

**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.*

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

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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 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 data collected and compiled and the beach characteristics were released on August 24, 2009

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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 enterococcus in the groundwater basin is included as part of Technical Memo #2.

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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 contact 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.

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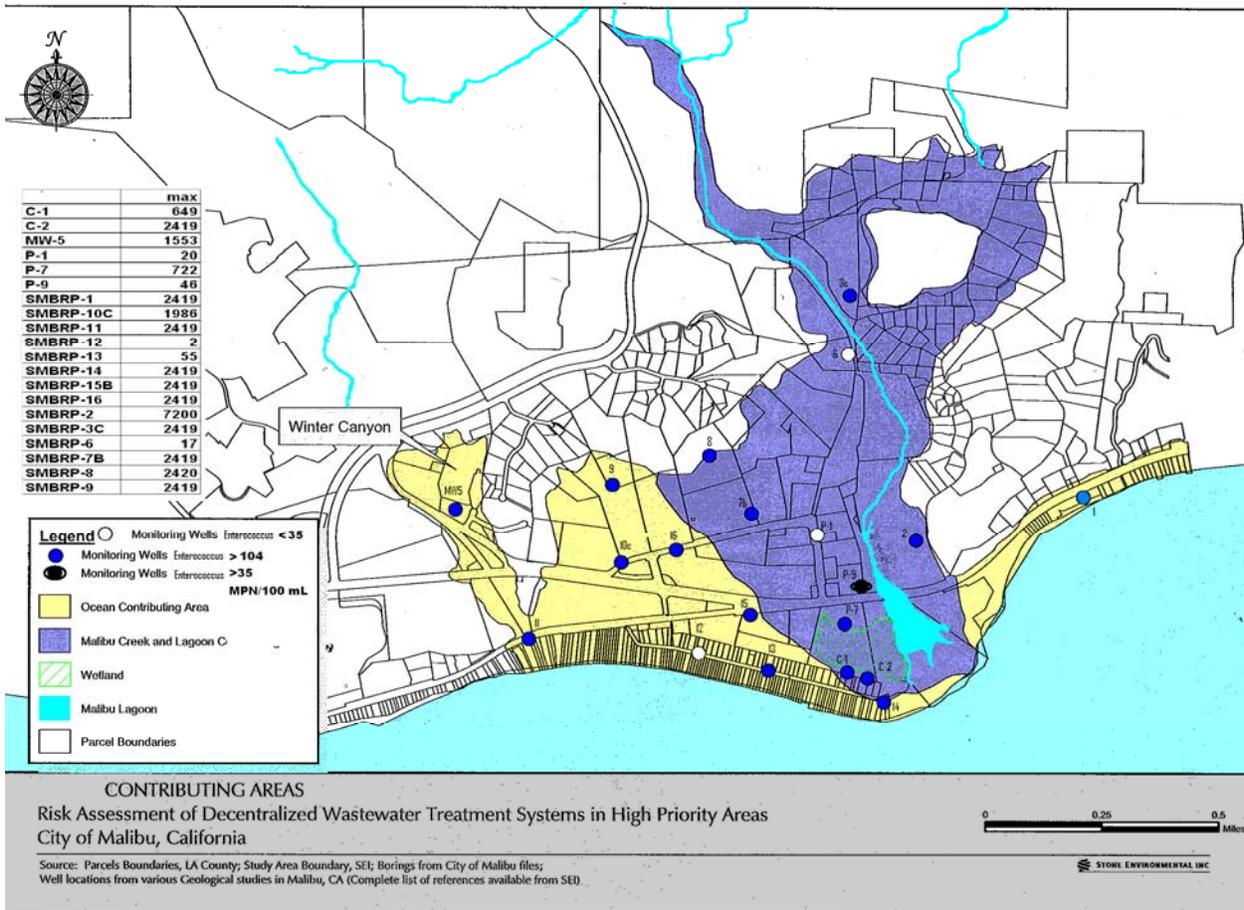
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Figure 1. The maximum enterococcus measures in wells in the Civic Center area after Stone 2004.



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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).

