COLORADO LAGOON:

WATER QUALITY ASSESSMENT REPORT

KLI.CL-02

Prepared for
City of Long Beach

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LIST OF ACRONYMS AND ABBREVIATIONS

BPTCP	Bay Protection and Toxics Control Program
CDF&G	California Department of Fish and Game
LACSD	Los Angeles County Sanitation District
LCP	Local Coastal Program
NOAA	National Oceanic and Atmospheric Administration
RWQCB	Regional Water Quality Control Board
SMW	State Mussel Watch Program
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency

1.0 EXECUTIVE SUMMARY

With the possible exception of AB411 monitoring, there have not been any consistent sampling programs in Colorado Lagoon to document the concentrations of contaminants in water, sediment and biota. Data used by the Los Angeles Regional Water Quality Control Board (RWQCB) to identify Colorado Lagoon as impaired is primarily from early evidence of high concentrations of certain contaminants in resident and transplanted bivalves that were first reported by the California Department of Fish and Game Mussel Watch Program in the 1980's. Further evidence of sediment and tissue contamination in Colorado Lagoon was documented as part of surveys conducted by the State's Bay Protection and Toxics Control Program (Anderson et al., 1998) in the early 1990's. Based upon this information, the Lagoon was placed on the 303(d) list for lead, zinc, chlordane, and PAHs in sediments. Organochlorine pesticides (chlordane, DDT, dieldrin and PCBs) were also cited as contributing to impairment due to bioaccumulation in tissues of fish and mussels. Although not listed for bacteria, concerns have been expressed regarding frequent beach advisories due to elevated bacteria concentrations.

Volunteer monitoring programs conducted by the Southern California Marine Institute and Surfrider Foundation have provided limited data for water quality constituents typically used to assess illegal or illicit discharges. Parameters have included nutrients, phenols, pH, turbidity and dissolved oxygen. These and other data show occasional spikes in nutrient levels and dissolved oxygen depression. These events are not necessarily concurrent.

The City of Long Beach Health Department has been conducting weekly surveys of indicator bacteria since January 2001. Exceedances of AB411 or Basin Plan criteria at this location are unusual in that they are often attributable to high levels of total coliform (>10,000 MPN/100 ml) or a combination of total coliform (> 1,000 MPN/100 ml) and *E. coli* concentrations that exceed 10 percent of the total coliform. These and other bacterial surveys at California beaches only focus on bacteria that are believed to be "indicators" of a pathogenic bacteria and viruses. Depending upon the source of the bacteria, these indicators may or may not provide an indication of a significant risk to people involved in water contact recreation. Although efforts are underway to develop immunoassay methods that are direct, cost effective and rapid, this technology is not currently available.

Recent sediment data from Colorado Lagoon was available from a brief survey by Tetra Tech conducted in December 2000 as well as from the three sites tested as part of this program. Results indicate a strong contamination gradient with high levels of certain contaminants in the western arm transitioning to much lower levels in the northern arm. Concentrations of many of these contaminants differ by an order of magnitude between Area CL-1 and CL-3. Five metals including cadmium, copper, lead, mercury and zinc exhibited this distributional pattern. Among the organic contaminants, DDT compounds, chlordane, dieldrin, PCBs and PAHs also demonstrated this strong gradient.

Water quality tests conducted as part of this program included analysis of total and dissolved metals, nutrients, TSS, chlorinated pesticides, PCBs, and organophosphate pesticides. A fourth sample was taken from a storm drain on the eastern shoreline of the Lagoon. Overall, concentrations of most analytes tested were extremely low. All chlorinated pesticides, PCBs and organophosphate pesticides were below detection limits and none of the trace metals exceeded California Toxics Rule criteria. Nutrient concentrations within the Lagoon were typical of coastal waters. Concentrations of nutrients entering the Lagoon through dry weather discharges from the adjacent residential neighborhood were typically an order of magnitude higher that found in the receiving waters although the flow rate was described as a trickle at the time of sampling.

Remediation options to improve water quality in the lagoon address eliminating pollutant sources and increasing circulation. Potential remediation options to further evaluate as part of the alternatives assessment task include: a) implementation of upstream watershed BMPs, b) elimination of storm drain outlets into the Colorado Lagoon in coordination with the County's Termino Avenue Drain Project, c) dry weather diversion into the County sewage treatment plant for additional storm drains, d) construction of bio-swales and berms, e) installation of street catch basin filters, f) improvement of trash management protocols at the lagoon, g) bird management protocols, and i) improvements to the tidal culvert.

The culvert to Colorado Lagoon restricts tidal flushing of the water body and results in less than optimum water quality conditions. Simple visual comparison between the Lagoon and nearby Marine Stadium, both of which ultimately connect to Alamitos Bay (considered equivalent to the ocean), shows Lagoon water quality to be degraded from the Bay. Lagoon water is murkier, and contains algal blooms and submergent plant growth (indicative of excess nutrients in the system), while Alamitos Bay is clear and contains no algal blooms and minimal submergent plant growth. The culvert is significantly filled in with marine growth and is partially restricted by tide gates at the Lagoon end, and by a sill on the Marine Stadium end. Debris may be present also partially blocking the Lagoon end. The effect of these restrictions is that tidal flushing is reduced and constituents in the Lagoon are not readily flushed to Marine Stadium, therefore accumulating in the lagoon and impairing the water quality. Solutions to the culvert restriction include cleaning and clearing the culvert, and opening the tide gates as much as possible to promote maximum tidal flow. Another option is to remove the culvert and replace it with an open channel. This option would generate maximum improvements to water quality but would also require significant costs that can be estimated as part of the Feasibility Study.

2.0 INTRODUCTION

The Los Angeles Regional Water Quality Control Board (RWQCB) 2002 303(d) list identifies Colorado Lagoon as impaired due to lead, zinc, chlordane, and PAHs in sediments. Organochlorine pesticides (chlordane, DDT, dieldrin and PCBs) were also cited as contributing to impairment due to bioaccumulation in tissues of fish and mussels. Although not listed for bacteria, frequent beach advisories due to elevated bacteria concentrations have deteriorated the swimming and recreational uses of the Lagoon. In 2003, the Colorado Lagoon was closed for 19 days, (Long Beach Press Telegram, 6 August 2004 citing Natural Resources Defense Council 14th annual beach report), making it the worst water quality swimming area in the City of Long Beach. Heal the Bay gave Colorado Lagoon-north grades of D or worse for 36% of the time from July 2001 to January 2004.

The only other available data for sediments in Colorado Lagoon was from a brief survey by Tetra Tech conducted in December 2000. Although chemistry reports were available from this survey, a final report was never completed documenting sampling procedures and specific locations. The laboratory reports indicate that one sample was taken from the western reach of the Lagoon and a second was taken from the eastern reach, near the culvert entrance.

A complete summary of existing and recent sediment data was previously provided in detail in the "Colorado Lagoon: Sediment Testing and Material Disposal Report" (KLI/M&N 2004).

The primary objectives of this report are to:

- Synthesize existing data on contaminants in Colorado Lagoon sediment, water and biota
- Conduct an initial environmental study to identify the full range of pollutants of concern
- Prepare an environmental site assessment indicating the presence, types and concentrations of soil and water contaminants.
- Examine the connection between Colorado Lagoon and Marine Stadium for possible improvements to water quality.
- Evaluate the data to identify potential sources of pollutants
- Develop preliminary remediation options for the various restoration alternatives
- Recommend source controls and remedies and evaluate diverting storm drain flows to the ocean or San Gabriel River as suggested in the City of Long Beach Local Coastal Program report.

This report provides an overall summary of existing sediment, water and bioaccumulation data from Colorado Lagoon. Additional sediment and water quality from the site investigation is then summarized. The complete data set is then used to evaluate possible sources and to discuss potential corrective measures. This following describes the overall organization and content of each section:

- Section 1.0 is the Executive Summary.
- Section 2.0 introduces the report and provides an overview of the report organization. Section 2.0 also lists the appendices in the report.
- Section 3.0 describes all available water and sediment quality data from Colorado Lagoon.
- Section 4.0 provides information on bioaccumulation studies conducted in Colorado Lagoon.
- Section 5.0 discusses potential sources of contaminants found in sediment, water and biota.
- Section 6.0 provides an initial examination of potential options for water quality improvements through either elimination of pollutant sources and/or increasing circulation.
- Section 7.0 is a list of the references cited in this report.

In addition, the following appendices are included with this report:

- Appendix A contains complete copies of analytical chemistry reports from water quality testing.

3.0 SEDIMENT AND WATER QUALITY DATA

This section describes sediment and water quality data for Colorado Lagoon from historical and ongoing monitoring efforts as well as data collected in association with this current program. Sediment data was previously summarized in detail in “Colorado Lagoon: Sediment Testing and Material Disposal Report” (KLI/M&N 2004). Sediment data are summarized in this report in order to be comprehensive.

