MISSION BAY
Clean Beaches Initiative
Source Identification Study
Phase I

Final Report

Prepared For:

State Water Resources Control Board

Prepared By:

The City of San Diego
General Services Department
Storm Water Pollution Prevention Program
1970 B Street, MS 27A
San Diego, California 92102

In Conjunction With:

MEC Analytical Systems, Inc.
2433 Impala Drive
Carlsbad, California 92008

June 30, 2003

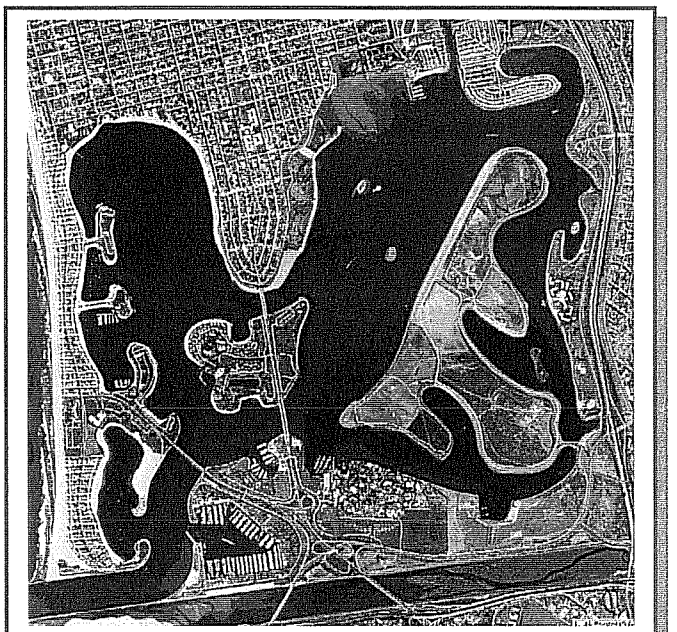
"Funding for this project has been provided in full or in part through a contract with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use."

Table Of Contents

Table Of Contents

Table Of Contents

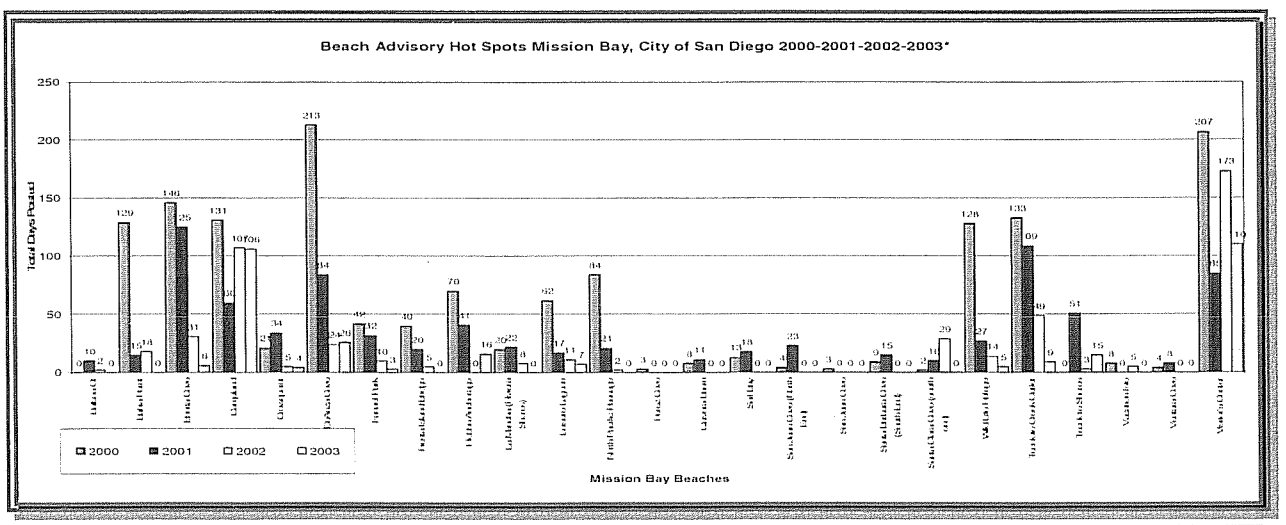
Introduction



Aerial Photograph of Mission Bay

Mission Bay, located in the City of San Diego, is used by millions of people each year for a variety of recreational activities. The Bay encompasses numerous smaller bays, coves, inlets, and stretches of beach that make it one of the City's most desirable places for aquatic recreation. The City recognizes Mission Bay as a precious civic resource and has taken action to protect Mission Bay water quality. These efforts span decades and continue today. The Metropolitan Wastewater Department has renewed its infrastructure, including sewer main replacements, trunk sewers, and pump station upgrades within the Mission Bay area at a cost of over $120 million from 1985 through 1996. In addition the City constructed the Mission Bay Sewage Interceptor System (MBSIS), a $10 million state-of-the-art low flow storm drain diversion system that encircles the Bay. The system diverts low dry weather flows, typically with high bacterial counts, from existing storm drains and directs these flows to the sanitary sewer system for treatment. Recently, the City's Storm Water Pollution Prevention Program created the Mission Bay Water Quality Management Plan to better manage and coordinate the seven water quality projects being undertaken on Mission Bay.

In 2000, the entire Bay was listed as an impaired water body under Section 303(d) of the Clean Water Act for exceedances of bacterial indicator standards. In 2001 the City conducted a statistical assessment of all bacterial data collected from 1993-2000 throughout the Bay. This study found that not all the recreational beach areas in Mission Bay suffer from bacterial water quality exceedances. The City has continued to track beach water quality throughout the Bay.

