APPENDIX Q

Huntington Beach Surf Zone Studies

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HUNTINGTON BEACH SURF ZONE STUDIES

HUNTINGTON BEACH SURF ZONE – ELEVATED BACTERIA LEVELS

Huntington State Beach was closed from July 1, 1999 until September 3, 1999 due to elevated levels of fecal indicator bacteria in the surf zone. Fecal indicator bacteria (total coliform, fecal coliform, and Enterococcus) live in the digestive tracts of warm-blooded animals, including humans. The Orange County Health Care Agency (OCHCA) suspected that there was a source of human wastewater that was contributing the high bacterial levels.

Elevated bacteria levels have resulted in chronic beach postings advising visitors against swimming for the last four years. Huntington State Beach is heavily used with over five million visitors per year. Surf zone pollution severely affects the economy of the City of Huntington Beach when the beach is closed or advisories have been posted. It is estimated that as many as 50,000 people per year may suffer from gastroenteritis as a result of ingesting bacteria while swimming and surfing in this water (Kim et. al., 2003).

Monitoring for fecal indicator bacteria is conducted three to five times per week in ankle deep water approximately every 3,000 feet along the shoreline of Huntington State Beach by the OCSD. OCHCA decides whether to notify the public (via beach postings) that the water may not be safe for swimming based on a comparison of the bacteria data to state standards, as shown in Table 1, State Standards for Beach Postings. If OCHCA knows or suspects that human wastewater may be responsible for the high levels of bacteria, the beach is closed for body contact recreation.

TABLE 1
STATE STANDARDS FOR BEACH POSTINGS

FECAL INDICATOR BACTERIA	SINGLE SAMPLE MAXIMUM	MONTHLY GEOMETRIC MEAN
Total Coliform, MPN/100 ml	10,000	1,000
Fecal Coliform, MPN/100 ml	400	200
Enterococcus, CFU/100 ml	104	35

MPN = Most Probable Number. The MPN technique provides a "statistical picture" of the number of coliforms present and is not an exact measurement.
CFU = Colony Forming Units. The CFU technique counts colonies of a bacteria within a sample. It is not an exact measurement of bacteria.

OCHCA summarized the beach monitoring data for 2000 through 2003 in their 2003 Annual Report (OCHCA, 2004). The data collected between Beach Boulevard (located approximately one-half mile northwest of HBGS) and the mouth of the Santa Ana River (located approximately two miles southeast of the HBGS) were combined and are presented in Table 2, Beach Postings from April to October in 2000 to 2003.