3.1 Historical and Ongoing Monitoring Programs

Historical sediment and water quality data was obtained from a variety of sources. These include:

- City of Long Beach, Department of Environmental Health (AB411 Monitoring)
  - Duration of Study: January 2001 to present.
  - Parameters: Water (Indicator bacteria)
- Southern California Marine Institute (Supplemental Environmental Project)
  - Duration of Study: February, 2003 to present (part of a 5-year effort)
  - Parameters: Water (Indicator bacteria, nutrients, dissolved oxygen, color, pH, salinity, temperature, secchi depth and turbidity)
- Surfrider Foundation
  - Duration of Study: April 2001 to November 2002.
  - Parameters: Nutrients, temperature, pH, salinity, dissolved oxygen, and phenols.
- Tetra Tech
  - Duration of Study: Single Survey, January 2001
  - Parameters: Sediment (Metals, herbicides, semivolatile organics, organochlorine pesticides, particle size); Water (dissolved oxygen, pH, turbidity, temperature, conductivity, suspended solids)

- Bay Protection and Toxics Control Program (BPTCP)
  - Duration of Study: Single Survey, January 1993
  - Parameters: Sediment (metals, herbicides, semivolatile organics, organochlorine pesticides, particle size)
- California Department of Fish and Game Mussel Watch Program
  - Duration of Study: Surveys in January 1982, January 1985, December 1985, December 1986
  - Parameters: Mussels (trace metals and synthetic organics)
- Current Study (done by Kinnetic Laboratories, Inc. and Moffatt & Nichol)
  - Duration of Study: July/August, 2004
  - Parameters: Sediment (Metals, organochlorine pesticides, organophosphate pesticides, particle size); Water (Total and Dissolved Metals, organochlorine pesticides, organophosphate pesticides); Water Quality Profiles of temperature, salinity, dissolved oxygen, and pH.

3.1.1 City of Long Beach Department of Health and Human Services

The City of Long Beach conducts weekly sampling at three locations in Colorado Lagoon (Figure 3-1) as part of AB411 sampling requirements. All sites are located on the pedestrian bridge that crosses the western arm of the Lagoon.

Figure 3-1 Locations of AB411 Monitoring Sites in Colorado Lagoon

The City's Health Department provided weekly data extending from January 2001 through June 2004 for total coliform, *E. coli*, and *Enterococcus*. In Southern California, the *E. coli* test is equated to fecal coliform for purposes of comparisons with AB411 and Basin Plan criteria. Also available were "City of Long Beach Health Department – Beach Warnings Posted" lists for 2000 and 2001.

Data from the three monitoring sites are summarized graphically in Figures 3-2 through 3-13. Figures 3-5, 3-9 and 3-13 summarize Colorado Lagoon results of the system used by Heal the Bay to assess overall quality of recreational beaches and City of Long Beach warnings posted for the years 2000 and 2001 (pink dots) . A description of the grading system used by Heal the Bay can be found at http://www.healthebay.org/brc/gradingsystem.asp. The grading system involves a 28-day rolling average with weighting factors that provides the greatest weight to the most recent data.

Trends at the three monitoring stations are generally similar due to their close proximity to one another. Surprisingly, however, the northernmost site has produced the most exceedances in recent years as a result of total coliform exceeding the 1000 MPN/100 ml and fecal coliform concentrations that exceeded 10% of the total coliform concentrations.

Exceedances of AB411 or Basin Plan criteria in Colorado Lagoon are unusual in that they are often attributable to high levels of total coliform (>10,000 MPN/100 ml) or a combination of total coliform (> 1,000 MPN/100 ml) and *E. coli* concentrations that exceed 10 percent of the total coliform. This is unlike patterns noted at Cabrillo Beach and several other beaches that are often impacted by elevated levels of bacteria.

Lastly, it is important to recognize that these surveys only focus on bacteria that are believed to be "indicators" of a pathogenic bacteria and viruses. Depending upon the source of the bacteria, these indicators may or may not provide an indication of a significant risk to people involved in water contact recreation. Although efforts are underway to develop immunoassay methods that are direct, cost effective and rapid, this technology is not currently available.

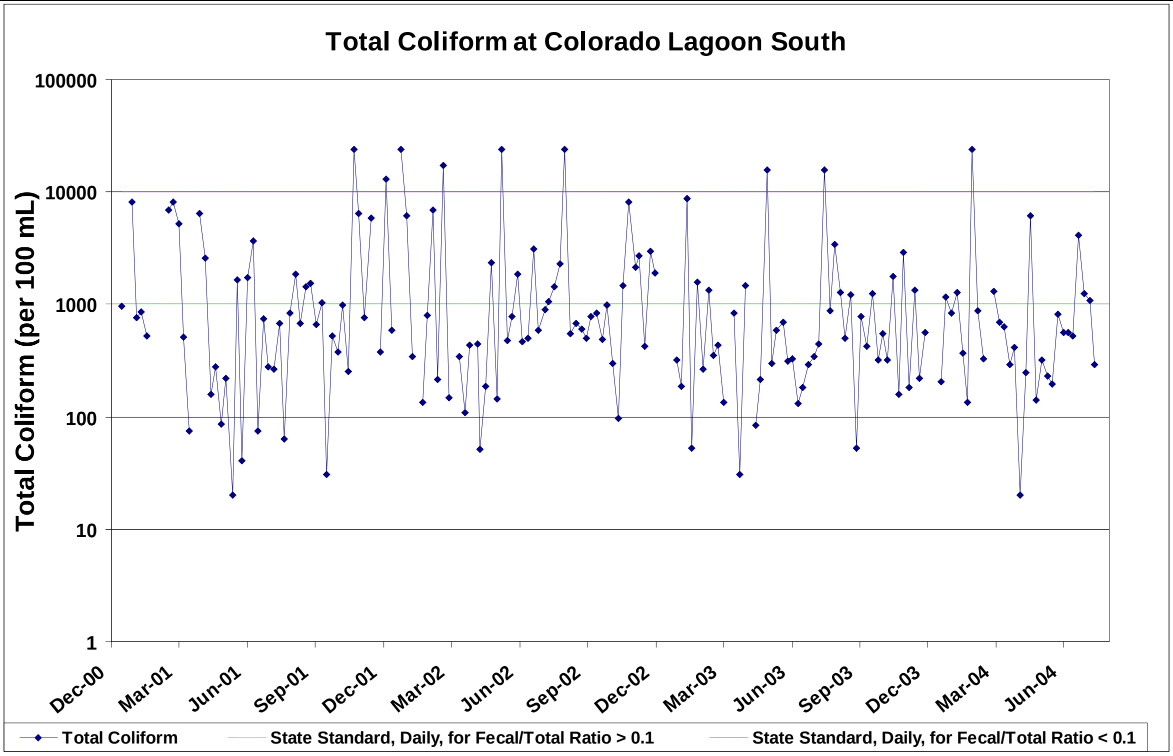


Figure 3-2 Total Coliform measured at City of Long Beach Site B-24, 12/2000-7/2004

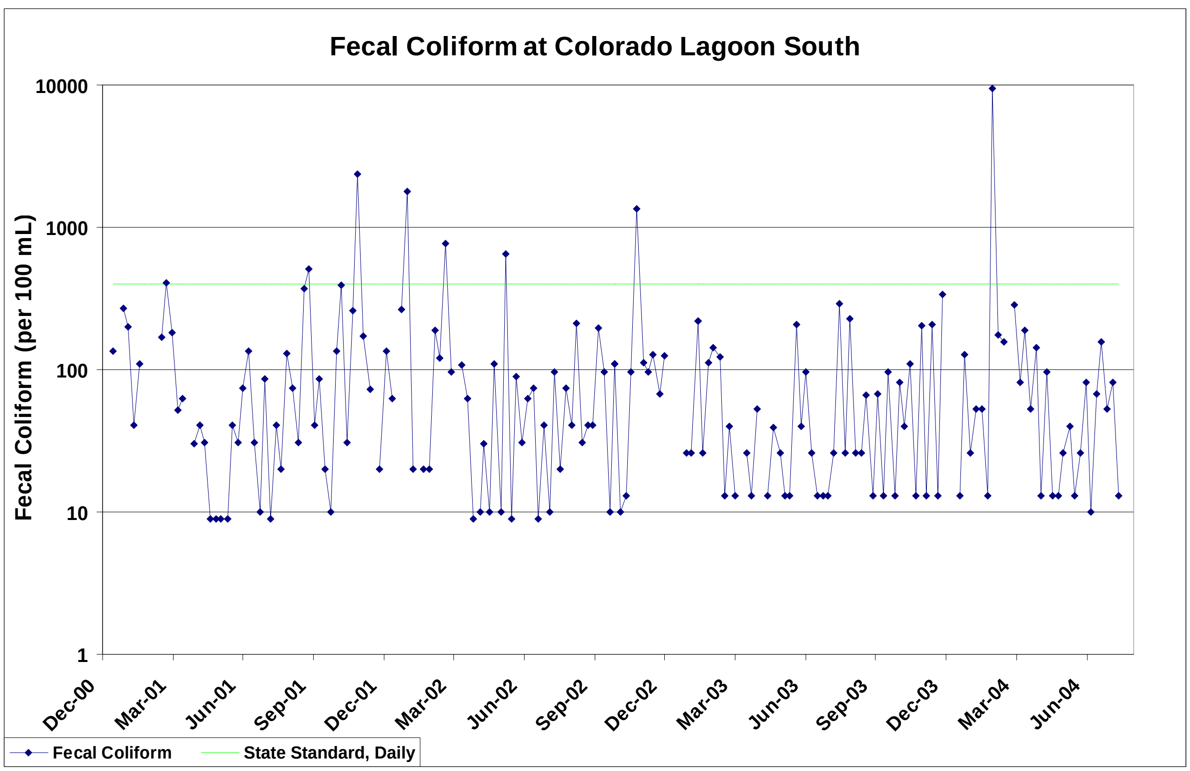


Figure 3-3 Fecal Coliform measured at City of Long Beach Site B-24, 12/2000-7/2004