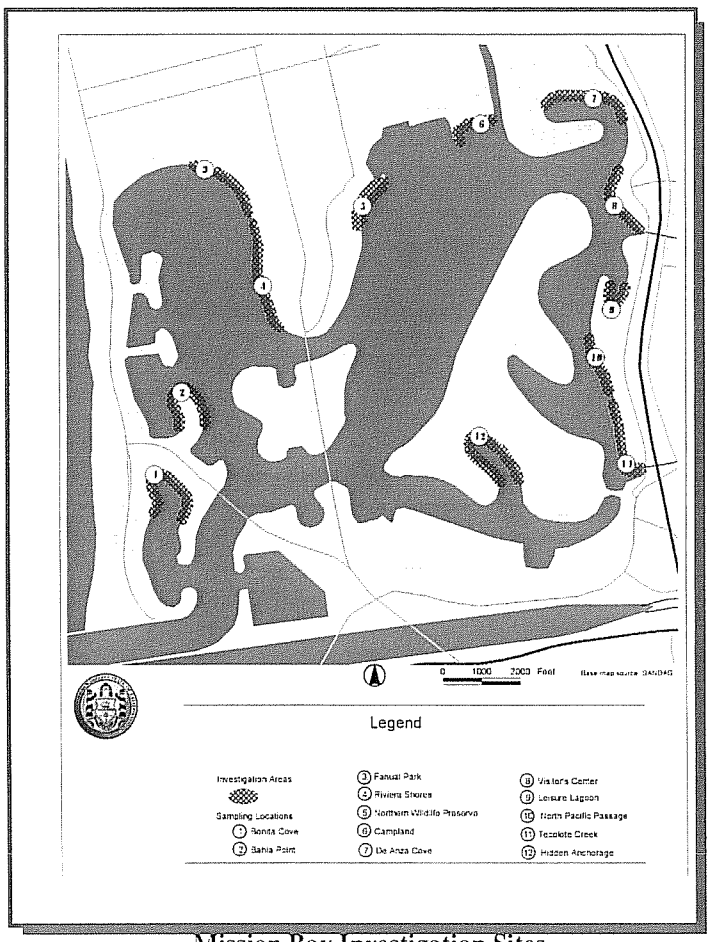


Based upon the findings of the historical data review, the City obtained a Clean Beaches Initiative Grant (funded under Proposition 13) to conduct bacterial source investigations. This report summarizes the efforts of the first phase of this project: The Mission Bay Bacteria Source Identification Study – Phase I. The purpose of the study was to plan, design and implement a bacterial source identification study to identify sources of bacterial contamination in Mission Bay and recommend appropriate actions and activities to eliminate the input of those sources. The project is being conducted in two phases. Phase I was initiated on July 1, 2002 and encompasses the first year of the study. The study was prepared for the California State Water Resources Control Board by the City of San Diego (City) and MEC Analytical Systems, Inc. (MEC).

Major Tasks of the Study

The goal of Phase I was to identify the major sources of bacterial contamination to Mission Bay. There were three major investigative tasks designed to achieve this goal:

- **Task 1** – Sources of Human Sewage from Park Restroom Infrastructure
- **Task 2** – Sources of Human Sewage from Moored or Anchored Boats
- **Task 3** – Visual Observations and Bacterial Assessment of Other Sources in the Park



Mission Bay Investigation Sites

A review of historical bacterial data in Mission Bay indicated that the entirety of the Bay doesn't suffer from persistent bacterial water quality exceedances. However, 12 specific beach areas were identified with persistently elevated bacterial levels.

In Task 1, the comfort stations at 12 locations within Mission Bay Park were evaluated to determine if leaking infrastructure from these facilities was the source of bacteria to the Bay. The lateral lines of the comfort stations, which carry sewage to the sewer mains, were visually inspected with a closed-circuit television (CCTV)

system to assess the conditions of the lateral lines. The inspections revealed that the integrity of the lateral lines of all of the comfort stations investigated was intact. These results suggest that the infrastructure of comfort stations within Mission Bay Park is not a likely source of bacteria to the Bay. The sewer mains themselves were not inspected as part of this study.

CCTV Inspection of Comfort Station Sewer Lines

In Task 2, illicit discharge of sewage from boat holding tanks was investigated as a potential source of bacteria at three locations in Mission Bay where boats moor or anchor: Bonita Cove, Santa Barbara Cove, and De Anza Cove. At each site, samples were collected for bacterial analyses in surface waters surrounding the moored or anchored boats and from a beach location where routine monitoring is conducted. The samples near the boats were collected by kayak. Each site was sampled in this way on three separate days. Very low concentrations of all three bacterial indicators were detected throughout the study at all three sites. In most cases, the concentrations were below or just above the detection limits. The lack of elevated levels of indicator bacteria from any of the samples collected indicates that illegal discharge of sewage from moored and anchored boats was not occurring during the time of sampling. The results also suggest that illegal sewage dumping from moored and anchored boats is not a likely chronic source of bacterial contamination at the beach. However, the illegal discharge of sewage holding tanks from moored boats is inherently episodic and the results of the study do not rule out the potential for isolated events.

Task 3 was designed to assess the numerous potential sources of bacteria to Mission Bay other than leaking comfort station infrastructure and illicit discharge from moored and anchored boats. The potential sources assessed in this Task included fecal matter from birds and feral and wild animals that inhabit the Park, the homeless population, the behavior of some Park visitors, and Park management practices, such as comfort station cleaning and irrigation procedures. To determine the extent to which these potential sources may be contributing to the bacterial contamination of Mission Bay, a comprehensive visual observation program was implemented at 12 sites throughout Mission Bay. The visual observation monitoring was conducted in conjunction with samples taken at the observation areas for analysis of indicator bacteria. Observations and sampling took place during three periods between mid-August and mid-October, 2002: low-use, medium-use, and high-use. Within each of these periods, the study included three days of observation. During each day of observation, samples for bacterial analyses (total coliform, fecal coliform, and *Enterococcus*)were taken at each of the 12 sampling locations, three times per day. In addition, "spot sampling" was conducted at areas where bacterial influx to the Bay was expected (e.g., flowing storm drains). Observations and sampling were conducted from sunrise to sunset with three shifts of six individual samplers per day covering all 12 sites.

A total of approximately 1,300 man-hours of visual observations were made during the nine days of the study (over 140 hours per site). In addition, over 500 samples from receiving waters of the Bay and suspected sources were collected and analyzed for indicator bacteria. The results from the observations and bacterial monitoring suggested that several potential bacterial sources identified at the beginning of the study were not likely to be contributing bacteria to the Bay. These included rodents and wildlife other than birds, leaking garbage cans, trash or food in the Park, illicit boat discharge, improper use of recreational vehicle pump-outs, the homeless population, and pet waste (except at one site). The results also indicated that each site examined in the study was unique in terms of potential bacterial sources. The potential sources identified throughout the Bay included birds, flowing storm drains, groundwater, creek drainage, irrigation, restroom washdown practices, and boat cleaning (one site). Pet waste was considered a likely source only at one site, Hidden Anchorage on Fiesta Island. Management actions related to this issue are discussed below in the site-specific conclusions.

Weekly Monitoring

After the field work for the three major tasks had been completed, two additional programs were initiated as part of the contract with the City: 1) Weekly monitoring of the 12 sites from November through March, and 2) Follow-up studies. The weekly monitoring included visual observations, water quality measurements (temperature, pH, conductivity, and turbidity), and water sample collection for bacterial analyses (total coliform, fecal coliform, and *Enterococcus*). The follow-up studies consisted of a series of investigations designed to track likely bacterial sources identified in Tasks 1, 2, and 3. The studies were all site-specific depending on the characteristics of the area.

