimates that range from 17 lb/day to 32 lb/day. All estimates are well above targets needed to restore water quality and protect beneficial uses in Malibu Lagoon.

DRAFT

[12] In the Malibu Creek Watershed Nutrient TMDL (March 21, 2003), the US EPA specifies a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies load allocations for onsite wastewater treatment systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

References:

California Division of Mines and Geology, 2001, "Seismic Hazard Zone Report for the Malibu Beach 7.5- Minute Quadrangle, Los Angeles, California", Seismic Hazard Zone Report 050, dated 2001.

California Department of Water Resources, Bulletin 63-5, "Seawater Intrusion in California", October 1965.

Crites, R. and Tchobanoglous. G., "Small and Decentralized Wastewater Management Systems" McGraw-Hill, 1998.

Dibblee, T. W., 1982, "Geology of Santa Monica Mountains and Simi Hills, Southern California" , pages 94-130, in Geology and Mineral Wealth of the California Transverse Ranges", 1982.

Dibblee, T. W., "Geologic Map of the Malibu Beach Quadrangle, Los Angeles, California", published by Dibblee Geological Foundation, 1993.

Fife, D. and Minch, J., eds., "Geology and Mineral Wealth of the California Transverse Ranges", South Coast Geological Society, Inc., 1982.

Fugro West, Inc., 2005, "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development, Project No. 3374.001.06, dated March 7, 2005.

Geosyntec Consultants, Inc., 2007, "Geotechnical Site Exploration and Intrepretation of Subsurface Conditions, Malibu Legacy Park Site", Project No. LA0142-02, dated July 30, 2007.

Leighton and Associates, Inc. 1994, "Report of Geotechnical Studies for Planning Purposes in the Civic Center Area, City of Malibu, California", Project No. 2920647-01, dated July 30, 2007.

Malibu Water Company, personal communication between Grant Adamson and Toni Callaway. The Adamson Family owned the Malibu Water Company. Records on water supply wells located in the lower Malibu Creek watershed, are stored at Mariposa Land Company, LLC, offices on Cross Creek Road (2009).

Metcalf & Eddy, Inc., " Wastewater Engineering Treatment, Disposal and Reuse", revised by Tchobanoglous, G. and Burton, F., McGraw-Hill, 3rd Edition, 1991.

Metcalf & Eddy, Inc., "Wastewater Engineering. Treatment and Reuse" McGraw-Hill, 4th Edition, 2003.

Salvato, J. A., 1982, "Environmental Engineering and Sanitation", John Wiley & Sons. 1982.

Stone Environmental, Inc., 2004, "Final Report, Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Project No. 011269-W, dated August 30, 2004.

D

R

A

F

T

Tetra Tech, Inc.. 2001. "Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies", prepared for U.S. Environmental Protection Agency, Region 9 and the Los Angels Regional Water Quality Control Board, dated May 22, 2001.

U.S. Environmental Protection Agency, 2003. "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", 2003.

U.S. Environmental Protection Agency, 2002, "Onsite Wasterwater Treatment Systems Manual", 2002.

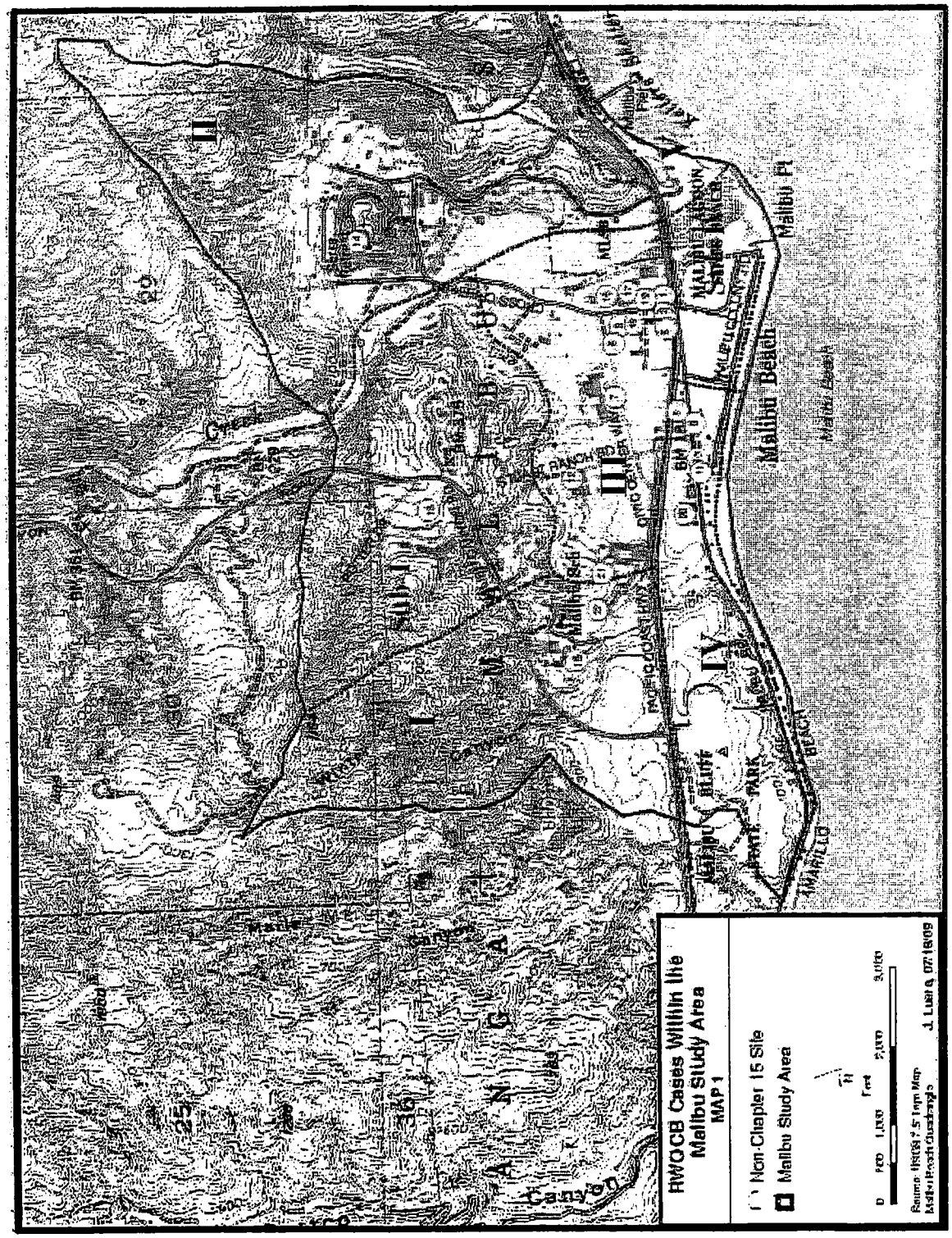
URS Greiner Woodward Clyde, 1999. "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon From On-Site Septic Systems", Project No. 964P170, dated June 7, 1999.

Van Beveren & Butelo, Inc., 2007, "Report of Geotechnical Investigation, Proposed Remodeling of Malibu Lumber Facility", Project No. 07-020, dated July 26, 2007.

Van Beveren & Butelo, Inc.. 2007, "Report of Hydrologic Study. Proposed Legacy Park Discharge Area", Project No. 07-020.2, dated September 26, 2007.

DRAFT

Map 1 – Malibu Civic Center Area



DRAFT

Figure – 1
Correlation of Groundwater and Tidal Levels

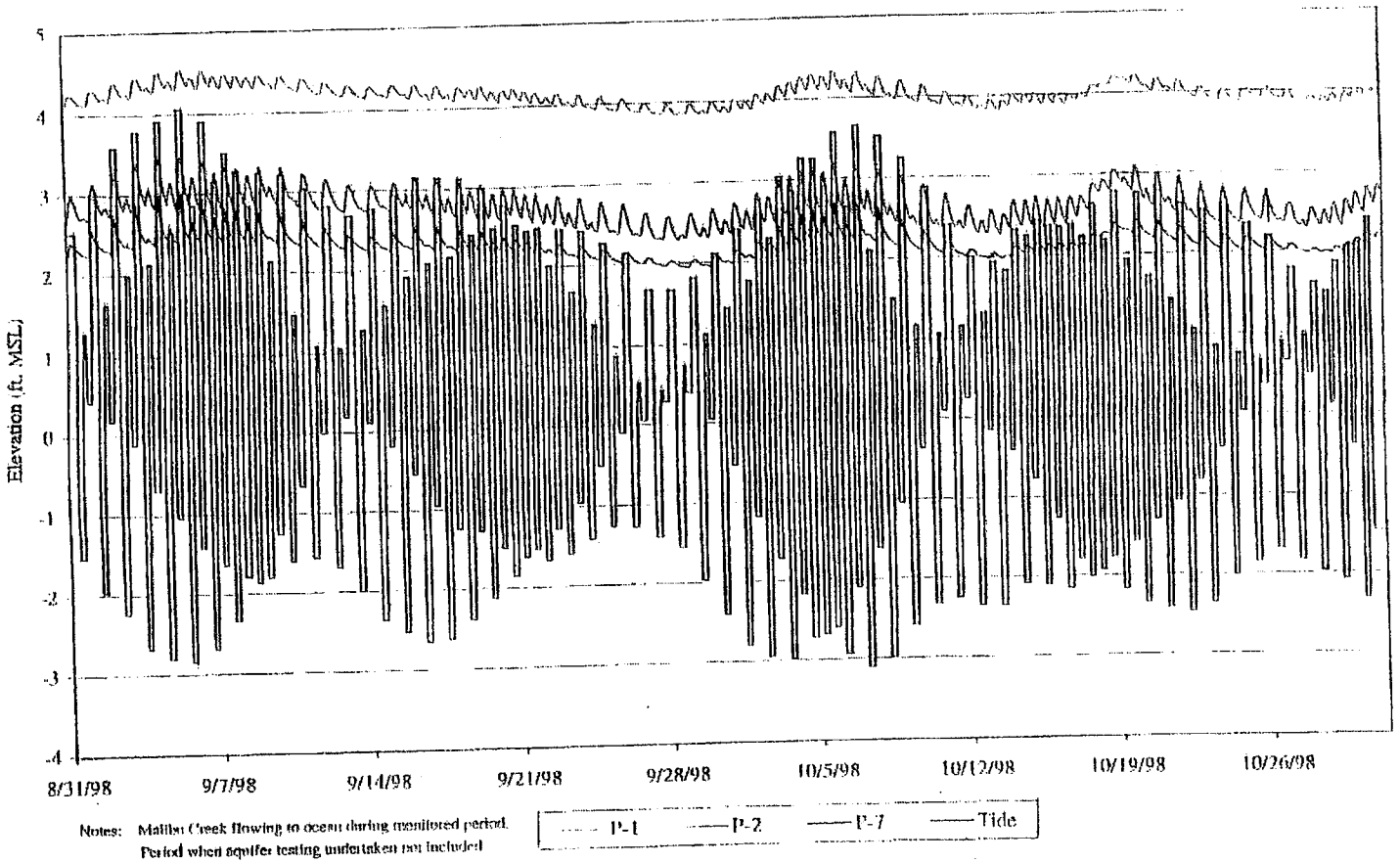


Figure -1 Adapted from Figure 4-1 in "Study of Potential Water Quality Impacts on Malibu Creek and Lagoon from On-site Septic Systems",1999, URS Greiner Woodward Clyde

LEAD

9-1295

Table 1 commercial and residential nitrogen loading				
Sector 1	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
HRI.^ -3011 Malibu Cyn Rd	3,428	45.0	1.287	469.86
L.A. Co. Main. Yard -3837 Winter Cyn Rd	252	40.0	0.084	30.70
*Malibu Colony Plaza^^ -Disposal In Winter Cyn	16,617	18.1	2.510	916.12
Malibu WPCP^^ -3260 Vista Pacifica	22,500	20.4	3.830	1,398.08
Webster Elementary^ -3602 Winter Cyn Rd	6,000	75.0	3.129	1,142.22
Our Lady of Malibu^ -3625 Winter Cyn Rd	2,500	75.0	1.585	571.11
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	75.0	0.939	342.67
Commercial - 7 Business Facilities	51,797		13.345	4,870.76
Residential 61 homes	17,800	45.0	6.684	2,439.79
Total			29.029	7,310.55

*The value of 18.1 for Malibu Colony Plaza was calculated from the 2nd Quarter 2007 to 2nd Quarter 2008 monitoring reports.
^ Assumed cafeteria food waste
^^ Advanced OWTS

Sector 2	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Serra Retreat^ -3401 Serra Rd	720	60.0	0.361	131.58
Commercial - 1 Business Facility	720		0.361	131.58
Residential 83 homes	31,100	45.0	11.679	4,262.77
Total			12.039	4,394.36

^ Retreat and conference center with food service - low utilization

Sector 3	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Malibu Animal Hospital -23431 PCH	500	40.0	0.167	60.92
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	40.0	1.348	491.98
Raquet Club -23847 Stuart Ranch Rd	1,500	75.0	0.939	342.67
Prudential Realty -23405 PCH	450	40.0	0.150	54.83
Malibu Country Mart I^ -3835 Cross Creek Rd	6,400	80.0	5.608	2,046.86
Malibu Country Mart II^ 23410 Civic Ctr Wy	6,300	80.0	4.206	1,535.15
Malibu Country Mart III^ -3900 Cross Creek Rd	3,400	80.0	2.270	828.49
Malibu Shell^^ -23367 PCH	300	4.2	0.011	3.84
Malibu Prof. Arts Bldg -23440 Civic Ctr Wy	450	40.0	0.150	54.83
Malibu Lumber^^ -23479 PCH	6,500	5.7	0.404	147.56
Mira Mar Properties -23805-23815 Stuart Ranch Rd	3,200	40.0	1.066	389.88
J & P Limited -3808 Cross Creek Rd	500	40.0	0.167	60.92
So. Calif. Edison	400	40.0	0.134	48.73
Verizon South, Inc. -3705 Cross Creek Rd	400	40.0	0.134	48.73
Mariposa Land Company, LLC -3728 Cross Creek Rd	400	40.0	0.134	48.73
Malibu Creek Plaza/Malibu Village^^	11,000	3.0	0.275	100.52
Commercial - 16 Business Facilities	49,736		17.163	6,264.65
Residential 2 homes	800	45.0	0.300	109.65
Total			17.464	6,374.30

^ Influent expected high level of Total Nitrogen (TN), but effluent level of TN reduced by weekly pumping of septic tanks

Table 1 – continue to next page

FILED

^^ Advanced OWTS

Sector 4	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Malibu Rd., LLC -23676-23712 Malibu Rd	400	40.0	0.134	48.73
Morton-Gerson -23730 Malibu Rd	400	40.0	0.134	48.73
L.A. Co. Fire Station #88 -23720 Malibu Rd	540	30.0	0.135	49.34
Lisa Krasnoff -23855 Malibu Colony Rd	400	40.0	0.134	48.73
Mesa, LLC 23915 PCH	400	40.0	0.134	48.73
Commercial - 5 Business Facilities	2,140		0.669	244.28
Residential 180 homes	65,800	45.0	24.710	9,018.98
Total			25.879	9,263.27

*187 homes were counted in Sector 4 with a total calculated flow of 65800 gpd

Sector 5	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Surfrider Co. Beach -23060 PCH	3,188	40.0	1.064	388.42
Malibu Pier State Park^^ -23000 PCH	3,000	11.7	0.293	106.91
Malibu Shores Motel^ -23033 PCH	2,843	60.0	1.423	519.57
Malibu Beach Inn^^ -22878 PCH	2,843	31.9	0.757	276.24
Jack-In-the-Box^^ -23017 PCH	4,500	26.26	0.986	359.94
Malibu Plaza 22917 PCH	1,500	40.0	0.501	182.76
Malibu Inn & Restaurant^ 22969 PCH	6,200	110.0	5.691	2,077.32
Surfshack/Fish Grill -22935 PCH	400	80.0	0.267	97.47
Spic & Span Cleaners/Chabad -22941 PCH	400	40.0	0.134	48.73
Commercial - 9 Business Facilities	24,074		10.715	3,911.16
Residential 23 homes	10,800	45.0	4.056	1,480.32
Total			14.771	5,391.48

^ Effluent assumed to have high TN because of low septic tank retention time

^^these facilities have package advanced OWTS

Study Area	Gallons per Day	Effluent Concentration of Nitrogen (mg/L)	Nitrogen Effluent Load to Study Area (lbs/day)	Nitrogen Effluent Load to Study Area (lbs/year)
Commercial	128,469		42.253	15,422.43
Residential	126,300		47.429	17,311.51
Total	254,769		89.682	32,733.94