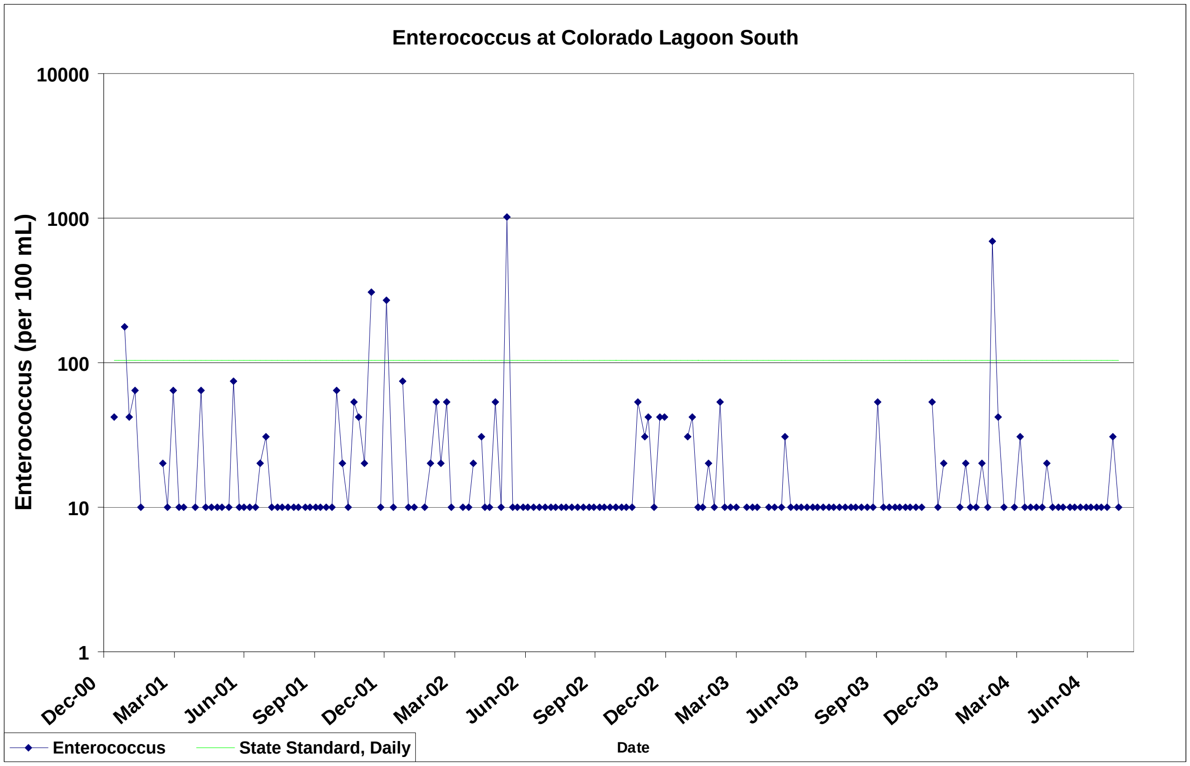


Figure 3-4 Enterococcus measured at City of Long Beach Site B-24, 12/2000-7/2004

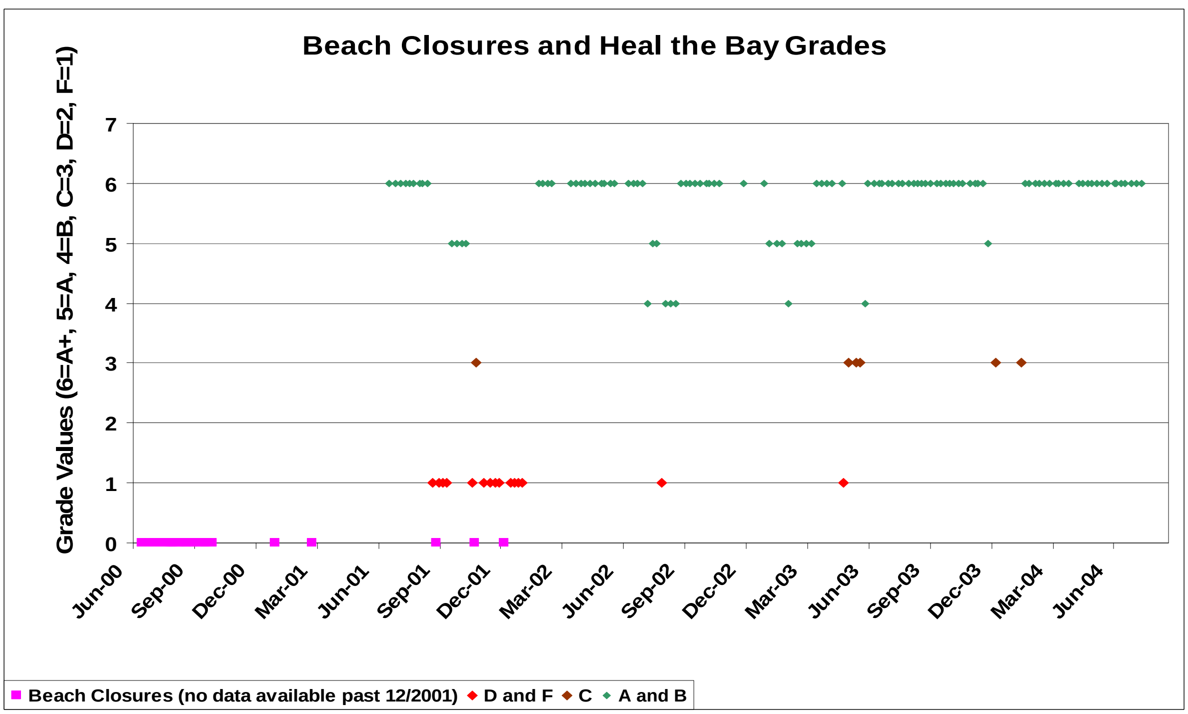


Figure 3-5 Beach Closures and Heal the Bay Grades for Colorado Lagoon Site B-24, 6/2000-6/2004

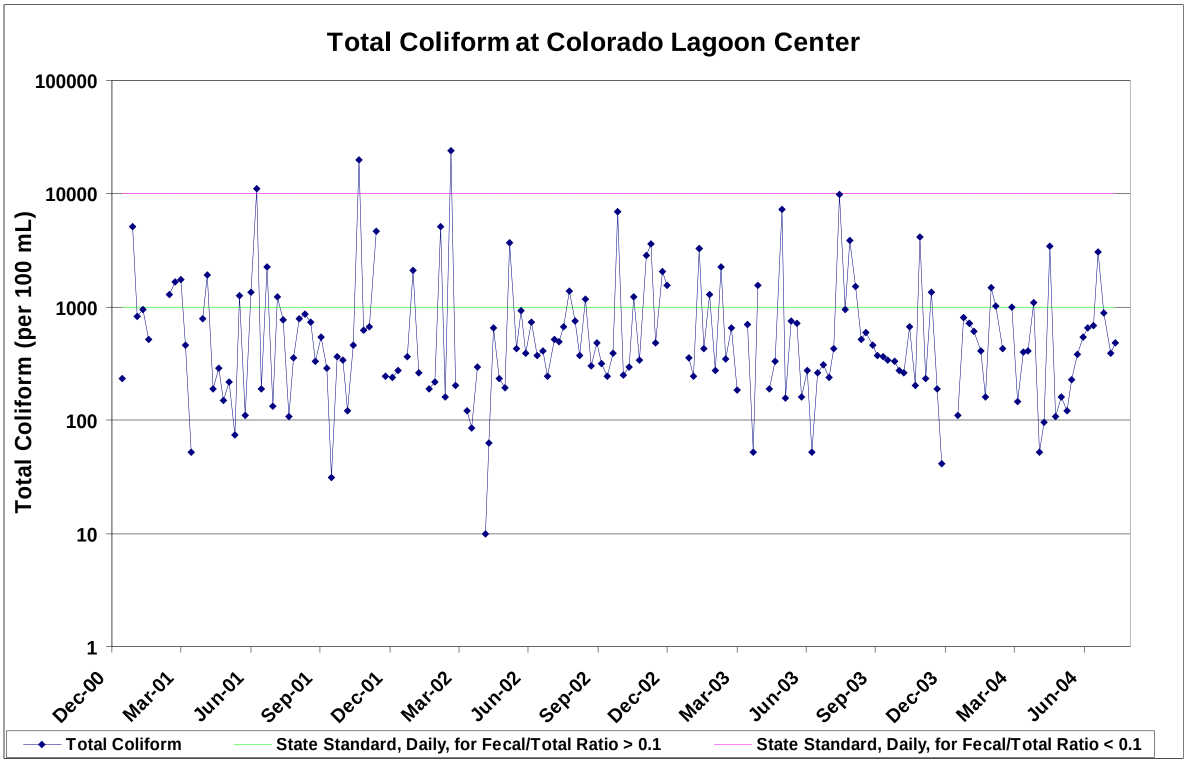


Figure 3-6 Total Coliform measured at City of Long Beach Site B-25, 12/2000-7/2004