The results of the weekly monitoring further demonstrated the unique characteristics of the 12 sites monitored in Mission Bay. Park management activities were minimal in the winter and there was no evidence that any management practice (e.g., restroom washdown) would lead to elevated bacterial levels in the Bay. Flowing storm drains were observed at several sites in the Bay during dry weather sampling, particularly at De Anza Cove and Visitor's Center. One storm drain at Visitor's Center had a constant flow during every site visit. Wildlife activity in the Park was dominated by birds. Visitor's Center had the greatest number of birds, followed by Leisure Lagoon, Bonita Cove, Tecolote Creek, Campland, Wildlife Refuge, and De Anza Cove. Water quality parameters were also site specific and tended to be related to a site's proximity to the ocean or major drainage, such as Rose Creek or Tecolote Creek. One exception was salinity. Fanuel Park, which is far removed from the ocean inlet and major drainages, had the second lowest mean and median salinity values in the Bay. It is likely that the large volume of groundwater that is pumped into Sail Bay by permanent groundwater de-watering systems of the surrounding condominium complexes causes the reduction in average salinity levels observed at this site.

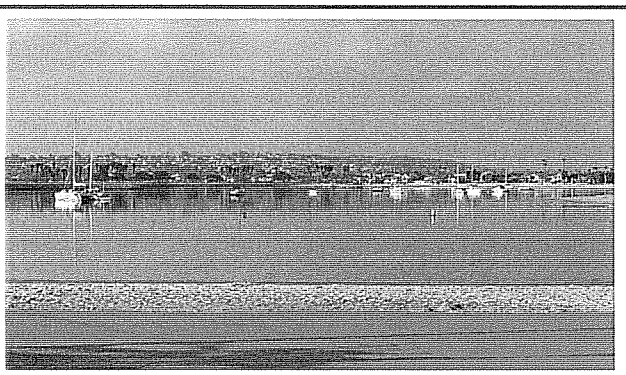
Overall, there were a total of 39 beach postings throughout the duration of the sampling period. Of these, 16 resulted from a single sample exceedance of *Enterococcus*, seven from fecal coliform exceedances, and only one from total coliform. The highest mean and median bacteria

values were found at Campland, Tecolote Creek, Visitor's Center, and Fanuel Park. Exceedances of standards at Tecolote Creek and Fanuel Park tended to be episodic, while those at Campland and Visitor's Center lasted several months.

Site Assessments and Conclusions

Phase I of the Mission Bay Source Identification Study demonstrates the complexity of identifying and accounting for bacterial sources in Mission Bay. The results of Phase I strongly suggest that the sources of elevated levels of indicator bacteria are site specific and dependent on a broad range of variables. At some sites, identifying the source was fairly straight-forward, while at others further investigations will be necessary. The suspected sources at each site are briefly summarized below.

Bonita Cove. The results of the Visual Observations Task suggest that there were several areas around Bonita Cove that could be contributing bacteria to the receiving waters of Mission Bay. High bacterial levels were recorded in samples taken from the ponded water in the grassy areas of the Park and from the washdown of both comfort stations at this site. Other potential sources of bacteria in Bonita Cove include birds, irrigation and storm drain runoff, and the periodic illicit discharge of sewage from boats that anchor in the Cove.

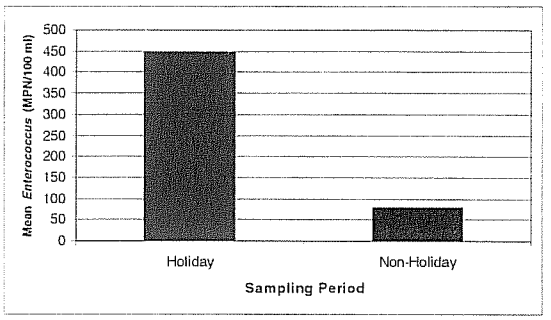


Anchored boats at Bonita Cove

In October, 2002, following completion of the major field efforts for the Visual Observations Task, the initial results of the Task were discussed with members of the City of San Diego Park and Recreation Department. After reviewing the results of the comfort station washdown procedures, City managers instituted changes in the way comfort stations were cleaned. City staff were instructed to contain the water from the comfort station wash down within the confines of the building. Drains inside the comfort stations convey the water to the sanitary sewer system. This program was initiated at all comfort stations in Mission Bay. During the weekly monitoring of all the sites in Mission Bay there were no observations that indicated that comfort station runoff during cleaning was leaving the buildings. Thus, the program instituted by the City appears to have been effective in eliminating this source of bacteria to Mission Bay.

Perhaps the most striking observation at this site is that *Enterococcus* values are nearly six times higher during summer holidays than non-holiday periods. At Bonita Cove the mean concentration of *Enterococcus* during summer holidays (449 MPN/100 ml) was significantly different than the concentration during non-holiday days (79 MPN/100 ml). The large difference in *Enterococcus* levels between holidays and non-holidays, suggests that there may be different

mechanisms at work during these two time periods related to bacterial levels in the water column. Two follow-up studies were conducted at Bonita Cove to explore the possible reason for the large difference in bacterial levels during holiday and non-holiday periods. The first was an investigation of beach sediments to assess whether they act as a reservoir for bacteria that are re-suspended by swimmers during summer holidays. The study was conducted on May 19, 2003. The results indicated that beach sediments at Bonita Cove had very low levels of *Enterococcus* bacteria and they were an unlikely source of bacteria to the receiving waters.



Mean *Enterococcus* concentrations during summer holidays and non-holidays at Bonita Cove.

The second study re-examined the potential for illicit discharge of sewage from boats anchored at Bonita Cove. The study was conducted over Memorial Day weekend, 2003. Similar to the results of Task 2, data from the two sampling dates and times indicated no direct source of *Enterococcus* from the anchored boats at Bonita Cove. All samples except one taken over the two days of the study had values of *Enterococcus* less than 10 MPN/100 ml.

A method for investigating this potential source could be to implement a study utilizing a remote sensor (SONDE) to collect water samples for various parameters including ammonia. The samples could be taken at ten minute intervals and the data can be collected over an extended period of time. This type of investigation would greatly increase the temporal data and the probability of noticing an illegal discharge from the anchored boats if it is occurring. In addition, during Phase II of the Mission Bay Bacterial Source Identification Study, molecular bacterial source tracking will be used to identify the origins of bacteria in the receiving waters and from suspected bacterial sources. At Bonita Cove, the study is designed to identify the origins of bacteria found in the receiving waters and attempt to account for the observed differences between summer holiday and non-holiday periods.