FILED

Table 2 –List of Residential Septic Systems

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458027034	3547 Malibu Colony Rd	Multi Family	6	3	onsite
I	4458026007	3400 Coast View Dr	Residential	4		onsite
I	4458027002	3401 Coast View Dr	Residential	4	4	onsite
I	4458026006	3436 Coast View Dr	Residential	2	2	onsite
I	4558026015	3502 Coast View Dr	Residential	4	3	onsite
I	4458026014	3504 Coast View Dr	Residential	3	4	onsite
I	4458026004	3524 Coast View Dr	Residential	3	3	onsite
I	4458026003	3536 Coast View Dr	Residential	2	2	onsite
I	4458027030	Coast View Dr	Residential			onsite
I	4458025020	3207 Colony View Cir	Residential	3	3	onsite
I	4458025016	3213 Colony View Cir	Residential	4	4	onsite
I	4458025015	3215 Colony View Cir	Residential	3	4	onsite
I	4458025012	3216 Colony View Cir	Residential	3	4	onsite
I	4458025010	3217 Colony View Cir	Residential	3	2	onsite
I	4458025011	3220 Colony View Cir	Residential	3	3	onsite
I	4458025025	3211 Colony View Cir	Residential	5	5	onsite
I	4458024004	32701 Harbor Vista Dr	Residential	3	3	onsite
I	4458024043	23702 Harbor Vista Dr	Residential	3	2	onsite
I	4458024025	23704 Harbor Vista Dr	Residential	4	3	onsite
I	4458024031	23706 Harbor Vista Dr	Residential	3	2	onsite
I	4458024001	23708 Harbor Vista Dr	Residential	3	2	onsite
I	4458024029	23721 Harbor Vista Dr	Residential	3	3	onsite
I	4458025014	23722 Harbor Vista Dr	Residential	3	4	onsite
I	4458024034	23741 Harbor Vista Dr	Residential	3	2	onsite
I	4458025013	23748 Harbor Vista Dr	Residential	3	3	onsite
I	4458024009	23803 Harbor Vista Dr	Residential	6	7	onsite
I	4458025019	23812 Harbor Vista Dr	Residential	3	2	onsite
I	4458024010	23813 Harbor Vista Dr	Residential	3	2	onsite
I	4458024011	23831 Harbor Vista Dr	Residential	5	4	onsite
I	4458024012	23837 Harbor Vista Dr	Residential	3	1	onsite
I	4458025024	23838 Harbor Vista Dr	Residential	5	6	onsite
I	4458025006	23850 Harbor Vista Dr	Residential	3	3	onsite
I	4458025018	23858 Harbor Vista Dr	Residential	3	3	onsite
I	4458024013	23843 Harbor Vista Dr	Residential	3	2	onsite
I	4458025017	3224 Malibu Canyon Rd	Residential	2	2	onsite
I	4458025004	3338 Malibu Canyon Rd	Residential			onsite
I	4458024038	23800 Malibu Crest Dr	Residential	4	3	onsite
I	4458024042	23805 Malibu Crest Dr	Residential	4	4	onsite
I	4458024041	23806 Malibu Crest Dr	Residential	5	6	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
I	4458024039	23808 Malibu Crest Dr	Residential	3	2	onsite
I	4458024040	23812 Malibu Crest Dr	Residential	3	4	onsite
I	4458024022	23814 Malibu Crest Dr	Residential	4	5	onsite
I	4458024023	23816 Malibu Crest Dr	Residential	3	2	onsite
I	4458024021	23854 Malibu Crest Dr	Residential	2	3	onsite
I	4458024015	23870 Malibu Crest Dr	Residential	3	4	onsite
I	4458024014	23880 Malibu Crest Dr	Residential	4	4	onsite
I	4458026010	23901 Malibu Knolls Rd	Residential	4	1	onsite
I	4458026011	23903 Malibu Knolls Rd	Residential	4	3	onsite
I	4458026012	23905 Malibu Knolls Rd	Residential	3	2	onsite
I	4458026013	23907 Malibu Knolls Rd	Residential	3	3	onsite
I	4458026009	23908 Malibu Knolls Rd	Residential	3	3	onsite
I	4458025001	23915 Malibu Knolls Rd	Residential	3	2	onsite
I	4458026008	23916 Malibu Knolls Rd	Residential	4	4	onsite
I	4458025022	23933 Malibu Knolls Rd	Residential	2	2	onsite
I	4458027904	Winter Canyon Rd	Multi-Family			
I	4458027025	3625 Winter Canyon Rd	Residential	6	6	onsite
I	4458027003	3431 Coast View Dr	Residential	3	2	onsite
I	4458027004	3453 Coast View Dr	Residential	5	5	onsite
I	4458027005	3505 Coast View Dr	Residential	4	3	onsite
I	4458027029	3525 Coast View Dr	Residential	3	3	onsite
subtotal			61	198	178	
II	4452015035	3501 Cross Creek LN	Residential	4	4	onsite
II	4452015034	3509 Cross Creek LN	Residential	3	4	onsite
II	4452015023	3510 Cross Creek LN	Residential	4	4	onsite
II	4452015033	3511 Cross Creek LN	Residential	5	6	onsite
II	4452015025	3512 Cross Creek LN	Residential	3	4	onsite
II	4452015026	3520 Cross Creek LN	Residential			onsite
II	4452015031	3535 Cross Creek LN	Residential	4	4	onsite
II	4452015027	3538 Cross Creek LN	Residential	4	3	onsite
II	4452015030	3539 Cross Creek LN	Residential	4	4	onsite
II	4452015042	3550 Cross Creek LN	Residential	5	4	onsite
II	4452014006	3415 Cross Creek Rd	Residential	3	3	onsite
II	4452015024	Cross Creek LN	Residential	5	5	onsite
II	4458023003	3469 Cross Creek Rd	Residential	4	9	onsite
II	4458023009	3515 Cross Creek Rd	Residential	4	4	onsite
II	4452015029	3551 Cross Creek LN	Residential			onsite
II	4458022021	3565 Cross Creek Rd	Residential	4	3	onsite
II	4458022004	Cross Creek Rd	Residential			onsite
II	4458022003	3661 Cross Creek Rd	Residential	2	2	onsite
II	4452015003	23110 Mariposa De Oro St	Residential	5	5	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452015014	2311 Mariposa De Oro St	Residential	3	3	onsite
II	4452015007	23122 Mariposa De Oro St	Residential	4	4	onsite
II	4452015010	23140 Mariposa De Oro St	Residential	5	4	onsite
II	4452015040	23146 Mariposa De Oro St	Residential	6	5	onsite
II	4452015006	23155 Mariposa De Oro St	Residential	4	5	onsite
II	4452015036	23160 Mariposa De Oro St	Residential	2	1	onsite
II	4452015021	23210 Mariposa De Oro St	Residential	5	5	onsite
II	4452015020	23215 Mariposa De Oro St	Residential	3	2	onsite
II	4452015022	23222 Mariposa De Oro St	Residential	5	5	onsite
II	4452015019	23233 Mariposa De Oro St	Residential	3	3	onsite
II	4452015018	23255 Mariposa De Oro St	Residential	5	5	onsite
II	4452027018	23247 Palm Canyon Ln	Residential	5	6	onsite
II	4452027016	23267 Palm Canyon Ln	Residential	2	2	onsite
II	4452027013	23301 Palm Canyon Ln	Residential	4	7	onsite
II	4452027012	23333 Palm Canyon Ln	Residential	3	4	onsite
II	4452027011	23333 Palm Canyon Ln	Residential	6	5	onsite
II	4452014004	23344 Palm Canyon Ln	Residential	4	3	onsite
II	4452012028	23500 Palm Canyon Ln	Residential	5	5	onsite
II	4452027021	3200 Retreat Ct	Residential	8	8	onsite
II	4452027022	3201 Retreat Ct	Residential	6	7	onsite
II	4452027019	3210 Retreat Ct	Residential	5	6	onsite
II	4452027023	3211 Retreat Ct	Residential	5	6	onsite
II	4452026008	3216 Serra Rd	Residential	5	5	onsite
II	4452026009	3220 Serra Rd	Residential	4	3	onsite
II	4452026007	3226 Serra Rd	Residential	5	5	onsite
II	4452026006	3226 Serra Rd	Residential			onsite
II	4452026010	3250 Serra Rd	Residential	4	6	onsite
II	4452026011	3264 Serra Rd	Residential	5	5	onsite
II	4452026019	3268 Serra Rd	Residential	4	4	onsite
II	4452026018	3270 Serra Rd	Residential			onsite
II	4452026012	3314 Serra Rd	Residential	4	3	onsite
II	4452026013	3350 Serra Rd	Residential	5	4	onsite
II	4452026016	3410 Serra Rd	Residential	5	4	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
II	4452026014	3426 Serra Rd	Residential	4	3	onsite
II	4452026015	3434 Serra Rd	Residential	4	4	onsite
II	4452018006	3611 Serra Rd	Residential	4	3	onsite
II	4452026003	Serra Rd	Residential			onsite
II	4452018011	3549 Serra Rd	Residential	3	3	onsite
II	4452013001	3556 Serra Rd	Residential	4	3	onsite
II	4452018012	3557 Serra Rd	Residential	3	3	onsite
II	4452013002	3560 Serra Rd	Residential	3	2	onsite
II	4452018013	3567 Serra Rd	Residential	4	4	onsite
II	4452013003	3574 Serra Rd	Residential	6	7	onsite
II	4452018015	3609 Serra Rd	Residential	2	3	onsite
II	4452013009	3610 Serra Rd	Residential	4	4	onsite
II	4452018008	3615 Serra Rd	Residential			onsite
II	4452018016	3621 Serra Rd	Residential	4	4	onsite
II	4452018009	3623 Serra Rd	Residential	4	2	onsite
II	4452018017	3625 Serra Rd	Residential	4	2	onsite
II	4452018018	3627 Serra Rd	Residential	5	4	onsite
II	4452018019	3629 Serra Rd	Residential	4	3	onsite
II	4452018020	3631 Serra Rd	Residential	5	4	onsite
II	4452012014	3633 Serra Rd	Residential	4	4	onsite
II	4452012012	3635 Serra Rd	Residential	3	3	onsite
II	4452012015	3637 Serra Rd	Residential	1	1	onsite
II	4452013005	3644 Serra Rd	Residential	4	7	onsite
II	4452017001	3700 Serra Rd	Residential	4	3	onsite
II	4452012007	3701 Serra Rd	Residential	3	3	onsite
II	4452012016	3705 Serra Rd	Residential	4	3	onsite
II	4452012013	3707 Serra Rd	Residential	2	3	onsite
II	4452012022	3227 Serra Rd	Residential	4	4	onsite
II	4452012009	3737 Serra Rd	Residential	4	4	onsite
II	4452012011	3751 Serra Rd	Residential	3	4	onsite
II	4452012020	3811 Serra Rd	Residential	4	6	onsite
subtotal			83	309	311	
III	4452027010	3200 Cross Creek RD	Residential	3	3	onsite
III	4452027009	3232 Cross Creek RD	Residential	5	5	onsite
subtotal			2	8	8	
IV	4458004044	70 Malibu Colony Rd	Residential	4	3	onsite
IV	4452008025	112 Malibu Colony Rd	Residential	5	5	onsite
IV	4452008017	23314 Malibu Colony Rd	Residential	3	3	onsite
IV	4452008016	23316 Malibu Colony Rd	Residential	4	4	onsite
IV	4452008014	23318 Malibu Colony Rd	Residential	3	5	onsite
IV	4452008030	23324 Malibu Colony Rd	Residential	5	7	onsite
IV	4452010017	23325 Malibu Colony Rd	Residential	2	2	onsite
IV	4452008028	23330 Malibu Colony Rd	Residential	2	4	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4452010024	23331 Malibu Colony Rd	Residential	2	3	onsite
IV	4452008027	23334 Malibu Colony Rd	Residential	3	4	onsite
IV	4452010023	23337 Malibu Colony Rd	Residential			onsite
IV	4452008026	23338 Malibu Colony Rd	Residential	3	4	onsite
IV	4452008024	23346 Malibu Colony Rd	Residential	3	2	onsite
IV	4452010032	23349 Malibu Colony Rd	Residential	4	4	onsite
IV	4452008023	23350 Malibu Colony Rd	Residential	4	4	onsite
IV	4452010031	23351 Malibu Colony Rd	Residential	3	3	onsite
IV	4452008022	23354 Malibu Colony Rd	Residential	2	3	onsite
IV	4452008021	23356 Malibu Colony Rd	Residential	3	3	onsite
IV	4452008020	23360 Malibu Colony Rd	Residential	3	4	onsite
IV	4452010012	23401 Malibu Colony Rd	Residential	4	6	onsite
IV	4452008019	23402 Malibu Colony Rd	Residential	6	4	onsite
IV	4452009027	23410 Malibu Colony Rd	Residential	3	3	onsite
IV	4452009017	23416 Malibu Colony Rd	Residential	4	3	onsite
IV	4452009016	23418 Malibu Colony Rd	Residential	3	4	onsite
IV	4452010008	23425 Malibu Colony Rd	Residential	3	4	onsite
IV	4452009024	23426 Malibu Colony Rd	Residential	4	4	onsite
IV	4452010028	23431 Malibu Colony Rd	Residential	4	4	onsite
IV	4452010009	23435 Malibu Colony Rd	Residential			onsite
IV	4452009018	23438 Malibu Colony Rd	Residential	4	6	onsite
IV	4452009019	23440 Malibu Colony Rd	Residential	5	6	onsite
IV	4452010029	23441 Malibu Colony Rd	Residential	4	3	onsite
IV	4452009022	23444 Malibu Colony Rd	Residential	4	3	onsite
IV	4452010027	23445 Malibu Colony Rd	Residential	5	3	onsite
IV	4452009021	23446 Malibu Colony Rd	Residential	5	4	onsite
IV	4452010005	23449 Malibu colony Rd	Residential	3	5	onsite
IV	4452009020	23450 Malibu Colony Rd	Residential	4	6	onsite
IV	4452009015	23456 Malibu Colony Rd	Residential	3	4	onsite
IV	4452010003	23457 Malibu Colony Rd	Residential	3	4	onsite
IV	4458004031	23460 Malibu Colony Rd	Residential	3	2	onsite
IV	4458004032	23500 Malibu Colony Rd	Residential	3	5	onsite
IV	4452010002	23501 Malibu Colony Rd	Residential	2	1	onsite
IV	4452010019	23505 Malibu Colony Rd	Residential	4	4	onsite
IV	4458004033	23506 Malibu Colony Rd	Residential	2	4	onsite
IV	4458004034	23510 Malibu Colony Rd	Residential	3	3	onsite
IV	4458003023	23511 Malibu Colony Rd	Residential	3	2	onsite
IV	4458004035	23512 Malibu Colony Rd	Residential	4	4	onsite
IV	4458003022	23515 Malibu Colony Rd	Residential	5	5	onsite
IV	4458004036	23516 Malibu Colony Rd	Residential	3	2	onsite
IV	4458003021	23517 Malibu Colony Rd	Residential	3	2	onsite
IV	4458004037	23520 Malibu Colony Rd	Residential	4	5	onsite
IV	4458004038	23524 Malibu Colony Rd	Residential	4	5	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458004039	23526 Malibu Colony Rd	Residential	5	7	onsite
IV	4458004040	23530 Malibu Colony Rd	Residential	4	4	onsite
IV	4458003019	23531 Malibu Colonr Rd	Residential	4	5	onsite
IV	4458003018	23533 Malibu colony rd	Residential	4	3	onsite
IV	4458004041	23536 Malibu colony rd	Residential	4	3	onsite
IV	4458004042	23538 Malibu Colony Rd	Residential	5	4	onsite
IV	4458003017	23543 Malibu Colony Rd	Residential	5	3	onsite
IV	4458004043	23544 Malibu Colony Rd	Residential	5	4	onsite
IV	4458003015	23555 Malibu Colony Rd	Residential	1	1	onsite
IV	4458004046	23556 Malibu Colony Rd	Residential	2	2	onsite
IV	4458004047	23560 Malibu Colony Rd	Residential	4	4	onsite
IV	4458003014	23561 Malibu Colony Rd	Residential	5	4	onsite
IV	4458004048	23562 Malibu Colony Rd	Residential	4	5	onsite
IV	4458004049	23566 Malibu Colony Rd	Residential	3	1	onsite
IV	4458003013	23567 Malibu Colony Rd	Residential	3	2	onsite
IV	4458004050	23570 Malibu Colony Rd	Residential	5	3	onsite
IV	4458004051	23600 Malibu Colony Rd	Residential	2	3	onsite
IV	4458003012	23601 Malibu Colony Rd	Residential			onsite
IV	4458004052	23604 Malibu Colony Rd	Residential	2	3	onsite
IV	4458004053	23608 Malibu Colony Rd	Residential	4	5	onsite
IV	4458004054	23610 Malibu Colony Rd	Residential	5	6	onsite
IV	4458003027	23611 Malibu Colony Rd	Residential	4	6	onsite
IV	4458004055	23614 Malibu Colony Rd	Residential	4	5	onsite
IV	4458003026	23615 Malibu Colony Rd	Residential	4	5	onsite
IV	4458005040	23618 Malibu Colony Rd	Residential	4	5	onsite
IV	4458005039	23620 Malibu Colony Rd	Residential	3	7	onsite
IV	4458005038	23622 Malibu Colony Rd	Residential	7	4	onsite
IV	4458003009	23623 Malibu Colony Rd	Residential	3	3	onsite
IV	4458005037	23626 Malibu Colony Rd	Residential	4	5	onsite
IV	4458003008	23629 Malibu Colony Rd	Residential			onsite
IV	4458005036	23630 Malibu Colony Rd	Residential	4	3	onsite
IV	4458005035	23632 Malibu Colony Rd	Residential	5	3	onsite
IV	4458005034	23634 Malibu Colony Rd	Residential	4	5	onsite
IV	4458003030	23639 Malibu Colony Rd	Residential	2	2	onsite
IV	4458005033	23640 Malibu Colony Rd	Residential	3	4	onsite
IV	4458003004	23641 Malibu Colony Rd	Residential			onsite
IV	4458005032	23644 Malibu Colony Rd	Residential	5	6	onsite
IV	4458005031	23648 Malibu Colony Rd	Residential	3	4	onsite
IV	4458003029	23649 Malibu Colony Rd	Residential	4	4	onsite
IV	4458005030	23652 Malibu Colony Rd	Residential	3	2	onsite
IV	4458005029	23654 Malibu Colony Rd	Residential	4	4	onsite
IV	4458003028	23655 Malibu Colony Rd	Residential	3	3	onsite
IV	4458005028	23660 Malibu Colony Rd	Residential	4	5	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458002014	23661 Malibu Colony Rd	Residential	5	5	onsite
IV	4458005027	23664 Malibu Colony Rd	Residential	3	2	onsite
IV	4458002011	23667 Malibu Colony Rd	Residential	3	3	onsite
IV	4458005026	23668 Malibu Colony Rd	Residential	3	2	onsite
IV	4458005025	23672 Malibu Colony Rd	Residential	4	5	onsite
IV	4458002010	23673 Malibu Colony Rd	Residential	4	2	onsite
IV	4458005024	23674 Malibu Colony Rd	Residential	3	4	onsite
IV	4458005023	23678 Malibu Colony Rd	Residential	6	6	onsite
IV	4458005022	23684 Malibu Colony Rd	Residential	4	3	onsite
IV	4458002006	23687 Malibu Colony Rd	Residential	5	4	onsite
IV	4458005021	23700 Malibu Colony Rd	Residential	8	8	onsite
IV	4458006041	23704 Malibu Colony Rd	Residential	6	3	onsite
IV	4458002004	23705 Malibu Colony Rd	Residential	4	5	onsite
IV	4458006040	23708 Malibu Colony Rd	Residential	5	5	onsite
IV	4458002003	23709 Malibu Colony Rd	Residential	4	3	onsite
IV	4458006038	23712 Malibu Colony Rd	Residential	6	7	onsite
IV	4458002017	23713 Malibu Colony Rd	Residential	2	1	onsite
IV	4458006037	23716 Malibu Colony Rd	Residential	5	4	onsite
IV	4458006036	23720 Malibu Colony Rd	Residential	2	3	onsite
IV	4458006035	23730 Malibu Colony Rd	Residential	5	5	onsite
IV	4458006034	23736 Malibu Colony Rd	Residential	4	4	onsite
IV	4452005025	23006 Malibu Rd	Residential	3	3	onsite
IV	4458004045	23554 Malibu Rd	Residential	3	2	
IV	4458006033	23740 Malibu Rd	Residential	5	4	onsite
IV	4458006032	23746 Malibu Rd	Residential	4	3	onsite
IV	4458006031	23750 Malibu Rd	Residential	4	5	onsite
IV	4458006030	23752 Malibu Rd	Residential	4	4	onsite
IV	4458006029	23754 Malibu Rd	Residential	4	4	onsite
IV	4458006028	23758 Malibu Rd	Residential	3	4	onsite
IV	4458006027	23762 Malibu Rd	Residential	3	4	onsite
IV	4458006026	23764 Malibu Rd	Residential	3	5	onsite
IV	4458006025	23768 Malibu Rd	Residential	3	4	onsite
IV	4458006023	23800 Malibu Rd	Residential	9	10	onsite
IV	4458006022	23808 Malibu Rd	Residential	4	4	onsite
IV	4458007028	23812 Malibu Rd	Residential	4	1	onsite
IV	4458007027	23816 Malibu Rd	Residential	2	3	onsite
IV	4458007026	23822 Malibu Rd	Residential	4	7	onsite
IV	4458007025	23826 Malibu Rd	Residential	4	3	onsite
IV	4458007024	23832 Malibu Rd	Residential	5	3	onsite
IV	4458007023	23834 Malibu Rd	Residential	2	3	onsite
IV	4458007022	23844 Malibu Rd	Residential	3	2	onsite
IV	4458007021	23850 Malibu Rd	Residential	7	5	onsite
IV	4458007016	23858 Malibu Rd	Residential	5	6	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4458007015	23864 Malibu Rd	Residential			onsite
iV	4458007020	23868 Malibu Rd	Residential	5	6	onsite
IV	4458007019	23872 Malibu Rd	Residential	3	2	onsite
IV	4458007018	23900 Malibu Rd	Residential	3	2	onsite
IV	4458007017	23910 Malibu Rd	Residential	3	6	onsite
IV	4458008017	23917 Malibu Rd	Residential	5	4	onsite
IV	4458008016	23920 Malibu Rd	Residential	5	7	onsite
IV	4458008015	23926 Malibu Rd	Residential	6	5	onsite
IV	4458008014	23930 Malibu Rd	Residential	4	5	onsite
IV	4458008013	23936 Malibu Rd	Residential	4	4	onsite
IV	4458008018	23940 Malibu Rd	Residential	6	7	onsite
IV	4458008003	23950 Malibu Rd	Residential	4	5	onsite
IV	4458008002	23952 Malibu Rd	Residential	2	3	onsite
IV	4458008001	23956 Malibu Rd	Residential	5	3	onsite
IV	4458009013	23962 Malibu Rd	Residential	3	2	onsite
IV	4458009012	24000 Malibu Rd	Residential	4	3	onsite
IV	4458009009	24016 Malibu Rd	Residential	3	3	onsite
IV	4458009001	24056 Malibu Rd	Residential	2	1	onsite
IV	4458010015	24058 Malibu Rd	Residential	4	2	onsite
IV	4458010016	24102 Malibu Rd	Residential	4	4	onsite
IV	4458010017	24108 Malibu Rd	Residential	3	4	onsite
IV	4458010019	24116 Malibu Rd	Residential	3	3	onsite
IV	4458010018	24116 Malibu Rd	Residential	3	3	onsite
IV	4458010012	24120 Malibu Rd	Residential	3	3	onsite
IV	4458010011	24124 Malibu Rd	Residential	2	2	onsite
IV	4458010010	24128 Malibu Rd	Residential	3	4	onsite
IV	4458010008	24134 Malibu Rd	Residential	2	3	onsite
IV	4458010007	24138 Malibu Rd	Residential	3	3	onsite
IV	4458010006	24142 Malibu Rd	Residential	2	2	onsite
IV	4458010005	24146 Malibu Rd	Residential	4	4	onsite
IV	4458010004	24150 Malibu Rd	Residential	4	3	onsite
IV	4458010003	24154 Malibu Rd	Residential	2	2	onsite
IV	4458010001	24172 Malibu Rd	Residential	3	2	onsite
IV	4458011002	24212 Malibu Rd	Residential	2	2	onsite
IV	4458011003	24216 Malibu Rd	Residential	3	2	onsite
IV	4458018005	24001 Malibu Rd	Residential	3	3	onsite
IV	4458018020	24031 Malibu Rd	Residential	3	2	onsite
IV	4458018011	24109 Malibu Rd	Residential	3	2	onsite
IV	4458018012	24111 Malibu Rd	Residential	3	2	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
IV	4452008018	23406 Malibu Colony Rd	Residential	4	3	onsite
IV	4452009026	23414 Malibu Colony Rd	Residential	4	3	onsite
IV	4452009025	23422 Malibu Colony Rd	Residential	4	4	onsite
IV	4452009023	23430 Malibu Colony Rd	Residential	6	6	onsite
subtotal			180	651	658	
V	4452025006	3395 Sweetwater Mesa Rd	Residential	2	2	onsite
V	4452016004	3401 Sweetwater Mesa Rd	Residential	5	10	onsite
V	4452016019	3415 Sweetwater Mesa Rd	Residential	6	7	onsite
V	4452016020	3431 Sweetwater Mesa Rd	Residential	5	7	onsite
V	4452016007	3451 Sweetwater Mesa Rd	Residential	4	4	onsite
V	4452017004	3509 Sweetwater Mesa Rd	Residential	5	8	onsite
V	4452017005	3535 Sweetwater Mesa Rd	Residential	6	7	onsite
V	4452017009	3620 Sweetwater Mesa Rd	Residential	6	8	onsite
V	4452013008	3655 Sweetwater Mesa Rd	Residential	4	4	onsite
V	4452013007	3669 Sweetwater Mesa Rd	Residential	2	2	onsite
V	4452016008	3330 Sweetwater Mesa Rd	Residential	4	3	onsite
V	4452016018	3362 Sweetwater Mesa Rd	Residential	4	3	onsite
V	4452016017	3380 Sweetwater Mesa Rd	Residential	4	3	onsite
V	4452016016	3416 Sweetwater Mesa Rd	Residential	3	3	onsite
V	4452016015	3464 Sweetwater Mesa Rd	Residential	4	4	onsite
V	4452017008	3556 Sweetwater Mesa Rd	Residential	6	6	onsite
V	4452005004	23018 Pacific Coast Hwy	Residential	3	3	onsite
V	4452005022	23022 Pacific Coast Hwy	Residential	2	2	onsite
V	4452005018	23030 Pacific Coast Hwy	Residential	2	2	onsite
V	4452005002	23034 Pacific Coast Hwy	Residential	2	2	onsite
V	4452005001	23038 Pacific Coast Hwy	Residential	3	2	onsite

DRAFT

Section	AIN	Property Location	Property Use	Bed	Bath	System Type
V	4452019008	22931 Pacific Coast Hwy	Residential	2	3	onsite
V	4452005020	22860 Pacific Coast Hwy	Multi-Family	12	13	onsite
subtotal			23	96	108	
TOTAL			349	1,262	1,263	

DRAFT

Table 3 Total Nitrogen Loading to the Lagoon After Adjustment of Flow and Leach Field Reduction

Site(s)	Daily Flow (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/day)
Sector 1									
"Jiffi," -3011 Malibu Cyn Rd	3,428	45%	1,542.6	45.0	>10	soil & bedrock	0%	45.0	0.58
L.A. Co. Main. Yard -3837 Winter Cyn Rd	252	1%	25.2	40.0	10	sand, silt & clay	20%	32.0	0.01
*Malibu Colony Plaza** -Disposal to Winter Cyn	16,617	1%	1,661.7	16.1	varies	sand & silt	0%	16.1	0.25
*Malibu WPCP** -3255 Vista Pacifica	22,500	1%	2,250.0	20.4	varies	sand & silt	0%	20.4	0.38
Webster Elementary* -3602 Winter Cyn Rd	5,000	1%	500.0	75.0	15	sand & silt	20%	60.0	0.25
Our Lady of Malibu* -3626 Winter Cyn Rd	2,500	1%	250.0	75.0		sand & silt	0%	75.0	0.16
Malibu Presbyterian Nursery School - 3324 Malibu Cyn Rd	1,500	45%	675.0	75.0		sand & silt	0%	75.0	0.42
Commercial - 7 Business Facilities	61,797		6,934.6						2.05
Residential 61 homes	17,600	45%	8,250.0	45.0				45.0	3.34
Total									7.24

*Seepage Pit Disposal or Failed Leachfield = 0% soil treatment
[A]Cafeteria food waste
**Those facilities have package advanced OW13

Site(s)	Daily Flow (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/day)
Sector 2									
Serra Retreat[A] -3401 Serra Rd.	720	95%	684.0	60.0	>10	sand & silt	20%	48.0	0.27
Commercial - 1 Business Facility	720		684.0						0.27
Residential 63 homes	31,100	95%	29,545.0	45.0				45.0	11.06
Total									11.60

[A] Retreat and conference center with food service - low utilization

Site(s)	Daily Flow (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lbs/day)
Malibu Animal Hospital -20431 PCH	500	95%	475.0	40.0	10	sand, silt & clay	20%	32.0	0.13
Malibu Adm. Center -23519 Civic Ctr Wy	4,038	60%	2,422.8	40.0	>10	sand, silt & clay	20%	32.0	0.65
Raquel Club -23847 Strand Ranch Rd	1,500	20%	300.0	75.0	like,	sand, silt & clay	0%	75.0	0.19
Prudential Realty -23405 PCH	450	95%	427.5	40.0	10	mostly sand	20%	32.0	0.11
Malibu Country Mart I -3835 Cross Creek Rd	9,400	85%	7,990.0	60.0	<5	sand & silt	0%	60.0	5.33
Malibu Country Mart II 23410 Civic Ctr Wy	6,300	85%	5,085.0	60.0	<5	sand & silt	0%	60.0	1.00
Malibu Country Mart III -3900 Cross Creek Rd	3,400	95%	3,230.0	60.0	<5	mostly sand & silt	0%	60.0	2.16
Malibu Shell[A] -23387 PCH	300	95%	285.0	4.2	5 to 10	mostly sand	20%	3.4	0.01
Malibu Prof. Arts Bldg -23420 Civic Ctr Wy	450	60%	270.0	40.0	10	sand, silt & clay	10%	36.0	0.06
Malibu Lumber [A] -23479 PCH	8,500	60%	5,100.0	5.7	5 to 10	fill, sand, silt & clay	20%	4.6	0.19
*Alta Mar Properties -23809-23815 Strand Ranch Rd	3,200	20%	640.0	40.0	>10	sand, silt & clay	0%	40.0	0.21
J & P Limited -3805 Cross Creek Rd	500	95%	475.0	40.0	10	mostly sand	20%	32.0	0.13
So. Calif. Edison	400	95%	380.0	40.0		mostly sand	20%	32.0	0.10
Verizon South, Inc. -3705 Cross Creek Rd	400	95%	380.0	40.0		sand & silt	20%	32.0	0.10
Mariposa Land Company, LLC -3728 Cross Creek Rd	400	95%	380.0	40.0		mostly sand	20%	32.0	0.10
Malibu Creek Plaza/Malibu Village[A] -PCH &Cross Creek	11,000	95%	10,450.0	3.0	<5	mostly sand	10%	2.7	0.24
Commercial - 16 Business Facilities	49,738		39,180.3						13.72
Residential 2 homes	800	95%	760.0	45.0				45.0	0.29
Total									14.01

[A]Expected high level of BOD and Total Nitrogen, but Total Nitrogen reduced by weekly pumping of septic tanks

Table 3 - continue to next page

T E A R D

^^these facilities have package advanced OWTS

^Seepage Pit Disposal or Failed Leachfield = 0% soil treatment

Sewer #)	Discharge (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lb/day)
Malibu Rd., LLC -23976-23712 Malibu Rd	400	1%	4.0	40.0	<10	sand, silt & clay	20%	32.0	0.00
Morton-Gensen -23730 Malibu Rd	400	1%	4.0	40.0	<10	sand, silt & clay	20%	32.0	0.00
L.A. Co. Fire Station #88^^ -23720 Malibu Rd	540	1%	5.4	00.0	<10	sand, silt & clay	20%	24.9	0.00
Lisa Krasnoff -23655 Malibu Colony Rd	400	1%	4.0	40.0	<10	sand & silt	0%	40.0	0.00
Mesa, LLC 23915 PCH	400	1%	4.0	40.0	unknown	unknown	0%	40.0	0.00
Commercial - 5 Business Facilities	2,140		21.4						0.01
73 of 180 Res.@50% Flow to Lagoon	25,900	46%	11,658.0	45.0				45.0	4.38
167 of 180 Res.@20% Flow toLagoon	39,900	1%	399.0	45.0				45.0	0.15
Total									4.58

*167 homes were counted in Sector 4 with a total calculated flow of 65500 gpd

^^these facilities have package advanced OWTS

Sector #)	Discharge (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lb/day)
Surfrider Co. Beach -23060 PCH	3,168	10%	316.8	40.0	>10	mostly beach sand	0%	40.0	0.11
Malibu Pier State Park^^ -23000 PCH	3,000	1%	30.0	11.7	<10	mostly sand	10%	10.5	0.00
Malibu Shores Motel^ -23033 PCH	2,843	1%	28.4	60.0	10	sand & silt	10%	54.0	0.01
Malibu Beach Inn^^ -22878 PCH	2,843	1%	28.4	31.9	<10	mostly sand	0%	31.9	0.01
Jack-in-the-Box^^ -23017 PCH	4,800	1%	48.0	26.26	>10	fill, sand & silt	20%	21.0	0.01
Malibu Pizza 22917 PCH	1,500	1%	15.0	40.0	~10	fill, sand & silt	0%	40.0	0.01
Malibu Inn & Restaurant^ 22969 PCH	6,200	1%	62.0	110.0	~10	sand, silt & clay	0%	110.0	0.06
Surfsand/Fish Grill -22935 PCH	400	1%	4.0	80.0	~10	fill, sand & silt	0%	80.0	0.00
Side & Sand Cleaners/Chabad -22841 PCH	400	1%	4.0	40.0	~10	fill, sand & silt	0%	40.0	0.00
Commercial - 9 Business Facilities	24,071		527.7						0.20
Residential 23 homes	10,600	1%	646.0	45.0				45.0	0.24
Total									0.45

^Effluent assumed to have high TN because of low septic tank retention time

^^these facilities have package advanced OWTS

Study Area	Discharge (gpd)	Estimated Percentage of Flow to Lagoon	Estimated Flow to Lagoon (gpd)	Effluent Concentration of Nitrogen (mg/L)	Depth to GW	Soil Type	Leach Field Reduction	Effluent Conc at the Lagoon (mg/L)	Nitrogen Load to the Lagoon (lb/day)
Commercial	125,469		47,317.9						16.25
Residential	126,300		51,907.0						15.49
Total	251,769		99,224.9						35.74

DRAFT

Technical Memorandum #4:
Nitrogen Loads from Wastewater Flowing to Malibu Lagoon are a Significant Source of Impairment to Aquatic Life

Attachment 4-1

Nitrogen Mass Loading for Malibu Lagoon and Review Summary of Previous Studies on Mass Loadings from OWDS to the Lagoon

C.P. Lai, Ph.D., P.E.

This memorandum summarizes the findings of previous studies on the mass loadings of nitrogen to Malibu Lagoon from onsite wastewater disposal systems (OWDS). Using recent data, staff then estimated the nitrogen loading into Malibu Lagoon based on previous numerical modeling results and a spread sheet model. Finally, staff estimated the nitrogen concentration in Lagoon water resulting from this mass loading by using a continuous stirred tank reactor (CSTR) mass balance model.

D R A F T

1.0 Briefing of Previous Studies

Three previous studies about the subject topics have been reviewed and their estimates of mass loadings of nitrogen at the edge of the Lagoon are summarized as follows:

1.1 Stone Report
(Groundwater-Flow and Solute Transport Modeling as Appendix 3 of the Final Report "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", August 2004)

A numerical model was used to simulate groundwater flow and solute transport in the alluvium deposited along Malibu Creek and Lagoon near the Malibu Civic Center area. The groundwater flow model used in this study is the USGS MODFLOW model and the solute transport model is the USEPA MT3D groundwater transport model. The model is limited by the amount of data that was used to build, calibrate, and verify the model.

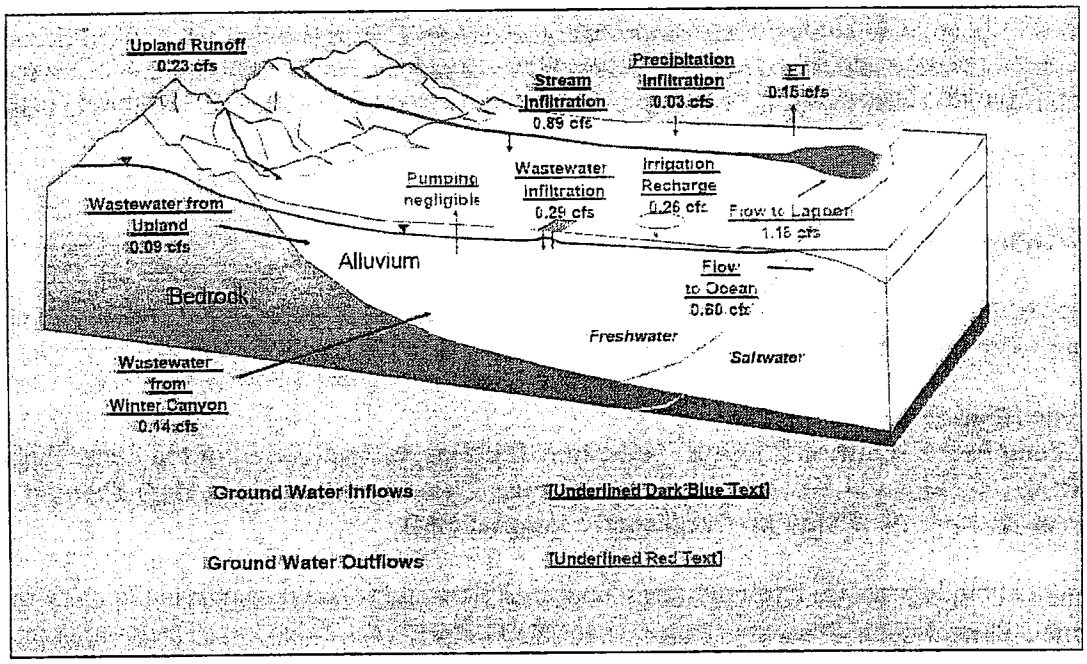
The purposes for constructing a model for the Malibu Civic Center area were to develop a water budget, to determine directions of groundwater flow, to identify which parts of the study area contribute groundwater flow to the beaches and to Malibu Lagoon, to estimate how long it takes groundwater from various parts of the study area to reach the beaches and Malibu Lagoon, and to estimate how much nitrogen is transported by the groundwater from OWDS to the Lagoon and to the ocean. No attempt was made in this model to estimate the mass loading for bacteria.

Results from the flow modeling were used to evaluate directions of groundwater flow, groundwater travel times in the flow system, and the contributing area for the Lagoon and ocean. The transport simulation was run for the period from 1930 through 2090, for a total of 160 years.

The total amount of wastewater disposal assumed as input for the model is approximately 0.52 cubic feet per second (cfs). Commercial wastewater disposal is estimated to be about 0.115 cfs. Source concentrations of nitrogen from OWDS were assumed to be 20 mg/l from domestic wastewater disposal systems and 50 mg/l from commercial systems.

The total average annual inflow to the alluvial groundwater flow system was estimated and is presented in Figure 1 below. The estimated total annual inflow to the alluvial groundwater flow system is approximately 1.93 cfs. The estimated total annual outflow is also 1.93 cfs, which includes 1.18 cfs to Malibu Lagoon, 0.60 cfs to the Pacific Ocean and 0.15 cfs for evapotranspiration.