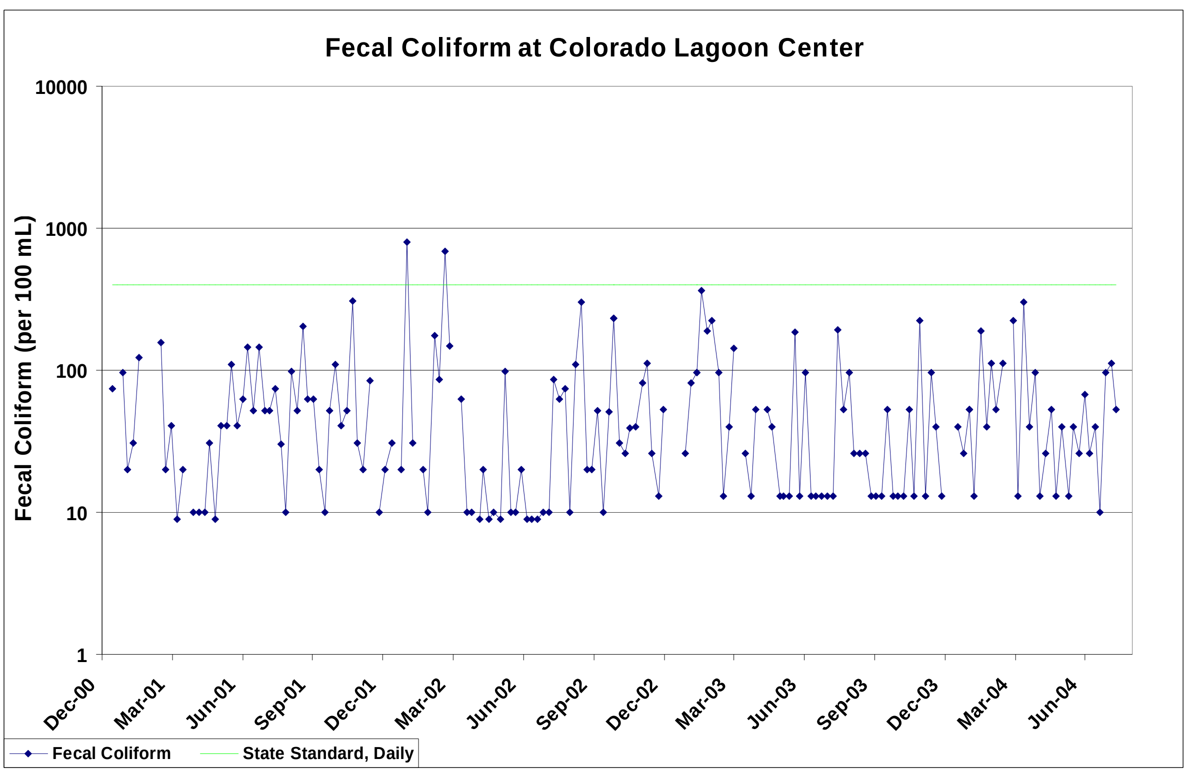


Figure 3-7 Fecal Coliform measured at the City of Long Beach Site B-25, 12/2000-7/2004