Curb Inlet upstream of Bahia Point storm drain

Bahia Point. The results of the Visual Observations Task suggest that there are few areas around Bahia Point that could be contributing bacteria to the receiving waters of Mission Bay. The results of the boat mooring study (Task 2) suggested that illicit discharge from moored boats in Santa Barabara Cove (just west of Bahia Point) was an unlikely source of bacteria to Bahia Point. During the Visual Observations Task, high bacterial levels were recorded in samples taken from the ponded water in the grassy areas of the Park, from the storm drains and gutters that drain these areas, and

from the washdown of the comfort station at the end of the peninsula. The management actions described for Bonita Cove regarding changes in comfort station wash down procedures should have eliminated this source of bacteria to the Bay. There were no observations in the weekly monitoring that suggested that the comfort station at Bahia Point was being washed down improperly. Other potential sources of bacteria in Bahia Pont include birds, irrigation and storm drain runoff.

Based on the information collected in Tasks 1 and 3 of this study, the most likely source of elevated bacterial levels at Bahia Point appears to be the runoff from the storm drains on the Bahia Point peninsula that are not part of the MBSIS. The drainage area for these Park storm drains is small, but they convey water from the grassy areas of the Park during irrigation, which had high levels of indicator bacteria. Bacterial concentrations may also increase as water flows to the storm drains from leaf litter and organic matter in the gutters at Bahia Point. High levels of indicator bacteria were measured from these storm drains during Task 3. In addition, the San Diego County Department of Environmental Health (County) sampling point is located directly in front of the discharge point of one of these storm drains. Because of the limited number of potential sources at this site, Bahia Point will not be assessed in Phase II of this project. However, the results from other sites with similar characteristics will be used to apply management actions designed to limit elevated bacterial levels at Bahia Point.

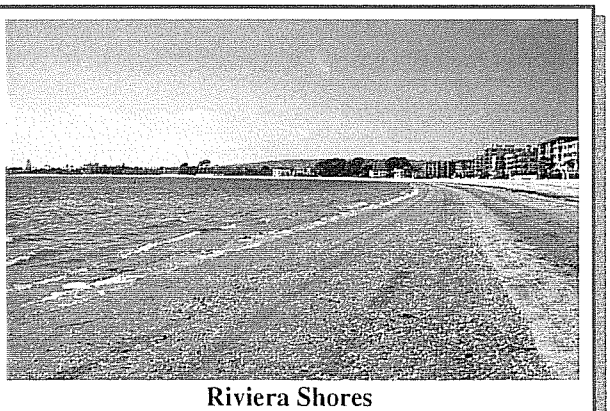
Fanuel Park. The results of the Visual Observations Task suggest that there are a few areas around Fanuel Park that could be contributing bacteria to the receiving waters of Mission Bay. High bacterial levels were recorded in samples taken from the washdown of the Fanuel Park comfort station, from the ponded water in the grassy areas of the Park, and from the storm drain system. The comfort station at Fanuel Park is different from those at the other sites investigated because the toilet areas do not have individual drains and the restroom washdown water is swept to French drains outside the building. Although, this represents a potential source of bacteria to the Bay via groundwater, the small volume of water involved and large distance from the comfort station to the Bay indicate that the impact is likely minimal. Other potential sources of bacteria at this site include birds, storm drain runoff, and groundwater. Fanuel Park is unique among the 12 sites examined in this study because of the potential for bacterial contamination from permanent groundwater de-watering systems located in the area described below.

Inlet to Fanuel Street storm drain.

On Monday April 28, 2003, a follow-up study was conducted at Fanuel Park to investigate potential bacterial sources associated with the storm drain system. The Fanuel Park area contains several residential properties with underground parking structures. Some of these structures (12 have been identified thus far) require de-watering systems to prevent the structures

from flooding. These permanent groundwater de-watering systems pump groundwater or rain water from sumps located within the structure to the storm drain system. Much of this water is not diverted to the sewer system, rather, it flows directly to the Bay. The investigation was initiated to determine if the de-watering operations and other sources of water in the area had an impact on the bacteria levels in the receiving waters at Fanuel Park. During the field investigations, samples were collected from several of the de-watering sump pumps, manhole inlets and vaults of the storm drain conveyance system, and storm drain effluent. Samples were analyzed for fecal indicator bacteria to determine potential sources of contamination within the storm drain conveyance system. Three of the four storm drain conveyance manholes had an exceedance of at least one of the bacterial indicators. The highest bacteria levels were found in the storm drain manhole at the terminus of Dawes Street and the manhole at the terminus of Fanuel Street. In addition, large volumes of water (approximately 250,000 gallons per day) were observed from the permanent groundwater de-watering operations entering the storm drains downstream of the diversion system and flowing directly to Mission Bay. During the weekly monitoring from November through March, Fanuel Park had the second lowest average salinity of any of the 12 sites monitored in Mission Bay. The lack of any obvious freshwater discharges in the area (e.g., creek drainage), suggests that the de-watering operations may have been the source of the lower salinity values. Bacterial levels in effluent from the de-watering operations measured during the follow-up study at Fanuel Park were low. However, given the large volumes of water associated with de-watering and the fact that the water is un-diverted, suggests that these operations should be monitored in the future when Fanuel Park is experiencing elevated bacterial levels. These sources will be further examined in Phase II of the Mission Bay Bacterial Source Identification Study.

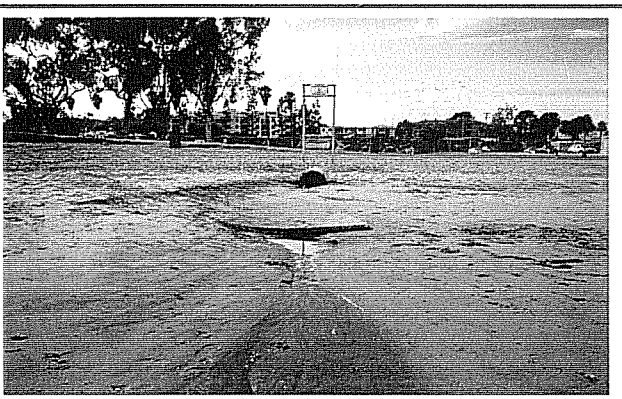
Riviera Shores. The results of the Visual Observations Task suggest that there are very few obvious potential sources of fecal indicator bacteria at Riviera Shores. There are no comfort stations at this site, no flowing storm drains, no irrigation, and no grassy park areas for the accumulation of water. Pets were never observed off leash at Riviera Shores and there was no pet waste observed on the beach. In addition, Rivera Shores had the lowest relative number of birds of any of the sites. However, the lack of obvious bacterial sources at Riviera Shores is confounded by the high number of bacterial exceedances recorded during the Visual Observations Task. During this task, there were more exceedances for *Enterococcus* standard from the receiving waters at Riviera Shores than any other site in the study except De Anza Cove. The high number of bacterial exceedances at Riviera Shores is difficult to explain. However, the lack of obvious bacterial sources in the Riviera Shores area suggests that excessive bacteria levels observed at this site may emanate from other areas. The closest potential source to this site is the de-watering operations at Fanuel Park noted above. Episodic events associated with elevated



Riviera Shores

bacterial levels at Riviera Shores may be correlated with periodic high levels from these operations. The results of Phase II for Fanuel Park will also be used to identify and remediate bacterial sources at Riviera Shores.