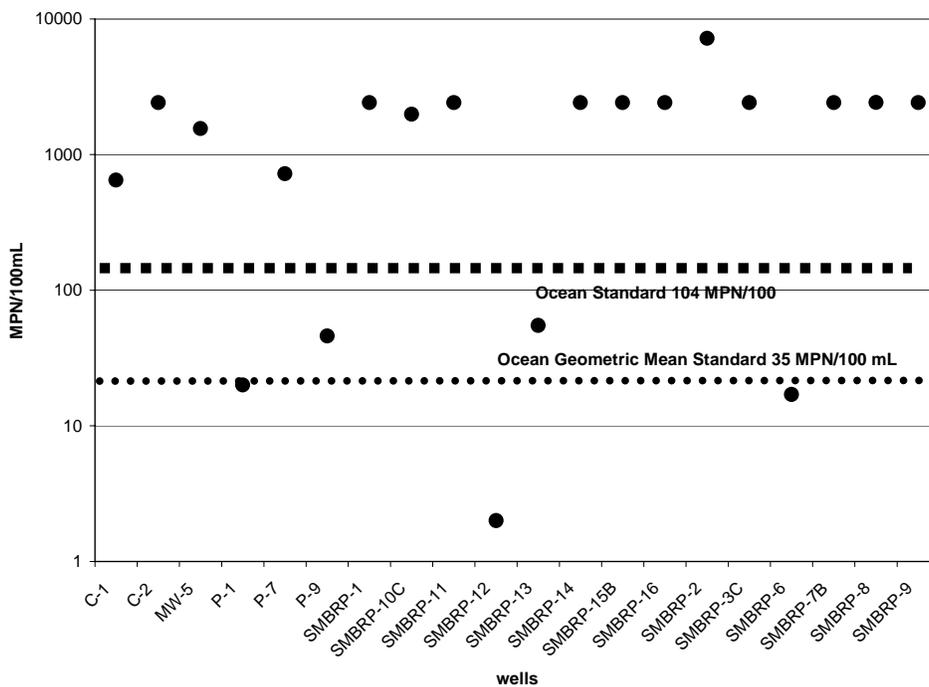
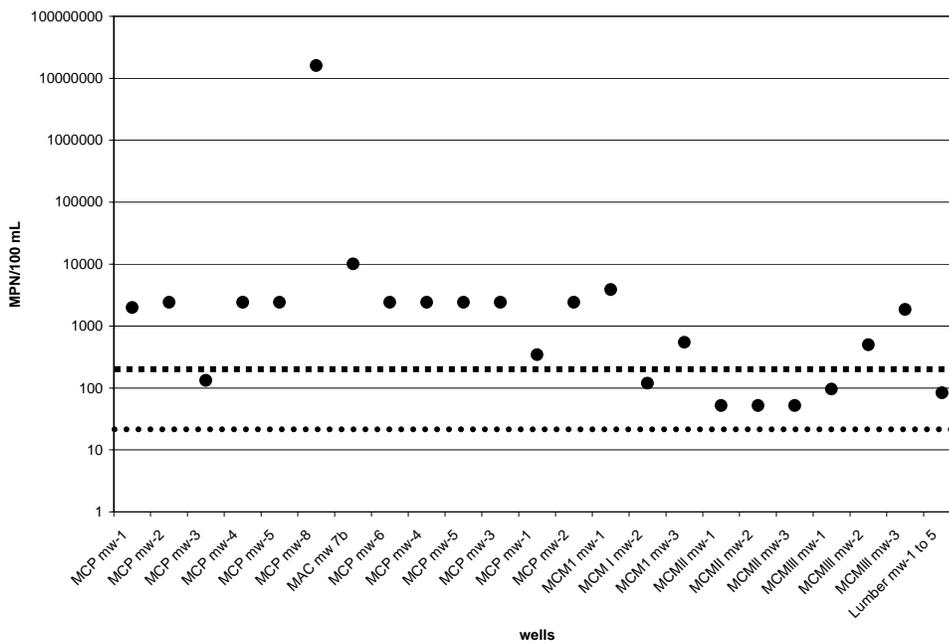


Figure 3: Chart of Maximum Enterococcus Density (MPN/100 mL) for 27 permit monitoring wells in the Civic Center area (well locations are shown in Figure 1 of Technical memorandum #2).