Figure 1 Average Annual Groundwater Budget for the Malibu Alluvium

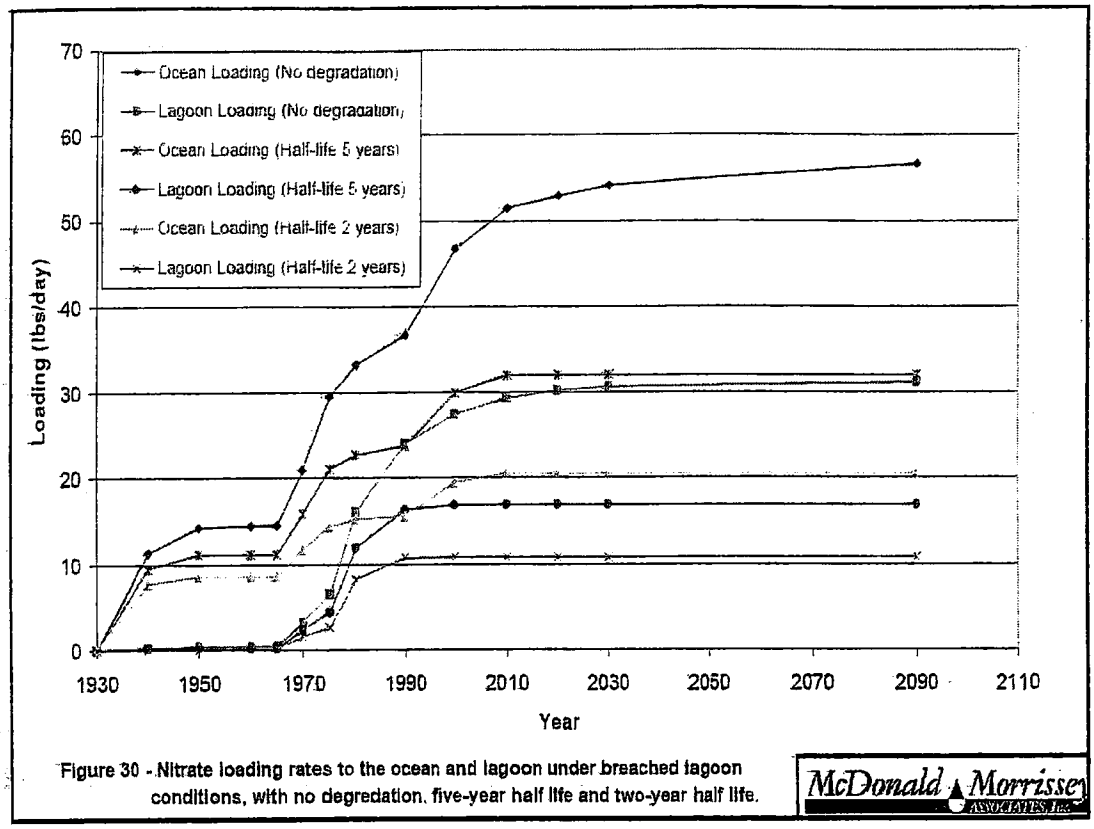


Transport model simulations were run with four steady-state hydraulic stresses, which represent changing source loadings over different time periods, for un-breached and breached Lagoon conditions in order to estimate nitrogen loadings to the ocean and Lagoon from OWDS. Depending upon the assumptions of nitrate degradation, the calculated maximum nitrogen loading to the Lagoon resulting from OWDS ranges from 31 lbs/day (un-breached Lagoon with no degradation) to 11 lbs/day (breached Lagoon with a 2-year half life). The calculated nitrogen mass loading rates to the Malibu Lagoon and the ocean under the breached Lagoon condition are shown in Figure 2. Figure 2 shows that the model predicted the nitrate loading, which is an approximation of the total nitrogen loading.

Additionally, the study modeled groundwater movement to determine the time of travel to Malibu Creek, Malibu Lagoon, the surf zone, and the ocean. Some areas had times of travel as short as six months and others as long as 50 years.

DRAFT

Figure 2 Calculated Nitrogen Loading Rates to the Malibu Lagoon and the Ocean under the Breached Condition



D R A F T

1.2. Questa Report

(Groundwater Modeling Report as Appendix D of the Final Report "Civic Center Integrated Water Quality Management Feasibility Study for City of Malibu", April 2005)

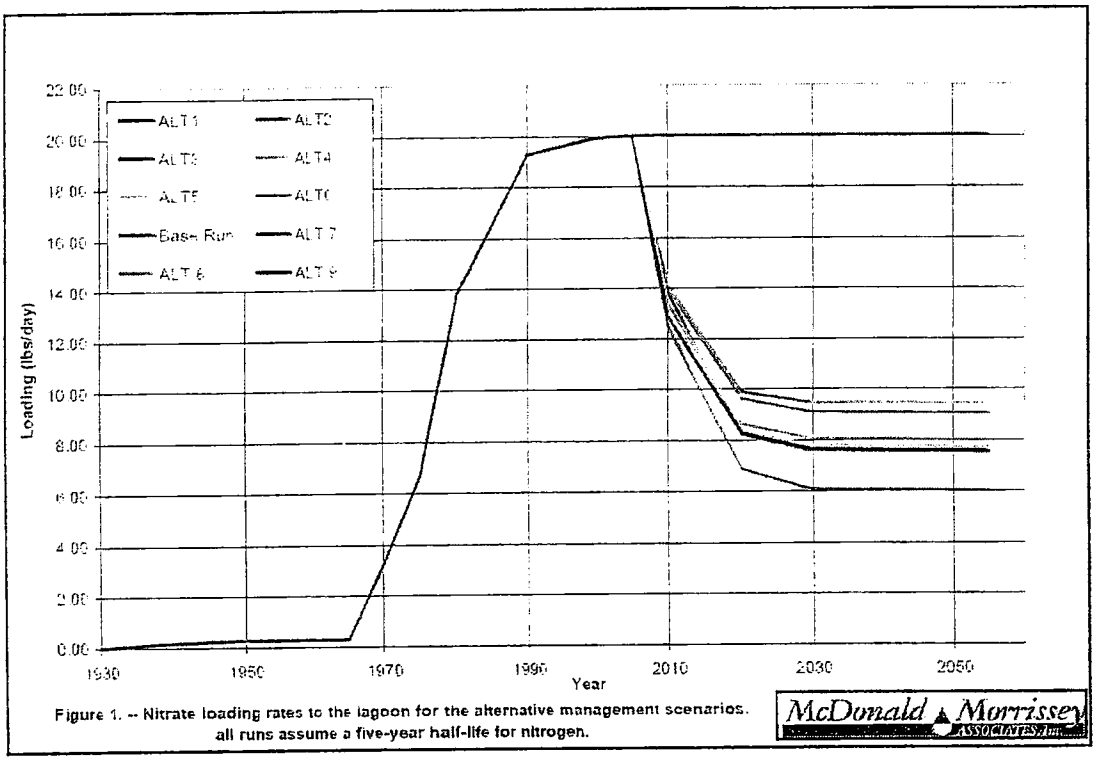
The three-dimensional groundwater flow and solute transport model developed for the Risk Assessment study (the Stone Report) was refined by McDonald Morrissey Associates to assess the potential water quality implications of various combinations of wastewater collection, treatment and dispersal options. Nine options were evaluated along with a baseline condition. Estimated wastewater flows from future development, as well as existing wastewater flows, were considered in the analysis. The model results of nitrogen mass loadings into the Malibu Lagoon for each wastewater management alternative, including the existing condition, are shown in Figure 3.

The nitrogen load at the present condition was estimated to be approximately 20 lbs/day. This result is slightly greater than the result obtained in the Stone Report (17 lbs/day) because

3-1312

additional loading from commercial OWDS was included. Figure 3 shows that the model predicted the nitrate loading. which is an approximation of the total nitrogen loading.

Figure 3 Calculated Nitrogen Loading Rates to the Malibu Lagoon for the Alternative



Management Scenarios

1.3 Tetra Tech Report (Nutrient and Coliform Modeling for the Malibu Creek Watershed TMDL Studies, December 2002)

The TMDL modeling report estimated that nitrogen loading from residential OWDS is 59.2 milligram/liter (mg/l) with 274 gallons per day (gpd) average effluent flow rate. It also assumed that there are two billion coliform counts per person per day discharged into OWDS, and an average population of 3.4 persons per household.

For "normal" OWDS, the TMDL report assumed 100% of the bacteria load is removed prior to reaching surface water bodies, and that 50% of the nitrogen loading reaches the surface water (TetraTech, 2002). For the "failed" OWDS, it was assumed that 40% of the bacteria reaches the Lagoon and 50% of the nitrogen reaches the Lagoon. For "short circuited" systems, 87% of the nitrogen loads and 20% of the bacteria loads were assumed to enter the Lagoon.

D R A F T

Based on the above assumptions, TetraTech (2002) estimated the current total annual bacteria load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 1,176,760 x 10^9 counts per year (3,224 x10^9 counts per day) for fecal coliform.

Similarly, the report estimated the current total annual nitrogen load that OWDS contribute to surface water in the Malibu Lagoon subwatershed to be 23,434 pounds per year, or 64.2 lb/day (TetraTech, 2002).

2.0 Staff Estimate of Mass Loading Rates into the Malibu Lagoon

2.1 Estimate using Questa Numerical Model Results

The Questa groundwater flow and transport modeling assumed that the unsaturated zone had a negligible effect on nitrogen species and that the tidal actions and influences had a negligible effect on the water table and solute transport. Based on local soil properties, the soil is mostly sand and less clay. As such, the assumption that infiltration flows directly into the saturated zone is reasonable. As far as tidal influences are concerned, the varied tidal level will slightly affect the local water table and will not have much of an effect on the up-gradient groundwater water elevation. Therefore, staff concludes that the model results obtained from the Questa Report can be used to estimate the nitrogen mass loading to the Malibu Lagoon using recent OWDS loading data.

From Figure 2, it can be seen that the maximum loading rate to the Malibu Lagoon for the breached Lagoon condition varies from 31 lbs/day (no degradation) to 17 lbs/day (5-year half life) depending on different nitrate degradation coefficients. To be conservative, staff assumed the breached condition and a 5-year half life for the nitrate degradation rate to estimate nitrogen mass loading to the Malibu Lagoon. The relationship of nitrogen mass loading from OWDS and mass loading entering the Lagoon from the Questa Report is presented in Figure 4. There are four loading periods shown in Figure 4 to represent general changes in rates of mass loading into the Lagoon based on changes in source loading to the groundwater system. The loading period A is the period during 1930 to 1964 in which the simulated sources were from Malibu Colony only. During loading period B from 1965 to 1974, the simulated source loading includes the additional loading from residential areas in uplands adjacent to the alluvium. The loading period C from 1975 to 1989 includes all sources in loading period B plus commercial systems in the main body of alluvium. For the loading period D from 1990 to 2009, the source loading includes all sources in the loading period C plus loading from increased commercial and wastewater disposal at the Malibu Bay Colony plant.

To estimate the current loading to the Malibu Lagoon, the flow rate and concentration of wastewater from OWDS for commercial and residential areas from 2008-2009 were used to calculate the mass loading from OWDS to groundwater in the study area and then, based on the relationship for the loading period D as shown in Figure 4, to estimate the mass loading of nitrogen to the Malibu Lagoon. The resulting estimate of nitrogen mass loading into the Lagoon is 28.7 lbs/day based on mass loading from OWDS of 89.7 lbs/day as shown in Table 1.

D R A F T

3-1314

2.2 Estimate using Spread Sheet Model

Since there are no numerical model input data available, the estimate of mass loading into the Lagoon assumes that the relationship between mass loading from OWDS and mass loading to the Lagoon is linear and the ratio of mass loading of 0.32 obtained from the Questa Report was used. However, the relationship between mass loading from OWDS and mass loading into the Lagoon may not be linear because the increased mass loading from OWDS could contribute more mass loading into the Lagoon due to the limited nitrogen capacity of groundwater during long term discharge and the effect of local groundwater flow net patterns. As such, Regional Board staff in the Groundwater Permitting Unit used a spread sheet model to estimate the mass loading entering the Lagoon based on local geotechnical data, hydraulic conductivity and groundwater flow net patterns. The estimate of mass loading into the Lagoon based on this spread sheet model is 39.4 lbs/day resulting from a mass loading from OWDS of 89.7 lbs/day.

The comparisons of the three previous modeling results and staff estimates of nitrogen mass loading to the Malibu Lagoon using a numerical model and a spreadsheet model are presented in Table 1.

2.3 Evaluation of Nitrogen Mass Loadings into the Lagoon using a Mass Balance Model

To evaluate which estimate of mass loading to the Lagoon presented in Table 1 is the best fit with actual conditions and to understand the effect of mass loading from OWDS to the Malibu Lagoon on nitrogen concentrations in Lagoon water, staff used a continuous stirred tank reactor (CSTR) mass balance model to estimate the resulting concentration due to the mass loading. The CSTR model results for different mass loadings are presented in Figure 5. The results are compared with actual Lagoon nitrogen concentration data. It can be seen from Figure 5 that the predicted nitrogen concentration in the Lagoon due to a mass loading entering the Lagoon of 20 lbs/day (as predicted by the Questa Report) is a good comparison with the average nitrogen concentration of 1.4 mg/L for receiving water data collected by the Tapia wastewater treatment plant from 1995-1999. In addition, the predicted nitrogen concentration due to the load allocations for OWDS developed in the TMDL of 6 lbs/day is less than the nitrogen numeric target of 1.0 mg/L. The maximum of nitrogen mass loading into the Lagoon to maintain the nitrogen numeric target of 1.0 mg/L is about 13 lbs/day.

Staff estimates that the current mass loading into the Lagoon from OWDS may vary from 29 lbs/day to 36 lbs/day based on the predicted nitrogen concentrations in the Lagoon water and measured Lagoon nitrogen concentrations for 2002-2003 data (SCCWRP Technical Report 441) as shown in Figure 5. The current estimate of mass loading into the Lagoon of 35.7 lb/day using the spread sheet method would produce a nitrogen concentration in the Lagoon water of 3.0 mg/L and the current estimate of mass loading of 28.7 lb/day using the Questa numerical model results would cause the nitrogen concentration in the Lagoon water to be 2.4 mg/L. According to the measured data during 1995-1999 and 2002-2003, the nitrogen concentration in the Lagoon water is increasing. As such, the resulting nitrogen concentration of 3.0 mg/L for 2008-2009 falls within the trend of measured data from 1995 to 2003. Thus, the mass loading into the Lagoon of 35.7 lb/day is considered to be an appropriate and reasonable estimate.

DRAFT

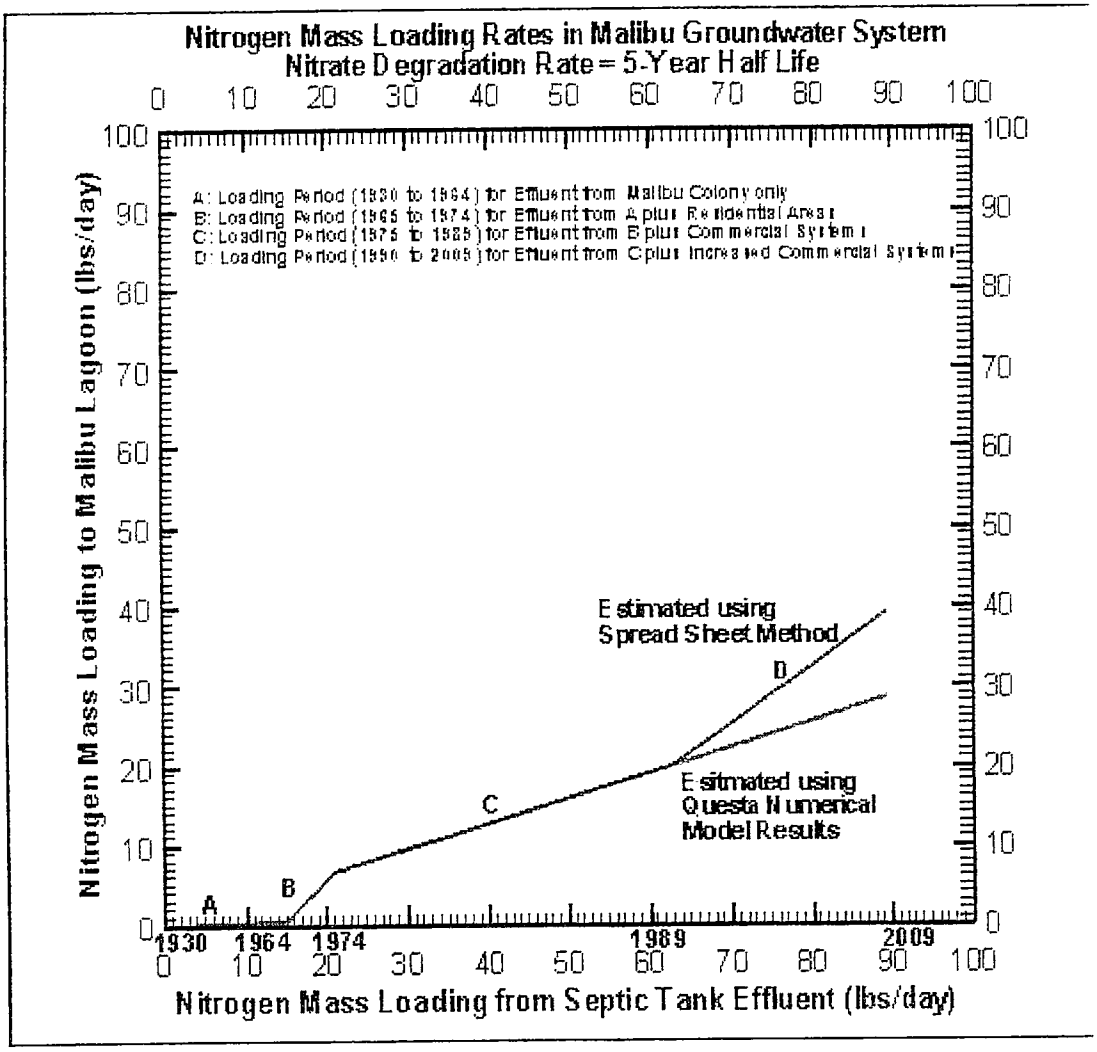
In summary, staff finds that the previous model developed by McDonald Morrissey Associates as presented in the Questa Report was calibrated with measured nitrate data and its modeling results can be used and have been used in this memo to estimate current nitrogen mass loading into the Lagoon. The spreadsheet model also provides a reasonable estimate of current mass loading to the Lagoon. By comparing the results of these two models with measured nitrogen concentration data in the Lagoon, staff estimates that 30-40 lbs/day of nitrogen are loaded to the lagoon, which exceeds the TMDL load allocation and results in exceedances of the TMDL numeric target.

3.0 References

1. "Risk Assessment of Decentralized Wastewater Treatment Systems in High Priority Areas in the City of Malibu, California", Final Report, prepared for Santa Monica Bay Restoration Commission, prepared by Stone Environmental, Inc., August 30, 2004.
2. "Ground-Water Flow and Solute Transport Modeling, Malibu, California", prepared for Santa Monica Bay Restoration Project, prepared by McDonald Morrissey Associates Inc., July 28, 2004.
3. "Malibu Civic Center Integrated Water Quality Management Feasibility Study", prepared for City of Malibu, prepared by Questa Engineering Corporation, April 28, 2005.
4. "Groundwater Modeling Report in the Appendix D of Malibu Civic Integrated Water Quality Management Feasibility Study", prepared by McDonald Morrissey Associates, Inc., April 26, 2005.
5. "Total Maximum Daily Loads for Nutrients Malibu Creek Watershed", United States Environmental Protection Agency, Region 9, 2003.
6. "A Steady-State Groundwater Flow Model for the Proposed Malibu-La Paz Ranch Development", prepared for Sterling Capitol, prepared by Furgo West, Inc., March 2005.
7. "Final Malibu Lagoon Restoration and Enhancement Plan", prepared for the California State Coastal Conservancy & California State Department of Parks and Recreation, prepared by Moffatt & Nichol, June 17, 2005.
8. "Summary of Stormwater Management and Water Quality Improvements for Lower Malibu Creek and Lagoon", prepared for City of Malibu, prepared by RMC, March 26, 2008.
9. "Lower Malibu Creek and Lagoon Resource Enhancement and Management ", Final Report to the California State Coastal Conservancy, prepared by Richard F. Ambrose and Antony R. Orme, University of California, Los Angeles, May 2000.
10. "Malibu Wetland Feasibility Study", prepared for Malibu Coastal Land Conservation, prepared by Huffman and Carpenter, Inc., August 2000.
11. "Sediments as a Non-Point Source of Nutrients to Malibu Lagoon, California, USA", Southern California Coastal Water Resources Project (SCCWRP) Technical Report 441, October 2004.
12. Las Virgenes Municipal Water District (LVMWD),Tapia Water Reclamation Facilities, Malibu Creek Monitoring Program. 1995-1999 Annual Report. NPDES Permit No. CA0056014.

DRAFT

Figure 4 Relationship of nitrogen mass loading from OWDS and mass loading into the Lagoon



DRAFT

Table 1 Comparisons of nitrogen mass loading to the Malibu Lagoon for three previous studies and staff estimates

	Stone Report (2004)[b]	Questa Report (2005)[b]	Tetra Tech Report (2003)[c]	Staff Estimate Using Spread Sheet Method[d]	Staff Estimate Using Numerical Model Method[e]
1.Wastewater Flow Rate from Commercial OWDS (gal/day)	62166	100000	75000	128469	128469
2.Concentration in Commercial Wastewater (mg/L)	50	50	59.2	3 - 110	3 – 110
3.Mass Loading from Commercial OWDS (lbs/day)	25.94	41.73	37.05	42.3	42.3
4.Wastewater Flow Rate from Residential OWDS (gal/day)	126121	126121	54800	126300	126300
5.Concentration in Residential Wastewater (mg/L)	20	20	59.2	45	45
6.Mass Loading from Residential OWDS (lbs/day)	21.05	21.05	27.07	47.4	47.4
7.Mass Loading from OWDS (lbs/day)	46.99	62.78	64.12	89.7	89.7
8.Ratio of Mass Loading[a]	0.36	0.32	0.50	0.40	0.32
9.Mass Loading to Malibu Lagoon (lbs/day)	17	20	32	35.7	28.7

Note: [a] the ratio of mass loading entering Malibu Lagoon versus mass loading from OWDS, i.e.. value of row 9 divided by value of row 7.

[b] the nitrogen loads were assumed to be mostly nitrate in the OWDS and the model only simulated the nitrate in the Stone and Questa Modeling Reports.

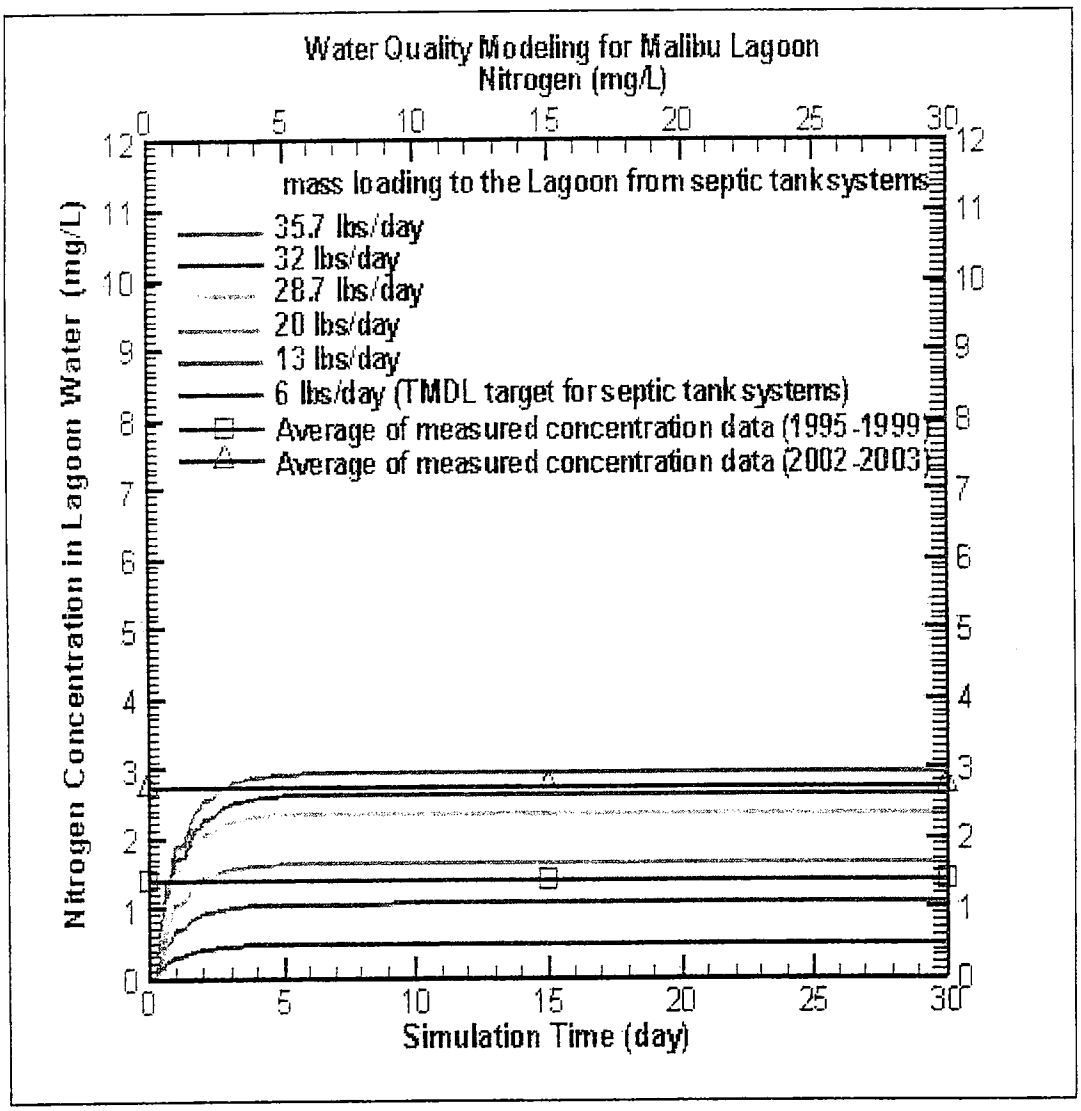
[c] 50 percent of nitrogen loads from the OWDS were assumed to enter the Malibu Lagoon.

[d] the nitrogen mass loading from OWDS was estimated based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L for OWDS. Staff estimated the nitrogen mass loading to Malibu Lagoon by using the spread sheet method.

[e] the nitrogen mass loading based on the commercial load from each OWDS and the residential load with an average concentration of 45 mg/L from OWDS were used in the model. Staff estimated the nitrogen mass loading to Malibu Lagoon by using Questa numerical model results.

DRAFT

Figure 5 Nitrogen concentrations in Lagoon water resulting from different mass loadings entering the Lagoon



DRAFT

State of California
California Regional Water Quality Control Board, Los Angeles Region

Draft Technical Staff Report

Evidence in support of an
Amendment to the
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

to Prohibit Onsite Wastewater Disposal System
in the Malibu Civic Center Area

D
R
A
F
T

Technical Memorandum 5:

Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities

by
Dionisia Rodriguez, Environmental Scientist
Ryan Thacher, Student Intern
Groundwater Permitting Unit

3-1320

Technical Memorandum 5: *Dischargers with Unsuitable Hydrogeologic Conditions for High Flows of Wastewaters Resort to Hauling Liquid Sewage and Sludge to Communities that have Sewer and Wastewater Treatment Facilities*

by
Dionisia Rodriguez, Environmental Scientist
Ryan Thacher, Student Intern
Groundwater Permitting Unit

1. Background

Septic systems, also known as onsite wastewater disposal systems (OWDSs), are used to reduce or eliminate the pathogenic organisms that are found in wastewater. Pathogenic organisms in wastewater pose a relatively minor threat to water resources when OWDSs are properly sited, designed, constructed, and operated. On the other hand, improperly, designed or operated OWDS can be a significant source of surface water and groundwater contamination that can lead to waterborne disease outbreaks and other adverse health effects. The bacteria and viruses found in the wastewater can cause numerous diseases including gastrointestinal illness, cholera, hepatitis A, and typhoid. Nitrogen, which is also found in the wastewater, primarily from urine, feces, and food waste, can cause methemoglobinemia (blue baby syndrome) in infants.[1]

Malfunctioning OWDSs can lead to illicit discharges of septic waste, which is the subsurface or surface release, for any reason or cause, of sewage, wastewater effluent, or any material or substance from an improperly functioning OWDS. An illicit discharge includes dumping, leaking, overflowing, pumping and spilling. This technical memo will quantify reliance on pumping and hauling off-site of septic waste to control wastewater generated by intensive land use activity in the Malibu Civic Center area.