Wildlife Refuge. In contrast to Sites 1 through 4 on the west side of Mission Bay, a review of the historical data for Wildlife Refuge indicates that seasonal trends in bacterial levels are present at this site and others on the east side of Mission Bay. For most years, the average *Enterococcus* concentration at Wildlife Refuge is typically lowest in the late spring and summer, begins to climb in the fall, and peaks in the winter. In the winter and early spring *Enterococcus* levels often remain high for weeks to months at a time. There are three likely explanations for this pattern of elevated *Enterococcus* levels in winter: 1) the increase in rainfall and associated surface runoff and/or groundwater flow; 2) fecal matter from the migratory bird population, which peaks in southern California in the winter; or 3) a combination of one and two. Although the data used for this assessment were only from dry-weather samples (taken at least 72 hours after a rain event), it is possible that residual levels of bacteria from surface runoff or groundwater was present 72 hours after the rain event.



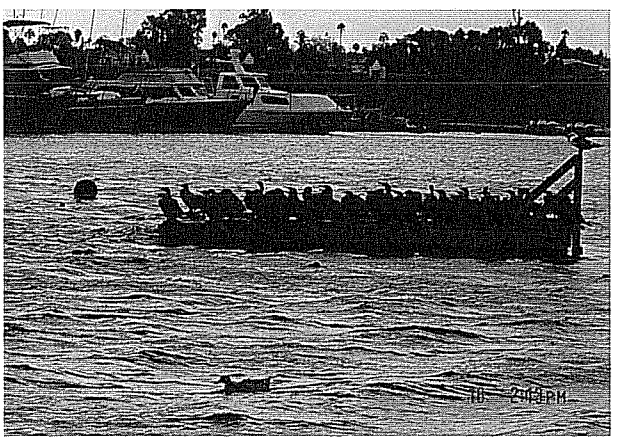
Storm Drain at Wildlife Refuge.

The seasonal changes in the migratory bird population in Mission Bay could explain the pattern. A bird usage survey conducted in Mission Bay Park and the San Diego River in 2000/2001 found that the bird population increased nearly ten-fold between summer and winter on the east side of Mission Bay, but a similar pattern was not seen in areas on the west side. This may explain the lack of observable temporal trends in *Enterococcus* levels at Sites 1 through 4 on the west side of the Bay and the clear seasonal trends observed at Wildlife Refuge and other sites on the east side of the Bay.

The results of the Visual Observations Task suggested that there are only a few likely sources of bacterial contamination at the Wildlife Refuge site, including birds, irrigation and storm drain runoff, and groundwater. The potential for birds as a source of bacterial contamination in winter at this site was discussed above. In summer, irrigation practices may also play a role. Several samples taken downstream of the diversion system from the storm drain located at the DEH sampling site had elevated bacterial levels during Task 3. This storm drain collects water from irrigation activities in the Park and very high levels of fecal indicator bacteria were measured in the grassy area surrounding the storm drain inlet during irrigation. The County AB411 monitoring site is located directly in front of this storm drain. In addition, a groundwater spring discharges along the beach face near the terminus of the storm drain. Bacterial levels were not measured in the effluent from this spring, but it remains a potential source due to the proximity to the Park area where high bacterial concentrations were measured.

The Wildlife Refuge site will not be assessed in Phase II of this project. However, the results from other sites with similar characteristics will be used to apply management actions designed to limit elevated bacterial levels.

Campland. The potential sources of indicator bacteria identified during the Visual Observations Task at Campland include birds, groundwater discharge, effluent from Rose Creek, and effluent from a pipe associated with vehicle and boat washdown that was frequently observed discharging to the Campland boat ramp. The restrooms and RV pump-out facilities at Campland were found to be very clean. In addition there are no grassy areas near the sampling site where bacteria might accumulate as at other sites, no obvious surface runoff from irrigation, and no flowing storm drains. The restroom infrastructure was not examined at Campland as part of Phase I and leaking sewage pipes remain a potential bacterial source at the beach via groundwater transport. In addition, a review of the historical data for Campland indicates strong seasonal trends in *Enterococcus* levels at this site, similar to those seen at Wildlife Refuge and other sites on the east side of Mission Bay.

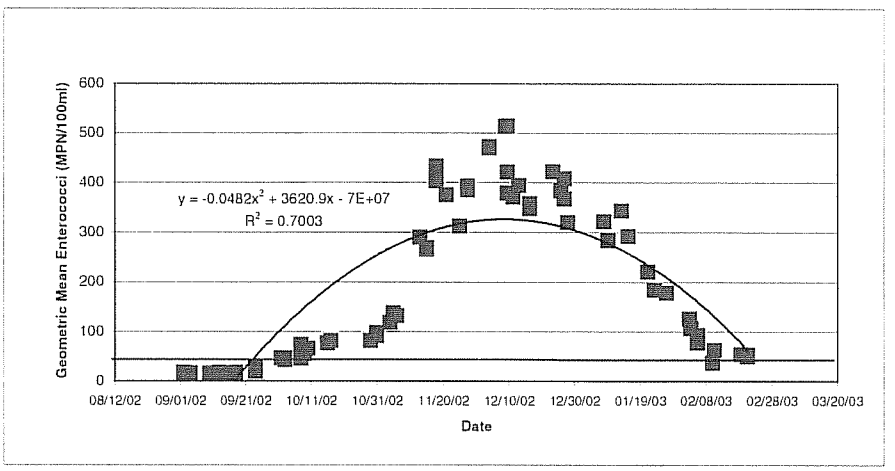


Birds at Campland

During the winter of 2002/2003, the beach at Campland was closed for several months due to concentrations of indicator bacteria that exceeded AB411 criteria. On November 21, 2002, a follow-up investigation was conducted to assess the potential sources of bacteria at this site. Samples were taken from several areas in and around the Campland beach, including Rose Creek, the area west of the Campland jetty, and several sites near the marina and associated docks. The results of the study suggested that the elevated bacterial levels at this site were confined to the Campland beach and a pipe located at the marina boat ramp that drained effluent from boat and vehicle wash down. Upon further investigation, a dead bird inside the marina boat ramp pipe was found to be the source of bacteria from this area. Indicator bacteria levels in the effluent from this pipe decreased dramatically after the bird was removed and the pipe cleaned.