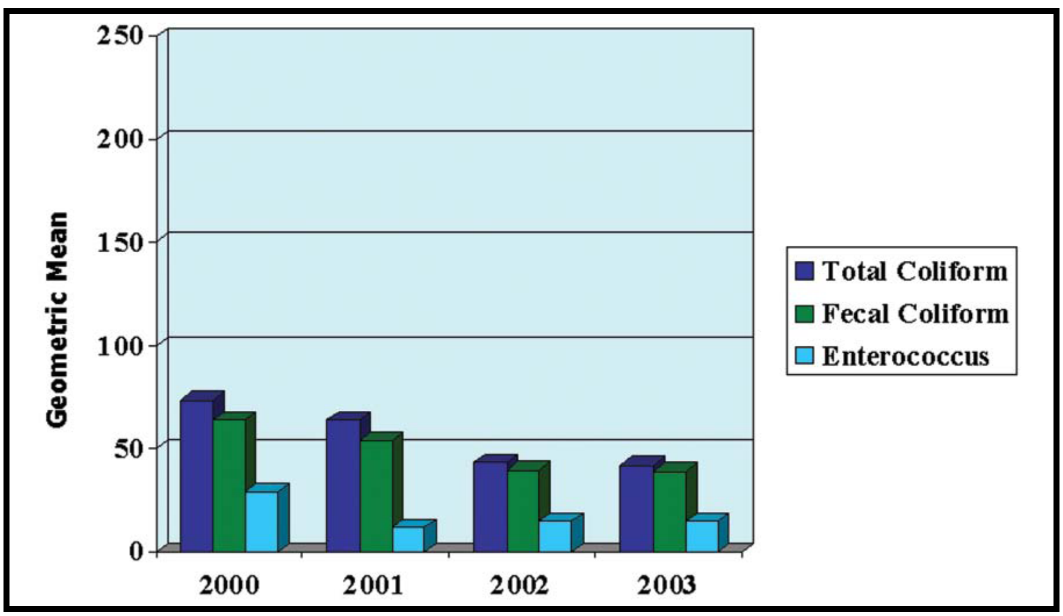
TABLE 2
BEACH POSTINGS IN HUNTINGTON BEACH FROM APRIL TO OCTOBER

YEAR	POSTINGS	DAYS	BEACH MILE DAYS
2000	28	223	67.6
2001	29	70	14.8
2002	31	89	23.8
2003	21	72	41.9

The number of “beach mile” days is an indicator of the extent of the problem. It is calculated by multiplying the number of days the beach is posted by the number of miles that are posted. There was a large decrease in both the number of days and the number of beach mile days between 2000 and 2001. This was the period when dry weather urban runoff was first diverted to OCSD for treatment rather than discharged to the ocean via the Santa Ana River or Talbert Marsh. For the last three years there has been an increasing trend in the number of beach mile days.

Figure 1, Geometric Means for Fecal Indicator Bacteria at Huntington State Beach (Station 6N) presents data from the OCHCA Annual Report on the mean concentrations of each of the three fecal indicator bacteria for 2000 to 2003 at Station 6N which is 3000 feet downcoast from the HBGS. This figure shows that total coliform and fecal coliform bacteria levels have decreased substantially. There was a decrease in Enterococcus between 2000 and 2001 but for the last three years the levels have remained fairly constant. Most of the postings during the last four years were due to exceedences of the Enterococcus standard.

FIGURE 1
GEOMETRIC MEANS FOR FECAL INDICATOR BACTERIA
AT HUNTINGTON STATE BEACH (STATION 6N)



* AB 411 Periods (4/1 through 10/31), 2000-2003

An analysis of the large amount of bacterial data that have been collected has shown that bacteria levels are highest in the surf zone during spring tides and lowest during neap tides. In addition, fecal indicator bacteria are significantly higher at night and lower during the day, presumably because of sunlight-induced mortality.

A number of potential sources of the fecal indicator bacteria have been investigated in studies funded by OCSD and others over the last four years. Each of these sources and the most recent information on their potential to contribute fecal indicator bacteria at Huntington State Beach are described below.

Urban Dry Weather and Storm Water Runoff

The Santa Ana River drains a highly urbanized watershed of 1,700 square miles and discharges to the ocean approximately 9,000 feet from the intake to the HBGS. The Greenville Banning Marsh is located east of the Santa Ana River and drainage from the marsh flows into the Santa Ana River through a diversion channel. The Huntington Beach and Talbert flood control channels discharge into the Talbert Marsh, which discharges to the ocean approximately 1,300 feet upcoast from the Santa Ana River.

Flows from the Santa Ana River and Talbert Marsh are tidally influenced in both dry and wet weather conditions. Ocean water flows inland up the river during flood tides and mixes with water from the river, which is heavily dominated by urban runoff. The mixture of ocean water and river water flows back through the river outlet during ebb tides and contaminants from the watershed enter the surf zone. Contaminants in the surf zone are transported parallel to the shore by wind and wave-driven currents in a direction controlled by the angle at which waves approach the shore. Other mechanisms such as rip and undertow currents carry contaminants offshore. A fraction of the contaminants carried offshore is returned to the surf zone (Kim, et. al., 2004).

Contaminants from the Santa Ana River and Talbert watersheds that flow into the nearshore ocean during ebb tides can be transported upcoast toward Huntington State Beach during the following flood tide. Peak longshore tidal velocities are in the range of 0.2 to 0.3 meters per second during spring tides (Kim et. al., 2004). This means that during one tidal cycle, contaminants can be transported four to six kilometers upcoast. Monitoring station 9-North (9N) is adjacent to the HBGS and is located 1.5 miles upcoast from the Santa Ana River outlet.