Proper operation and maintenance of the OWDSs is a crucial preventive measure to avoid septic system failures. Inadequate septic system operation and maintenance can lead to failure even when systems are designed and constructed according to regulations; therefore, dischargers pump their OWDSs at regular intervals to avoid potential problems or complete failure of the system. Local health officers recommend that residential septic systems be pumped at least once every three years and commercial systems be pumped twice a year. They also recommend that restaurants, as part of their Best Management Practices, pump out their grease interceptors once a month. The presence of grease in the septic system causes scum formation that can lead to septic failure. However, it has come to the attention of Regional Board staff that some of the large commercial establishments in the Malibu Civic Center area are pumping their septic systems multiple times per week, for large volumes of waste. Regional Board staff believes that the septic systems may be adequately treating a portion of the wastewater generated by intensive land use activities, but lack sufficient onsite capacity to dispose of the effluent. Many of the seepage pits

[1] EPA Source Water Protection Practices Bulletin, "*Managing Septic Systems to Prevent Contamination of Drinking Water.*"

3-1321

DRAFT

and leach fields in the area have been in use for decades and can no longer serve their purpose. Also there are hydrogeologic constraints, such as the lack of suitable surface area for new leach fields, as well as the extremely limited vertical separation between leach field disposal sites and the groundwater table, that further limit wastewater disposal on-site. These factors cause a trend of increasing reliance on septic pumping and hauling off-site.

2. Sources of Data

Within the study area, there are twenty commercial dischargers (Table 1) with Waste Discharge Requirements (WDRs) from the Los Angeles Regional Water Quality Control Board (Regional Board). There are five commercial facilities with discharges of less than 2,000 gallons per day (gpd) that were permitted by the Regional Board, but oversight was transferred to the City of Malibu in February 2005. Septic waste hauling data for each discharger was gathered from quarterly monitoring reports submitted by these dischargers, including waste hauling dates, quantity of waste hauled, and information on the hauling companies. The City of Malibu does not collect hauling data for the commercial facilities under their oversight; therefore, no data are available for them. There are thirteen unpermitted dischargers within the study area, and no hauling information is available for these dischargers.

D R A F T

Table 1. Dischargers permitted by the Regional Board in the Malibu Civic Center area.

Discharger Name
Cross Creek Plaza/Malibu Creek Reservation
Los Angeles County Fire Station #88
Hughes Research Labs (HRL)
Checker Board Properties (Jack in the Box)
Malibu Beach Inn
Malibu Admin. Center (Malibu Civic Center)
Malibu Colony Plaza/ Colony Plaza LLC
Malibu Country Mart I (MCM 1)
Malibu Country Mart II (MCM II)
Malibu Country Mart III (MCM III)
Malibu Lumber
Malibu Pier State Park
Malibu Shores Motel
Malibu WPCP
Mira Mar Properties (MiraMar Investments Co).
Prudential Malibu Realty
Morton Gerson
Road Maintenance Yard 336
Serra Retreat
Surfrider Beach

The five commercial facilities under oversight from the City of Malibu are: Equilon Enterprises, J & P Limited, Malibu Animal Hospital, Malibu Professional Arts Building, and Malibu Road, LLC.

Seven dischargers in the study area are left out in this analysis. MiraMar Investments Co. is omitted because it did not submit monitoring reports (subsequently the Regional Board issued a Notice of Violation (NOV) to MiraMar Investments Co. for non-submittal of monitoring reports). Prudential Malibu Realty and Fire Station #88 are not included in the study due to relatively insignificant annual waste flows and volumes of septic waste hauled off site. Malibu Pier State Park data is omitted as well, due to relatively small volumes of septic waste hauled off site. In 2008, Malibu Pier State Park disconnected its treatment system from the existing leach field and began transporting the effluent to an upgraded system at the Malibu Pier Wastewater Treatment Plant. During its start-up period, Malibu Pier State Park hauled septic waste off-site frequently, but hauling was minimal before and after this time. Cross Creek Plaza was responsible for more combined hauling than any other discharger from 2004 to 2007 (combined total of 6.56 million gallons of septic waste hauled off-site), but in late 2007 they completed an upgrade of their treatment and disposal systems. Very little hauling has been necessary at Cross Creek Plaza since October of 2007. Malibu Lumber was permitted in late 2008 by the Regional Board, and is not included in this analysis due to a lack of relevant data.

Commercial dischargers are the main focus of this analysis, but it is also important to consider the impacts from the large number of residential septic systems within the study area. Using the list of residential properties in "Risk Assessment of Decentralized Waste Water Treatment System, City of Malibu" prepared by the Stone Environmental, Inc. in August 2004, Regional Board staff determined that there are 349 residential homes in the study area. Regional Board staff determined the number of bedrooms in each residence using information gathered from the Los Angeles County assessor's database. The waste flows generated from each residence was estimated by multiplying the number of bedrooms in each house by 100 gallons per day, which is an accepted assumption of waste discharge from homes. It was estimated that 126,300 gallons of wastewater per day are discharged from the residences in the study area. These residences are regulated by the City of Malibu, which currently does not maintain septic hauling records for residences. However, local health officials recommend pumping residential septic systems once every three to five years depending on tank size, wastewater volume, and types of solid entering the system.[2]

DRAFT

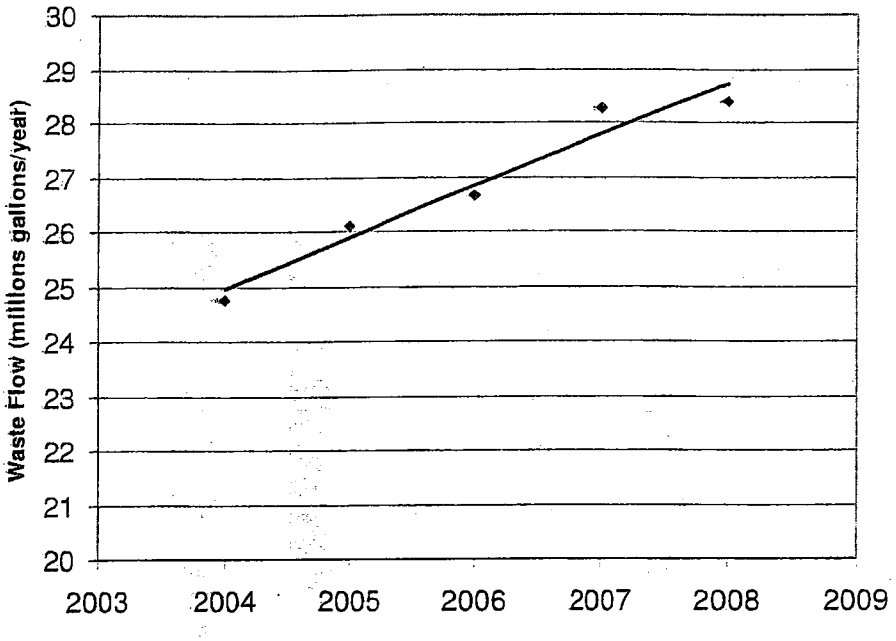
3. Wastewater Generation Analysis

Waste flow volumes have been steadily increasing in the City of Malibu as shown in Figure 1. Most dischargers do not use continuous flow meters to measure waste flows, but instead assume that 95% of the water used within the facility goes to the OWDSs. The remaining 5% accounts for water use outdoors (i.e., hose use, irrigation). As a result the waste flow values presented are estimates, based on repeated assumptions.

The twelve dischargers included in Figure 1 are MCM I, MCM II, MCM III, Surfrider Beach, HRL, Malibu Shores Motel, Malibu Colony Plaza, Serra Retreat Center, Malibu WPCP, Malibu

[2] EPA Source Water Protection Practices Bulletin, "*Managing Septic Systems to Prevent Contamination of Drinking Water*".

Figure 1. Combined annual waste flow trend for select dischargers in Malibu.



Civic Center[3], Road Maintenance Yard No. 336, and Jack in the Box. The combined annual waste flows for the dischargers listed above have increased 15% from 24.8 million gallons in 2004 to 28.4 million gallons in 2008.

A breakdown of the total annual waste flows within the study area is shown in Figure 2. This outlines the biggest contributors to wastewater flows in the Civic Center area; specifically Malibu WPCP and Malibu Colony Plaza.

4. Wastewater Hauling Analysis

Septic waste hauling has been steadily increasing in Malibu as shown in Figure 3. Data for 2006 was omitted from Figure 3 due to a drastic and uncharacteristic increase in hauled sewage from Malibu Colony Plaza (see Figure 4 for explanation).

The dischargers used for the above figure are MCM I, MCM II, MCM III, Surfrider Beach, Malibu Beach Inn, Malibu Shores Motel, Malibu Colony Plaza, Serra Retreat Center, Malibu WPCP, and Jack in the Box. Malibu Civic Center, Road Maintenance Yard No. 336, HRL, and Malibu Pier State Park were left out due to insignificant quantities of septic waste hauled off site.

[3] The dischargers at Malibu Civic Center claimed in the 2007 monitoring report that over 3 million gallons of wastewater had been discharged to the septic system. This number was 95% of the total water use in 2007 at the Civic Center. Upon issuance of a NOV for flow violation, the discharger responded with a letter saying only 23% of consumed water entered the septic system, and that the other 77% was due to irrigation, an irrigation leak, and water used for washing city vehicles. Regional Board staff adjusted data accordingly.

3-1324

DRAFT

Septic waste hauling increased 29% from 1.52 million gallons in 2004 to 1.96 million gallons in 2008. Septic waste hauling data and the waste flow data are attached in Appendix A.

Figure 2. Combined annual waste flows for select dischargers. (Dischargers included in Figure 1 but absent from Figure 2 were omitted due to insignificant waste flows on the scale presented above.)

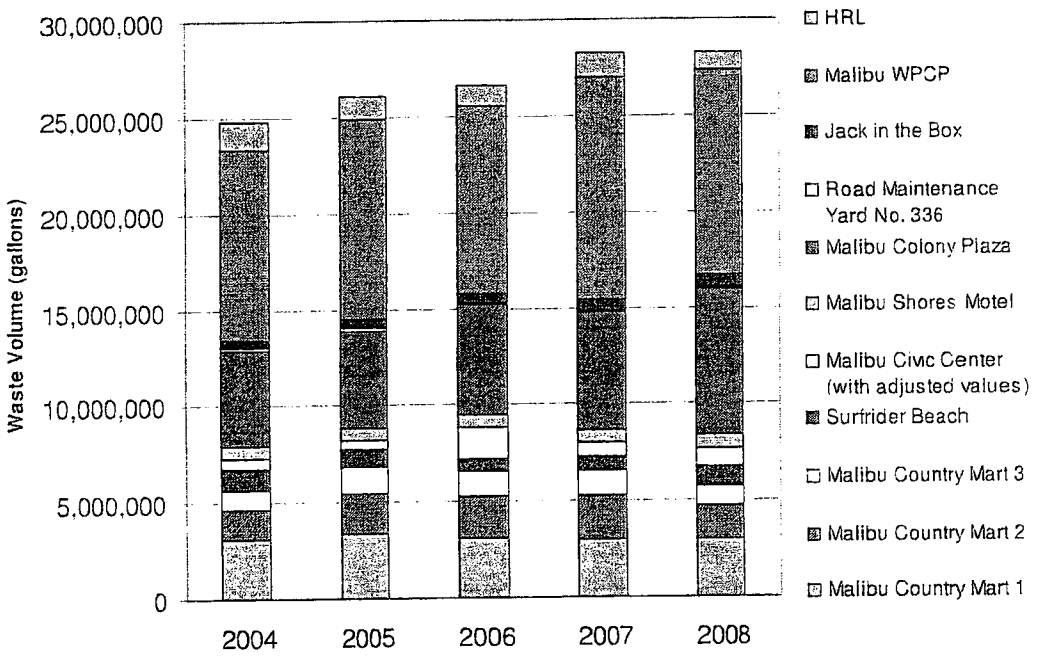
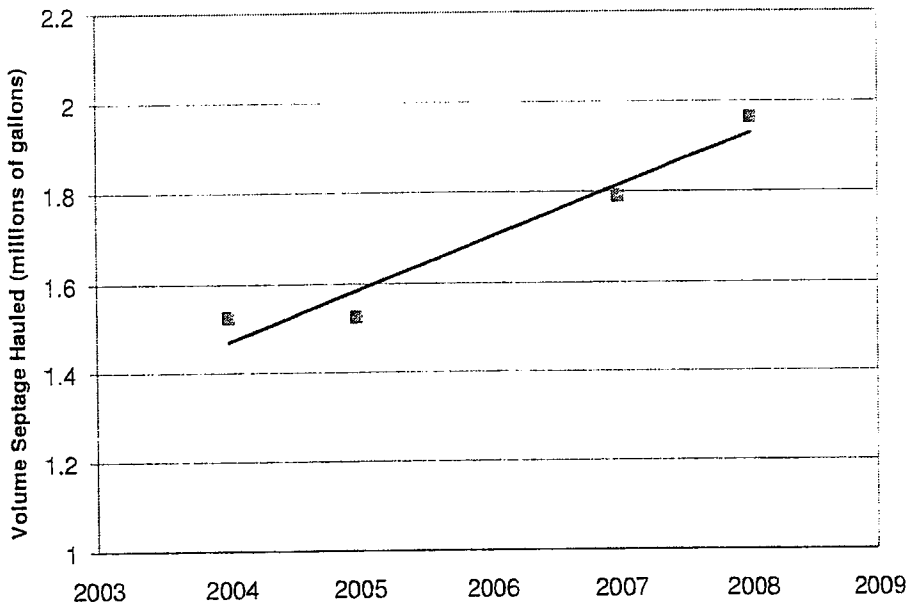


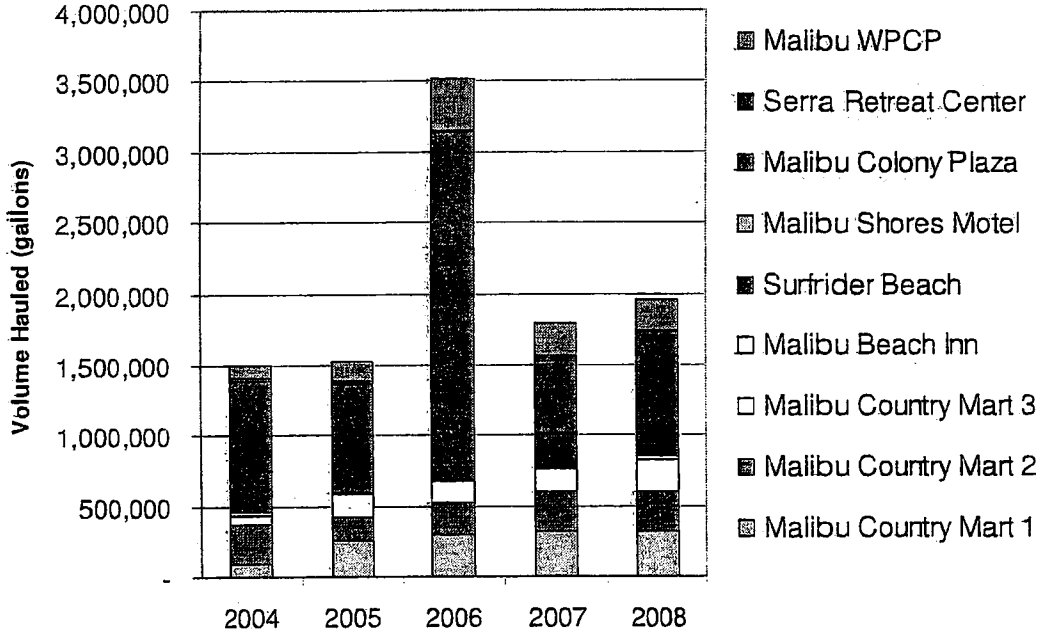
Figure 3. Septic waste hauling trend for Malibu Civic Center area outlines continual rise in waste hauling.



DRAFT

A breakdown of annual hauling by discharger is shown in Figure 4. Most septic waste hauled off-site came from Malibu Colony Plaza, Malibu WPCP, MCM I, MCM II, and MCM III. Septic waste hauling records for all three Malibu Country Marts show increasing hauling trends since 2004.

Figure 4. Combined annual septic waste hauling for select dischargers. Three facilities with relatively insignificant hauled volumes included in Figure 3 are excluded here. The large spike in hauled waste in 2006 from Malibu Colony Plaza was due to the completion and start-up of the Winter Canyon Wastewater Treatment Plant. The plant was unable to meet the effluent limitations during its start-up period and the waste had to be hauled off-site for treatment.



DRAFT

In 2004, about 6% of generated waste within the study area was hauled off-site for treatment, and this increased to 7% in 2008. Certain dischargers contribute much more to the percent of annual hauled septic waste to total waste flows than others. For example in 2008, Malibu Colony Plaza hauled 41% of their total waste flow off-site, MCM III hauled 23.2% of their total waste flow off-site, and MCM II hauled 16% of their total waste flow off-site. More data on annual percentages of septic waste hauled are included in Appendix A.

5. Septic Pumping and Hauling Regulations

Regional Board staff also reviewed regulations related to the pumping and hauling of septic waste. The firms that engage in the business of cleaning of septic tanks, chemical toilets, cesspools, sewage seepage pits, or disposing of the cleanings are regulated under California Health and Safety Code Section 117400-1177450. These firms must register with the local health officer before they can engage in these activities. In Los Angeles and Ventura counties, the county health officers regulate these firms. A public information bulletin from the City of Malibu

lists five firms that are engaged in hauling septic waste in the area. They are A & B Malibu Pumping. County Sanitation Company, Ely Jr's. Pumping, McDermott Pumping and W.A.S.T.E.C. All these firms have valid registrations from Los Angeles County Environmental Health. The registrations are good for one year and their vehicles are scheduled for annual inspection each June. The vehicles are inspected to make sure that they are not leaking, that their openings can be tightly closed and that the pumps are functioning properly. The inspectors also make sure that the drivers of the trucks are trained to handle septic waste properly. In the case of a spill, the drivers must make sure that the discharge is contained and the spill area properly sanitized.

There is one recorded complaint against septic waste haulers in the Civic Center area. Residents complained about an odor caused by septic wastes being transferred from a "milk run" truck to a bigger truck for disposal. There are no regulations related to the transfer of waste from one truck to another. However, City of Malibu local health officers directed the truck drivers to transfer waste at locations away from residences to mitigate the odor nuisance.

To further gather information regarding the transportation of septic waste, two Regional Board staff conducted a drive-through type of inspection on June 16, 2009. They observed waste being pumped from one of the dischargers in the study area. The observations of that inspection are documented in the inspection report included as Appendix B.

6. Carbon Footprint Analysis

i. Sources of Data

Three pumping companies do the majority of septic pumping and hauling in the City of Malibu: Ely Jr's Pumping, A & B Malibu Pumping, and McDermott Pumping. Regional Board staff interviewed representatives from the pumping companies to gather information on the types of trucks used to haul waste and the frequency of waste pick-up done in the City of Malibu. Regional Board staff used this information to calculate the carbon footprint. A carbon footprint analysis was done to determine the impact of septic waste hauling trucks on climate change. A reasonable estimate of carbon dioxide emissions from a truck is based on the miles traveled per trip, the miles driven per gallon of fuel burned, and the amount of carbon dioxide generated per gallon of fuel burned. Miles per gallon estimates were based on truck information provided by each pumping company, and miles per trip estimates were based on the distance from the company's headquarters to the pumping sites, pumping sites to the disposal location, and disposal location back to headquarters.

ii. Data Analysis

Regional Board Staff used the data obtained from septic waste hauling contractors and septic waste hauling information from monitoring reports to develop Table 2.

DRAFT

Table 2. Tons of carbon dioxide produced each year by the three main septic waste pumping companies in Malibu.[4]

Pumping Contractors	Round trip Route (miles)	MPG	Frequency[5] (days/week)	# Trucks	Tons CO2 per year
A&B Malibu Pumping	67	6	3	1	19
Ely Jr's. Pumping	178	6	5	2	171
McDermott Pumping	64	6	5	2	62
				sum	252

Diesel engines produce approximately 22.2 pounds of carbon dioxide per gallon of fuel burned according to *Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel.*[6] The diesel trucks used for hauling are estimated to get anywhere from four to ten miles per gallon, but more often on the lower end of that scale. Due to constant stop and go driving on the Pacific Coast Highway, six miles per gallon is used for the calculation. The result of 252 tons of carbon dioxide produced per year from septic waste hauling within the study area is an estimate (see footnote 5).

Manhattan Beach, California, is a coastal city with almost three times the population of Malibu, and the city inventories its emissions. In 2005, Manhattan Beach officials calculated 6,245 tons of carbon dioxide were released into the atmosphere. The inventory includes emissions associated with city operated facilities and parks, vehicle fleet fuel usage, employee commute emissions, water and sewage pump stations, street lights, and traffic signals[7]. If the City of Manhattan Beach reduced its emissions by 252 tons per year (estimated amount of CO_2 produced from hauling in Malibu per year), this would equate to a 4% decrease in carbon dioxide emissions from municipal activities.

iii. Implications

The California Air Resource Board, Local Government Action for Climate Change, does not have standards for Greenhouse Gas Emissions for each municipality at present. Most actions taken by the municipalities are voluntary. Some cities such as Manhattan Beach have conducted an inventory of Greenhouse Gas Emissions from their municipal activities for the purpose of studying how to reduce such emissions, and help meet Kyoto Protocol type goals.

[4] Information gathered from interviews with Ely Simental of Ely Jr's' Pumping and Amy McDermott of McDermott Pumping Company.

[5] Both trip frequency and the number of trucks in service at once were determined from conversations with representatives from pumping contractors. The representatives could only provide educated guesses regarding trip frequency and average number of trucks out at once.

[6] http://www.epa.gov/oms/climate/420f05001.html

[7] http://www.ci.manhattan-beach.ca.us/Index.aspx?page=1510

DRAFT

Although currently the State of California does not have a mandate base for carbon dioxide emissions, eliminating septic waste hauling in the City of Malibu has the potential to lower greenhouse gases emitted from Civic Center activities.

7. Discussion of Spills in the Study Area

Another manner in which an illicit discharge occurs is spilling of septic waste. Regional Board staff gathered information regarding spills in the City of Malibu from the Los Angeles County Department of Public Health's sewage discharge incident report webpage. Additional data came from the California Integrated Water Quality System (CIWQS) and the Office of Emergency Services (OES) databases. The information from these databases includes the location, time and duration of the spill, the quantity of sewage spilled, the quantity of sewage contained, and the quantity of sewage that entered a drain or surface water. It also lists the cause of the spill and what remedial action was taken.

From August 2006 through March 2009, forty-two spill incidents were reported in the City of Malibu, for a combined discharge of nearly 15,000 gallons of sewage. Although only three of these spills were within the study area, uncontrolled illicit discharges are another common problem with septic systems. Sewage spills from septic systems can result from a variety of causes, yet the majority of spills are a result of poor management of the OWDS. Six of the reported spills involved discharge to either a storm drain or surface water. The spill incidents that occurred in the City of Malibu are included as Appendix C.

8. Conclusion

Our study shows that the volume of waste generated by the facilities in our study area has increased since 2004 by 15%. Consequently, septic waste hauling has increased at an even greater rate, with 2008 values 29% higher than 2004. Currently within the study area, 7% of the annual waste flow is pumped and hauled off site for disposal. Because of the pumping frequency and volumes of waste involved that is hauled off-site, Regional Board staff concludes that the waste is being hauled off site for disposal and not just part of regular septic system maintenance.

Our study also shows that the ongoing practice of frequently hauling septic waste off-site emits an estimated 252 tons of carbon dioxide per year. All vehicles on the road contribute to greenhouse gas emissions, but tanker trucks contribute much more due to their poor miles per gallon rating, and because they run on diesel fuel.

Wastewater flows in the Civic Center area have been increasing consistently each year. Many of the discharge sites are constrained by hydrogeologic conditions mentioned earlier, making them unsuitable for disposal of high flows of wastewater. Many commercial facilities produce wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant volumes into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities.

DRAFT

Appendix A: Septic Waste Flow and Hauling Data

* See last page of Appendix A for assumptions used in data sets marked with an asterisk

Discharger	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Monthly Capacity (gal)	Percent Annual Flow Hauled
Malibu Country Mart 1							
*	2004	85,000	7,083	3,116,916	18,000	540,000	2.73
	2005	255,000	21,250	3,331,380	18,000	540,000	7.65
	2006	290,000	24,167	3,126,045	18,000	540,000	9.28
	2007	320,000	26,667	3,002,800	18,000	540,000	10.66
	2008	320,000	26,667	3,022,084	18,000	540,000	10.59
Malibu Country Mart 2							
	2004	280,000	23,333	1,537,140	14,000	420,000	18.22
	2005	160,000	13,333	2,094,399	14,000	420,000	7.64
	2006	230,000	19,167	2,182,840	14,000	420,000	10.54
	2007	280,000	23,333	2,265,040	14,000	420,000	12.36
	2008	280,000	23,333	1,753,612	14,000	420,000	15.97
Malibu Country Mart 3							
*	2004	70,000	5,833	991,976	5,000	150,000	7.06
*	2005	163,000	9,417	1,388,200	5,000	150,000	11.74
	2006	150,000	12,500	1,249,280	5,000	150,000	12.01
	2007	160,000	13,333	1,292,000	5,000	150,000	12.38
	2008	230,000	19,167	991,576	5,000	150,000	23.20

DRAFT

Discharger	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Monthly Capacity (gal)	Percent Annual Flow Hauled
Malibu Beach Inn							
	2004	17,000			12,000		
	2005	17,000			12,000		
	2006	15,000			12,000		
	2007	1,400			12,000		
	2008	26,700	2,225	964,600	12,000	360,000	2.77
Surfrider Beach							
	2004	2,500		1,105,817	2,250	67,500	0.23
	2005	2,500	208	968,801	2,250	67,500	0.26
	2006	86,853	7,238	652,985	2,250	67,500	13.30
	2007	245,430	20,453	764,006	2,250	67,500	32.12
*	2008	238,267	19,856	971,022	2,250	67,500	24.54
Malibu Civic Center							
	2004	8,000		502,514	16,000		
	2005			449,254	16,000		
	2006			1,602,989	16,000		
	2007			745,999	16,000		
	2008	4,800		899,056	16,000		

DRAFT

Discharger	Year	Annual Total Hauled(gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Monthly Capacity(gal)	Percent Annual Flow Hauled
Malibu Shores Motel							
	2004			647,928	2,500		
	2005			647,928	2,500		
	2006	6,500		631,629	2,500		
	2007			625,494	2,500		
	2008	3,000		706,767	2,500		
Malibu Colony Plaza							
*	2004	918,500	76,542	5,000,000	45,000	1,350,000	18.37
*	2005	752,450	62,704	5,000,000	45,000	1,350,000	15.05
*	2006	2,359,700	196,642	5,753,176	45,000	1,350,000	41.02
	2007	515,600	42,967	6,099,999	45,000	1,350,000	8.45
*	2008	625,500	104,250	7,616,840	45,000	1,350,000	8.21

Discharger	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)
Public Works Road Maintenance Yard No. 336				
	2004	0		123,218
	2005	0		126,929
	2006	0		81,943
	2007	1,500		96,573
*	2008	0		91,919

DRAFT

Discharger	Year	Annual Total Hauled (gal)	Monthly Average (gal)	Annual Waste Flow (gal)	Daily Capacity (gal)	Percent Annual Flow Hauled
Jack in the Box	2004	24,550	2,046	412,085	1,200	5.96
	2005	2,500	208	488,005	1,200	0.51
	2006	15,000	1,250	470,941	1,200	3.19
	2007	200	17	548,139	1,200	0.04
	2008	10,000	833	607,299	1,200	1.65
Malibu WPCP						
	2004	90,000	7,500	9,935,987	45,000	0.91
	2005	140,000	11,667	10,413,640	45,000	1.34
*	2006	369,280	30,773	9,750,365	45,000	3.79
	2007	222,720	18,560	11,584,832	45,000	1.92
	2008	215,540	17,962	10,707,434	45,000	2.01
HRL						
	2004			1,389,829		
*	2005			1,192,739		
*	2006	22,000		1,141,598		
	2007	11,000		1,251,311		
*	2008	8,000		923,572		

DRAFT

Serra Retreat Center	Date	Volume Hauled (gal/Q)	Monthly Hauled (gal/month)	Est Daily Discharge (gal/day)	Est. Monthly Discharge (gal/month)	Septic System Volume (gal)	Percent of total discharge/month hauled
	2004			720	21600	4266	
	Q1	6700	2233				10.3
	Q2	3750	1250				5.8
	Q3	9850	3283				15.2
	Q4	9000	3000				13.9
	Sum	**29300**	9767				
	2005						
	Q1	2200	733				3.4
	Q2	8000	2667				12.3
	Q3	8300	2767				12.8
	Q4	8050	2683				12.4
		26550	8850				
	2006						
	Q1	2700	900				4.2
	Q2	0	0				0.0
	Q3	0	0				0.0
	Q4	10000	3333				15.4
		12700	4233				
	2007						
	Q1	19400	6467				29.9
	Q2	10200	3400				15.7
	Q3	3000	1000				4.6
	Q4	3900	1300				6.0
		36500	12167				
	2008						
	Q1	4200	1400				6.5
	Q2	3200	1067				4.9
	Q3	3000	1000				4.6
	Q4	3000	1000				4.6
		13400	4467				

DRAFT

Assumptions for Sewage Hauling Data

Malibu Country Mart I:

2004, Q1: 10,000 gallons hauled, based on hauling data from Q2

2004, Q4: Waste flow estimated from Q3 volumetric flow rate

Malibu Country Mart III:

2004, Q4: Hauled volume chosen based on trends seen from Q1-Q3

2004, Q4: Waste flow estimated based on trends seen from Q1-Q3

2005, Q1: Hauled volume chosen to match that of Q2

2005, Q1: Waste flow estimated based on trends from Q1-Q3

Surfrider Beach:

2008, Q4: Q4 data missing, used average values from first three quarters.