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

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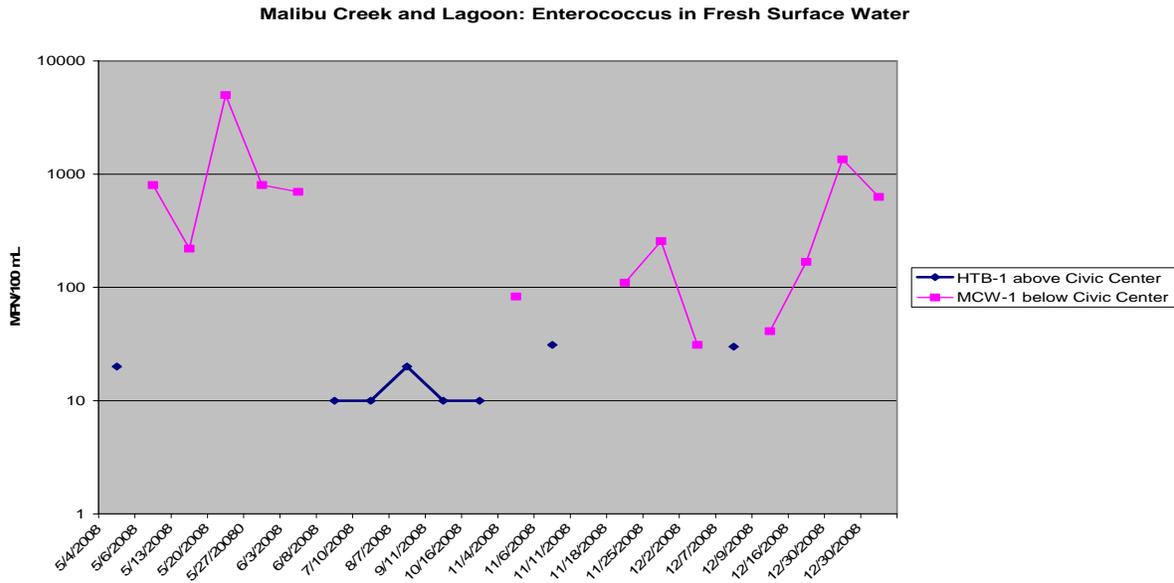
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Figure 5: Summer 2008 Enterococcus above and below Malibu Civic Center in the Lagoon



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.

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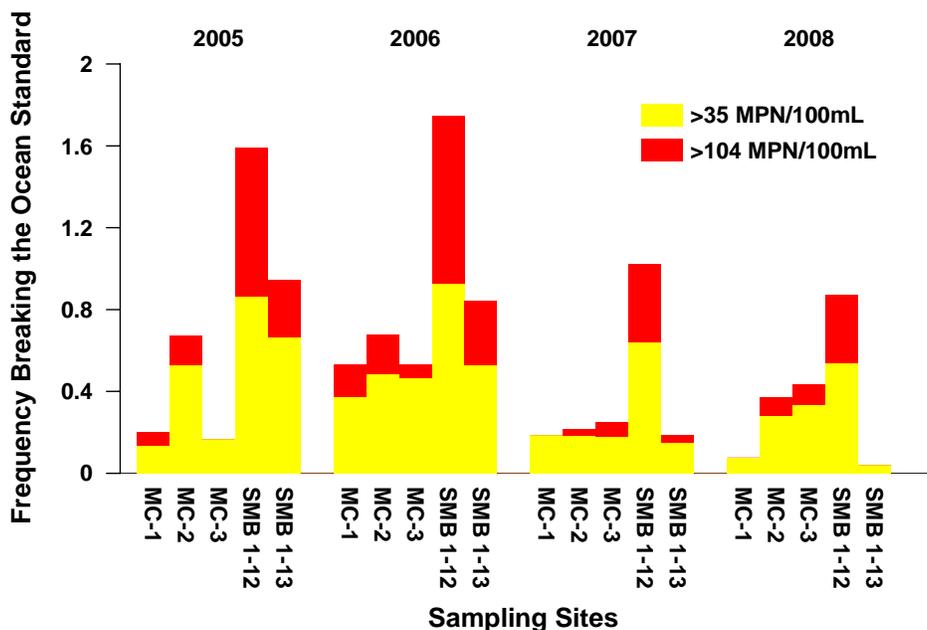
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Table 2: Exceedences of single sample Enterococcus water quality standard.

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%)

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.