Four separate field studies were conducted by U.C. Irvine during the summer of 2001. Over 2000 samples were collected and analyzed for total coliforms, E.coli (a subset of fecal coliforms) and Enterococci bacteria. These studies determined that fecal indicator bacteria in the surf zone are highly variable and governed by a complex set of environmental conditions, including the input of bacteria to the surf zone during ebb tides, the magnitude of coastal currents, and the prevailing wave direction (Kim, et.al. 2004). The concentration of total coliforms is highest during the transition from the nighttime falling to rising tide and mostly confined to the region of the surf zone upcoast of the Santa Ana River and Talbert Marsh outlets. Results indicate that total coliforms enter the nearshore ocean from the Santa Ana River and Talbert Marsh during ebb flows and are carried upcoast by wave driven surf zone currents and/or tidally driven coastal currents. The patterns for E.coli and Enterococcus are different than the total coliform pattern. The concentrations of E.coli and Enterococcus are highest in the region between 6N (near Magnolia Street) and 9N. Based on a detailed analysis of the data collected in 2001 and on modeling studies, it appears that there are potentially other sources of E.coli and Enterococcus in the vicinity of stations 6N and 9N. A microbial source tracking study concluded that human wastewater was the source of a portion of the bacteria in the vicinity of 9N (Kim et. al., 2004).

During storm events, significant amounts of bacteria are delivered to the surf zone. One study estimated that on an annual basis over 99 percent of the fecal bacteria are delivered in storm events with less than one percent delivered during dry weather conditions (Reeves, et. al., 2004). Although bacteria standards are exceeded after storm events, fewer people are impacted because most usage of the ocean occurs during the dry spring and summer months. However, the contaminated sediments and particles that enter the nearshore ocean during storms could be deposited and lead to chronic contamination of beach areas located near the Santa Ana River and Talbert marsh outlets.

Beginning in 1999, the City of Huntington Beach and County of Orange began diverting dry weather runoff to OCSD for treatment and offshore disposal. Thirteen diversion facilities, including ten pump stations and three in-channel diversion facilities were constructed at a cost of approximately $7.5 million (County of Orange, et. al., 2004). These facilities collect urban runoff from approximately 90 percent of the watershed area and divert up to 2.4 MGD of dry weather runoff to the OCSD system. All diversions are terminated during storms, which generally occur from November to March. A study of the effectiveness of the diversions in the Talbert Marsh watershed, conducted by U.C. Irvine, showed that the diversions reduced the flow of fecal indicator bacteria from urban runoff to the outlet of Talbert Marsh. During the three years of the study, the concentrations of the three indicator bacteria increased in urban runoff stored in the forebays of the channels that drain the Talbert watershed. However, in general, the average concentrations of fecal indicator bacteria did not change significantly at the coastal outlet of Talbert Marsh. This indicates that the diversions were effective in controlling the flow of fecal indicator bacteria from urban runoff in the Talbert watershed but there may be other sources of fecal indicator bacteria, such as bird droppings or regrowth of bacteria in sediments.

The County of Orange and the Cities of Costa Mesa and Newport Beach recently submitted a workplan to the Santa Ana Regional Water Quality Control Board (SARWQCB) to address dry weather runoff from the areas where runoff is currently not diverted, which equates to approximately 10 percent of the watershed (County of Orange, et. al., 2004). These areas are adjacent to the Greenville-Banning Channel and lower Santa Ana River downstream of the existing in-channel diversion dams.

<u>OCSD Discharge</u>

At the time of the beach closure in 1999, OCSD was discharging 245 mgd of wastewater at an outfall that is located 4.5 miles offshore at a depth of 195 feet. At that time, all wastewater received primary treatment and 50 percent of the wastewater also underwent secondary treatment. OCSD also has an emergency outfall that is closer to shore but it has not been used since construction of the deep outfall. During early investigations of high levels of bacteria in the surf zone, OCSD maintained that the OCSD discharge could not be the cause because: 1) the discharge plume was contained below the thermocline and could not mix with surface waters; 2) intensive monitoring offshore and nearshore showed no indication of bacteria traveling from offshore to the nearshore zone; and 3) other water quality monitoring efforts conducted by OCSD had never detected the plume near the shore.