Malibu Colony Plaza

2004: Annual waste flow estimated to be 5 million gallons

2005: Annual waste flow estimated to be 5 million gallons

2006, Q4: Hauled volume estimated to be the same as Q3

2006: Annual waste flow estimated as four times the value reported in Q4 (the only quarter with data provided)

2008: Annual waste flow estimated as two times the sum of Q1 and Q2 (Q3 and Q4 waste flow data missing)

Malibu WPCP

2006: No Q4 data, used average of other three quarters

Public Works Road Maintenance Yard No. 336

2008: Q3 and Q4 monitoring reports missing. Doubled the sum of data from Q1 and Q2

HRL

2005: No Q4 data; used average of other three quarters

2006: Only Q3 data available; used as data for other three quarters

2008: No Q3 data; used average of other three quarters

DRAFT

Appendix B:

INSPECTION REPORT

CITY OF MALIBU HAULERS

Name of Inspectors: Dionisia Rodriguez
Ryan Thacher

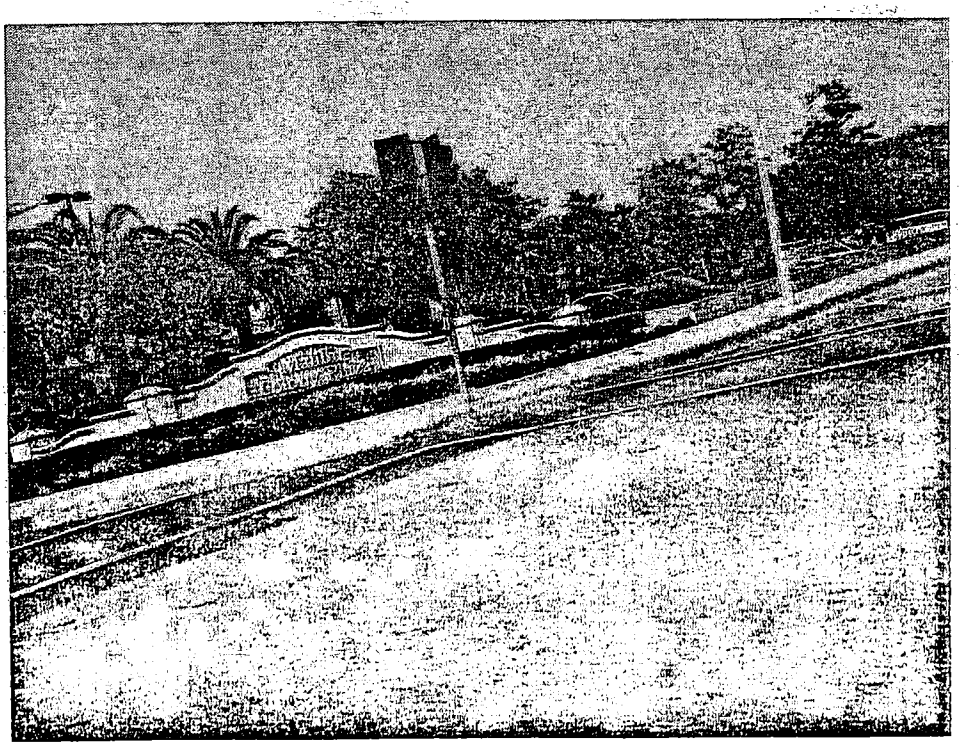
Date of Inspection: June 16, 2009

PURPOSE

In order to gather some information about septic waste hauling in the City of Malibu, we decided to conduct a drive-through the city. The following pictures were taken during that drive-through conducted on Tuesday, June 16, 2009 between 10:00 a.m. and 11:30 a.m.

OBSERVATIONS

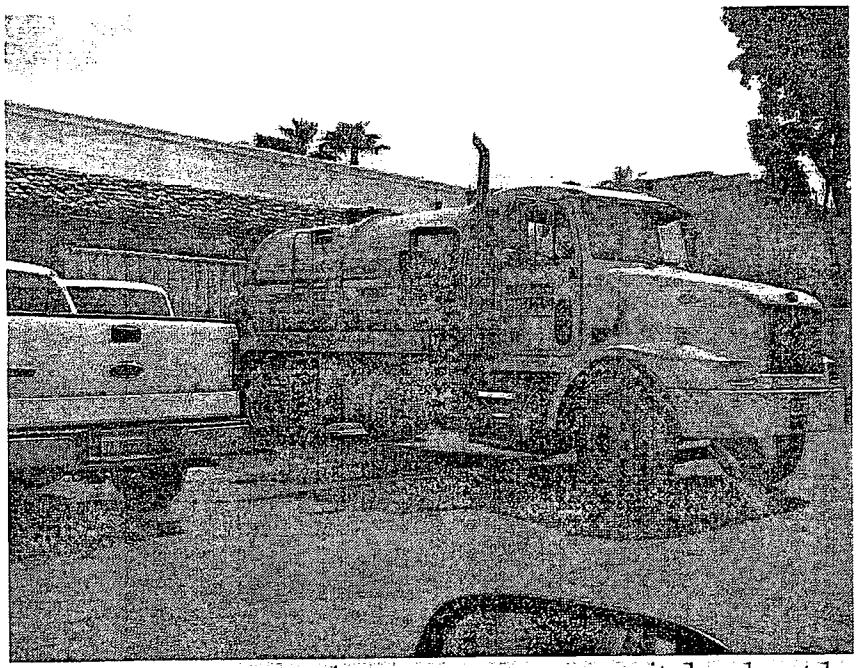
We chose Malibu Colony Plaza as our primary destination due to the frequent pumping of large volumes of waste from its septic system as reported by quarterly Monitoring Reports. We believed this site would provide us the best probability of seeing a pumping truck. This photo is the entrance of Malibu Colony Plaza, at the intersection of the Pacific Coast Highway and Webb Way.



DRAFT

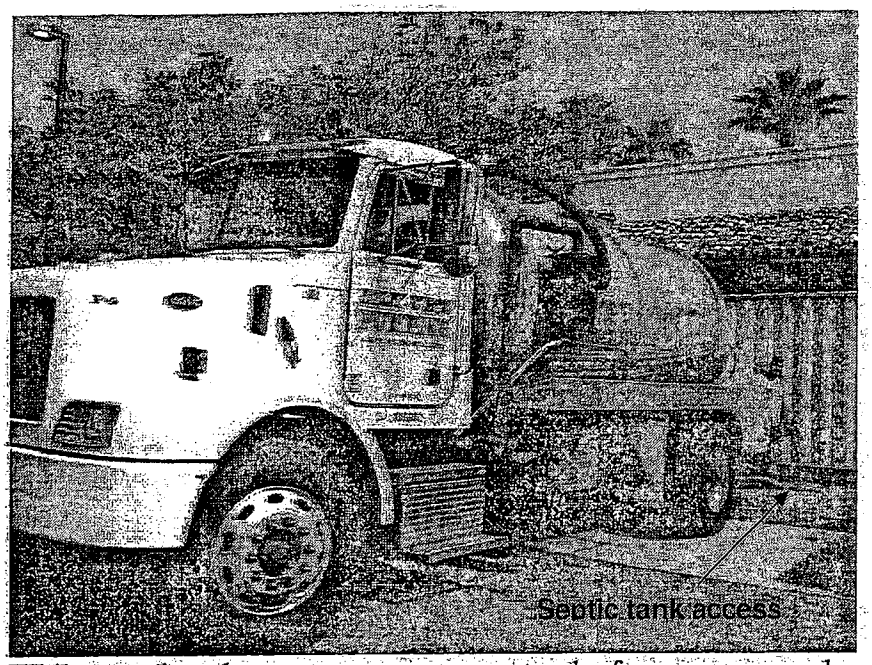


Behind the Malibu Colony Plaza, just off of Malibu Road, we observed an Ely Jr's Pumping truck.

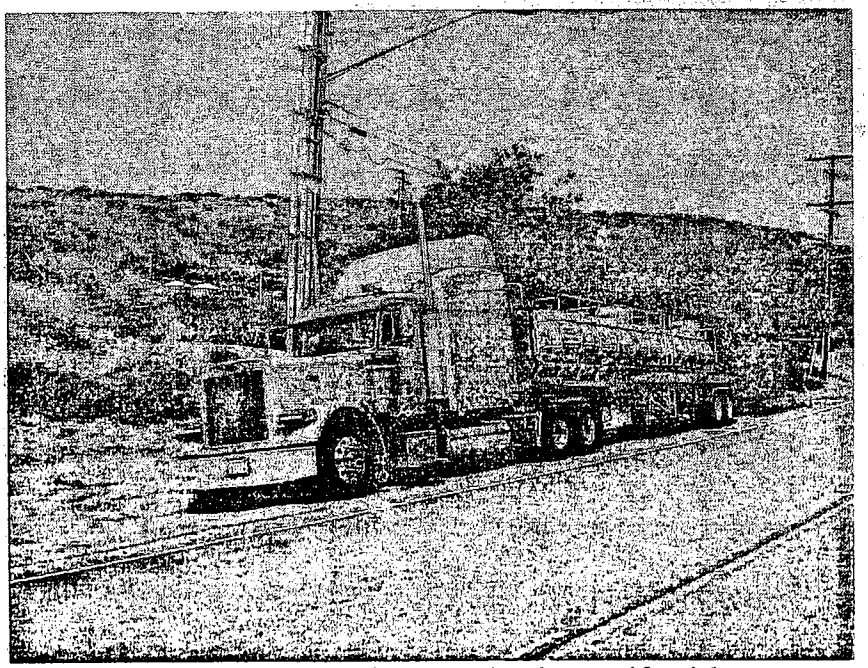


The operator was preparing to pump, so we waited and watched to observe any notable information about this process.

DRAFT

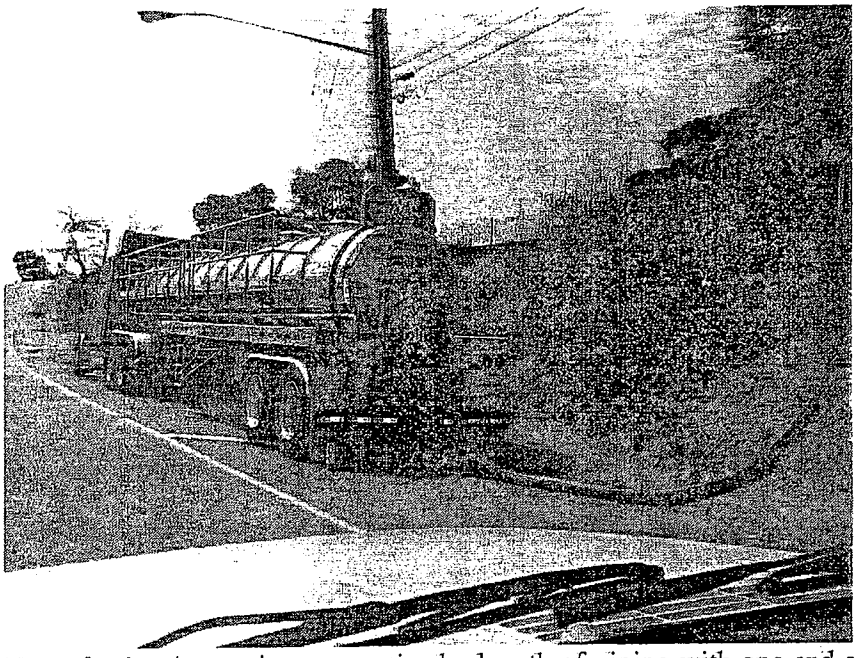


While pumping, there was a very strong stench of raw sewage, and noise levels required raising your voice significantly for conversation. No spills or leaks were observed during the pumping process.

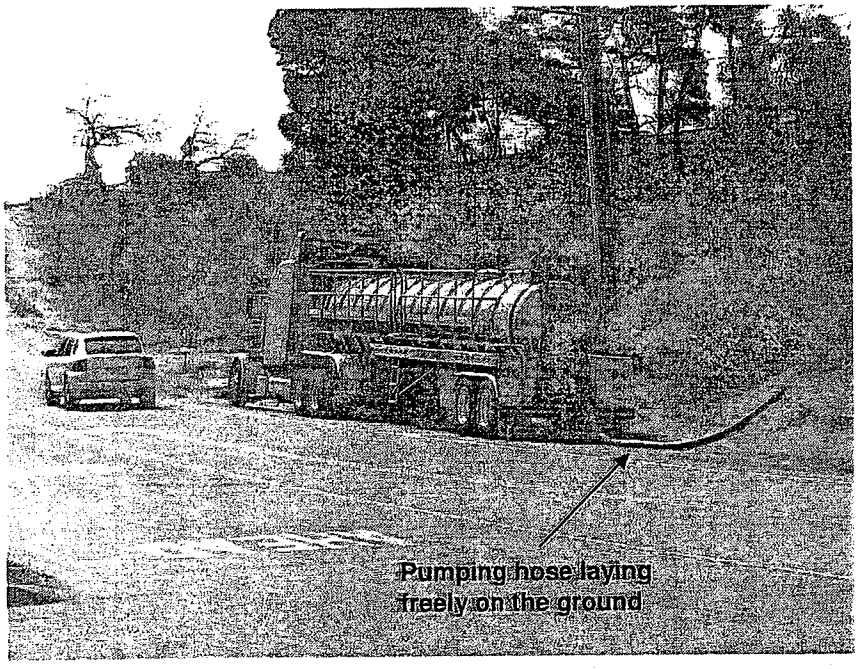


We were interested in observing pumping in a residential area, so we arbitrarily chose to drive north on Winter Canyon Road. At this location at 11:00 a.m. we encountered a large, unmanned sewage hauling truck belonging to Ely Jr's Pumping. We believe it was parked next to the leach field at Winter Canyon Road.

DRAFT



Upon further inspection, we noticed a length of piping with one end attached to the truck's tank, and the other laying freely on the side of the road.



DRAFT

Driving on the Pacific Coast Highway we saw three separate pumping vehicles belonging to McDermott Plumbing, apparently pumping residential septic tanks. We were only able to photograph one shown below at 11:20 a.m. It was unclear whether these trucks were performing routine sludge removal or pumping due to septic tank capacity problems.



CONCLUSION

We will use this inspection report for our technical memo regarding septic hauling in Malibu for the Malibu Prohibition case.

Report Prepared by: Dionisia Rodriguez

Ryan Thacher

Report Approved by: Dr. Rebecca Chou

DRAFT

Appendix C: LA County Department of Public Health Sewage Discharge Incident Reports for Malibu, CA.

Date	Location	Discharged (gal)	Contained (gal)	Into Drain / River (gal)	Cause
3/21/2009	6625 Sea Level Drive, Malibu. CA. 90265	100	100	0	Blockage
3/4/2009	24255 Pacific Coast Highway. Malibu. CA, 90263	10	10	0	Blockage
3/3/2009	Castlerock and Wavecrest. Malibu. CA	10	10	0	Roots
1/13/2009	Malibu Cyn Rd. Malibu, CA. 90263	Unknown	Unknown	0	Pump failure
12/13/2008	6338 Paseo Canyon, Malibu CA. 90265	900	Unknown	Unknown	Unknown
10/6/2008	6225 Point Lechuza Dr, Malibu. CA. 90265	300	300	0	Unknown
9/8/2008	Malibu Cyn Rd. Malibu, CA. 90265	10000	Unknown	0	Rock
7/25/2008	28128 Pacific Coast Highway. Malibu. CA	Unknown			Possibly septic failure
7/21/2008	21150 Pacific Coast Highwway. Malibu. CA. 90265	10	10	0	Pump failure
7/19/2008	29600 Pacific Coast Highway. Malibu. CA. 90265	100	100	0	Septic tank overflow
7/19/2008	28128 Pacific Coast Highway. Malibu. CA	Unknown			
7/6/2008	29600 Pacific Coast Highway. Malibu. CA. 90265	100	100	0	Overflowing septic system
5/14/2008	28128 Pacific Coast Highway. Malibu. CA	125	125		
4/29/2008	28128 Pacific Coast Highway. Malibu. CA	300			Septic failure
4/25/2008	28128 Pacific Coast Highway. Malibu. CA	5	5		Clean-out
4/4/2008	28128 Pacific Coast Highway. Malibu. CA	5	5		Clean-out
3/3/2008	28128 Pacific Coast Highway. Malibu. CA	Unknown			From manhole/Septic failure
2/6/2008	21544 Rambla Vista. Malibu. CA. 90265	Unknown	All	0	Private line
2/5/2008	3917 Spray Lane. Malibu. CA.	100	Unknown	100	Roots
11/26/2007	6338 Paseo Canyon. Malibu CA. 90265	900	900	0	Influent at treatment plant

DRAFT

Date	Location	Discharged (gal)	Contained (gal)	Into Drain / River (gal)	Cause
11/19/2007	28128 Pacific Coast Highway, Malibu, CA	10			Blockage
10/7/2007	28128 Pacific Coast Highway, Malibu, CA	50			Septic failure
9/22/2007	28128 Pacific Coast Highway, Malibu, CA	Unknown			Septic overflow
9/21/2007	28128 Pacific Coast Highway, Malibu, CA	Unknown			From manhole
9/21/2007	28128 Pacific Coast Highway, Malibu, CA	Unknown	0		From manhole
9/21/2007	28128 Pacific Coast Highway, Malibu, CA	10			Septic failure
9/13/2007	28128 Pacific Coast Highway, Malibu, CA	200	200	0	Unknown
9/10/2007	28128 Pacific Coast Highway, Malibu, CA	150	0	150	Flowed into street
9/4/2007	18700 Topanga Beach Rd, Malibu, CA	200	170	30	Unknown
8/24/2007	28128 Pacific Coast Highway, Malibu, CA	200	200	0	Unknown
8/15/2007	28128 Pacific Coast Highway, Malibu, CA	Unknown			Reported by resident
7/20/2007	28128 Pacific Coast Highway, Malibu, CA	150	0	Ramirez Creek	Septic overflow
7/15/2007	Malibu Creek Plaza	50	0		Septic overflow
6/25/2007	22935 Pacific Coast Highway, Malibu CA	Unknown	Unknown	Unknown	Pump failure
5/16/2007	23440 Civic Center Way, Malibu, CA	200	200	0	Pump failure
5/13/2007	22761 Pacific Coast Highway, Malibu, CA	0	All	0	No discharge
5/9/2007	28128 Pacific Coast Highway, Malibu, CA	200	200	0	Unknown
5/1/2007	5939 Kanan-Dune Rd, Malibu, CA, 90265	1	1	0	Unknown
5/1/2007	28128 Pacific Coast Highway, Malibu, CA	200		Walnut Canyon Creek	Cracked pipe
4/30/2007	28128 Pacific Coast Highway, Malibu, CA	200		Walnut Canyon Creek	Sewage Spill
9/17/2006	28128 Pacific Coast Highway, Malibu, CA	Unknown			Repored by resident
8/19/2006	28128 Pacific Coast Highway, Malibu, CA	Unknown			Reported by Owner

DRAFT

State of California
California Regional Water Quality Control Board, Los Angeles Region

Environmental Staff Report

Containing substitute environmental documentation in accordance with the California Environmental Quality Act in support of an Amendment to the *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties*

to Prohibit Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

D
R
A
F
T

Draft dated July 31, 2009

Table of Contents

Page Number

Introduction 3

Proposed Action 3
Lead Agency 3
Scope of Environmental Staff Report 5
California Environmental Quality Act 6
Public Resources and Water Code Requirements 6

Proposed Action 8

Description of Proposed Action 8
Goal of Proposed Action 8
Environmental Setting 8
Background 8
Water Resources 9
Impairments to Beneficial Uses of Water Resources 9
Technical Evidence in Support of the Proposed Prohibition 10
Schedule for Compliance with the Proposed Prohibition 11

Program Alternatives 13

Program Alternative 1 – Local Government Initiative 13
Program Alternative 2– No Action 14
Recommendation 15

Options for Compliance Projects 16

Introduction 16
Summary of Economics 17
Compliance Project A – Integrated Water Resources Management Facility 18
Compliance Project B – Interceptor Sewer 19
Compliance Project C – Decentralized Wastewater Management 20

CEQA Analysis 27

Environmental Checklist and Discussion 27
Other Environmental Considerations 45
Cumulative Impacts 45
Growth-Inducing Impacts 46
Unavoidable Significant Adverse Impacts 48
Statement of Overriding Considerations and Determination 49

DRAFT

3-1345

Environmental Staff Report

in support of an Amendment to
Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties

to Prohibit Onsite Wastewater Disposal Systems in the Malibu Civic Center Area

Introduction

Proposed Action

The California Regional Water Quality Control Board, Los Angeles Region (Regional Board) proposes to amend the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties (Basin Plan)* to prohibit discharges from on-site wastewater disposal systems (OWDSs) in the Civic Center area of the City of Malibu. This proposed regulatory action is referred to as the prohibition, or project, throughout this report.

The area that would be affected by the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1), which includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Types of subsurface disposal systems, or OWDSs, that would be prohibited by the amendment to the *Basin Plan* range from passive systems with conventional septic tanks to active systems that have equipment to more aggressively remove pollutant loads from sewage before subsurface disposal. The prohibition would cover an OWDS that serves an individual property (residential, commercial, industrial, and public properties) as well as a group of properties.

Existing residents, businesses, and public facilities that discharge wastewaters through OWDSs in the Malibu Civic Center area would be affected by the proposed prohibition as well as future dischargers who may plan to discharge in this area. The proposed regulatory action would immediately prohibit all new discharges from OWDSs in the Malibu Civic Center area.[1] For an existing discharger, the proposed regulatory action would establish a five-year schedule to cease discharge.

Lead Agency

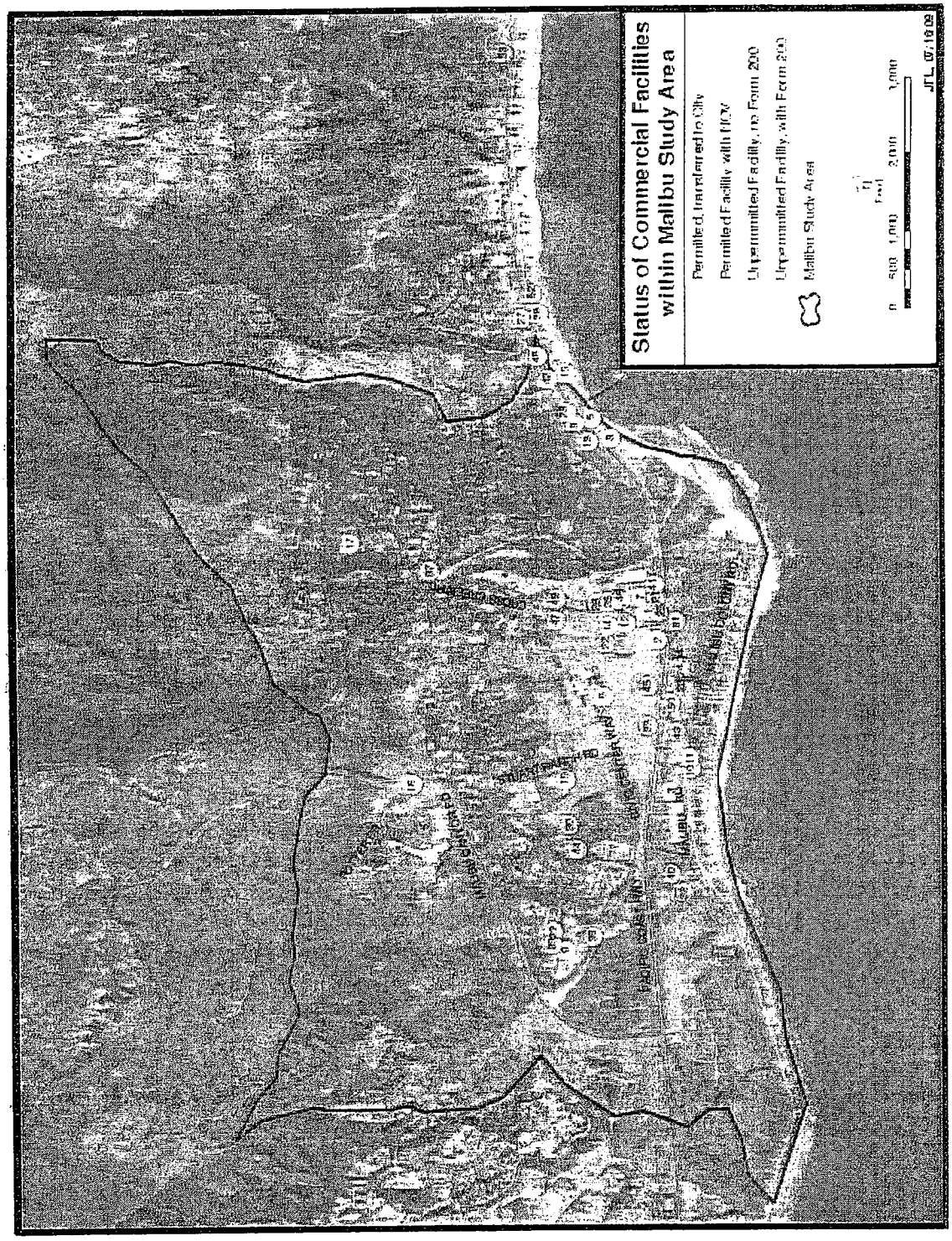
The Regional Board is the lead agency for evaluating environmental impacts from the proposed prohibition on OWDSs in the Malibu Civic Center area.

D R A F T

[1] An exemption would allow for "zero-discharge" projects if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the *Basin Plan*.

3-1346

Figure 1: Malibu Civic Center Area



DRAFT

Scope of Environmental Staff Report

The Regional Board's basin planning process is exempt from certain requirements of CEQA, including preparation of an initial study, negative declaration, and environmental impact report (California Code of Regulations, title 14, section 15251(g)). As the proposed amendment to the *Basin Plan* is part of the basin planning process, the Regional Board prepares environmental information and analyses that are the functional equivalent of an environmental impact report. The Regional Board describes it as "substitute environmental documentation," which complies with Public Resources Code section 21080.5. In this substitute environmental documentation, alternatives to the proposed project, reasonably foreseeable environmental impacts arising from those alternatives and from methods of complying with the proposed prohibition are disclosed in accordance with the California Environmental Quality Act (CEQA) and CEQA regulations.

This information is also presented to meet a requirement of section 13283 of the California Water Code (CWC), which requires a preliminary review of possible alternatives to achieve protection of water quality and present and future beneficial uses of water, and prevention of nuisance, pollution, and contamination.