Table 3: Surf rider 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	

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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

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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: Malibu 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

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.

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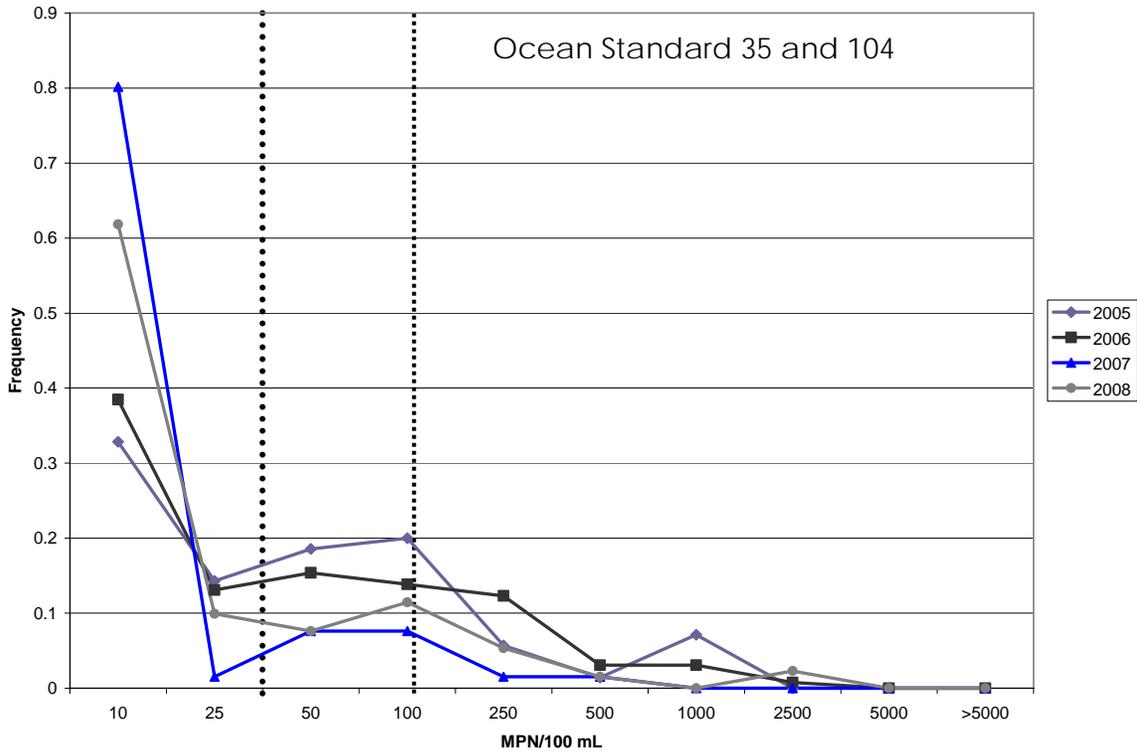
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Figure 7: Surfrider Beach (site MC-2) Enterococcus Interval Frequency for May-October Summer Single Measures