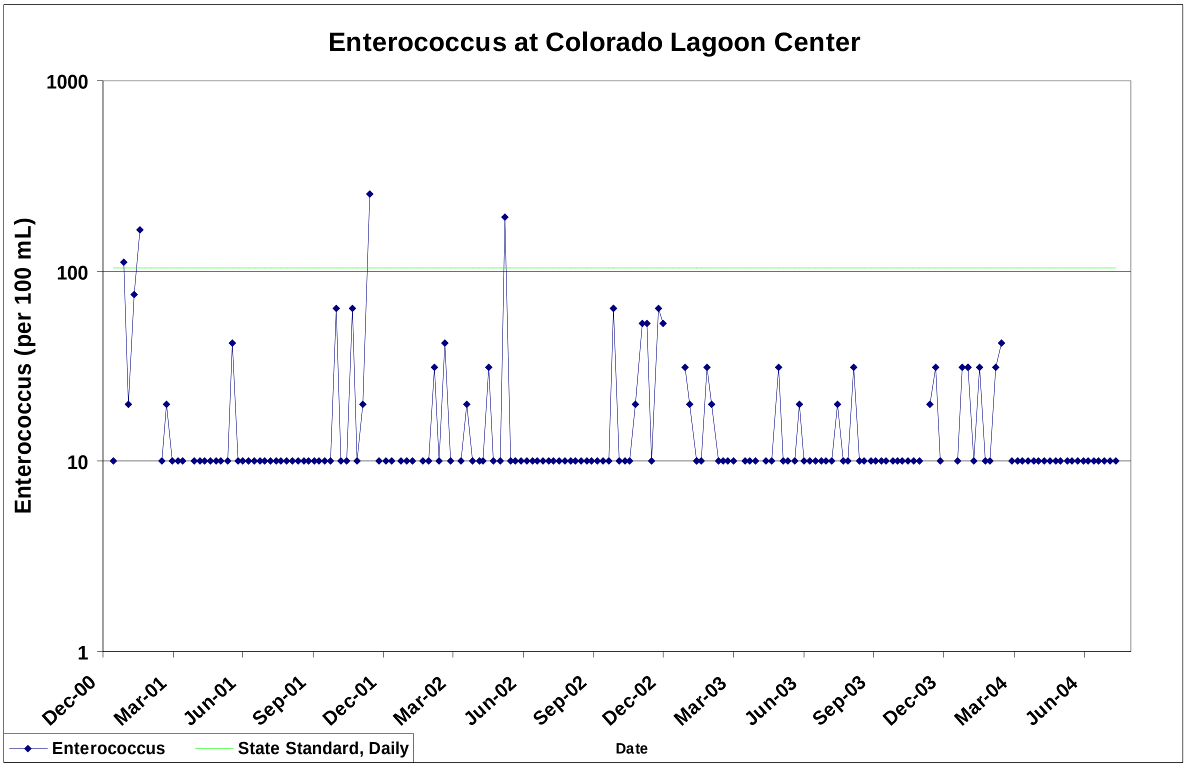


Figure 3-8 Enterococcus measured at City of Long Beach Site B-25, 12/2000-7/2004

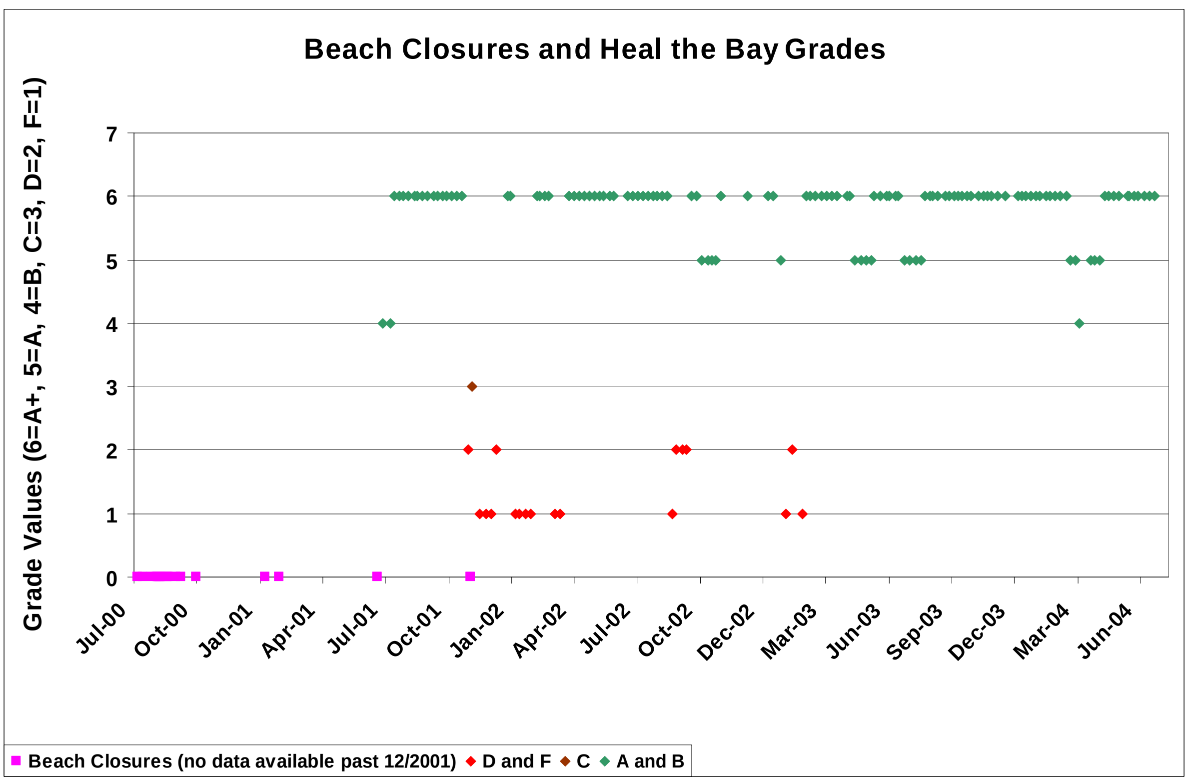


Figure 3-9 Beach Closures and Heal the Bay Grades for Colorado Lagoon Site B-25, 6/2000-6/2004

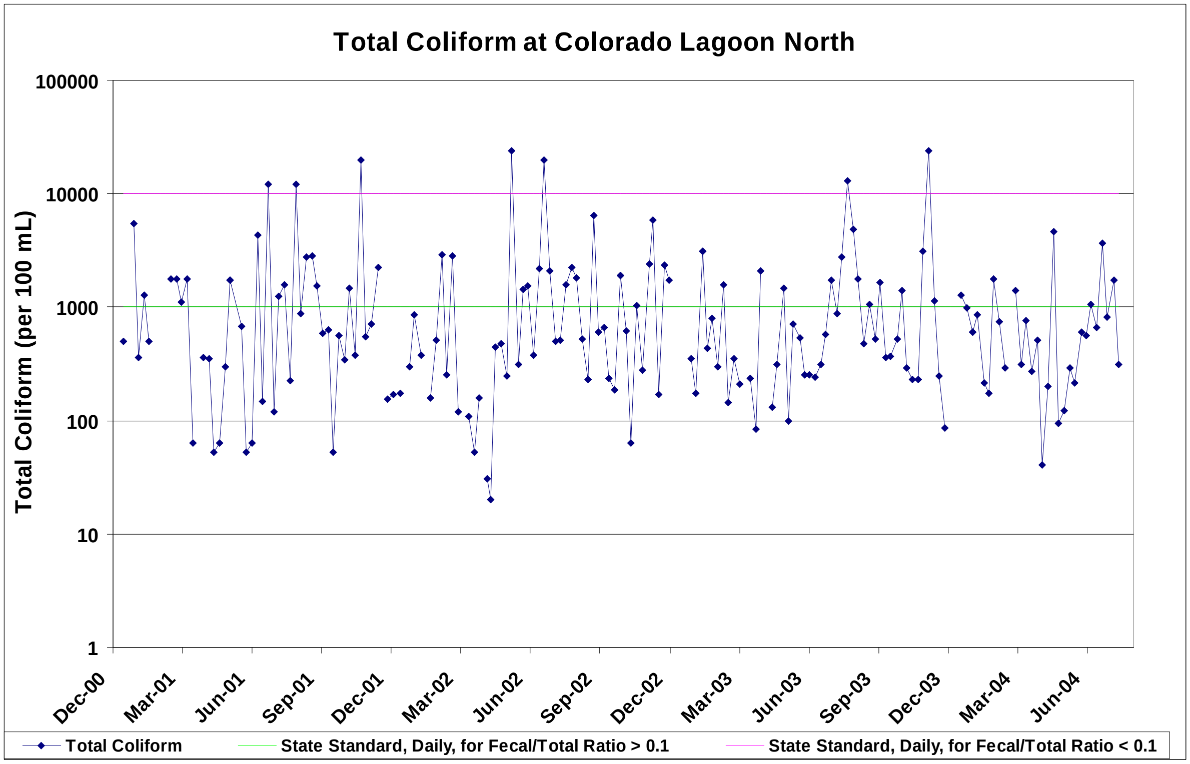


Figure 3-10 Total Coliform measured at City of Long Beach Site B-26, 12/2000-7/2004

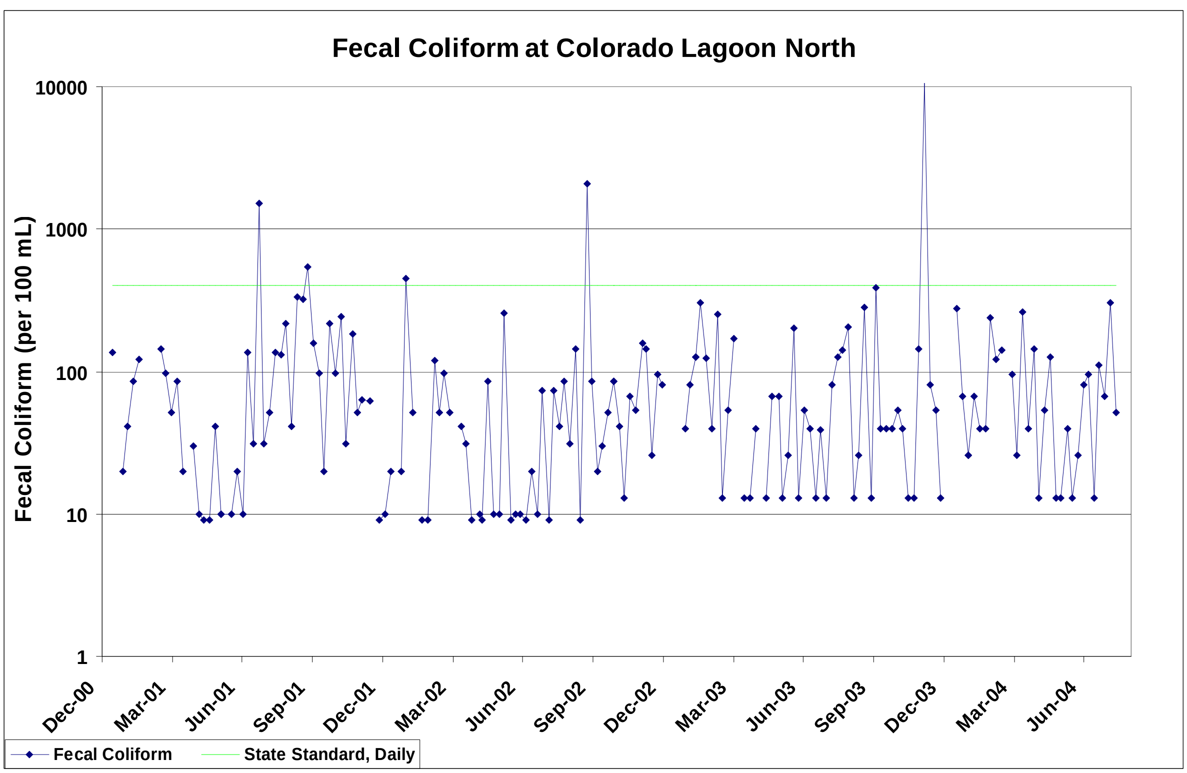


Figure 3-11 Fecal Coliform measured at City of Long Beach Site B-26, 12/2000-7/2004