Consideration of the factors in section 13241 of the CWC is required by section 13281. Staff has presented preliminary cost information for conceptual options, or projects, that the community and stakeholders could select and implement to comply with the prohibition. These projects are analyzed on a conceptual basis only, as a local government will need to select and implement a specific wastewater management strategy and project. As this occurs, it will be the responsibility of a local government to perform a specific project-level analysis and disclose environmental impacts (Pub. Res. Code, section 21159.2).

The Regional Board has analyzed environmental impacts. This substitute environmental documentation is based on the proposed prohibition that will be considered by the Regional Board and, if adopted, implemented through an amendment to the *Basin Plan*. Evidence in support of the proposed prohibition is presented in a technical staff report that, together with this environmental staff report and a tentative resolution, are part of the substitute environmental documentation which will be considered on October 1, 2009. Approval of the substitute environmental documentation is separate from approval of a specific project alternative or a component of an alternative. Approval of the substitute environmental documentation refers to the process of: (1) addressing comments, (2) confirming that the Regional Board considered the information in the substitute environmental documentation, and (3) affirming that the documentaion reflects independent judgment and analysis by the Regional Board (Cal. Code Regs., tit. 14, section 15090).

DRAFT

3-1348

California Environmental Quality Act

This prohibition is evaluated at a program level of detail under a Certified Regulatory Program and the information and analyses are presented in this substitute environmental documentation as discussed in this section.

CEQA's basic purposes are to: 1) inform the decision makers and public about the potential significant environmental effects of a proposed project, 2) identify ways that environmental damage may be mitigated, 3) prevent significant, avoidable damage to the environment by requiring changes in projects, through the use of alternative or mitigation measures when feasible, and 4) disclose to the public why an agency approved a project if significant effects are involved. (Cal. Code Regs., tit. 14, section 15002(a).)

To fulfill these functions, a CEQA review need not be exhaustive, and CEQA documents need not be perfect. They need only be adequate, complete, and good faith efforts at full disclosure. (Cal. Code Regs., tit.14, section 15151.) The Court stated in *River Valley Preservation Project v. Metropolitan Transit Development Board* (1995) 37 Cal.App.4th 154, 178:

> "As we have stated previously, "[our limited function is consistent with the principle that ""[t]he purpose of CEQA is not to generate paper, but to compel government at all levels to make decisions with environmental consequences in mind. . . ."" (*City of Santee v. County of San Diego* (1989) 214 Cal.App.3d 1438, 1448 [263 Cal.Rptr. 340]; quoting *Laurel Heights I*, supra, 47 Cal.3d at p. 393.) "We look 'not for perfection but for adequacy, completeness, and a good faith effort at full disclosure.' (Guidelines, section 15151.)" (*City of Fremont v. San Francisco Bay Area Rapid Transit Dist.*, supra, 34 Cal.App.4th at p. 1786.)"

Nor does CEQA require unanimity of opinion among experts. The analysis is satisfactory as long as those opinions are considered. (Cal.Code Regs.,tit. 14, section 15151.)

In this document, the Regional Board staff has strived to perform a good faith effort at full disclosure of the reasonably foreseeable environmental impacts that could be attendant with the prohibition. Our analysis and conclusions follow.

Public Resources and Water Code Requirements

While the "certified regulatory program" of the Regional Board is exempt from certain CEQA requirements, it is subject to the substantive requirements of California Code of Regulations, title 23, section 3777(a), which requires a written report that includes a description of the proposed activity, an analysis of reasonable alternatives, and an identification of mitigation measures to minimize any significant adverse environmental impacts. Section 3777(a) also requires the Regional Board to complete an environmental checklist as part of its substitute environmental documents. This checklist is provided within this document.

In addition, pursuant to the California Water Code, section 13281(a), the Regional Board must consider all relevant evidence related to the discharge, including, but not limited to, those factors

DRAFT

set forth in Section 13241 information provided pursuant to Section 117435 of the Health and Safety Code, possible adverse impacts if the discharge is permitted, failure rates of any existing individual disposal systems, whether due to inadequate design, construction, maintenance, or unsuitable hydrogeologic conditions, evidence of any existing, prior or potential contamination, existing and planned land use, dwelling density, historical population growth, and any other criteria as maybe established pursuant to guidelines, regulations, or policies adopted by the state board. This evidence is presented in the technical and environmental staff reports.

Pursuant to the California Water Code, section 13241, the Regional Board may establish water quality objectives in water quality control plans as in its judgment will ensure the reasonable protection of beneficial uses and the prevention of nuisance; however, it is recognized that it may be possible for the quality of water to be changed to some degree without unreasonably affecting beneficial uses. In so doing, the Regional Board is to consider factors, including but not necessarily limited to, all of the following:

(a) Past, present, and probable future beneficial uses of water.
(b) Environmental characteristics of the hydrographic unit under consideration, including the quality of water available thereto.
(c) Water quality conditions that could reasonably be achieved through the coordinated control of all factors which affect water quality in the area.
(d) Economic considerations.
(e) The need for developing housing within the region.
(f) The need to develop and use recycled water.

Although the proposed regulatory action does not establish a new water quality objective, staff has nonetheless presented such information in the technical and environmental staff reports.

Public Resources Code section 21159(d) specifically states that the public agency is not required to conduct a "project level analysis." Rather, a project level analysis must be performed by the local agencies that are required to implement the requirements of the prohibition (Pub. Res. Code § 21159.2.) Notably, ***the Regional Board is prohibited from specifying the manner of compliance with its regulations*** (Water Code § 13360), and accordingly, the ***actual*** environmental impacts will necessarily depend upon the compliance strategy selected by the local agencies.

This substitute environmental documentation identifies the reasonably foreseeable environmental impacts of the ***reasonably foreseeable*** methods of compliance (Pub. Res. Code, section 21159(a)(1)), based on information developed before, during, and after the CEQA scoping process that is specified in California Public Resources Code section 21083.9. This analysis is a program-level (i.e., macroscopic) analysis. CEQA requires the Regional Board to conduct a program-level analysis of environmental impacts. (Pub. Res. Code, section 21159(d).) Similarly, the CEQA substitute documents do not engage in speculation or conjecture (Pub. Res. Code, section 21159(a).) When the CEQA analysis identifies a potentially significant environmental impact, the accompanying analysis identifies reasonably foreseeable feasible mitigation measures. (Pub. Res. Code, section 21159(a)(2).) The substitute environmental documentation has identified the reasonably foreseeable alternative means of compliance. (Pub. Res. Code. section 21159(a)(3).)

D R A F T

Proposed Action

Description of Proposed Action

The proposed regulatory action by the Regional Board would prohibit discharge of wastewater through an OWDS in the Civic Center area of the City of Malibu. The prohibition would be effected through an amendment, set forth in the tentative resolution, to the *Water Quality Control Plan for the Coastal Watersheds of Ventura and Los Angeles Counties (Basin Plan).*

The area that would be affected by the proposed prohibition is referred to as the Malibu Civic Center area (Figure 1), which includes Malibu Valley, Winter Canyon, and the adjacent coastal strips of land and beaches. Existing residents, businesses, and public facilities that discharge wastes through an OWDS in the Malibu Civic Center area would be affected by the proposed prohibition as well as future dischargers who may plan to discharge in this area. The regulatory action would immediately prohibit all new discharges from OWDS in the Malibu Civic Center area, and establish a five-year schedule to cease discharges from existing systems.[2]

Types of subsurface disposal systems, or OWDSs, that would be prohibited range from passive systems with conventional septic tanks to active systems with equipment that more aggressively removes pollutant loads from sewage before subsurface disposal. The prohibition would cover an OWDSs that serves an individual property (residential, commercial, industrial, and public properties) as well as a group of properties.

Goal of the Proposed Action

The goal of the proposed prohibition on OWDSs is to remedy pollution of water resources, including beaches, Malibu Lagoon and Creek, and groundwater, that are affected by discharges from OWDSs. The prohibition, together with other efforts, is expected to restore beneficial uses of these water resources.

Environmental Setting

Background

The Malibu Civic Center area supports a population of about 1,000 residents and is the core of the City's business, cultural, and commercial activities. The area, which includes the renowned Surfrider Beach, attracts a high volume of visitors.

[2] An exemption would allow for "zero-discharge" projects if a discharger can demonstrate, to the satisfaction of the Executive Officer, that reuse, evaporation, and/or transpiration will use 100% of the wastewater generated by activities on a site, will not contribute to a rise in the water table, and will contain and properly handle any brines and/or off-specification wastewaters that cannot be reused/discharged in a manner that meets water quality objectives established in the *Basin Plan.*

DRAFT

Without community sewers and wastewater treatment infrastructure, residents, businesses, and public facilities in the area discharge wastewaters totaling about 255,000 gallons per day (gpd) through OWDSs to the subsurface and underlying groundwater. These high flows of wastewater, coupled with unfavorable hydrogeologic conditions, have raised concerns about reliance on this wastewater disposal strategy.

Water Resources

Surface waters in the Malibu Civic Center area include Malibu Creek, Malibu Lagoon, a critical fresh/saltwater habitat for rare, threatened, and endangered species, and the ocean beaches that are heavily used by the resident population as well as visitors. Also, groundwater in the area is a historic and potential source of drinking water. In the *Basin Plan*, the Regional Board has formally designated these plus other beneficial uses for water resources as follows:

> **Malibu Lagoon:** Navigation; Water Contact Recreation; Non-contact Water Recreation; Estuarine Habitat; Marine Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.
>
> **Malibu Creek:** Water Contact Recreation; Non-contact Water Recreation; Warm Freshwater Habitat; Cold Freshwater Habitat; Wildlife Habitat; Rare, Threatened, or Endangered Species Habitat; Migration of Aquatic Organisms; Spawning, Reproduction, and/or Early Development; Wetland Habitat.
>
> **Malibu Beach and Malibu Lagoon Beach (Surfrider Beach), Amarillo Beach, and Carbon Beach:** Navigation; Water Contact Recreation; Non-contact Water Recreation; Commercial and Sport Fishing; Marine Habitat; Wildlife Habitat; Spawning, Reproduction, and/or Early Development; and Shellfish Harvesting.
>
> **Groundwater:** Municipal and Domestic Supply (Potential), Industrial Process and Service Supply, and Agricultural Supply.

D R A F T

Also in the *Basin Plan*, the Regional Board has established water quality objectives to protect the beneficial uses identified above.

Impairments to Beneficial Uses of Water Resources

In a 2006 Clean Water Act Section 303(d) list, approved by the United States Environmental Protection Agency (US EPA) on June 28, 2007, impairments to beneficial uses are formally identified for the following water resources:

> Malibu Lagoon: impaired by Coliform Bacteria, Eutrophication.
> Malibu Creek: impaired by Coliform Bacteria, Nutrients (Algae).
> Malibu Beach: impaired by Indicator Bacteria.
> Malibu Lagoon Beach (Surfrider Beach): impaired by Coliform Bacteria.
> Carbon Beach: impaired by Indicator Bacteria.

To restore water quality and impaired beneficial uses, the US EPA and/or Regional Board have adopted the following Total Maximum Daily Loads (TMDLs):

a. **Malibu Creek Watershed Nutrient TMDL:** The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.

b. **Malibu Creek and Lagoon Bacteria TMDL:** The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite wastewater disposal systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater disposal systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

c. **Santa Monica Bay Beaches Wet and Dry Bacteria TMDL:** For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as a major source. The TMDLs did not provide load allocations for onsite wastewater disposal systems, meaning that no exceedances of the numeric targets are permissible as a result of discharges from non-point sources, including onsite wastewater disposal systems. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 to October 31), there are no allowable exceedance days, in winter dry weather (November 1 to March 31), there are three allowable exceedances days, and in wet weather (defined as days with >=0.1 and the three days following the rain event), there are 17 allowable exceedance days.

D R A F T

Technical Evidence in Support of the Proposed Prohibition

In the technical staff report, staff presents evidence in support of the proposed prohibition, in accordance with the requirements of the California Water Code, sections 13280 and 13281, for a

determination that discharges of OWDSs in the Malibu Civic Center area result in violation of water quality objectives, will impair present or future beneficial uses of water, will cause pollution, nuisance, or contamination, or will unreasonably degrade the quality of any water of the state. The conclusions, based on the evidence in the technical staff report, are as follows:

i. Dischargers subject to Orders from the Regional Board that specify waste discharge requirements (WDRs) for OWDSs have poor records of compliance. (See Technical Memoranda #1 appended to the technical staff report.)

ii. Discharges of wastewaters released from OWDSs to groundwater contain elevated levels of pathogens and nitrogen that impair underlying groundwater as a potential source of drinking water. (See Technical Memoranda #2 appended to the technical staff report.)

iii. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with beaches along the mouths of unsewered watersheds transport pathogens that elevate risks of infectious disease from water contact recreation. (See Technical Memoranda #3 appended to the technical staff report.)

iv. Discharges of wastewaters released from OWDSs to groundwater that is in hydraulic connection with Malibu Lagoon transport a nitrogen load significantly in excess of the wasteload allocation in the TMDL established to restore water quality to a level sufficient to protect aquatic life and prevent nuisance resulting from eutrophication. (See Technical Memoranda #4 appended to the technical staff report.)

v. Wastewater flows in the Civic Center area have been increasing. On many sites, hydrogeologic conditions are unsuitable for high flows of wastewater, and many dischargers generate wastewater flows at rates that exceed their capacity to discharge on-site. These dischargers rely on pumping significant flows into tanker trucks that haul liquid sewage and sludge via public roadways to communities that have sewer and wastewater treatment facilities. (See Technical Memoranda #5 appended to the technical staff report.)

D R A F T

Based on these conclusions, the technical staff report presents a recommendation for Regional Board action to prohibit OWDSs in order to protect the quality of water resources and to restore beneficial uses of water resources in the Malibu Civic Center area. This recommendation is set forth in a tentative resolution for the proposed amendment to the *Basin Plan*, which the Regional Board will consider for adoption on October 1, 2009.

Schedule for Compliance with the Proposed Prohibition

Although the Regional Board is not specifying the *manner* of compliance with the prohibition, staff has reviewed options for conceptual projects that could provide the community with wastewater services in compliance with federal and state regulations, water quality objectives, and the proposed prohibition. These compliance projects include construction, operation, and maintenance of:

A. Integrated water resources management facilities that would collect and treat wastewaters in, and distribute recycled water from, a centralized plant within the community.

B. A community sewer collection system and interceptor sewer to export sewage for treatment at a facility in another community.

C. Decentralized wastewater management facilities that would collect and treat and wastewaters in, and distribute recycled water from, small plants within the community.

The proposed prohibition anticipates that the community would select, design, and construct one of the above projects, or a similar project, and cease discharges from OWDSs within five years, in accordance with the following schedule:

April 1, 2010:	Completion of 25% of a master facilities plan for possible projects to comply with the prohibition, including initiation of a strong public participation program.
October 1, 2010:	Completion of 50% of a master facilities plan and initiation of environmental review, with strong, on-going public participation. Concurrently, initiation of preliminary engineering and a feasibility study for possible projects to comply with the prohibition.
April 1, 2011:	Substantial completion of a master facilities plan, preliminary engineering and a feasibility study, and engagement of the public in selection of a project to comply with the prohibition.
October 1, 2011:	Completion of a master facilities plan, preliminary engineering and a feasibility study, and selection of a project to comply with the prohibition.
October 1, 2012:	Completion of a final design for selected project.
October 1, 2013:	Completion of 50% of construction of selected project.
October 1, 2014:	Completion of project selected to comply with prohibition, including successful startup of the project and termination of discharge from all OWDSs.

Depending on the community response – or lack of a response, the Regional Board could enforce the prohibition through issuance of Cease and Desist Orders to dischargers operating under Regional Board Orders that specify waste discharge requirements (WDRs). There are currently 21 dischargers subject to WDRs in the Malibu Civic Center area.

DRAFT

Program Alternatives

In this section, staff analyzed two alternatives, or actions, to the proposed project within the jurisdiction of the Regional Board, municipalities, and other local agencies. These alternatives include:

1. An initiative by a municipality, utility, or other local authority (local government) to cease discharge through OWDSs by providing community services to collect and dispose/reuse wastewater in a manner that will restore water quality and beneficial uses of impaired waters.

2. A 'no action' alternative, in which dischargers continue to rely on existing OWDSs.

Staff did not analyze an alternative that assumes that dischargers would elect to haul large quantities of sewage off-site, by tanker truck, to other communities with wastewater disposal facilities and capacity to accept liquid wastes from dischargers in the Malibu Civic Center area. As discussed in the technical staff report (Technical Memoranda #5), a subset of ten commercial dischargers haul about 7% of their sewage (almost 2 million gallons) from the Malibu Civic Center area to communities that have wastewater treatment facilities. This need results from on-site hydrogeologic limitations and/or facility limitations. The hauling practice already has impacts to traffic, odor, and aesthetics, and staff did not deem this to be a practical alternative on a larger scale (capable of handling flows of about 250,000 gpd to 300,000 gpd) and on a long-term basis, for reasons among which include:

- Tanker truck capacities are small, ranging from 2,500 gallons to 7,000 gallons.
- Public nuisances, including noise and odor, have been observed during the pumping of raw sewage at various commercial facilities for transfer into the tanker trucks.
- Round trips for the tanker trucks are between 60 miles and 180 miles (including routes through other communities), and are expected to have adverse impacts on roads and transportation flows.
- Staff estimates that this practice of managing raw sewage contributes to climate change, at a rate of 250 tons of carbon dioxide per year.

D R A F T

Program Alternative 1– Local Government Initiative

Under program alternative 1, a municipality, utility or other local authority would provide community services to collect and dispose/reuse wastewater in the Malibu Civic Center area in a manner that will restore water quality and beneficial uses of impaired waters.

While a local government may be an existing entity, such as the City of Malibu or and existing utility or other government authority, it also may be a newly formed utility or government authority. California law provides for a number of institutional options for providing community services. For example, the City can contract for services from a nearby government entity that already has wastewater management capabilities and capacity. Alternatively, an existing utility, such as the Los Angeles County Waterworks District No. 29, Malibu, or a regional water

authority, such as the West Basin Municipal Water District, could expand their scope of services and provide wastewater management services, integrated with potable water services already offered to the Malibu Civic Center area. Such an option also offers the potential to manage wastewater as a resource for recycling. Finally, a private organization – while not a government entity – could nevertheless be formed by community members and stakeholders to provide wastewater management services.

Program alternative 1 – for a local government initiative – anticipates achieving water quality objectives and TMDL targets through compliance projects that would provide the community with wastewater services in compliance with federal and state regulations, water quality objectives, and the proposed prohibition. These compliance projects include construction, operation, and maintenance of:

A. Integrated water resources management facilities that would collect and treat wastewaters in, and distribute recycled water from, a centralized plant within the community.

B. A community sewer collection system and interceptor sewer line to export sewage for treatment at a facility in another community.

C. Decentralized wastewater management facilities that would collect and treat and wastewaters in, and distribute recycled water from, small plants within the community.

An overview and analysis of conceptual projects, or options, that the community and stakeholders could implement to comply with these program alternatives is provided in the next section (Options for Compliance Projects). These compliance projects are expected to have positive environmental impacts, in that they are expected to reduce water quality impairments and help restore beneficial uses. However, these projects also have potential significant adverse impacts to the environment that would occur from the construction, operation, and maintenance these community facilities. These impacts, which are of relatively short duration, can either be mitigated or alternative projects to achieve water quality objectives may be available.

DRAFT

Program Alternative 2 – No Action

This 'no action' program alternative assumes that neither the Regional Board nor a local government takes action to prohibit discharges from OWDSs. Although dischargers could voluntarily implement projects to achieve water quality objectives and TMDL targets, staff believes that this is unlikely. Accordingly, under this program alternative, it is assumed that the cumulative rate of pollutant loading does not decline. As a result, this program alternative would result in continuing or worsening impairments to beneficial uses of the water resources in and around the Malibu Civic Center area, including:

- Malibu Valley groundwater, as a potential source of drinking water.
- beaches, for body contact recreation, and

- Malibu Creek and Lagoon, as support for aquatic and wildlife habitat, including rare, threatened, and endangered species.

Recommendation

Staff concludes that the proposed project (Regional Board prohibition) is the most environmentally advantageous program. Program alternative 2 (no action) is not a preferred alternative because, while it avoids impacts due to construction and operation of wastewater management projects, it allows continued impairment of beaches, Malibu Lagoon and Creek, and underlying groundwater.

Both the proposed project (Regional Board prohibition) and program alternative 1 (local government initiative) have potential to achieve water quality objectives and to restore beneficial uses. However, program alternative 1 relies on an existing or newly formed government entity to voluntarily plan, design, construct, and operate a project that would provide dischargers in the Malibu Civic Center area with community wastewater collection, treatment, and disposal services. Such a voluntary, or discretionary, effort is not currently available. Or, if such an initiative does form, it may not be able to act in a timely manner to complete projects to achieve water quality goals and restore beneficial uses. Therefore, program alternative 1 is not a preferred alternative.

DRAFT

Options for Compliance Projects

Introduction

The program alternatives in the previous section do not specify a particular project to achieve compliance,[3] and it will be the responsibility of the community and stakeholders to select a strategy for compliance. Project-level impacts to the environment will depend on the selected strategy and it will be the responsibility of a local government (local agency) to perform a specific project-level analysis and disclose those environmental impacts (Pub. Res. Code § 21159.2).

Nevertheless, the Regional Board can analyze and disclose, on a conceptual basis, foreseeable environmental impacts from possible projects that may be selected for compliance. Accordingly, in this section, staff provides an overview and analysis of three conceptual options, or projects, that the community and stakeholders could implement to comply with the proposed prohibition and program alternative 1 – the local government initiative. These possible compliance projects include:

A. "Integrated Facilities," including the construction and operation of a central wastewater treatment plant in the community, a local sewer collection system, and recycled water distribution system. The community may also elect to broaden the scope of such a project, in order to integrate these services with delivery of potable water supplies; however, for purposes of this analysis, a more limited scope was assumed.

B. "Interceptor Sewer," including construction and operation of a local sewer collection system and an interceptor sewer to export sewage for treatment at a facility in another community.

C. "Decentralized Facilities," including the construction and operation of small plants in the community, small sewer collection systems, and limited recycled water distribution systems.

These projects are expected to have positive environmental impacts, in that they are expected to reduce water quality impairments to:

- Groundwater – which has pollutants from OWDSs at levels that would impact human health should the community need groundwater as part of its potable water supply in the future.

- Malibu Lagoon – which has a nitrogen load from OWDSs at levels that contribute to eutrophication and impair habitat for aquatic life and wildlife.

[3] The Regional Board is prohibited from specifying the manner of compliance with its regulations (Water Code § 13360).

3-1359

DRAFT

- Nearby beaches – which consistently fail to meet standards set to protect swimmers and surfers from infectious disease resulting from incidental ingestion of or direct exposure to polluted water.

However, these projects also have potential significant adverse impacts to the environment, which would occur from the construction, operation, and maintenance these facilities. These impacts, which are generally of relatively short duration, can either be mitigated or alternative means of compliance with the Regional Board prohibition may be available.

Summary of Economics

Wastewater costs for systems currently operating in the Malibu Civic Center area vary widely. Many residents have passive septic systems installed decades ago which, if replaced today, would roughly cost between $8,000 to $21,000. Maintenance costs for such systems are not significant; assuming a homeowner pumped sludge on a three-year schedule, operating and maintenance costs would be $600 (or $200 annually spread over three years). At the other extreme are capital costs for the wastewater management systems for larger commercial properties that generate high flows of wastewater relative to land available plant and equipment and for subsurface disposal. For example, capital costs for the treatment system at Malibu Lumber – the most recent system to come on line (in April 2009) – totaled millions of dollars.

To estimate costs for the three compliance projects considered in this analysis, staff assumed that the projects would be sized to replace the total existing OWDS capacity in the community, and that the projects would not be designed to accommodate increases in wastewater flows. Accordingly, all three compliance projects were sized to handle a flow of approximately 300,000 gpd.

Based on preliminary estimates for the three compliance projects considered in this analysis, capital costs, in today's dollars, would range from $17 million to $80 million, as follows:

Summary of Capital Costs for Compliance Projects

Capitol Costs	Integrated Facilities	Interceptor Sewer to a:		Decentralized Facilities
		Hyperion Connection	Tapia Connection	
Local Sewer System	$7,800,000	$7,800,000	$7,800,000	$7,800,000
Interceptor Sewer	--	$49,000,000	$72,500,000	--
Treatment Plant(s)	$5,900,000	--	--	$5,800,000
Recycled Distribution System	$3,000,000	0	0	$3,000,000
total	***$16,700,000***	***$56,800,000***	***$80,300,000***	***$16,600,000***

D R A F T

Also, in switching from OWDSs to one of the above projects, all dischargers would incur costs for abandonment of their systems. For a residential property, these costs are estimated to range from $1,700 to $2,700.

Compliance Project A – Integrated Water Resources Management Facilities

Under the "Integrated Facilities" method of compliance, the City of Malibu, an existing utility or local authority, or a newly formed utility or local authority would construct and operate a centrally located wastewater treatment plant, with a local sewer collection system and a local recycled water distribution system. Capital cost estimates for this compliance project total $16,700,000 and include the following major components and key assumptions:

Integrated Water Resources Management Facilities

Component	Capital Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Treatment Plant	$5,900,000	300,000 gpd capacity using activated sludge, filtration, and disinfection to produce a Title 22 recycled water for direct reuse.
		Cost of land not included.
Recycled Water Distribution System	$3,000,000	15,000 ft of 8-inch diameter pipe, to distribute 150,000 gallons of recycled water
		Construction Technique: Open Cut Trenching
		50% of flow recycled; 50% disposed to subsurface.
total	***$16,700,000***	

For purposes of this preliminary analysis, staff assumed that there would be demand to directly reuse only half of the treated effluent (and a market analysis would need to be conducted to determine the community's capacity for recycling). Community planners may consider the promotion of additional uses for recycled water by requiring dual plumbing for any new development or retrofits.

Staff also assumed that the portion of treated effluent not recycled is discharged through subsurface methods, which will require a larger project footprint, unless the discharge can be integrated into management with other water projects such as stormwater treatment. As an alternative to subsurface disposal, the community may elect to consider an ocean outfall. Costs for construction of this outfall, additional treatment capabilities such as temperature controls for the treated effluent, and diffusers at the outfall, have not been included in this analysis.

DRAFT

Compliance Project B – Interceptor Sewer

Under the "Interceptor Sewer" method of compliance with the proposed prohibition, the community would design and construct a wastewater collection system in the Malibu Civic Center area that would feed into an interceptor sewer that exports the sewage out of the area to another community with wastewater treatment facilities. The nearest connections are sewers that are part of the Hyperion Wastewater Treatment Plant in El Segundo and the Tapia Water Reclamation Facility in Calabasas.

Hyperion Interceptor Sewer: An interceptor sewer designed to export sewage to the Hyperion system is expected to require tunneling under the Pacific Coast Highway to the nearest connection point in Castellammare, which is 7-1/2 miles from the Civic Center area. Cost estimates for this compliance project total $56,800,000 and include the following major components and key assumptions:

Hyperion Interceptor Sewer

Component	Capital Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Interceptor Sewer Line	$49,000,000	40,000 ft of 24-inch diameter pipe, to export 300,000 gpd by gravity flow to a connection point in Castellammare.
		Connection fee of $1,700,000 included
		Construction Technique: Trenchless Tunneling
		California Department of Transportation permitting fees not included.
total	***$56,800,000***	

The interceptor sewer line costs include the capital costs of a local collection system, the interceptor line, and four wet well lift stations that would be needed for gravity flow transport of sewage with a vertical lift of 300 feet over 7-1/2 miles to a connection in Castellamarre.

Tapia Interceptor Sewer: An interceptor sewer designed to export sewage to the Tapia Water Reclamation Facility is expected to require tunneling under Las Virgenes Road and installation of pumps to lift the sewage to a connection point with the Tapia plant in Calabasas. Cost estimates for this compliance project total $80,300,000 and include the following major components and key assumptions:

DRAFT

Tapia Interceptor Sewer

Component	Capital Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Interceptor Sewer Line	$72,500,000	58,000 ft of 24-inch diameter pipe, to export and lift 300,000 gpd by pressurized flow Tapia.
		Connection fee of $1,700,000 included
		Construction Technique: Trenchless Tunneling
		Permitting fees not included.
total	***$80,300,000***	

The interceptor sewer scenario includes capital costs for the local collection system, the interceptor line, and ten wet well lift stations needed to lift and transport the sewage 800 vertical feet over a distance of 11 miles to the Tapia connection.