Observations made during the follow-up study suggested that there were numerous birds on the Campland beach and surrounding area. A swim platform used primarily during the summer was frequently populated by a large number of double-crested cormorants (*Phalacrocorax auritus*) and other birds. Large numbers of birds were also observed on the Campland boat docks and beach. Fecal matter from the large bird population at Campland was apparent on the docks, swim platform, and especially the Campland beach. During the observations made during the follow-up study it was noted that the beach was littered with numerous piles of bird waste. On one day of observations over 200 individual piles were counted.

Based on these observations, it was assumed that the high bacterial levels observed in the receiving waters may have been a result of the bird waste in the area. The City worked with the Campland management and staff to reduce the impact of the large bird population by removing structures where birds congregate in the area and by removing bird fecal matter on the beach several times a week. Campland management also informed visitors not to feed the birds. Additional education of Park visitors will be conducted by the City of San Diego during Phase II. These management actions were initiated in mid-December 2002 to mid-January 2003. By the end of January 2003, the *Enterococcus* concentrations at Campland had decreased dramatically from levels recorded earlier in the winter. This pattern is typically seen in the spring at Campland so it is unclear whether or not the management actions were directly responsible for the decline in bacterial levels. A similar management program will be initiated in the winter of 2003/2004 at Campland to determine its effectiveness in reducing the peak in bacteria levels that is seen annually at this site. In addition, samples will be taken at Campland in Phase II to determine the host origin of the bacteria during different seasons. The sediment at the mouth of Rose Creek will also be assessed.



***Enterococcus* concentrations at Campland during winter of 2002/2003**

De Anza Cove. As with other sites on the east side of Mission Bay, birds are a potential source of elevated bacterial levels at De Anza Cove, particularly in the winter. However, concentrations of elevated bacterial levels are also frequently observed during the summer at this site. During the Visual Observations Task, several of the storm drains that empty onto the beach at De Anza Cove were flowing during dry weather. Many of the samples taken from these storm drains had elevated bacterial levels, suggesting that they may be contributing to the AB411 exceedances.

Storm Drains and Springs at De Anza Cove

De Anza Cove is also located in an area of Mission Bay that receives a lot of groundwater flow. Several springs are located along the beach face at De Anza Cove south of the site where the County AB411 monitoring site is located. Bacterial levels were not measured from the springs, but they are a potential source of bacteria via groundwater transport.

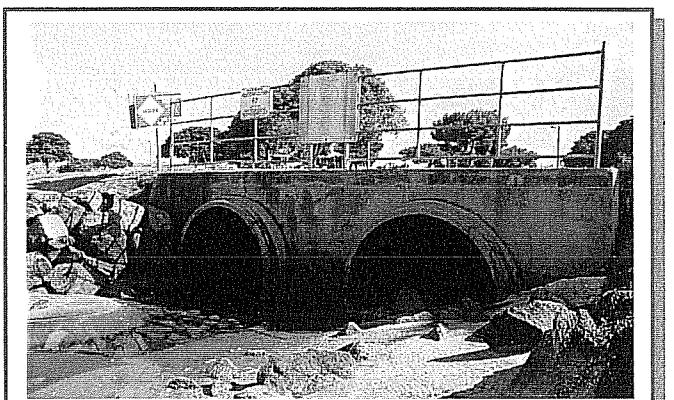
There are eight storm drains that terminate in De Anza Cove, more than any other area in Mission Bay. Of these, six are part of the MBSIS and the other two are unlikely sources of indicator bacteria at the County AB411 monitoring site. The six storm drains in the area that are part of the MBSIS were inspected on January 31 and February 5, 2003. Several of these were flowing during the Visual Observations Task and during the weekly monitoring and flows were frequently associated with consistently high bacterial levels. The County AB411 monitoring site is located in front of a storm drain whose storm water diversion vault was found to be free of debris and effectively diverting dry weather flows to the sanitary sewer. However, the diversion vaults of the five remaining storm drains in the area were all filled with sediment, organic matter (primarily eel grass), and trash during the inspection. The check valves of all of these storm drains were propped open with the debris so that dry weather flow was not diverted and flowed directly to the Bay. Samples collected from the ends of each of the three storm drains had elevated bacterial levels on the day of the investigation as well as during the Visual Observations Task of this study. During the Visual Observations Task and subsequent weekly sampling, flow was observed from three of the five storm drains, suggesting that urban runoff flows had been reaching the Bay since at least August 2002.

Two follow-up studies were conducted at De Anza Cove. The first was initiated on January 31, 2003 in response to prolonged elevated bacterial levels that had been recorded at De Anza Cove prior to that date and the large amounts of runoff that were being discharged from the numerous storm drains and springs in the area. The purpose of the study was to examine the sources and extent of the freshwater discharge at the site. Water quality measurements (temperature, pH, and salinity) were measured at the surface along 12 transects positioned perpendicular to the beach. At each transect, measurements were made at the shore then every five feet for a total length of approximately 20 feet. The measurements were made on both a flooding and ebbing tide. The results of the study suggested that there was not a large plume of freshwater emanating from the storm drains and beach springs. In most cases the freshwater appeared to be fairly localized, although there was a small freshwater plume observed near one storm drain. Bacterial samples taken from the storm drain effluent at that time had elevated levels of *Enterococcus*, but at the time of the surveys bacterial levels were low at the County AB411 monitoring site located approximately 75 feet to the west.

The second follow-up study at De Anza Cove was conducted on May 21, 2003 to assess the concentration of indicator bacteria in the sediments and determine how much bacteria is re-suspended in the water column by swimming activity. The study design was the same as that described above for the Bonita Cove sediment study. The results of the study at De Anza Cove showed that the sediments at this site have a lower grain size and higher TOC level than those at Bonita Cove. The *Enterococcus* concentrations were also higher at De Anza Cove, but in general were also fairly low. As with Bonita Cove, the results suggest that the beach sediments at De Anza Cove are an unlikely source of long-term storage of fecal indicator bacteria and that

the re-suspension of sediments by swimmers is not a likely source of *Enterococcus* to the receiving waters. A similar investigation should be conducted in the winter when the site experiences the seasonal peak in indicator bacterial levels. Samples will be taken at De Anza Cove during Phase II to determine host origin of the bacteria at this site.