Stanley Grant, a professor at U.C. Irvine, advanced a theory that a submerged edge of the OCSD wastewater plume may be transported shoreward by subsurface currents and then entrained in the discharge from HBGS and transported into the surf zone (Grant et. al., 2000). Intensive monitoring conducted by the U.S. Geological Survey (USGS) in 2001 did not identify a connection between ocean processes and bacterial contamination of the beach (USGS, 2003). The OCSD plume rises toward the thermocline when it first enters the ocean because it is less saline and warmer than ocean water. The plume mixes with ocean water that is about 12 to 14 degrees Celsius and is generally carried out of the area by alongshore currents. Although internal tides were shown to intermittently transport cold water toward the shore in July and August 2001 and the OCSD plume is occasionally detected in shallow water (20 meters), there is no connection between the cold water intrusions and exceedences of beach standards. Intensive bacteria monitoring conducted during the summer of 2001 showed that when the beaches have high bacteria levels, water about 0.4 kilometers from the beach also has measurable bacteria, although well below the beach standards. There was a gap between the nearshore contamination and the bacteria measured 3.3 kilometers offshore below the thermocline in the OCSD plume. The lowest levels of bacteria were consistently found about 0.8 kilometers from the beach. This gap indicates that the bacteria from the OCSD outfall do not reach the beaches (OCSD, 2002).

In August 2002 OCSD began disinfecting its effluent with chlorine to determine if there was any undetected mechanism by which the effluent plume was reaching the surfzone in an effort to ensure that OCSD was not a contributor to the exceedence of bacteria standards. OCSD has set a goal of meeting the shoreline standards in the zone of initial dilution around the outfall (OCSD website). The daily operational goals for the final effluent are shown in Table 3, *OCSD TREATMENT FACILITY OPERATIONAL* GOALS. The total coliform, fecal coliform, and enterococcus levels in the final effluent are generally far below the goals. Bacteria levels at nearshore monitoring stations have continued to exceed beach standards since OCSD began disinfecting its wastewater. This supports the previous studies that concluded that the OCSD plume was not the source of the nearshore bacteria. OCSD is also taking steps to treat 100 percent of the wastewater to secondary standards. At the end of 2003, 64 percent of the wastewater received secondary treatment and 36 percent received primary treatment.

TABLE 3
OCSD TREATMENT FACILITY OPERATIONAL GOALS

INDICATOR BACTERIA	BEACH SANITATION STANDARDS (30 DAY GEOMETRIC MEAN AFTER INITIAL DILUTION OF 180:1)	DAILY OPERATIONS (TARGET AT THE FINAL EFFLUENT SAMPLER USING 100:1 DILUTION)
Total Coliform, MPN/100 ml	180,000	<100,000
Fecal Coliform, MPN/100 ml	36,000	<20,000
Enterococci, MPN/100 ml	6,300	<3,500