Compliance Project C – Decentralized Wastewater Management Facilities

Under the "Decentralized Facilities" method of compliance, the City of Malibu, an existing utility or local authority, or a newly formed utility or local authority would construct and operate small plants in the community, small sewer collection systems, and limited recycled water distribution systems. Or, alternatively, such projects could be led by private sector developers. Cost estimates for this compliance project total $16,600,000 and include the following major components and key assumptions:

DRAFT

Decentralized Wastewater Management Facilities

Component	Cost	Key Assumptions
Local Sewer System	$7,800,000	22,000 ft of 8-inch diameter pipe, to collect 300,000 gpd by gravity flow to 3 wet wells.
		Construction Technique: Open Cut Trenching
Treatment Plant 1	$1,200,000	67,000 gpd capacity using activated sludge, filtration, and disinfection to produce a Title 22 recycled water for direct reuse.
		Cost of land not included.
Recycled Water Distribution System Treatment Plant 1	$600,000	3,000 ft of 8-inch diameter pipe, to distribute Construction Technique: Open Cut Trenching
		50% of flow recycled; 50% disposed to subsurface.
Treatment Plant 2	$4,600,000	233,000 gpd capacity using activated sludge, filtration, and disinfection to produce a Title 22 recycled water for direct reuse.
		Cost of land not included.
Recycled Water Distribution System Treatment Plant 2	$2,400,000	12,000 ft of 8-inch diameter pipe, to distribute Construction Technique: Open Cut Trenching
		50% of flow recycled; 50% disposed to subsurface.
Total	***$16,600,000***	

For purposes of this preliminary analysis, staff assumed that there would be demand to directly reuse only half of the treated effluent, and a market analysis would need to be conducted to determine the capacity for recycling within each sector served by the treatment plants. Community planners may consider the promotion of additional uses for recycled water by requiring dual plumbing for any new development or retrofits. Staff assumed that effluent that could not be recycled is discharged via subsurface mechanisms, which would require more land. Staff did not expect that an ocean outfall for the non-recycled portion of the treated effluent would be practical for these smaller scale plants.

DRAFT

Other Environmental Considerations

Analyses of other environmental impacts resulting from reasonably foreseeable options of complying with the proposed prohibition include:

- Cumulative Impacts of the Program Alternatives (as required by CEQA Guidelines Section 15130): Cumulative impacts, defined in Section 15355 of the CEQA Guidelines, refer to two or more individual effects, that when considered together, are considerable or that increase other environmental impacts. A cumulative impact assessment must consider not only impacts of the proposed prohibition, but also impacts from other municipal and private projects that would occur in the area during the period of implementation.

- Potential Growth-Inducing Effects of the Program Alternatives (as required by CEQA Guidelines Section 15126).
- Unavoidable Significant Impacts (as required by CEQA Guidelines Section 15126.2).

Cumulative Impacts

On a programmatic level, the Regional Board expects a net environmental benefit to water quality and beneficial uses from the proposed prohibition, TMDLs, and other future regulatory actions. The Regional Board's proposed prohibition is a regulatory action that is related to TMDLs that have been developed by the Regional Board and US Environmental Protection Agency, including:

a. The Malibu Creek Watershed Nutrient TMDL: The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.
b. The Malibu Creek and Lagoon Bacteria TMDL: The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan*, to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite wastewater treatment systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater treatment systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 – October 31), there are no allowable exceedance days, in winter dry weather (November 1 - March 31), there are three allowable exceedances days, and in wet weather (November 1 - October 31), there are 17 allowable exceedance days.
c. The Santa Monica Bay Beaches Wet and Dry Bacteria TMDL: For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as the major source. The TMDLs did not specify load allocations for onsite wastewater treatment systems. This effectively means that no loading is permissible from discharges from on-site wastewater disposal systems.

The proposed prohibition, in that it is a remedy to water quality impairments, is closely related to the Malibu Creek Watershed Nutrient TMDL, Malibu Creek and Lagoon Bacteria TMDL, and Santa Monica Bay Beaches Wet and Dry Bacteria TMDL. Additionally, the Regional Board has issued other TMDLs that affect the area, such as a trash TMDL in the Malibu Creek watershed. The Regional Board and other agencies may issue future regulations that affect the area. When

DRAFT

future regulatory actions are taken, such as adoption of additional TMDLs, programmatic impacts, including cumulative impacts, would be analyzed.

On a project level, the Regional Board expects a net environmental benefit over the long term from projects undertaken to comply with the prohibition, TMDLs, and other regulatory actions, in that water quality will be improved and beneficial uses will be restored. Specific projects to comply with the prohibition must be environmentally evaluated and cumulative impacts considered as the implementing municipality or agency considers such projects.

Growth-Inducing Impacts

Staff's analyses of other environmental impacts resulting from reasonably foreseeable options of complying with the proposed prohibition also includes growth-inducing impacts, including:

- an overview of the CEQA Guidelines relevant to evaluating growth inducement,
- a discussion of the types of growth that can occur in the Malibu Civic Center area,
- a discussion of obstacles to growth in the area, and
- an evaluation of the potential for the Program Alternatives to induce growth.

Growth-inducing impacts are defined by the State CEQA Guidelines as:

> The ways in which a proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are impacts which would remove obstacles to population growth. Increases in the population may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects... [In addition,] the characteristics of some projects.. .may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It is not assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.
>
> (CEQA Guidelines, Section 15126.2(d)).

Growth inducement indirectly could result in adverse environmental effects if the induced growth is not consistent with or accommodated by the land use plans and growth management plans and policies. Local land use plans provide for land use development patterns and growth policies that encourage orderly urban development supported by adequate public services, such as water supply, roadway infrastructure, sewer services, and solid waste disposal services.

Public works projects that are developed to address future unplanned needs (i.e., that would not accommodate planned growth) could result in removing obstacles to population growth. Direct growth inducement would result if, for example, a project involved the construction of new wastewater treatment facilities to accommodate populations in excess of those projected by local or regional planning agencies. Indirect growth inducement would result if a project accommodated unplanned growth and indirectly established substantial new permanent employment opportunities (for example, new commercial, industrial, or governmental enterprises) or if a project involved a construction effort with substantial short-term employment opportunities that indirectly would stimulate the need for additional housing and services.

D R A F T

Growth inducement also could occur if the project would affect the timing or location of either population or land use growth, or create a surplus in infrastructure capacity.

Types of Growth: The primary types of growth that occur within the area affected by the proposed prohibition are:

- development of land, and
- population growth. (Economic growth, such as the creation of additional job opportunities, also could occur; however, such growth generally would lead to population growth and, therefore, is included indirectly in population growth.)

Growth in land development is the physical development of residential, commercial, and industrial structures in the Malibu Civic Center area. Land use growth is subject to general plans, community plans, parcel zoning, and applicable entitlements and is dependent on adequate infrastructure to support development.

Population growth is growth in the number of persons that live and work in the Malibu Civic Center area and other jurisdictions within the boundaries of the area. Population growth occurs from natural causes (births minus deaths) and net emigration to or immigration from other geographical areas. Emigration or immigration can occur in response to economic opportunities, life style choices, or for personal reasons.

Although land use growth and population growth are interrelated, land use and population growth could occur independently from each other. This has occurred in the past where the housing growth is minimal, but population within the area continues to increase. Such a situation results in increasing population densities with a corresponding demand for services, despite minimal land use growth.

Overall development in the unincorporated areas of the County of Los Angeles and County of Ventura and in incorporated municipalities is governed by general plans, which are intended to direct land use development in an orderly manner. The framework for general plans under which development occurs, and, within this framework, other land use entitlements (such as variances and conditional use permits) can be obtained. Because the general plans guide land use development and allow for entitlements, they do not represent an obstacle to land use growth. The Malibu Civic Center area that would be affected by the proposed prohibition is within the City of Malibu, which has plans that guide land use development.

Existing Obstacles to Growth: Obstacles to growth could include inadequate infrastructure (e.g. an inadequate water supply that results in rationing or inadequate wastewater treatment capacity that results in restrictions in land use development). Policies that discourage either natural population growth or immigration also are considered to be obstacles to growth.

Potential for Compliance with the Proposed Prohibition to Induce Growth

The prohibition on OWDSs in the Malibu Civic Center area is not expected to directly induce growth, in that it would not result in the construction of new housing.

Furthermore, the prohibition on OWDSs in the Malibu Civic Center area is not expected to indirectly induce growth, in that it would not result generate long-term economic opportunities

DRAFT

that could lead to additional immigration, and would not remove an obstacle to land use or population growth. However, and although construction activities associated compliance projects for the prohibition would increase the economic opportunities in the area and region, this construction activity is not expected to result in or induce substantial or significant population or land use development growth because the majority of the new jobs that would be created by this construction are expected to be filled by persons already residing in the area or region, based on the existing surplus of unemployed persons in the area and region.

Unavoidable Significant Adverse Impacts

Section 15126.2(c) of the CEQA Guidelines requires a discussion of potential significant, irreversible environmental changes that could result from a proposed project. Examples of such changes include commitment of future generations to similar uses, irreversible damage that may result from accidents associated with a project, or irretrievable commitments of resources. Although the proposed TMDL would require resources (materials, labor, and energy) they do not represent a substantial irreversible commitment of resources.

In addition, implementation of the TMDL will have substantial benefits to water quality and will enhance beneficial uses. Enhancement of the recreational beneficial uses (both water contact recreation and non-contact water recreation) will have positive social and economic effects by decreasing potential trash hazards and increasing the aesthetic experience at beaches, parks around the lake, and other recreation areas. In addition, habitat carries a significant non-market economic value. Enhancement of habitat beneficial uses will also have positive indirect economic and social benefits. Section 6 of this SED identifies the anticipated environmental effects for each resource area, identifies mitigation measures for potentially significant impacts, and determines that impacts after implementation of mitigation are insignificant.

Statement of Overriding Considerations and Determination

The Regional Board staff has balanced the economic, legal, social, technological, and other benefits of this proposed prohibition on OWDSs against the unavoidable environmental risks in determining whether to recommend that the Regional Board approve the prohibition. Upon review of the environmental information generated for this prohibition and in view of the entire record supporting the need for a prohibition, staff has determined that specific economic, legal, social, technological, and other benefits of this proposed prohibition outweigh the unavoidable adverse environmental effects, and that such adverse environmental effects are acceptable under the circumstances.

The implementation of this amendment to the *Basin Plan* will result in improved water quality in the waters of the Region and will have significant positive impacts to the environment (including restoration and enhancement of beneficial uses) and the economy over the long term. Enhancement of recreational uses of beaches, aquatic habitat in Malibu Lagoon, and drinking water potential in groundwater will have positive social and economic effects. Specific projects implemented to comply with the prohibition may have adverse significant impacts to the environment, but these impacts are generally expected to be limited. short-term or may be mitigated through design and scheduling.

D R A F T

This environmental staff report, together with the technical staff report and tentative resolution provide the necessary information pursuant to Public Resources Code section 21159 to conclude that properly designed and implemented compliance projects generally should not foreseeably have a significant adverse effect on the environment. Any potential impacts can be mitigated at the subsequent project level when specific sites and methods have been identified, and responsible local governments can and should implement the recommended mitigation measures.

Specific projects to comply with this prohibition that may have a significant impact will be implemented by local agencies and jurisdictions and would therefore be subject to a separate environmental review. A lead agency for the compliance projects would have the ability to mitigate project impacts, can and should mitigate project impacts, and are required under CEQA to mitigate any environmental impacts it identifies, unless it has reason not to do so. Notably, in almost all circumstances, where unavoidable or unmitigable impacts would present unacceptable hardship upon nearby receptors or venues, a local agency has a variety of alternative implementation measures available instead.

The implementation of this prohibition is expected to result in improved water quality in the Malibu Civic Center area and reduction of public nuisance, but it may result in short-term localized significant adverse impacts to the environment as a large construction projects may be undertaken in the vicinity of the area. These impacts are generally expected to be limited, short-term or may be mitigated through careful design and scheduling. The technical and environmental staff reports for this proposed prohibition in the Malibu Civic Center area, including the CEQA checklist, provide the necessary information pursuant to Public Resources Code section 21159 to conclude that properly designed and implemented compliance project should mitigate and generally avoid significant adverse effects on the environment, and the agency responsible for implementing the prohibition should ensure that its projects are properly designed and implemented.

All of the potential impacts must, however, be mitigated at the subsequent, project level because they involve specific sites and designs not specified or specifically required by the *Basin Plan* amendment to implement the prohibition. At this stage, any more particularized conclusions would be speculative. The Regional Board does not have legal authority to specify the manner of compliance with its orders or regulations (CWC, section 13360), and thus cannot dictate that an appropriate location be selected for any particular project, that it be designed consistent with standard industry practices, or that routine and ordinary mitigation measures be employed. These measures are all within the jurisdiction and authority of an agency, or local government, that would be responsible for implementing this prohibition, and that agency can and should employ those alternatives and mitigation measures to reduce any impacts as much as feasible. (14 Cal. Code Regs., section 15091(a)(2).)

Implementation of the proposed prohibition is both necessary and beneficial. To the extent that the alternatives, mitigation measures, or both, that are examined in this analysis are not deemed feasible by those local agencies, the necessity of implementing the prohibition and restoring beneficial uses (an action required to achieve the express, national policy of the Clean Water Act) remains.

DRAFT

CEQA Analysis

Environmental Checklist and Discussion

The Regional Board has endeavored to analyze and disclose impacts to the environment that are expected to result from possible projects that would achieve compliance with the proposed Regional Board prohibition. These compliance projects, described in the previous section, include construction, operation, and maintenance of:

D. "Integrated Facilities," including the construction and operation of a central wastewater treatment plant in the community, a local sewer collection system, and recycled water distribution system. The community may also elect to broaden the scope of such a project, in order to integrate these services with delivery of potable water supplies; however, for purposes of this analysis, a more limited scope was assumed.

E. "Interceptor Sewer," including construction and operation of a local sewer collection system and an interceptor sewer to export sewage for treatment at a facility in another community.

F. "Decentralized Facilities," including the construction and operation of small plants in the community, small sewer collection systems, and limited recycled water distribution systems.

These compliance projects are expected to have positive environmental impacts, in that discharges through OWDSs should cease, resulting in improvement to water quality and restoration of beneficial uses. However, these projects also have potential significant adverse impacts to the environment that would occur from the construction, operation, and maintenance of these community facilities, and from abandonment of OWDSs currently in use. These impacts, which are generally of relatively short duration, can either be mitigated or alternative means of compliance with the Regional Board prohibition may be available.

The impacts from the possible compliance projects are analyzed below on a conceptual basis. A review of possible projects[4] and a more detailed, project specific analysis should be led by community leaders with robust participation among stakeholders. It will be the responsibility of the community and stakeholders to select a strategy for compliance. And as a strategy and compliance project are selected, it will be the responsibility of a local government (local agency) to perform a specific project-level analysis and disclose environmental impacts in accordance with CEQA (Pub. Res. Code § 21159.2).

[4] The Regional Board is prohibited from specifying the manner of compliance with its regulations (Water Code § 13360).

DRAFT

3-1370

ENVIRONMENTAL CHECKLIST		Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
1.	**Earth. Will the proposal result in:**				
	a. Unstable earth conditions or in changes in geologic substructures?		X		
	b. Disruptions, displacements, compaction or overcoming of the soil?		X		
	c. Change in topography or ground surface relief features?				X
	d. The destruction, covering or modification of any unique geologic or physical features?				X
	e. Any increase in wind or water erosion of soils, either on or off the site?		X		
	f. Changes in deposition or erosion of beach sands, or changes in siltation, deposition or erosion which may modify the channel of a river or stream or the bed of the ocean or any bay, inlet or lake?			X	
	g. Exposure of people or property to geologic hazards, such as earthquakes, landslides, mudslides, ground failure, or similar hazards?		X		

Discussion:

a. Many of the areas where the compliance projects would be located are already developed and significantly altered, and the projects would not subject people or structures to seismic risk or unstable soils. However, portions of the Interceptor Sewer and portions of the collection system for all compliance projects might be constructed through zones of slope instability. During this construction period, compliance with standard design and construction specifications and implementation recommendations to mitigate geologic hazards, prepared at a project level, would reduce the risk of geologic hazards.

b. Implementation of any of the compliance projects would disturb soils during excavations and trenching for sewers, pump stations, and/or recycled water distribution lines, and also during foundation work for treatment plant facilities for the Integrated Facilities and Decentralized Facilities. To the extent that any soil is disturbed during construction, standard construction techniques, including but not limited to, shoring, piling and soil stabilization would mitigate any potential impacts. Prior to earthwork, geotechnical studies would be conducted to evaluate geology and soil conditions.

   Upon completion of any of the compliance projects, trenching for lateral sewer lines and proper abandonment of existing OWDSs may disturb soils. Standard practices and techniques for stabilizing soils and minimizing erosion and sedimentation during trenching and installation activities should mitigate these impacts, and would be further evaluated on a project basis.

c. No impact, as infrastructure for the compliance projects could be of a size or scale that minimizes impact to topography and relief.

DRAFT

3-1371

d. No impact.

e. For all compliance projects, construction activities would require soil displacement and could result in the loss of topsoil. Trenching equipment would be required to install sewer lines, interceptor line, and recycled water delivery lines. Construction activities would include the use of machinery for rough and final grading. To mitigate these impacts, topsoil could be stockpiled and standard best management practices (BMPs) could be identified and implemented to prevent/control erosion from water and wind.

f. Portions of all compliance projects would occur in loosely consolidated beach sands. As documented in 1(e) above, construction activities would require soil displacement. Trenching equipment would be required to install sewer lines, an interceptor line, and recycled water delivery lines. Construction activities would include the use of machinery for rough and final grading. To mitigate these impacts, standard BMPs would be identified and implemented to prevent/control erosion from water and wind.

g. Portions of the Interceptor Sewer and portions of the the collection system for all compliance projects might be sited and constructed in zones of slope instability. As documented in 1(a) above, compliance with standard design and construction specifications and implementation recommendations to mitigate geologic hazards, prepared at a project level, would reduce the risk of geologic hazards.

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
2.	**Air. Will the proposal result in:**				
	a. Substantial air emissions or deterioration of ambient air quality?		X		
	b. The creation of objectionable odors?		X		
	c. Alteration of air movement, moisture or temperature, or any change in climate, either locally or regionally?				X

Discussion:

a. All compliance projects would be located in the South Coast Air Basin, which is classified as an extreme non-attainment area for ozone and serious non-attainment area for PM_{10} and CO. Due to a coastal influence in the area, air quality is generally considered better than much of the South Coast Air Basin.

During construction of all compliance projects, short-term increases in traffic and short-term use of construction equipment would increase air emissions and generate minor amounts of NOX, CO, SO_2, ROG. and PM_{10}; these emissions would be quantified during planning and design at the project level. With mitigation measures, these emissions should be within the South Coast Air Quality Management District's construction significance thresholds. Measures to mitigate these impacts might include use of construction and maintenance vehicles with lower-emission engines, use of soot reduction traps or diesel particulate filters, and use of emulsified diesel fuel.

During operation of treatment facilities associated with the Integrated Facilities, Decentralized Facilities, and pump stations for local sewers associated with all compliance projects,

maintenance activities and solid waste removal are not expected to significantly increase air emissions. Furthermore, solid waste removal schedules could be synchronized with general trash removal schedules.

b. All compliance projects have the potential to eliminate existing odors from problematic OWDSs and from pumping excess sewage into tanker trucks for off-site hauling. However, the projects may also create odors in the treatment facilities such as the Integrated Facilities and Decentralized Facilities. The potential for such odors would be evaluated during planning and design at the project level. Mitigation measures, such as siting, design, and buffer zones, would be identified and considered at a project level.

c. No impact.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
3.	**Water. Will the proposal result in:**				
	a. Changes in currents, or the course of direction or water movements, in either marine or fresh waters?				X
	b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?			X	
	c. Alterations to the course of flow of flood waters?				X
	d. Change in the amount of surface water in any water body?				X
	e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?		X		
	f. Alteration of the direction or rate of flow of ground waters?	X			
	g. Change in the quantity or quality of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	X			
	h. Substantial reduction in the amount of water otherwise available for public water supplies?				X
	i. Exposure of people or property to water related hazards such as flooding or tidal waves?				X

Discussion:

a. No changes in currents or surface water flow are expected.

DRAFT

b. Decreases in absorption rates resulting and changes in surface water runoff from hardscape at the plant(s) for the Integrated Facilities and Decentralized Facilities are expected to be minimal. These impacts would be evaluated at the project level, and minimized through siting and design of the facilities during the planning stages.

c. No alterations to the course of flow of flood waters is expected.

d. No change in the amount of flow of surface water is expected.

e. Water quality problems, including eutrophication in Malibu Lagoon and pathogen levels at beaches that necessary beach advisories, are well known in the area. Implementation of compliance projects is expected to improve, over the long-term, the quality of surface waters in the area and to restore beneficial uses.

However, during construction of all of the compliance projects, possible short-term impacts may result. The potential for such impacts, such as increased turbidity and sediment in runoff from construction sites, would be evaluated during planning and design at the project level. Mitigation measures, such as construction BMPs to control pollution in stormwater, would be identified and considered at a project level.

Furthermore, for compliance projects such as the Integrated Facilities, there may not be sufficient demand for recycling of all of the wastewaters, and a portion of the 300,000 gpd flow may need to be discharged. Should areas with favorable hydrogeologic conditions for subsurface disposal not be identified, such projects may require export of the treated wastewater through an ocean outfall. With proper design and operation of treatment facilities and outfall equipment such as diffusers and temperature controls, an ocean outfall discharge should meet water quality objectives, including temperature and turbidity. These impacts, together with mitigation measures, would be considered at a project level.

f. Upon operation of all compliance projects, termination of discharges from OWDSs would alter, on a local scale, groundwater flow patterns. Should subsurface disposal mechanisms be used for all or a portion of the discharge from the Integrated Facilities and Decentralized Facilities, groundwater flow patterns would be altered on a larger scale.

In anticipation of restoration of groundwater quality, integrated planning and design for disposal field sites should consider potential sites for future production wells to meet a portion of the community's potable water needs or as a short-term water supply in the event of disrupted delivery from the Los Angeles County Waterworks District No. 29 – Malibu. Future groundwater production would significantly alter the direction and rate of flow of groundwater. These and other impacts would be evaluated during planning and design at the project level, and monitored during operation of disposal mechanisms.

g. One of the goals of the Regional Board's proposed prohibition is to improve the quality of groundwater and restore this resource as a potential source of drinking water. See also 3(f) above.

h. No reduction to public water supplies is expected. One of the goals of the Regional Board's proposed prohibition is to improve the quality of groundwater and restore this resource as a potential source of drinking water. See also 3(f) above.

i. No impact is expected from exposure of people or property to water-related hazards during either construction or operation of the compliance projects.

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
4.	**Plant Life. Will the proposal result in:**				
	a. Change in the diversity of species, or number of any species of plants (including trees, shrubs, grass, crops, microflora and aquatic plants)?		X		
	b. Reduction of the numbers of any unique, rare or endangered species of plants?		X		
	c. Introduction of new species of plants into an area, or in a barrier to the normal replenishment of existing species?				X
	d. Reduction in acreage of any agricultural crop?				X

Discussion:

a. As much of the Malibu Civic Center area is urbanized, construction and operation of facilities associated with all compliance projects would not disturb or change plant diversity or change or reduce the number of unique, rare, or endangered species of plants. However, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including special-status species and habitats, wetlands, and trees protected under local ordinances or policies. Important plant communities include the coastal salt marsh and coastal stand. The diversity of species, or number of any species of plants, could be maintained by siting and/or by preserving plants prior, during, and after the construction of facilities by re-establishing and maintaining the plant communities after construction.

b. As documented in 4(a) above, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including unique, rare or endangered species of plants. When the specific projects are developed and sites identified, a search of the California Natural Diversity Database could be employed to confirm that any potentially sensitive plant species or biological habitats in the site area are properly identified and protected as necessary. Focused protocol plant surveys for special-status-plant species could be conducted. Responsible agencies should endeavor to avoid compliance measures that could result in reduction of the numbers of any unique, rare or endangered species of plants. If sensitive plant species occur on a project site, a local agency should require mitigation in accordance with the Endangered Species Act. These mitigation measures would be developed in consultation with the California Department of Fish and Game (CDFG) and the United States Fish and Wildlife Service (USFWS).

c. No impact.

d. No impact.

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
5.	**Animal Life. Will the proposal result in:**				
	a. Change in the diversity of species, or numbers of any species of animals (birds, land animals including reptiles, fish and shellfish, benthic organisms, insects or microfauna)?		X		
	b. Reduction of the numbers of any unique, rare or endangered species of animals?		X		
	c. Introduction of new species of animals into an area, or result in a barrier to the migration or movement of animals?				X
	d. Deterioration to existing fish or wildlife habitat?		X		

Discussion:

a. As much of the Malibu Civic Center area is urbanized, construction and operation of facilities associated with all compliance projects would not disturb or change the diversity of animal species or change or reduce the numbers of any of species. However, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including the wetlands and riparian habitat. Malibu Lagoon is a refuge for migrating birds. When specific projects are developed and sites identified, measures should also be identified to avoid and mitigate impacts to habitat and direct impacts to animals and wildlife during construction and operation.

b. As documented in 5(a) above, portions of the area are environmentally sensitive and, depending on the location selected for the facilities, impacts could potentially occur to biological resources including unique, rare or endangered species of animals. Construction activities may be proposed within and/or adjacent to areas potentially supporting these species and may result in the temporary and/or permanent modification of their habitat. When the specific projects are developed and sites identified, a search of the California Natural Diversity Database could be employed to confirm that any potentially special-status animal species in the site area be properly identified and protected as necessary. When specific projects are developed and sites identified, measures should be identified that will avoid or mitigate impacts to the habitats and also direct impacts to animals during construction and operation. If a project site is located in a habitat for a sensitive animal species, a local agency should require mitigation in accordance with the Endangered Species Act. These mitigation measures would be developed in consultation with the California Department of Fish and Game (CDFG) and the United States Fish and Wildlife Service (USFWS).

c. No impact.

d. As documented in 5(a) above, portions of the area are environmentally sensitive and, should facilities be located in a habitat supporting fish or wildlife habitat, some short-term deterioration to this habitat might occur during construction. When specific projects are developed and sites identified, measures should be identified that will avoid or mitigate impacts to habitat and also direct impacts to animals during construction and operation.

DRAFT

However, it is expected that all the compliance projects will, over the long-term, considerably improve habitat for aquatic life and wildlife.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
6.	**Noise. Will the proposal result in:**				
	a. Increases in existing noise levels?		X		
	b. Exposure of people to severe noise levels?		X		

Discussion:

a. During construction, all compliance projects would be expected to result in noise and/or vibration. When specific projects are developed, measures should be identified to ensure that noise is kept to levels that comply with any noise standard or ordinance.

During operation, no significant increase in noise is anticipated from any of the possible compliance projects. There may be a reduction in noise on commercial sites that on tanker trucks to regularly pump raw sewage for off-site hauling once these sites are connected to one of the compliance projects.

b. As noted in 6(a) above, all compliance projects would be expected to result in noise and/or vibration during construction. Machinery used for construction would likely include standard equipment such as graders, dozers, backhoes, and other similar equipment. It is unknown at this time if pile driving equipment would be required to construct any facilities. Noise impacts from vehicles, machines, and equipment, would be short-term and of a temporary duration. When specific projects are developed, measures should be identified to ensure that noise is kept to levels that comply with any noise standard or ordinance.

During operation, no significant increase in noise is anticipated from any of the possible compliance projects.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
7.	**Light and Glare. Will the proposal:**				
	a. Produce new light or glare?			X	

Discussion:

a. Construction of the compliance projects is not likely to produce new light or glare, assuming none of the reasonably foreseeable mitigation measures involve additional lighting. For the Interceptor

DRAFT

Sewer, however, should construction night-time schedules be used to mitigate traffic impacts during construction, additional lighting will be needed. Such impacts, which would be short-term, should be evaluated at the project level.

During operation of all compliance projects, no need for significant lighting is expected. For lighting that may needed, light and glare to passing vehicles, neighborhood homes, and businesses during operation, can be minimized by a lighting plan specifying hoods or shields on all light fixtures and limiting light trespass and glare through the use of shielding and directional lighting methods.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
8.	**Land Use. Will the proposal result in:**				
	a. Substantial alteration of the present or planned land use of an area?	X			

Discussion:

a. Sewer lines for all three compliance projects will not have impacts on land use, zoning, or the physical arrangement of the community. After installation of the sewer lines, pre-project conditions would be restored.