Visitor's Center. The Visitor's Center is one of the most complex sites examined in this study in terms of identifying potential bacterial sources. The results of the Visual Observations Task suggested that there are several potential bacterial sources at Visitor's Center, including birds, irrigation and storm water runoff, groundwater, and drainage from Cudahy Creek. As with other sites on the east side of Mission Bay, a review of the historical data for Visitor's Center indicates strong seasonal trends in *Enterococcus* levels at this site. Concentrations peak annually in the winter and then begin to decrease usually in early to mid-spring corresponding with the seasonal changes in the migratory bird population in the area. Bacterial levels at this site often exceeded AB411 criteria, particularly during the winter. During the weekly monitoring, criteria were exceeded at this site more than any other in Mission Bay and the site had an advisory posting for several months due to excessive bacterial levels.

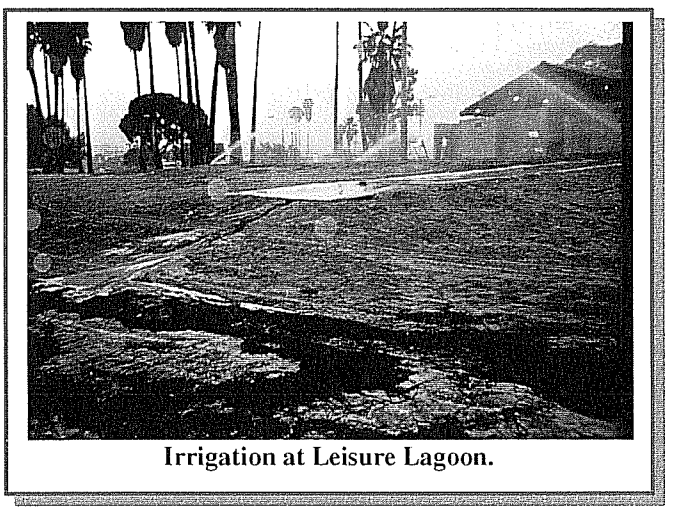


Storm Drains at Visitor's Center.

In addition to birds, storm drains were also identified as a potential bacterial source at Visitor's Center. The County AB411 monitoring site is located directly in front of two large storm drains that receive flow from a freshwater spring. The spring is located on the east side of Interstate 5 downstream of the diversion system and appears to generate a constant flow from the terminus of one of the storm drains. *Enterococcus* levels in samples taken from the storm drain exceeded AB411 criteria in almost all cases throughout Phase I during the Visual Observations Task, the weekly monitoring, and follow-up studies. The Visitor's Center site may also be impacted from the Cudahy Creek discharge. The mouth of Cudahy Creek is located approximately 800 feet to the south of the County AB411 monitoring site. Although dry weather runoff is diverted, the creek bed (a concrete channel) runs all the way under Interstate 5 and is typically full of organic matter and sediment washed up from the Bay. Supplemental information gathered by the City indicates that *Enterococcus* levels at the mouth of Cudahy Creek frequently exceed AB411 criteria. The three storm drains at Visitor's Center were inspected (two at the County AB411 sampling site and Cudahy Creek) were inspected on January 31 and February 5, 2003. None of the diversion vaults of these storm drains are tidally influenced and they appeared to be diverting dry weather flow to the sewer system. Thus, elevated bacterial levels measured in runoff from these drains originates downstream of the MBSIS diversion structures.

On January 31, 2003 a follow-up study was conducted at Visitor's Center to determine the sources and extent of the freshwater discharge at the site and assess the extent to which bacteria

associated with the freshwater affects bacterial levels at the County AB411 sampling site. The results of the study showed that there are several sources of freshwater at Visitor's Center, including a spring on the east side of Interstate 5 that is conveyed to the Bay via a storm drain, several groundwater springs that discharge along the beach face, and effluent from Cudahy Creek. In general, the freshwater appeared to be fairly localized and there was no evidence of a large freshwater lens at the site from these sources. Several of the sources had elevated bacterial levels, including the mouth of Cudahy Creek, a groundwater spring just north of the mouth, the terminus of the storm drain at the County AB411 sampling site, the spring upstream of that storm drain, and a storm drain entrance in between the two. *Enterococcus* levels were moderately high (86 MPN/100 ml) 35 feet from the terminus of SD8-1. These data suggest that groundwater near Visitor's Center combined with the storm drain effluent downstream of the MBSIS may be the source of the numerous AB411 exceedances at this site. In Phase II, the origin of the bacteria at the County AB411 monitoring site will be compared to that from several potential sources identified in Phase I.



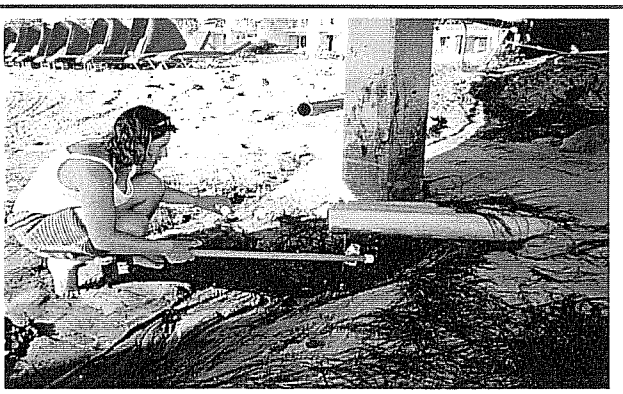
Irrigation at Leisure Lagoon.

Leisure Lagoon. The potential sources of bacteria identified during the Visual Observations Task at Leisure Lagoon included birds, storm water and irrigation runoff, and groundwater. The County AB411 monitoring site at Leisure Lagoon is located directly in front of an un-diverted storm drain that is not part of the MBSIS. The drainage area of the storm drain is small, encompassing a parking lot and grassy areas of the Park. *Enterococcus* levels in samples taken from the storm drain during the Visual Observations Task were extremely variable, but ranged as high as 68,000 MPN/100 ml. The most likely source of the high concentrations is runoff from the grassy areas of the Park during irrigation. There is one other storm drain that empties into Leisure Lagoon. It is also un-diverted, but levels of indicator bacteria were very low in samples taken from this storm drain during the Visual Observations Task. Excessive watering appeared to be somewhat problematic at this site, particularly at the south end, and surface runoff to the Bay was common during irrigation. Steep slopes in this area likely contribute to the elevated runoff. Samples taken from the surface runoff and from ponded water in the grass frequently had very high levels of indicator bacteria (*Enterococus* levels over 1,000 MPN/100 ml were common), but the extent to which this sources of bacteria effects the receiving waters of Leisure Lagoon is unclear.