Wastewater Collection System

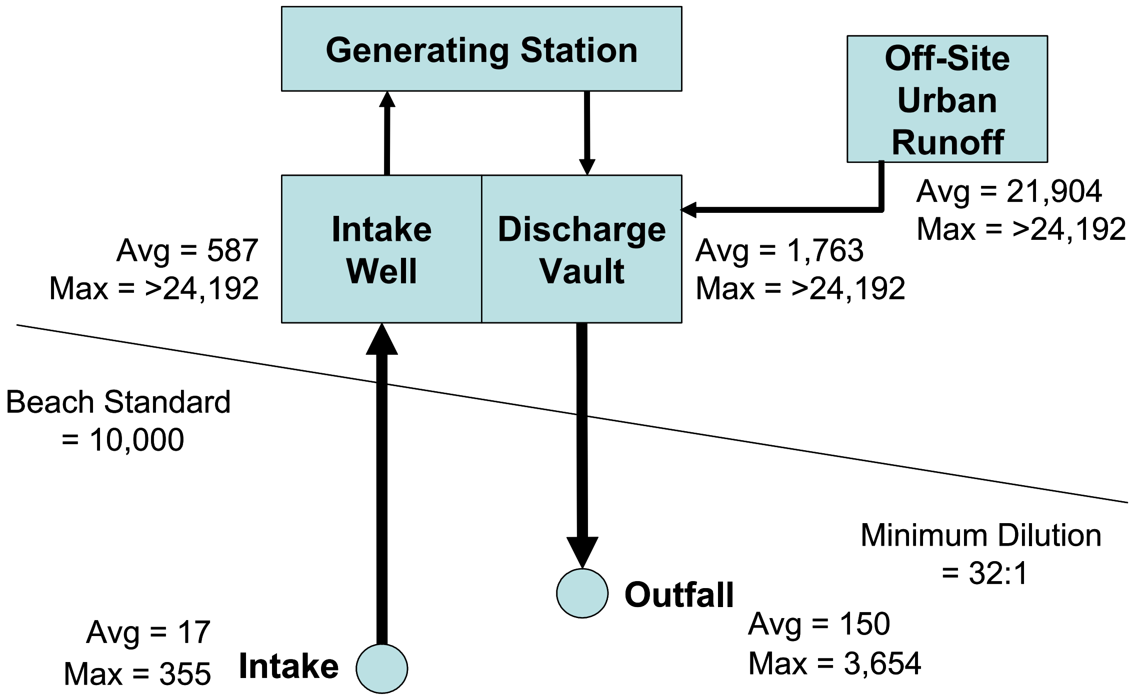
During the Phase I bacterial investigation in 1999, closed circuit television inspection of OCSD's coast trunk line that runs along Pacific Coast Highway revealed no leaks. No leaks were detected in OCSD's outfall. A small leak was found in the Huntington State Beach restroom system and was fixed. During the summer of 2001 the Huntington State Beach restrooms and sewers along the Pacific Coast Highway near the HBGS were tested for leaks using hydrostatic, air pressure, and dye testing methods. Sewer lines between several restrooms were leaking with the most severe leak in 800 to 900 feet of sewer line connecting two restrooms that are near HBGS and adjacent to Station 9N. The dye testing revealed that wastewater flowed from the restrooms to the shoreline via the tidally influenced groundwater near the beach. Dye was detected in groundwater monitoring wells near the restrooms and in the surf zone within 48 hours of injection at the restrooms (OCSD, 2002). These studies indicated that the restroom sewers could potentially be a source of bacteria to the shoreline, and may be the additional source of E.coli and Enterococcus between Stations 6N and 9N discussed above. OCSD recommended that the California Department of Parks and Recreation (California State Parks) take corrective measures to eliminate the leaks and to routinely test their sewers in the future. California State Parks closed the restrooms with the leaking sewers and submitted plans to abandon the leaking sewer near the HBGS and replace it with a direct connection to OCSD's coast trunkline.

HBGS

There has been considerable speculation that the HBGS in someway contributes to the bacterial contamination of the nearshore ocean around monitoring station 9N, either as a source of bacteria or by "sucking" in the OCSD plume and then discharging it in nearshore waters. USGS conducted an intensive ocean monitoring program in the summer of 2001 to determine if the OCSD plume could potentially reach the shore. USGS concluded that the interaction of the HBGS and the OCSD plume could not be responsible for the beach contamination (USGS, 2003).