Land for treatment plant facilities for the Integrated Facilities and Decentralized Facilities might require changes in land use. The Integrated Facilities' wastewater/recycled water plant would require land for construction and operation of this facility. Should disposal of treated wastewater that cannot be recycled be discharged to the subsurface, additional land for infiltration would be required. The Decentralized Facilities also would require land for plant(s) and subsurface disposal, although such land requirements may be on a smaller scale and require a smaller footprint. Impacts would be considered at a project level.

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
9.	**Natural Resources. Will the proposal result in:**				
	a. Increase in the rate of use of any natural resources?				X
	b. Substantial depletion of any nonrenewable natural resource?				X

Discussion:

a. No impact. The compliance projects would not use or deplete any mineral resources in the area. The use of electrical power and fuel is discussed in the Energy portion of the checklist.

During operations, no impact to natural resources is anticipated, other than land. See the discussion under Land – 8(a).

b. No Impact. See Natural Resources – 9(a) above.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
10.	**Risk of Upset. Will the proposal involve:**				
	a. A risk of an explosion or the release of hazardous substances (including, but not limited to: oil, pesticides, chemicals or radiation) in the event of an accident or upset conditions?			X	

Discussion:

a. For all compliance projects, it is reasonably foreseeable that hazards or hazardous materials would be used during construction, operation, and maintenance of the facilities. However, the use of these materials is not expected to create a significant hazard to the public or environment through the routine transport, use, or disposal of hazardous materials. The hazardous materials that might be used are controlled substances regulated at the state and local levels. Materials would be delivered by contractors licensed to handle and transport these materials in accordance with applicable laws and regulations. The storage and use of materials would be strictly regulated and a hazardous materials management program would be developed for use by construction contractors and plant operators. This information would also be filed with the fire department. See also the discussion under 14(a).

Due to the nature (wastewater management) of all compliance projects, the risk of exposure to raw sewage and partially treated wastewater should be lowered, as the projects are intended to better control and manage wastewaters generated within the community.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
11.	**Population. Will the proposal:**				
	a. Alter the location, distribution, density, or growth rate of the human population of an area?			X	

DRAFT

Discussion:

a. All compliance projects would replace existing on-site wastewater disposal systems, and should not affect population and growth. However, during construction of all compliance projects, there may be brief, temporary periods during which construction workers are employed in the area. These workers are not expected to substantially add to new employment and population density.

The compliance projects are expected to be sized to replace existing OWDS flows only, and no population increases stemming from increased housing stock are expected. See the discussion under Housing – 12(a).

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
12.	**Housing. Will the proposal:**				
	a. Affect existing housing, or create a demand for additional housing?			X	

Discussion:

a. All compliance projects would replace existing on-site wastewater disposal systems, and should not increase or stimulate demand for housing. However, during construction of all compliance projects, there may be brief, temporary periods during which construction workers are employed in the area. These temporary workers are expected to be present for one shift per work day, and should not add to housing demands.

The compliance projects are not expected to be sized to provide capacity for existing wastewater flow rates only, and do not anticipate new connections. During operation of all compliance projects, no increased demand for housing stemming from job creation at the compliance projects is anticipated.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
13.	**Transportation/Circulation. Will the proposal result in:**				
	a. Generation of substantial additional vehicular movement?		X		

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
	b. Effects on existing parking facilities, or demand for new parking?		X		
	c. Substantial impact upon existing transportation systems?			X	
	d. Alterations to present patterns of circulation or movement of people and/or goods?				X
	e. Alterations to waterborne, rail or air traffic?				X
	f. Increase in traffic hazards to motor vehicles, bicyclists or pedestrians?		X		

DRAFT

Discussion:

a. Construction of all three compliance projects would require construction crews and earthmoving equipment, and may require soil transport, resulting in some traffic congestion of a short-term, temporary duration. Measures to mitigate these impacts, which would be examined more closely on a project level, could include development of a traffic mitigation plan. For the Interceptor Sewer, a project level analysis should consider night-time schedules for construction along the Pacific Coast Highway, which is the most heavily traveled highway in the area and which is an important regional link.

   During operation of the compliance projects, no impacts are expected to traffic. Traffic conditions may improve upon completion of the compliance projects, as the need for frequent pumping from many commercial facilities will be eliminated.

b. During construction, all compliance projects may cause some loss of parking capacity. However, this impact is temporary. Measures to mitigate such impacts would be examined more closely on a project level, could include development of a traffic mitigation plan which addresses parking issues.

   During operation, no significant impacts are expected.

c. During construction, all compliance projects may impact existing roadways and parking capacity. The Interceptor Sewer project would have significant impacts on vehicle traffic on the Pacific Coast Highway; however, this impact will be temporary and limited to the construction phase and for intermittent maintenance activity. Impacts would be examined more closely on a project level, and measures to facilitate traffic movement, such as minimizing construction traffic in peak traffic times and providing temporary traffic signals/flagging could be developed in a traffic mitigation plan.

   During operation, no significant impacts are expected

3-1381

d. No impact.

e. No impact. No waterborne, air, or rail traffic is expected to be generated from any of the compliance projects during construction or operation.

f. No permanent road or design hazards are associated with operation of any of the possible compliance projects. However, during construction, all three compliance projects would require construction crews, earthmoving equipment, and – for Interceptor Sewer – possible night-time construction activity. These activities would result in some traffic congestion of a short-term, temporary duration. Hazards arising from such conditions would be considered at a project level, and measures to lower risk to vehicles, bicyclists, and pedestrians might include signage and markings, barricades, and traffic flow controls (signals or traffic control personnel), and coordination with local police and the California Highway Patrol. These methods would be selected and implemented by responsible local agencies considering project level concerns.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
14.	**Public Service. Will the proposal have an effect upon, or result in a need for new or altered governmental services in any of the following areas:**				
	a. Fire protection?		X		
	b. Police protection?			X	
	c. Schools?				X
	d. Parks or other recreational facilities?	X			
	e. Maintenance of public facilities, including roads?				X
	f. Other governmental services?				X

DRAFT

Discussion:

a. Construction of all three compliance projects, and operation of the treatment facilities for the Integrated Facilities and Decentralized Facilities would use hazardous materials, and incidents of upset, such as spills, could result in the need for emergency and/or fire suppression response. Traffic impacts during construction of all compliance projects could result in delays in emergency responses; however, most jurisdictions have in place established procedures to ensure safe passage of emergency vehicles during periods of road maintenance, construction, or other attention to physical infrastructure. Impacts to fire protection and response capabilities, and measures to mitigate these impacts, would be considered at a project level.

b. Mitigation of traffic impacts during construction of all compliance projects would require coordination with local police and the California Highway Patrol. See the discussion under 13(f).

These impacts could result in delays in police emergency responses; however, most jurisdictions have in place established procedures to ensure safe passage of emergency vehicles during periods of road maintenance, construction, or other attention to physical infrastructure. Impacts to police protection and response capabilities, and measures to mitigate these impacts, would be considered at a project level.

No impact during operation of any of the compliance projects.

c. No impact is expected to schools.

d. See the discussion of land use impacts under 8(a) above and recreational impacts under 14(a) below. The Integrated Facilities – a centralized integrated wastewater/recycled water plant – would require land for construction and operation of this facility. A possible site for this is Legacy Park. Impacts to parks and measures to mitigate these impacts would be considered at a project level.

Implementation of one of the possible projects to comply with the proposed prohibition is a remedy to restore beneficial uses, including beach closures that currently impair swimming along beaches in the Malibu Civic Center area.

e. No impact to maintenance of public roads is expected. During sewer installation of all three compliance projects, the City of Malibu and other entities with utilities along the public roads may have opportunities to coordinate maintenance and repair activities.

Positive impacts (lower road maintenance) might result from a reduction in tanker truck traffic that will no longer be needed to haul a portion of the community's sewage to facilities in other areas (e.g. Carson).

f. No impact.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
15.	**Energy. Will the proposal result in:**				
	a. Use of substantial amounts of fuel or energy?			X	
	b. Substantial increase in demand upon existing sources of energy, or require the development of new sources of energy?			X	

Discussion:

a. During the construction phase of all compliance projects, construction vehicles, equipment, and machinery would require fossil fuel and/or power. These energy demands are not expected to significantly affect the power grid or deplete resources of fossil fuels; nor are the energy demands expected to conflict with energy conservation plans or use non-renewable resources in a wasteful

DRAFT

manner. Such impacts, and mitigation measures to promote energy efficiency, would be evaluated on a project basis.

During operation of treatment plant facilities for Integrated Facilities, Decentralized Facilities and pumping stations to lift wastewater in sewers for all compliance projects, incremental amounts of energy would be required. Demand on the power grid is expected to be minimal. Such impacts, and mitigation measures to promote energy efficiency, would be evaluated on a project basis.

b. See discussion under 15(a).

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
16.	**Utilities and Service Systems. Will the proposal result in a need for new systems, or substantial alterations to the following utilities:**				
	a. Power or natural gas?			X	
	b. Communications systems?				X
	c. Water?			X	
	d. Sewer or septic tanks?	X			
	e. Storm water drainage?		X		
	f. Solid waste and disposal?			X	

Discussion:

a. Refer to discussion under Energy, 15(a) and 15(b) above.

b. No impact.

c. Operation of the Integrated Facilities, if undertaken in conjunction with capital improvements to the community's water supply system, could improve the reliability of water service.

Furthermore, and by their nature, operation of all the possible projects to comply with the prohibition is expected to result in substantial improvements to water quality, including the quality of groundwater (which is a potential source of drinking water for the community, especially in the event of a disruption to deliveries of imported water supplies).

See also the discussion under Water, 3(g) above.

d. The purpose of the prohibition and possible compliance projects is to eliminate reliance on OWDSs, which have severe constraints, including hydrogeological, siting, capacity, and

DRAFT

operational constraints. By the nature of the prohibition, elimination of the on-site systems will result in a need for sewers and treatment facilities.

e. Refer to discussion under Water, 3(b), 3(c), 3(d), 3(e) above.

f. During construction of all compliance projects, excavated soils should be re-used as fill material to the extent feasible. However, a minimal amount of soils and other construction materials may be wasted. For example, soils and aggregate wastes could be transported to aggregate recycling centers and prepared for reuse, and/or applied as daily cover at landfills. These impacts, which are expected to be less than significant, would be evaluated on a project level.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
17.	**Human Health. Will the proposal result in:**				
	a. Creation of any health hazard or potential health hazard (excluding mental health)?			X	
	b. Exposure of people to potential health hazards?			X	

Discussion:

a. During construction of all three possible compliance projects, there may be an increased risk to the health of construction workers who may be handling hazardous materials. This would be evaluated on a project basis, and appropriate measures – such as Health and Safety Plans and compliance with Cal OSHA regulations – to mitigate these risks should be identified. For a discussion on the risk of Upset, refer to discussion under 10(a).

During operation of the wastewater treatment plants for the Integrated Facilities and Decentralized Facilities and during maintenance of sewers and pump stations for all compliance projects, operating personnel may be exposed to raw sewage and partially treated wastewaters. These possible impacts would be evaluated on a project basis and appropriate measures – such as Health and Safety Plans and compliance with Cal OSHA regulations – to mitigate these risks should be identified.

Due to the nature of the proposed prohibition and possible projects to comply with the prohibition, wastewaters from domestic, commercial, and industrial activities will be better controlled, treated, and discharged (or recycled).

b. See discussion under 17(a) above.

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
18.	**Aesthetics. Will the proposal result in:**				
	a. The obstruction of any scenic vista or view open to the public?			X	
	b. The creation of an aesthetically offensive site open to public view?			X	

Discussion:

a. During construction of all three possible compliance projects, the aesthetics of residents and visitors may be offended by construction equipment and activities. These impacts, which would be temporary, together with appropriate mitigation measures, would be considered at a project level.

After installation of sewers for all three compliance projects, pre-project conditions would be restored, and the sewers would not permanently impact aesthetics.

Facilities such as a treatment plant and reservoir for storing recycled water could impact scenic vistas or views open to the public. These impacts would be evaluated on a project level, and designs could be required that are acceptable to the community.

b. See discussion under 18(a) above.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
19.	**Recreation. Will the proposal result in:**				
	a. Impact upon the quality or quantity of existing recreational opportunities?	X			

Discussion:

a. The Integrated Facilities – a centralized integrated wastewater/recycled water plant – would require land for construction and operation of this facility. A possible site for this is Legacy Park. During construction of the Integrated Facilities, the park may be temporarily unavailable for recreation. Such impacts, together with mitigation measures, would be considered at a project level.

DRAFT

Implementation of one of the possible projects to comply with the proposed prohibition is a remedy to restore beneficial uses, including beach closures that currently impair swimming along beaches in the Malibu Civic Center area. This long-term impact and restoration of water quality in Malibu Lagoon and along beaches will enhance recreational opportunities.

See also the discussions for Land use under 8(a) above and for Public Services—Parks under 14(d) above.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
20.	**Archeological/Historical. Will the proposal:**				
	a. Result in the alteration of a significant archeological or historical site structure, object or building?				X

Discussion:

a. With the exception of a possible site for the treatment plant in Integrated Facilities, sewers and facilities for the possible compliance projects would generally be located in public streets and on public property that has already undergone significant disturbance. Should a relatively undisturbed site such as a portion of Legacy Park be selected for a treatment plant under compliance Integrated Facilites, impacts and mitigation measures for possible archeological resources would be evaluated on a project level.

It is not expected that any of the compliance projects would affect historic structures.

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
21.	**Mandatory Findings of Significance**				
	Potential to degrade: Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	X			

DRAFT

	ENVIRONMENTAL CHECKLIST	Potentially Significant Impact	Less Than Significant with Mitigation Incorporated	Less Than Significant	No Impact
	Short-term: Does the project have the potential to achieve short-term, to the disadvantage of long-term, environmental goals? (A short-term impact on the environment is one which occurs in a relatively brief, definitive period of time, while long-term impacts will endure well into the future.)			X	
	Cumulative: Does the project have impacts which are individually limited, but cumulatively considerable? (A project may impact on two or more separate resources where the impact on each resource is relatively small, but where the effect of the total of those impacts on the environment is significant.)			X	
	Substantial adverse: Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?			X	

D R A F T

Other Environmental Considerations

Analyses of other environmental impacts resulting from reasonably foreseeable options of complying with the proposed prohibition include:

- Cumulative Impacts of the Program Alternatives (as required by CEQA Guidelines Section 15130): Cumulative impacts, defined in Section 15355 of the CEQA Guidelines, refer to two or more individual effects, that when considered together, are considerable or that increase other environmental impacts. A cumulative impact assessment must consider not only impacts of the proposed prohibition, but also impacts from other municipal and private projects that would occur in the area during the period of implementation.
- Potential Growth-Inducing Effects of the Program Alternatives (as required by CEQA Guidelines Section 15126).
- Unavoidable Significant Impacts (as required by CEQA Guidelines Section 15126.2).

Cumulative Impacts

On a programmatic level, the Regional Board expects a net environmental benefit to water quality and beneficial uses from the proposed prohibition, TMDLs, and other future regulatory actions. The Regional Board's proposed prohibition is a regulatory action that is related to TMDLs that have been developed by the Regional Board and US Environmental Protection Agency, including:

3-1388

d. The Malibu Creek Watershed Nutrient TMDL: The US EPA, on March 21, 2003, specified a numeric target of 1.0 mg/l for total nitrogen during summer months (April 15 to November 15) and a numeric target of 8.0 mg/L for total nitrogen during winter months (November 16 to April 14). Significant sources of the nutrient pollutants include discharges of wastewaters from commercial, public, and residential landuse activities. The TMDL specifies a load allocation for onsite wastewater disposal systems of 6 lbs/day during the summer months and 8 mg/L during winter months.
e. The Malibu Creek and Lagoon Bacteria TMDL: The Regional Board specified numeric targets, effective January 24, 2006, based on single sample and geometric mean bacteria water quality objectives in the *Basin Plan*, to protect the water contact recreation use. Sources of bacteria loading include storm water runoff, dry-weather runoff, onsite wastewater treatment systems, and animal wastes. The TMDL specifies load allocations for onsite wastewater treatment systems equal to the allowable number of exceedance days of the numeric targets. There are no allowable exceedance days of the geometric mean numeric targets. For the single sample numeric targets, based on daily sampling, in summer (April 1 – October 31), there are no allowable exceedance days, in winter dry weather (November 1 - March 31), there are three allowable exceedances days, and in wet weather (November 1 - October 31), there are 17 allowable exceedance days.
f. The Santa Monica Bay Beaches Wet and Dry Bacteria TMDL: For beaches along the Santa Monica Bay impaired by bacteria in dry and wet weather, the Regional Board specified numeric targets, effective July 15, 2003, based on the single sample and geometric mean bacteria water quality objectives in the *Basin Plan* to protect the water contact recreation use. The dry weather TMDL identified the sources of bacteria loading as dry-weather urban runoff, natural source runoff and groundwater. The wet weather TMDL identified stormwater runoff as the major source. The TMDLs did not specify load allocations for onsite wastewater treatment systems. This effectively means that no loading is permissible from discharges from on-site wastewater disposal systems.

The proposed prohibition, in that it is a remedy to water quality impairments, is closely related to the Malibu Creek Watershed Nutrient TMDL, Malibu Creek and Lagoon Bacteria TMDL, and Santa Monica Bay Beaches Wet and Dry Bacteria TMDL. Additionally, the Regional Board has issued other TMDLs that affect the area, such as a trash TMDL in the Malibu Creek watershed. The Regional Board and other agencies may issue future regulations that affect the area. When future regulatory actions are taken, such as adoption of additional TMDLs, programmatic impacts, including cumulative impacts, would be analyzed.

On a project level, the Regional Board expects a net environmental benefit over the long term from projects undertaken to comply with the prohibition, TMDLs, and other regulatory actions, in that water quality will be improved and beneficial uses will be restored. Specific projects to comply with the prohibition must be environmentally evaluated and cumulative impacts considered as the implementing municipality or agency considers such projects.

Growth-Inducing Impacts

Staff's analyses of other environmental impacts resulting from reasonably foreseeable options of complying with the proposed prohibition also includes growth-inducing impacts, including:

- an overview of the CEQA Guidelines relevant to evaluating growth inducement,

DRAFT

- a discussion of the types of growth that can occur in the Malibu Civic Center area,
- a discussion of obstacles to growth in the area, and
- an evaluation of the potential for the Program Alternatives to induce growth.

Growth-inducing impacts are defined by the State CEQA Guidelines as:

> The ways in which a proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly, in the surrounding environment. Included in this are impacts which would remove obstacles to population growth. Increases in the population may tax existing community service facilities, requiring construction of new facilities that could cause significant environmental effects... [In addition,] the characteristics of some projects.. .may encourage and facilitate other activities that could significantly affect the environment, either individually or cumulatively. It is not assumed that growth in any area is necessarily beneficial, detrimental, or of little significance to the environment.
>
> (CEQA Guidelines, Section 15126.2(d)).

Growth inducement indirectly could result in adverse environmental effects if the induced growth is not consistent with or accommodated by the land use plans and growth management plans and policies. Local land use plans provide for land use development patterns and growth policies that encourage orderly urban development supported by adequate public services, such as water supply, roadway infrastructure, sewer services, and solid waste disposal services.

Public works projects that are developed to address future unplanned needs (i.e., that would not accommodate planned growth) could result in removing obstacles to population growth. Direct growth inducement would result if, for example, a project involved the construction of new wastewater treatment facilities to accommodate populations in excess of those projected by local or regional planning agencies. Indirect growth inducement would result if a project accommodated unplanned growth and indirectly established substantial new permanent employment opportunities (for example, new commercial, industrial, or governmental enterprises) or if a project involved a construction effort with substantial short-term employment opportunities that indirectly would stimulate the need for additional housing and services. Growth inducement also could occur if the project would affect the timing or location of either population or land use growth, or create a surplus in infrastructure capacity.

Types of Growth: The primary types of growth that occur within the area affected by the proposed prohibition are:

- development of land, and
- population growth. (Economic growth, such as the creation of additional job opportunities, also could occur; however, such growth generally would lead to population growth and, therefore, is included indirectly in population growth.)

Growth in land development is the physical development of residential, commercial, and industrial structures in the Malibu Civic Center area. Land use growth is subject to general

DRAFT

plans, community plans, parcel zoning, and applicable entitlements and is dependent on adequate infrastructure to support development.

Population growth is growth in the number of persons that live and work in the Malibu Civic Center area and other jurisdictions within the boundaries of the area. Population growth occurs from natural causes (births minus deaths) and net emigration to or immigration from other geographical areas. Emigration or immigration can occur in response to economic opportunities, life style choices, or for personal reasons.

Although land use growth and population growth are interrelated, land use and population growth could occur independently from each other. This has occurred in the past where the housing growth is minimal, but population within the area continues to increase. Such a situation results in increasing population densities with a corresponding demand for services, despite minimal land use growth.

Overall development in the unincorporated areas of the County of Los Angeles and County of Ventura and in incorporated municipalities is governed by general plans, which are intended to direct land use development in an orderly manner. The framework for general plans under which development occurs, and, within this framework, other land use entitlements (such as variances and conditional use permits) can be obtained. Because the general plans guide land use development and allow for entitlements, they do not represent an obstacle to land use growth. The Malibu Civic Center area that would be affected by the proposed prohibition is within the City of Malibu, which has plans that guide land use development.

Existing Obstacles to Growth: Obstacles to growth could include inadequate infrastructure (e.g. an inadequate water supply that results in rationing or inadequate wastewater treatment capacity that results in restrictions in land use development). Policies that discourage either natural population growth or immigration also are considered to be obstacles to growth.

Potential for Compliance with the Proposed Prohibition to Induce Growth

The prohibition on OWDSs in the Malibu Civic Center area is not expected to directly induce growth, in that it would not result in the construction of new housing.

Furthermore, the prohibition on OWDSs in the Malibu Civic Center area is not expected to indirectly induce growth, in that it would not result generate long-term economic opportunities that could lead to additional immigration, and would not remove an obstacle to land use or population growth. However, and although construction activities associated compliance projects for the prohibition would increase the economic opportunities in the area and region, this construction activity is not expected to result in or induce substantial or significant population or land use development growth because the majority of the new jobs that would be created by this construction are expected to be filled by persons already residing in the area or region, based on the existing surplus of unemployed persons in the area and region.

Unavoidable Significant Adverse Impacts

Section 15126.2(c) of the CEQA Guidelines requires a discussion of potential significant, irreversible environmental changes that could result from a proposed project. Examples of such changes include commitment of future generations to similar uses, irreversible damage that may result from accidents associated with a project, or irretrievable commitments of resources.

DRAFT

Although the proposed TMDL would require resources (materials, labor, and energy) they do not represent a substantial irreversible commitment of resources.

In addition, implementation of the TMDL will have substantial benefits to water quality and will enhance beneficial uses. Enhancement of the recreational beneficial uses (both water contact recreation and non-contact water recreation) will have positive social and economic effects by decreasing potential trash hazards and increasing the aesthetic experience at beaches, parks around the lake, and other recreation areas. In addition, habitat carries a significant non-market economic value. Enhancement of habitat beneficial uses will also have positive indirect economic and social benefits. Section 6 of this SED identifies the anticipated environmental effects for each resource area, identifies mitigation measures for potentially significant impacts, and determines that impacts after implementation of mitigation are insignificant.

Statement of Overriding Considerations and Determination

The Regional Board staff has balanced the economic, legal, social, technological, and other benefits of this proposed prohibition on OWDSs against the unavoidable environmental risks in determining whether to recommend that the Regional Board approve the prohibition. Upon review of the environmental information generated for this prohibition and in view of the entire record supporting the need for a prohibition, staff has determined that specific economic, legal, social, technological, and other benefits of this proposed prohibition outweigh the unavoidable adverse environmental effects, and that such adverse environmental effects are acceptable under the circumstances.

The implementation of this amendment to the *Basin Plan* will result in improved water quality in the waters of the Region and will have significant positive impacts to the environment (including restoration and enhancement of beneficial uses) and the economy over the long term. Enhancement of recreational uses of beaches, aquatic habitat in Malibu Lagoon, and drinking water potential in groundwater will have positive social and economic effects. Specific projects implemented to comply with the prohibition may have adverse significant impacts to the environment, but these impacts are generally expected to be limited, short-term or may be mitigated through design and scheduling.

This environmental staff report, together with the technical staff report and tentative resolution provide the necessary information pursuant to Public Resources Code section 21159 to conclude that properly designed and implemented compliance projects generally should not foreseeably have a significant adverse effect on the environment. Any potential impacts can be mitigated at the subsequent project level when specific sites and methods have been identified, and responsible local governments can and should implement the recommended mitigation measures.

Specific projects to comply with this prohibition that may have a significant impact will be implemented by local agencies and jurisdictions and would therefore be subject to a separate environmental review. A lead agency for the compliance projects would have the ability to mitigate project impacts, can and should mitigate project impacts, and are required under CEQA to mitigate any environmental impacts it identifies, unless it has reason not to do so. Notably, in almost all circumstances, where unavoidable or unmitigable impacts would present unacceptable

DRAFT

hardship upon nearby receptors or venues, a local agency has a variety of alternative implementation measures available instead.

The implementation of this prohibition is expected to result in improved water quality in the Malibu Civic Center area and reduction of public nuisance, but it may result in short-term localized significant adverse impacts to the environment as a large construction projects may be undertaken in the vicinity of the area. These impacts are generally expected to be limited, short-term or may be mitigated through careful design and scheduling. The technical and environmental staff reports for this proposed prohibition in the Malibu Civic Center area, including the CEQA checklist, provide the necessary information pursuant to Public Resources Code section 21159 to conclude that properly designed and implemented compliance project should mitigate and generally avoid significant adverse effects on the environment, and the agency responsible for implementing the prohibition should ensure that its projects are properly designed and implemented.

All of the potential impacts must, however, be mitigated at the subsequent, project level because they involve specific sites and designs not specified or specifically required by the *Basin Plan* amendment to implement the prohibition. At this stage, any more particularized conclusions would be speculative. The Regional Board does not have legal authority to specify the manner of compliance with its orders or regulations (CWC, section 13360), and thus cannot dictate that an appropriate location be selected for any particular project, that it be designed consistent with standard industry practices, or that routine and ordinary mitigation measures be employed. These measures are all within the jurisdiction and authority of an agency, or local government. that would be responsible for implementing this prohibition, and that agency can and should employ those alternatives and mitigation measures to reduce any impacts as much as feasible. (14 Cal. Code Regs., section 15091(a)(2).)

Implementation of the proposed prohibition is both necessary and beneficial. To the extent that the alternatives, mitigation measures, or both, that are examined in this analysis are not deemed feasible by those local agencies, the necessity of implementing the prohibition and restoring beneficial uses (an action required to achieve the express, national policy of the Clean Water Act) remains.

DISCUSSION OF ENVIRONMENTAL EVALUATION (Based on information in the technical staff report and environmental staff report for the proposed prohibition on OWDSs in the Malibu Civic Center area)

This environmental analysis concludes that there are potentially significant impacts from implementation projects to comply with the proposed prohibition on OWDSs, but notes that there are mitigation measures available to reduce potentially significant environmental impacts to less than significant levels. However, implementation of these mitigation measures are within the responsible and jurisdiction of responsible agencies. These agencies have the ability to implement these mitigation measures, can and should implement these mitigation measures, and are required under CEQA to implement mitigation measures unless mitigation measures are deemed infeasible through specific considerations (Title 14, California Code of Regulations, section 15091(a)(3)).

DRAFT

The environmental analysis also concludes that the possible projects to comply with the prohibition are expected to result, over the long term, in positive environmental improvements to the environment, including water quality and restoration of beneficial uses of water resources.

PRELIMINARY STAFF DETERMINATION

☐ The proposed project COULD NOT have a significant effect on the environment, and, therefore, no alternatives or mitigation measures are proposed.

☑ The proposed project MAY have a significant or potentially significant effect on the environment, and therefore alternatives and mitigation measures have been evaluated.

D R A F T

Wendy Phillips — July 31, 2009

signature — date

Wendy Phillips — July 31, 2009

printed name — Date

Note: Authority cited: Sections 21083 and 21087, Public Resources Code. Reference: Sections 21080(c), 21080.1, 21080.3, 21082.1, 21083, 21083.3, 21093, 21094, 21151, Public Resources Code; Sundstrom v. County of Mendocino, 202 Cal.App.3d 296 (1988); Leonoff v. Monterey Board of Supervisors, 222 Cal.App.3d 1337 (1990).