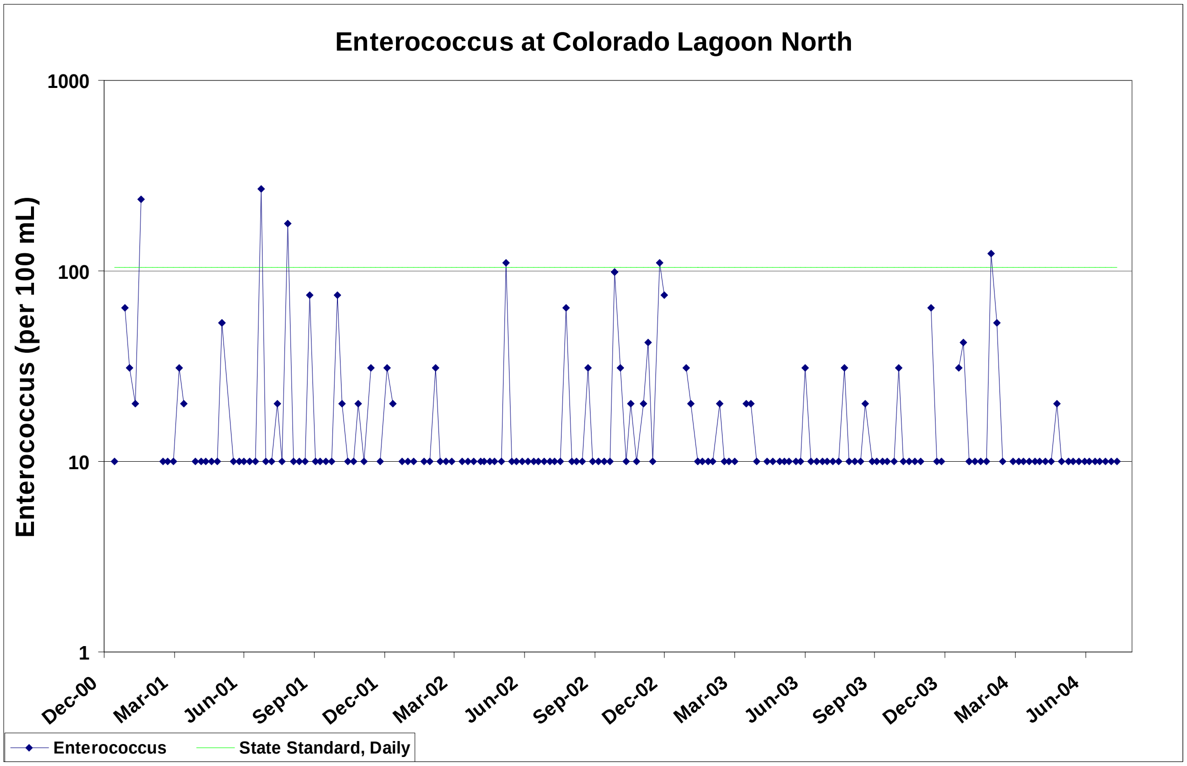


Figure 3-12 Enterococcus measured at City of Long Beach Site B-26, 12/2000-7/2004

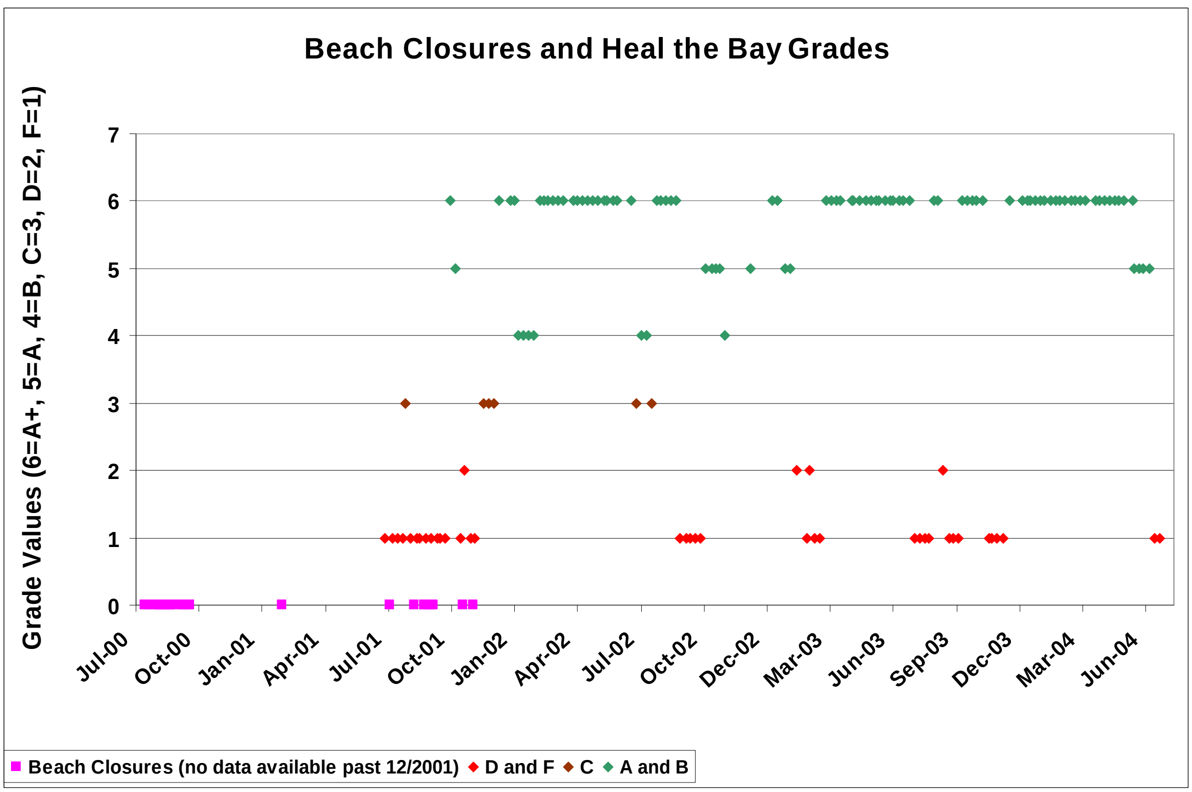


Figure 3-13 Beach Closures and Heal the Bay Grades for Colorado Lagoon Site B-26, 6/2000-6/2004

3.1.2 Surfrider Foundation

The Surfrider Foundation monitored routine water quality parameters in Colorado Lagoon from April 2001 through November 2002. Water quality was measured by use of field test kits by volunteers. Methods were consistent with those used by SCMI in their Supplemental Environmental Projects. Results are summarized in Table 3-3.

Data from this program demonstrated periods of low dissolved oxygen (< 5 mg/L) and occasional periods when nitrate-N was elevated.

Table 3-1 Nutrients and General Water Quality, April 2001 through November 2002

Date	Tide	Time	Water Temp (°C)	Dissolved Oxygen (mg/L)	pH	Sal (g/Kg)	NH4-N (mg/L)	$N0_3$-N (mg/L)	P (mg/L)	Phenols (mg/L)
4/29/01	high	17:30	18	10	7.9	32	0.19	0.06	0.12	0.06
5/20/01	high	15:00	22	9.2	7.8	31	0.77	0.06	0.09	0.03
6/23/01	high	14:00	24	8.4	7.8	30	0.30	0.06	0.13	0.06
7/29/01	high	13:00	23	6.8	7.7	31	0.29	0.02	0.23	0.09
8/25/01	flood	9:30	24	4.4	7.8	27	0.49	0.11	0.63	0.28
9/23/01	high	12:30	22	8.2	7.8	30	0.30	0.03	0.11	0.08
10/28/01	low	14:30	19	9.2	7.9	31	0.10	2.36	0.13	ND
1/26/02	ebb	11:20	14	10.8	8.0	32	0.72	ND	0.08	ND
2/16/02	flood	8:30	15	9.2	7.7	32	0.02	0.02	0.09	0.07
3/27/02	high	10:00	15	9.1	7.5	31	0.10	ND	0.48	0.11
4/6/02	ebb	9:20	16.5	6.2	7.3	31	0.09	0.61	0.08	ND
5/18/02	ebb	9:10	19	7.6	7.6	32	ND	0.12	0	ND
6/22/02	high	9:10	22	3.6	7.6	32	0.07	1.99	0.07	0.05
7/27/02	flood	9:10	22	2.0	7.6	30	0.49	0.06	0.05	ND
8/24/02	flood	10:45	22.5	4.6	7.7	31	0.4	0.07	0.07	ND
9/28/02	flood	9:05	20.5	7.0	7.9	31	0	0.1	0.08	ND
10/19/02	high	9:00	17	5.2	7.7	35	0.05	0.24	0.16	ND
11/23/02	flood	9:15	16	6.2		36	0.09	0.15	0.07	ND

3.1.3 Southern California Marine Institute

The Southern California Marine Institute conducted a on year supplemental environmental project (SCMI 2004) to “provide narrative and numerical bacteriological data for ten sample sites over five discrete times (November, February, May, August and after the first flush) over the course of a year”. Colorado Lagoon was one of the sites included in this work. The sampling location is identified as 33^o 46’ 13’’ N, 118^o 09’ 48’ W.

They are also continuing with a five-year supplemental environmental program (SCMI 2004) that started in January 2004. Monitoring of bacteria is conducted using IDEXX Colilert® and Enterolert® tests that are now commonly used for AB411 monitoring in Southern California. Test kits are typically used for nutrients and dissolved oxygen. A refractometer is used to estimate salinity of the receiving water.

Summaries of the results of the SCMI’s monitoring efforts are presented in Tables 3-1 and 3-2.