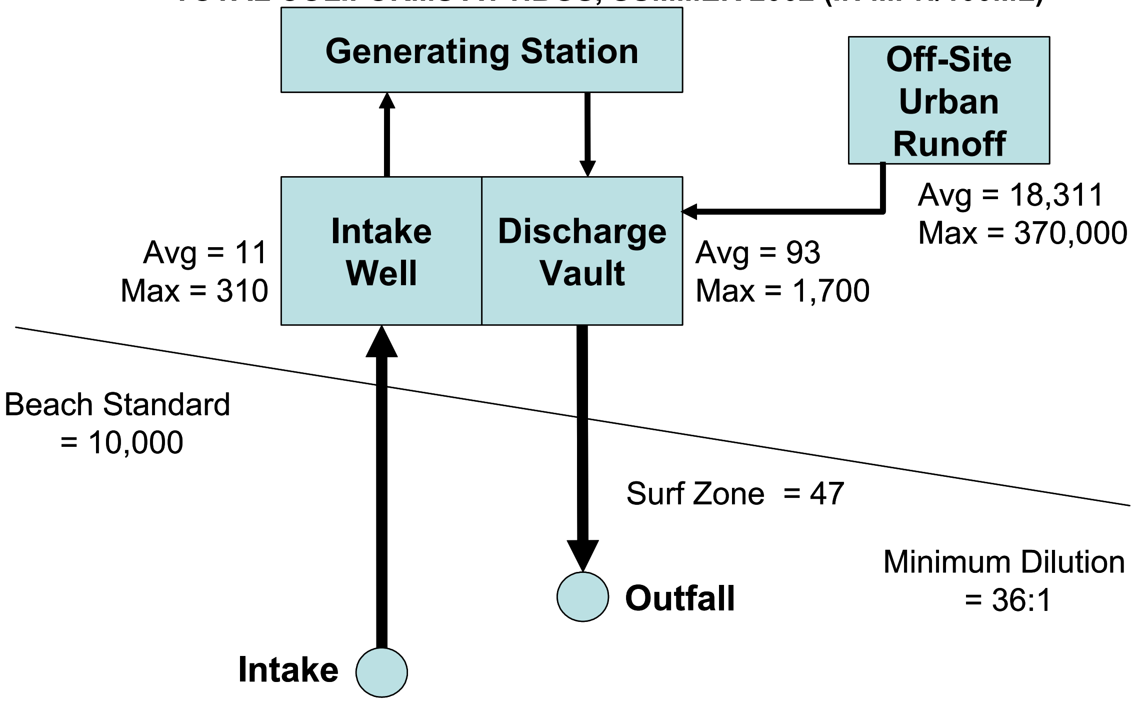
MBC conducted a water quality monitoring program during the summer of 2001 to identify potential sources of bacteria at the HBGS. MBC found high concentrations of fecal indicator bacteria in the HBGS discharge vault and determined that the sources of the bacteria were the HBGS retention basins and the off-site Pacific Coast Highway (PCH)/Newland Street storm drain that flows into the HBGS discharge vault. The PCH/Newland Street storm drain collects urban runoff from an area west and north of HBGS, including the adjacent RV/trailer park. Although high levels of fecal indicator bacteria were found in the discharge vault, intensive sampling of the ocean near the HBGS discharge revealed much lower concentrations. The total coliform data from the summer of 2001 are summarized on Figure 2, Total Coliforms At HBGS, Summer 2001. MBC concluded that the HBGS was not responsible for the bacteria contamination of the beach at Station 9N due to the dilution of the discharge with cooling water and with ocean water in the immediate vicinity of the outfall (MBC, 2002).

FIGURE 2
TOTAL COLIFORMS AT HBGS, SUMMER 2001 (IN MPN/100ML)



The California Energy Commission (CEC) required a study of the impact of the HBGS on Huntington Beach bacterial contamination as part of the retooling of the generating station in 2001 (Komex, 2003). An intensive water quality monitoring program was conducted during the summer of 2002 and dye studies were performed to determine if the HBGS was a source of fecal indicator bacteria to the surf zone. Samples were collected daily from a number of locations at the HBGS from mid-July to mid-October. In addition, samples were collected every three hours from four locations during a two-week intensive study. Data were also collected in the ocean near the intake and outfall of the HBGS. The total coliform data for 2002 are summarized on Figure 3, *TOTAL COLIFORMS AT HBGS,SUMMER 2002*. The study found that urban runoff from an area adjacent to the HBGS that is discharged to the discharge vault of the HBGS contained high levels of fecal indicator bacteria. Because the urban runoff is blended with cooling water from the generating station, the generating station discharge contained much lower concentrations of fecal indicator bacteria. These findings are consistent with the findings from the MBC study conducted the previous year.