High bacteria levels were also measured in samples taken of the comfort station wash down at this site. Comfort station washdown has been eliminated as a potential source due to the management actions taken by the City of San Diego Park and Recreation Department described for Bonita Cove. The lateral lines of the comfort stations were inspected and found to be in good condition. There are several springs that discharge along the beach face at Leisure Lagoon, but

they were not analyzed for bacteria in Phase I. During summer holidays, Leisure Lagoon is one of the most crowded beaches in Mission Bay. However, in contrast to Bonita Cove, statistical analyses of bacterial data collected between 1993 and 2003 did not show any difference in the concentrations of indicator bacteria between holiday and non-holiday periods at this site. In Phase II, the host origins of bacterial will be analyzed from several potential sources at Leisure Lagoon.

North Pacific Passage. There were relatively few potential bacterial sources identified at North Pacific Passage during the Visual Observations Task. There are no grassy areas near the site and the bird population is small. There is one comfort station at North Pacific Passage at the far south end of the site. The lateral line of the comfort station was inspected and found to be in good shape and effluent from restroom washdown was not found to be a problem during the Visual Observations Task. There is one small groundwater spring at this site, but it is located a long distance (several thousand feet) from the sampling site.

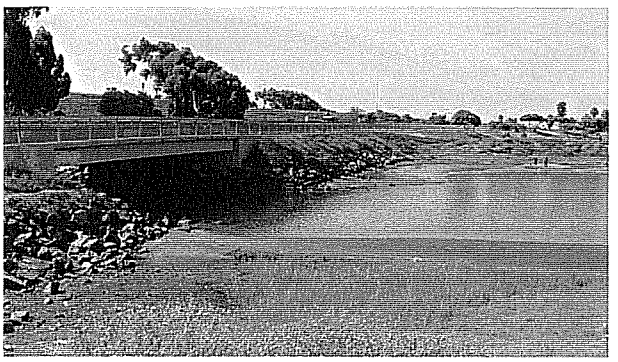


Runoff from koi pond at North Pacific Passage.

The one source of indicator bacteria that was identified during the Visual Observations Task was four 6-inch PVC pipes located at the Hilton Hotel boat dock, south of the County AB411 monitoring site. One or more of the pipes were flowing during nearly all of the observations of Task 3 and concentrations of indicator bacteria in the effluent were frequently elevated. On October 31, 2002, a follow-up study was conducted at North Pacific Passage to determine the source of elevated bacterial levels from these pipes. The investigation showed that the source of the elevated bacterial levels was a koi pond located on the Hilton hotel property next to the swimming pool. The pond had not been properly maintained and water fouled with bird feces was continually flowing through an overflow stand pipe that discharged to the Bay. Once the problem had been identified, the pond was cleaned, the overflow drain was fixed, and water and aeration pumps were replaced to alleviate the problem. Hotel management was extremely cooperative and proactive in identifying and eliminating this source of bacteria to the Bay. At no time during the weekly observations was flow observed from the pipes after the repairs were made to the pond. There have been no exceedances of AB411 criteria at North Pacific Passage since the flow from the Hotel's pipes was eliminated.

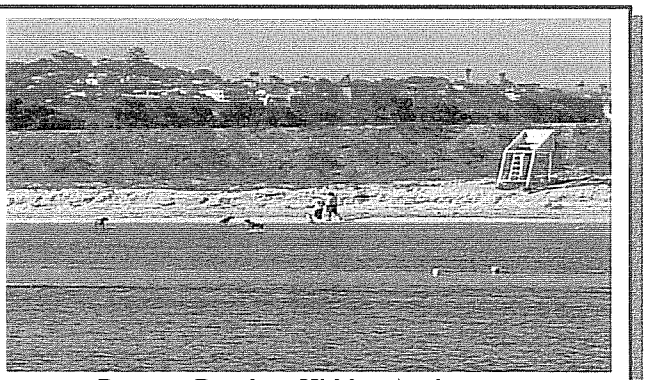
Due to the limited potential sources of bacteria at this site and lack of exceedances of AB411 criteria since remediation actions were take, North Pacific Passage will not be included in the sampling design for Phase II.

Tecolote Creek. The Tecolote Creek site is located at the mouth of Tecolote Creek at the East Mission Bay drive bridge. There is one comfort station in the area located over 1,000 feet away from the sampling site, just west of the playground. The infrastructure of the comfort station is intact and there were no observations of improper wash down procedures during the visual observations task at this site. Elevated levels of *Enterococcus* were measured in samples taken form ponded water in the grass at this site, but these Park areas are a long distance from the sampling site. In addition, there are no storm drains that discharge directly to the Tecolote Creek site. The most obvious potential source of bacteria to this site is the drainage from the creek itself. Indicator bacteria may originate from numerous sources within an urban watershed, including birds and other wildlife, waste from domestic and feral pets, and human waste from leaking sewer lines and the homeless population. Although Tecolote Creek is diverted, all of these sources have the potential to create elevated bacterial levels at the Tecolote Creek site because the inputs can occur downstream of the diversion point. In addition, the storage of bacteria in sediments at the mouth of the creek may act as a reservoir for bacteria that is subsequently re-suspended in the water column. These sources will be investigated as part of Phase II of this study.



Drainage from Tecolote Creek.

Hidden Anchorage. There were very few potential sources of indicator bacteria identified during Phase I at Hidden Anchorage. There is no irrigation of grassy park areas for the accumulation of bacteria, no comfort stations or sewer lines, and no groundwater springs or creek drainages at this site. None of the storm drains that discharge to the area were flowing during dry weather sampling. In addition, Hidden Anchorage has a very small bird population. The one variable that is most likely responsible for elevated levels of indicator bacteria at this site is the dogs. Hidden Anchorage is a favored spot by many dog owners because dogs are allowed to run off leash. During the Visual Observations task, there were more observations of dogs and dog waste on the beach at this site than any other in the study. A follow-up study conducted at this site also suggested that dog waste was the source of indicator bacteria. Subsequent management action taken by the City of San Diego Park and Recreation Department, which consisted of the installation of dog waste baggie dispensers and additional trash cans, appears to have been effective in nearly eliminating bacterial exceedances at this site. There is no sampling planned for Hidden Anchorage in Phase II of this study.



Dogs on Beach at Hidden Anchorage.

The investigative tasks conducted in Phase I were very effective in determining which of the many potential bacterial sources were actually impacting area beaches. During the study, as potential bacterial sources were identified, the City implemented numerous management activities that abated those identified sources to eliminate or reduce their input to the Bay. The reduced list of potential sources for each site will be crucial to focusing efforts in Phase II of the study. In Phase II, bacterial sources to the Bay will be further identified and appropriate actions and activities will be recommended to eliminate the input of those sources to Mission Bay.

Remaining contents of Final Report are in Master File for reference.