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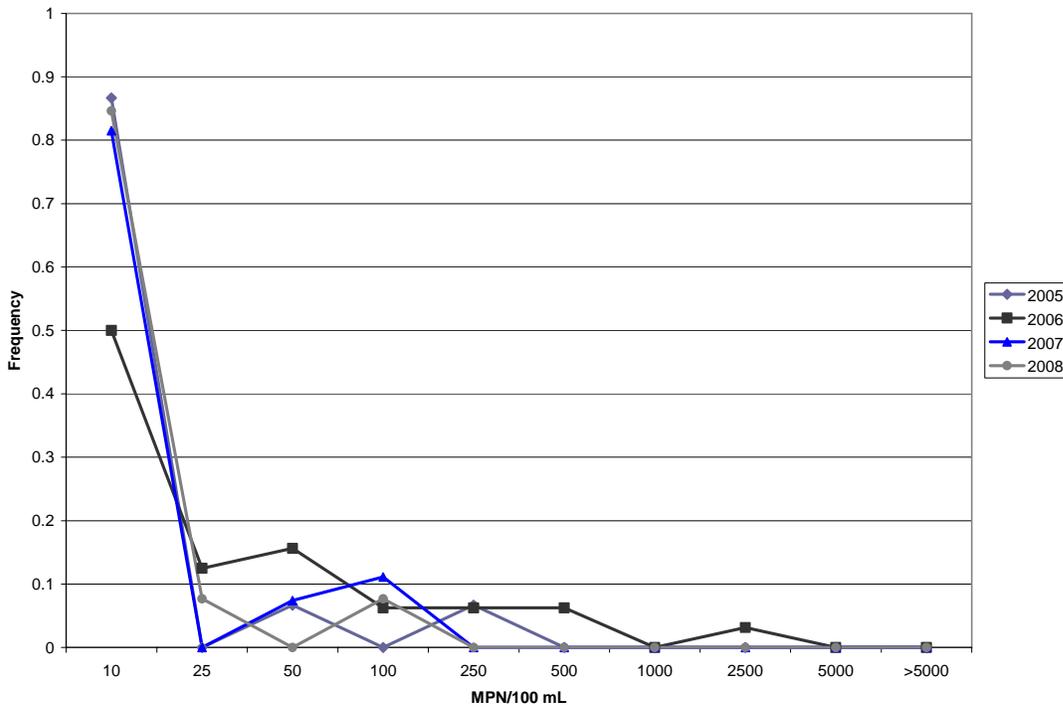
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Correlation coefficients between annual enterococcus frequency distributions for Surfrider Beach (MC-2) ranged from 0.82 to 0.98 suggesting little change in frequency distribution from year-to-year.

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



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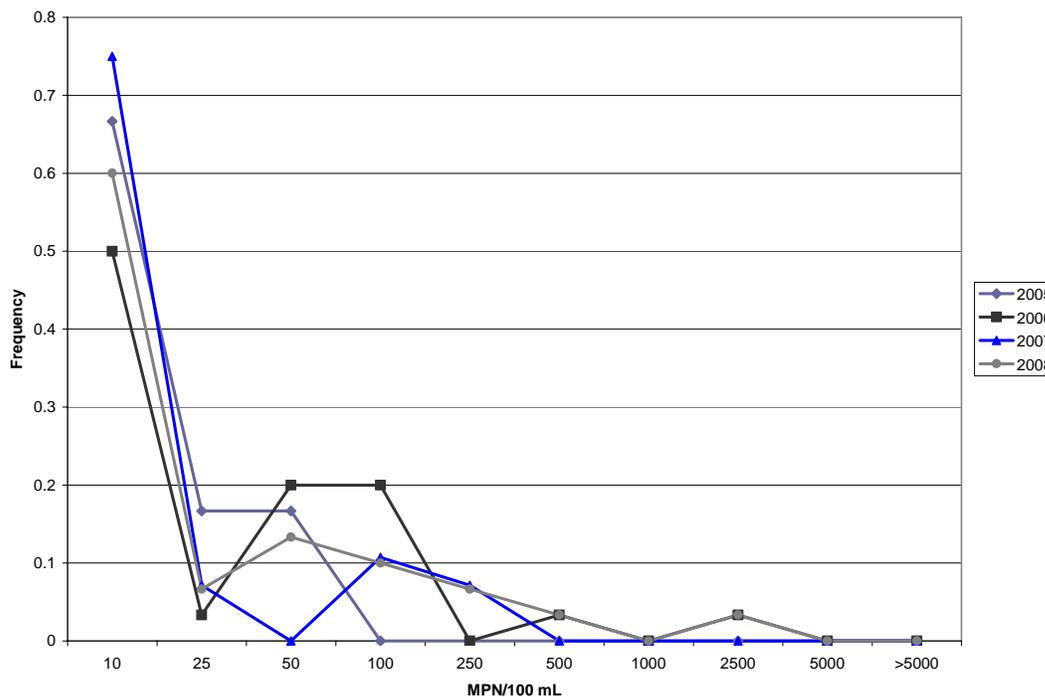
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Figure 9: Malibu Pier (site MC-3) Enterococcus Interval Frequency for May-October Single Measures



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 Surfriider 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
Surfriider Beach	26	34.6
100 yards northwest	4	5.1
100 yards southeast	14	17.9

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 Gasterointestinal 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 Studies¹

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

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).

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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

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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.

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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 Pathogens²

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.

In 2008, De Siewes 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 Siewes 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.

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 septic systems 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).