FIGURE 3
TOTAL COLIFORMS AT HBGS, SUMMER 2002 (IN MPN/100ML)



Komex (2003) conducted a dye study on the HBGS discharge to determine if the discharge has the potential to reach the surfzone. Dye was injected into the discharge vault at HBGS five times on one day in August 2002. The dye surfaced over the outfall and then spread radially in all directions. The average dilution between the discharge and the beach was 277 to one. The lowest calculated dilution was 36 to one. Based on the water quality sampling and the modeling studies, Komex concluded that the HBGS was not contributing to the beach contamination problem.

Bird Droppings

A two-week study in May 2000 showed that the Talbert Marsh is a source of total coliform, Enterococcus and E. coli (Komex, 2003). The study showed that the marsh produces about 100 billion of all three indicator bacteria each day. These organisms are transported to the ocean with each ebb tide. The source of the bacteria appears to be seagull feces, which are deposited in the marsh. Marine vegetation and marsh sediment become potential reservoirs of the bacteria. OCSD conducted bacteria monitoring upstream and downstream of the PCH bridge over the Santa Ana River in the summer of 2001. Bacteria levels downstream of the bridge were consistently and substantially higher than upstream levels. Birds roosting under the PCH bridge were thought to be a possible cause of the high levels downstream (OCSD, 2002).

There has also been speculation that bird droppings on the beach could be partially responsible for the high bacteria levels in the surfzone. During the summer of 2001, OCSD conducted visual observations of birds in the area between Stations 6N and 12N. Groups of up to 400 birds were observed on the beach and groups of 200 to 300 birds were observed floating in the water beyond the surfzone (OCSD, 2002). Bacterial monitoring studies were not conducted to determine the impact of bird droppings.

Pet Waste

There have been no studies in Huntington Beach on the potential contribution of pet wastes to bacteria in the nearshore ocean. A study conducted at the Dog Beach in San Diego found that areas with large accumulations of dog feces did not produce higher concentrations of bacteria than areas with low accumulations of dog feces. However, the study concluded that the combination of decaying marine vegetation, dog feces, and bird droppings in the kelp line was likely the source of bacteria at that beach (MBC, 2003).

Groundwater Discharge

During the summer of 2003, researchers from Stanford University conducted a study to determine if groundwater near Station 9N could transport fecal indicator bacteria to the surf zone (Boehm, et.al. 2003). Radium isotope studies were conducted to confirm that groundwater enters the surfzone during ebb tides. Groundwater samples were analyzed for fecal indicator bacteria. Most of the samples contained less than 60 MPN/100 mL (60 most probable number/100 milliliters) but one sample contained total coliform of greater than 24,192, fecal coliform of 17,329, and enterococcus of 776 MPN/100 mL. An experiment was conducted to determine if the sand at Huntington Beach would filter out Enterococcus as the groundwater moved through the sand. The experiment showed that Enterococcus are not filtered out and readily move through the sand with the groundwater. This study and the dye study conducted by OCSD in 2002 show that groundwater enters the surf zone near Station 9N. Groundwater entering the surf zone could transport bacteria from a variety of sources such as leaks in the wastewater collection system, bird droppings, and/or pet waste,

Conclusions

Based on the extensive studies conducted on bacterial pollution of Huntington State Beach, the Santa Ana River and Talbert Marsh appear to be the primary sources of fecal indicator bacteria to the near shore ocean. During the summer months, most of the dry weather runoff is currently diverted to OCSD although approximately 10 percent of the watershed near the mouth of the Santa Ana River still discharges to the river. Bird droppings and a reservoir of bacteria stored in the sediment and on marine vegetation may continue to be the source of bacteria at the mouths of the river and marsh. Modeling studies and monitoring data indicate that there is likely another unidentified source of bacteria in the vicinity of Stations 6N and 9N. Three separate studies conducted between 2001 and 2002 have demonstrated that HBGS is not the source of bacteria in the surf zone.

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