Table 3-2 Indicator Bacteria, February 2003 through May 2004

Sample Date	Total Coliforms	E. coli	Enterococcus
04-Feb-03	129	41	<10
17-May-03	273	30	<10
06-Aug-03	789	30	<10
04-Nov-03	>24196	836	546
17-Nov-03	682.8	52	10
26-Feb-04	>24196	2063	521
25-May-04	756	36	<10

Table 3-3 Nutrients and General Water Quality Data, February 2003 through May 2004

Sample Date	DO (mg/L)	Forel-ule Color	Nitrate-N (mg/L)	OrthoP (mg/L)	pH	Salinity (g/Kg)	Secchi (meters)	Temp (°C)	Turbidity (NTU)
04-Feb-03	4.5	10				33.0	2.0	16	
17-May-03	6.8	12	0.05	0.06	8.1	36.0[a]	1.8	18	0.91
06-Aug-03	6.4	6	0.14	0.19	8	33.0	1.8	21	1.53
04-Nov-03	3.8		0.08	0.21	7.8	32.1	2.0	18	3.3
17-Nov-03	4		0.15	0.19	7.6	32.7	2.0	15.5	1.1
26-Feb-04	6		0.15	0.21	7.8	25.2		16.5	2.8

[a]This number appears to be an outlier since salinities of this magnitude are only likely to occur in salt pannes where the effects of evaporation can increase levels above those found in the open ocean

3.1.4 Bay Protection and Toxics Control Program

The BPTCP sampled surficial sediments collected by divers from one site in the western arm of Colorado Lagoon in January of 1993. BPTCP data are included the BPTCP database available on the State Water Resources Control Board web site. Data were analyzed in a report by Anderson et al (1998) titled Sediment Chemistry, Toxicity, and Benthic Community Conditions in Selected Water Bodies of the Los Angeles Region, Final Report.

Sediment data from this program was the primary data set used to place Colorado Lagoon on the Regional Board's listed of impaired water bodies. Data are summarized in Table 3-4 along with previous sediment data from Tetra Tech, EMI (Section 3.1.5) and from the current vibracore survey. The table provides a comparison of the three data sets with Effects Range Low (ERL) and Effects Range Median (ERM). Data were previously summarized and discussed in KLI/M&N (2004).

3.1.5 Tetra Tech, EMI

Tetra Tech, EMI sampled two locations in the Lagoon in December 2000. One station (CL-West) was located in the western arm of the Lagoon. The second (CL-East) was located near the culvert entrance. These sites roughly correspond to Areas CL-1 and CL-2. Sediment analyses performed by Tetra Tech were also based upon surficial samples. Data are summarized in Table 3-4 along with previous sediment data from BPTCP (1998) (Section 3.1.4) and from the current vibracore survey.

Contaminant concentrations in sediments from the two sites sampled by Tetra Tech in 2000 also indicated a spatial gradient going from high concentrations in the western portion of the Lagoon to substantially lower concentrations in the central portion of the Lagoon. Nevertheless, differences between these two areas were not as extreme as found in core composites from these two regions.

Water quality data were taken along with this sampling effort. The water quality survey was conducted by personnel from the City of Long Beach Health Department. Data are summarized in Table 3-5. Conductivity values appear to be erroneous due to values far over the expected range. A key result of this survey was the low dissolved oxygen values found throughout the Lagoon.

Table 3-4 Comparison with Historical Sediment Data Sets

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
Conventionals									
Percent Moisture	Percent (wet)						41	34.6	28.6
TRPH	mg/kg (dry)				2000	440	490	ND (76U)	ND (70U)
Solids, Percent	Percent (wet)				39	41	59	65.4	71.4
Metals									
Antimony	mg/kg (dry)			2.7			1.7	0.77	0.57
Arsenic	mg/kg (dry)	8.2	70	**9.5**	**10**	**8.9**	7.5	6.1	4.9
Barium	mg/kg (dry)						342	538	107
Beryllium	mg/kg (dry)						0.53	0.49	0.37
Cadmium	mg/kg (dry)	1.2	9.6	**2.0**	**2.8**	**1.5**	**2.1**	0.65	0.38
Chromium	mg/kg (dry)	81	370	56	55	51	34	29	21
Cobalt	mg/kg (dry)						6.1	6.0	4.1
Copper	mg/kg (dry)	34	270	**87**	**120**	**100**	**55**	27	15
Lead	mg/kg (dry)	47	218	**510**	**390**	**180**	**409**	**81**	40
Mercury	mg/kg (dry)	0.15	0.71	**0.36**	0.02U	0.02U	**0.33**	**0.17**	0.053
Molybdenum	mg/kg (dry)						12	8.7	6.7
Nickel	mg/kg (dry)	21	51.6	**34**	**36**	**32**	18	14	8.9
Selenium	mg/kg (dry)						0.53	0.28	0.32
Silver	mg/kg (dry)	1.0	3.7	0.62	**1.4**	**1.8**	**1.2**	**1.7**	0.28
Thallium	mg/kg (dry)						0.91	0.45	0.36
Vanadium	mg/kg (dry)						56	53	39.
Zinc	mg/kg (dry)	150	410	**690**	**600**	**340**	**266**	97	46

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

Table 3-4 Comparison with Historical Sediment Data Sets (continued)

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
Herbicides									
2,4,5-TP (Silvex)	ug/kg (dry)						ND (422U)	ND (76U)	ND (70U)
2,4-D	ug/kg (dry)						ND (422U)	ND (76U)	ND (70U)
Pentachlorophenol (PCP)	ug/kg (dry)						ND (422U)	ND (76U)	ND (70U)
PAHs									
Naphthalene	ug/kg (dry)						15	ND (31U)	ND (28U)
Fluorene	ug/kg (dry)	19	540	**95.6**	ND (25U)	ND (25U)	ND (34 U)	ND (31U)	ND (28U)
Phenanthrene	ug/kg (dry)	240	1500	**1770**	230	54	**253**	18	9.0J
Anthracene	ug/kg (dry)	85	1100	**188**	43	25	ND (34 U)	7.9J	ND (28U)
Acenaphthene	ug/kg (dry)	16	500	**113**	ND (25U)	ND (25U)	**17J**	6.0J	ND (28U)
Acenaphthylene	ug/kg (dry)	44	640		ND (25U)	ND (25U)	12J	ND (31U)	ND (28U)
Fluoranthene	ug/kg (dry)	600	5100	**2330**	530	150	372	53	31
Pyrene	ug/kg (dry)	665	2600	**2210**	**1300**	190	625	73	34
Benzo(a)anthracene	ug/kg (dry)	261	1600	**701**	**330**	100	ND (34 U)	ND (31U)	ND (28U)
Chrysene	ug/kg (dry)	384	2800	**889**	**510**	140	ND (34 U)	ND (31U)	ND (28U)
Benzo(a)pyrene	ug/kg (dry)	430	1600	**691**	410	130	ND (34 U)	ND (31U)	ND (28U)
Benzo(b)fluoranthene	ug/kg (dry)				590	140	ND (34 U)	ND (31U)	ND (28U)
Benzo(k)fluoranthene	ug/kg (dry)				480	140	ND (34 U)	ND (31U)	ND (28U)
Dibenzo(a,h)anthracene	ug/kg (dry)	63.4	260	**125**	ND (180U)	ND (170U)	ND (34 U)	ND (31U)	ND (28U)
Benzo(g,h,i)perylene	ug/kg (dry)				410	ND (200U)	ND (34 U)	ND (31U)	ND (28U)
Indeno(1,2,3-cd)pyrene	ug/kg (dry)				610	ND (170U)	ND (34 U)	ND (31U)	ND (28U)
Total Low MW PAH	ug/kg (dry)	552	3160	**738**[1]	273	79	282	32	9.0
Total High MW PAH	ug/kg (dry)	1700	9600	**9301**[1]	**5170**	990	1279	158	73
Total PAH	ug/kg (dry)	4022	44792	**10039**[1]	5453	1069	1561	190	82
Benzyl butyl phthalate	ug/kg (dry)				640	250	ND (34U)	ND (31U)	34
bis-(2-Ethylhexyl)phthalate	ug/kg (dry)				14000	1800	3600	410	260
Diethyl phthalate	ug/kg (dry)				48	39	47	42	65
Dimethyl phthalate	ug/kg (dry)				31	ND (25U)	19	ND (31U)	3.2J
Di-n-butyl phthalate	ug/kg (dry)				180	91	ND (34U)	38	27
Di-n-octyl phthalate	ug/kg (dry)				310	ND (250U)	ND (34U)	ND (31U)	ND (28U)

1. Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.
2. Totals include additional PAHs not analyzed in the current program

Table 3-4 Comparison with Historical SedimentData Sets (continued)