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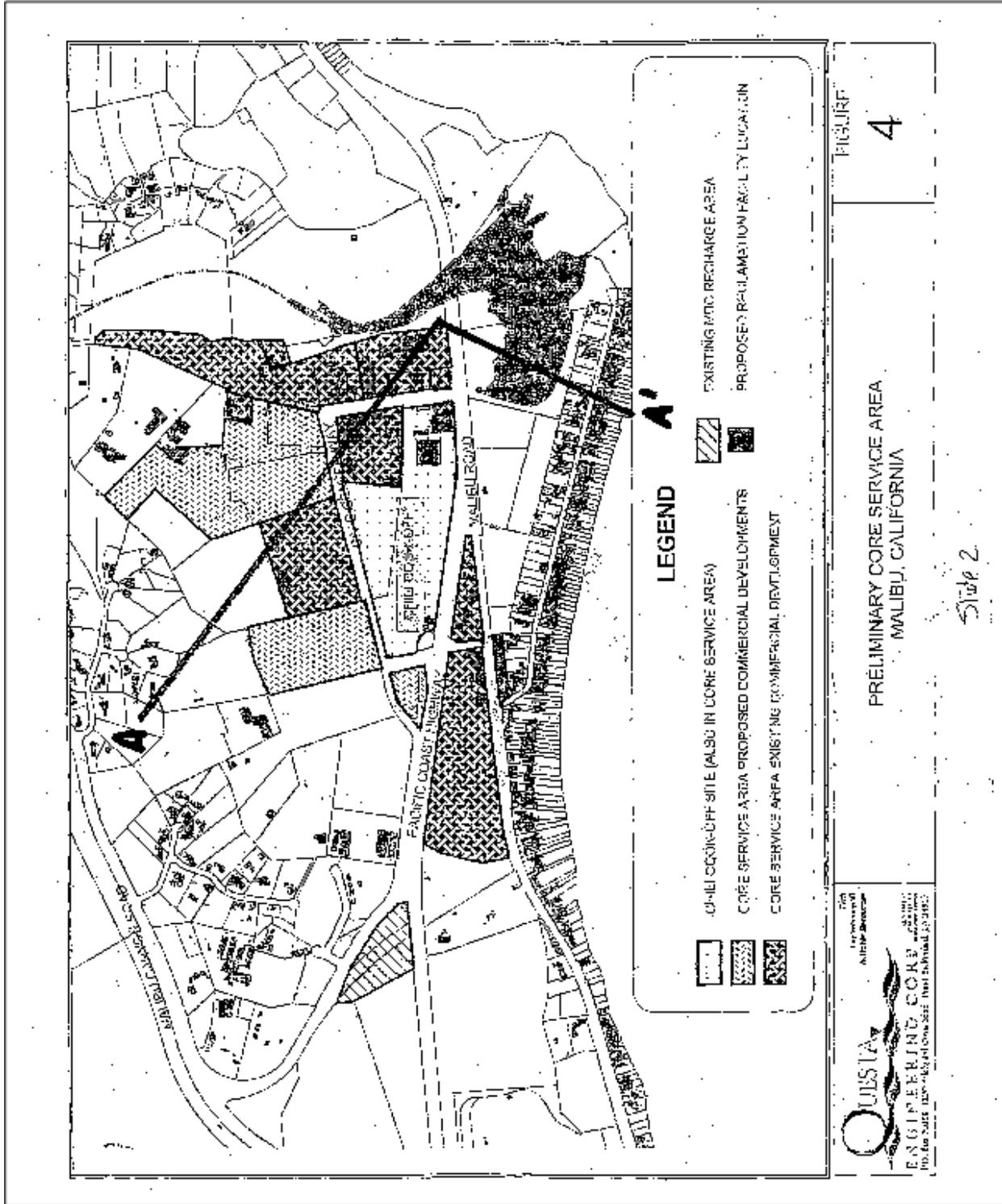
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Figure 10. Planned development in the Malibu Civic Center from Questa 2003 and cross section line



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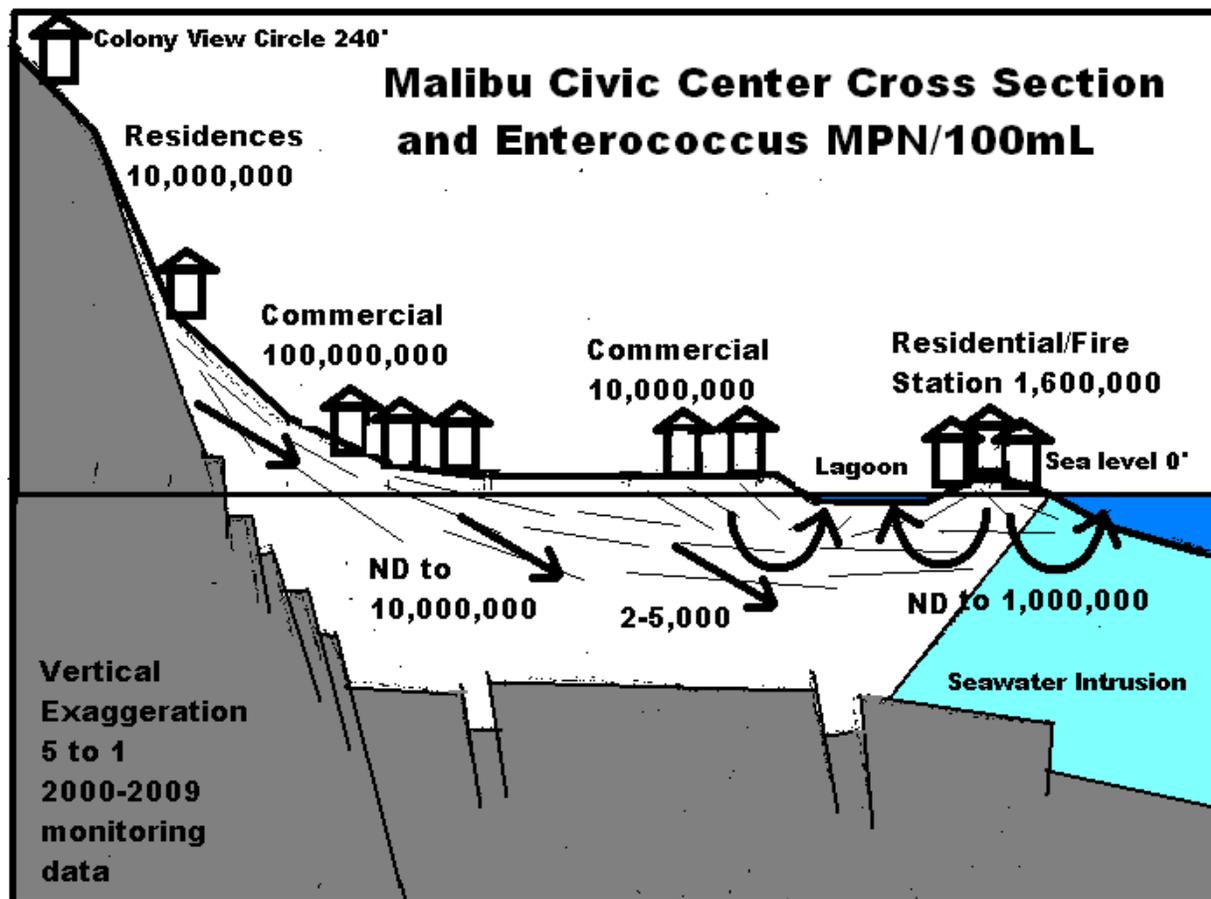
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Figure 11. Cross Section A to A' showing facility and groundwater bacteria and flow paths



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

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.

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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

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County Beach							R E V I S E D D R A F T
ID	Project Name	Location	System	Permit	Area	Year	
17	SMB 1-17	Tuna Canyon	Tuna	Septic	N	1,013	0 9 1 0 2 0 0 9
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	

35	SMB 3-02	Wilshire Storm Drain, Santa Monica State Beach	Santa Monica	Sewer	Y	8,850	R E V I S E D	
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		D R A F T
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	1 0 2	
54	SMB 6-06	Malaga Cove	Redondo	Sewer	N	3,544		
55	SMB BC- 01	Ballona Creek	Ballona Creek	Sewer	Y	81,980		

56	SMB 01	MC- Malibu Point on Malibu State beach	Malibu Creek	Septic	Y	70,410	R E V I S E D D R A F T 0 9 1 0 0 9
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	

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