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
DDT Compounds									
4,4'-DDD	ug/kg (dry)	2	20	**40.6**	**46**	**8.9**	ND (3.4U)	**3.5**	ND (2.8U)
4,4'-DDE	ug/kg (dry)	2.2	27	**89.9**	**110**	**44**	**67**	**16**	**4.3**
4,4'-DDT	ug/kg (dry)	1	7	**50.9**	**11**	**2.7**	**14**	ND (12U)	ND (11U)
Total DDT	ug/kg (dry)	1.58	46.1	**181.4**[2]	**167**	**55.6**	**81**	**20**	**4.3**
Chlordane Compounds									
alpha-Chlordane	ug/kg (dry)			70.3	73	13	50	ND (3.1U)	ND (2.8U)
gamma-Chlordane	ug/kg (dry)				61	15	55	3.3	ND (2.8U)
Heptachlor	ug/kg (dry)			1.5	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Heptachlor epoxide	ug/kg (dry)			2.5	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Total Chlordane	ug/kg (dry)	0.5	6.0	**74.3**[2]	**134**	**28**	**105**	**3.30**	ND (2.8U)
Other OC Pesticides									
Aldrin	ug/kg (dry)			8.2	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
alpha-BHC	ug/kg (dry)				ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
beta-BHC	ug/kg (dry)				ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
delta-BHC	ug/kg (dry)				ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
gamma-BHC (Lindane)	ug/kg (dry)			0.8	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Dieldrin	ug/kg (dry)	0.02	8	**24.3**	**19**	**3.2**	**27**	ND (3.1U)	ND (2.8U)
Endosulfan I	ug/kg (dry)			0.7	ND (5.1U)	ND (4.9U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endosulfan II	ug/kg (dry)			2.8	ND (1.3U)	ND (1.2U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endosulfan sulfate	ug/kg (dry)			2.7	ND (25U)	ND (25U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endrin	ug/kg (dry)				17	5.7	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endrin aldehyde	ug/kg (dry)				ND (2.5U)	ND (2.5U)	ND (3.4U)	ND (3.1U)	ND (2.8U)
Endrin ketone	ug/kg (dry)				ND (2.8U)	2.0	ND (3.4U)	ND (3.1U)	ND (2.8U)
Kepone	ug/kg (dry)						ND (17U)	ND (15U)	ND (14U)
Methoxychlor	ug/kg (dry)				ND (25U)	ND (25U)	ND (6.8U)	ND (6.1U)	ND (5.6U)
Mirex	ug/kg (dry)						ND (17U)	ND (15U)	ND (14U)
Toxaphene	ug/kg (dry)				ND (76U)	ND (74U)	ND (34U)	ND (31U)	ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

1. Total Chlordane including cis-nonachlor, trans-nonachlor, and oxychlordane equaled 134.5 ug/Kg-dry.
2. Total DDT including 2,4'-DDD, 2,4'-DDE, and 2,4'-DDT equaled 208 ug/Kg-dry.

Table 3-4 Comparison with Historical Sediment Data Sets (continued)

	Units	ERL	ERM	1/14/1993 BPTCP	12/8/2000 CL-West	12/8/2000 CL-East	6/30/2004 CL-1 Top	7/1/2004 CL-2 Top	6/30/2004 CL-3 Top
PCBs									
PCB-1016 (Aroclor 1016)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1221 (Aroclor 1221)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1232 (Aroclor 1232)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1242 (Aroclor 1242)	ug/kg (dry)	23	180		ND (25U)	ND (25U)	ND (34 U)	ND (31U)	ND (28U)
PCB-1248 (Aroclor 1248)	ug/kg (dry)	23	180				ND (34 U)	ND (31U)	ND (28U)
PCB-1254 (Aroclor 1254)	ug/kg (dry)	23	180		ND (25U)	ND (25U)	ND (34 U)	ND (31U)	ND (28U)
PCB-1260 (Aroclor 1260)	ug/kg (dry)	23	180		ND (25U)	ND (25U)	**98**	ND (31U)	ND (28U)
Total PCBs	ug/kg (dry)	22.7	180	**100.5**	ND (25U)	ND (25U)	**98**	ND (31U)	ND (28U)

Red highlighting indicates ERM exceedances, Yellow highlighting indicates ERL exceedances.

Table 3-5 Colorado Lagoon Survey Water Quality Results, City of Long Beach Health Department, January 19, 2000.

Station	Depth (m)	Dissolved Oxygen (mg/L)	pH	Turbidity (NTU)	Temperature (°C)	Conductivity (mS/cm)[1]	TSS (mg/L)
1- 70 yds east of west end in middle	0	4.93	7.83	3	15.2	79.4	
	1	4.17		5	15.1	79.9	23
	2	3.77		3	14.9	80.0	
	3	3.52		4	14.9	80.1	
	4	3.87		2	14.9	80.1	
2- 17 yds from shore at southwest culvert	0	4.30	7.84	5	15.4	79.6	
	1	4.71		5	15.1	79.7	
3- Center of southeast corner adjacent to tide gate	0	4.70	7.78	2	15.0	79.4	
	1	4.11		3	15.1	79.8	
	2	3.89		3	14.9	79.8	
	3	3.91		4	14.9	80.1	
	4	4.18		79	14.9	74.9	
4- 130 yds east of bridge/dock in middle	0	4.69	7.82	2	15.1	79.1	
	1	4.20		2	15.0	79.1	
	2	3.92		5	14.9	79.7	
	3	4.04		4	14.9	79.8	
	4	4.03		9	14.9	79.9	
5- 30 yds from west shore at start of north-south channel section	0	4.28	7.79	4	15.3	79.5	
	1	3.98		3	15.1	79.8	100
	2	3.81		4	14.9	80.0	
	3	3.71		4	14.9	80.2	
	4	3.42		95	14.9	80.1	
6- 100 yards from north end in middle	0	4.16	7.43	3	15.3	79.9	
	1	4.05		3	15.1	75.5	
	2	3.83		5	15.0	75.2	
	3	3.74		8	14.9	75.2	
	4	3.91		13	14.9	68.1	

1. Conductivity values are as reported but should not be considered valid since they are twice the expected range for full strength seawater.

3.2 Present Sediment and Water Quality Survey

Sediment data from cores taken in July 2004 were previously reported in KLI/M&N (2004). They are summarized in Table 3-4 along with other data from the two previous sediment surveys in the Lagoon.

Water quality testing was conducted in association with the sediment testing program. Three samples (Figure 3-14) were taken at the centroid of the sediment coring sites. Sampling was conducted on June 29th, 2004, prior to starting the sediment testing program. Samples were analyzed for the same set of analytes currently included in the Long Beach Stormwater Monitoring Program (KLI 2004). These included total and dissolved metals, nutrients, TSS, chlorinated pesticides, PCBs, and organophosphate pesticides. A fourth sample was taken from a storm drain on the eastern shoreline of the Lagoon. This sample was only tested for nutrients and salinity. This was the only storm drain that exhibited dry weather flows at the time of sampling.

The results of the water quality survey are summarized in Table 3-6. Overall, concentrations of most analytes tested were extremely low. All chlorinated pesticides, PCBs and organophosphate pesticides were below detection limits and none of the trace metals exceeded California Toxics Rule criteria. Nutrient concentrations within the Lagoon were typical of coastal waters. Concentrations of nutrients entering the Lagoon through dry weather discharges from the adjacent residential neighborhood were typically an order of magnitude higher that found in the receiving waters. At the time of the survey flows from this site were reported to be trickling out from under a flap gate.

A special bacteria survey was conducted on August 2, 2004 in association with the City's AB411 monitoring in Colorado Lagoon. This survey involved sampling for total coliform, *E. coli* and *Enterococcus* during three different time periods. The first set of data was collected early in the morning at approximately 0700. Samples were taken from four dry weather discharges (Figure 3-15) and from six receiving water sites. Two of the receiving water sites (MN-6 and MN-8) were located at the shoreline in the swimming portion of the Lagoon. The remaining four receiving water sites were located in open water areas of the Lagoon. The second and third sets of samples were taken at 1200 when the City of Long Beach typically conducts sampling in the Lagoon and again at 1700. Only the six receiving water sites were tested during these surveys.

Data from this survey are summarized in Table 3-8 and Figure 3-16 through 2-19. As expected, high concentrations of bacteria were measured in dry weather discharges from the storm drains at 0700 in the morning. Concentrations of total coliform ranged from 10^4 to 10^5 MPN/100 ml, *E. coli* concentrations ranged from 10^3 to 10^4 MPN/100 ml and *Enterococcus* was typically on the order of 10^3 MPN/100 ml except at one site. The concentration of *Enterococcus* in dry weather flows from MN-5 was only 74 MPN/100 ml. This site drains the local residential area to the south of the Lagoon. Concentrations of all indicator bacteria measured in the receiving waters at the same time (0700) were typically an order of magnitude less than measured in the storm drains. The concentration of *Enterococcus* at MN-7 was an anomaly in that it was the highest concentration detected in both the receiving waters and storm drains.

The early morning survey indicated exceedances of AB411/Basin Plan criteria at MN-6, MN-7, MN-9 and MN-11. By the noon survey, concentrations of all indicator bacteria had declined by up to an order of magnitude. Changes in bacterial concentrations were typically not substantial between the noon and 1700 survey. All measured bacterial concentrations remained below AB411/Basin Plan criteria. In particular, all measured concentrations of *Enterococcus* were below detection limits.

The results of this survey suggest that bacteria are introduced into the Lagoon at night. As expected, bacterial populations die back during the day with exposure to UV radiation. This could be through dry weather discharges, birds, regrowth in sediments or any number of other factors. Dry weather discharges are typically largest in the early morning when automatic irrigation systems can produce runoff. Dry weather discharges into the Lagoon have been estimated at roughly 140,000 gallons per day (Boyle Engineering Corp. 2003).

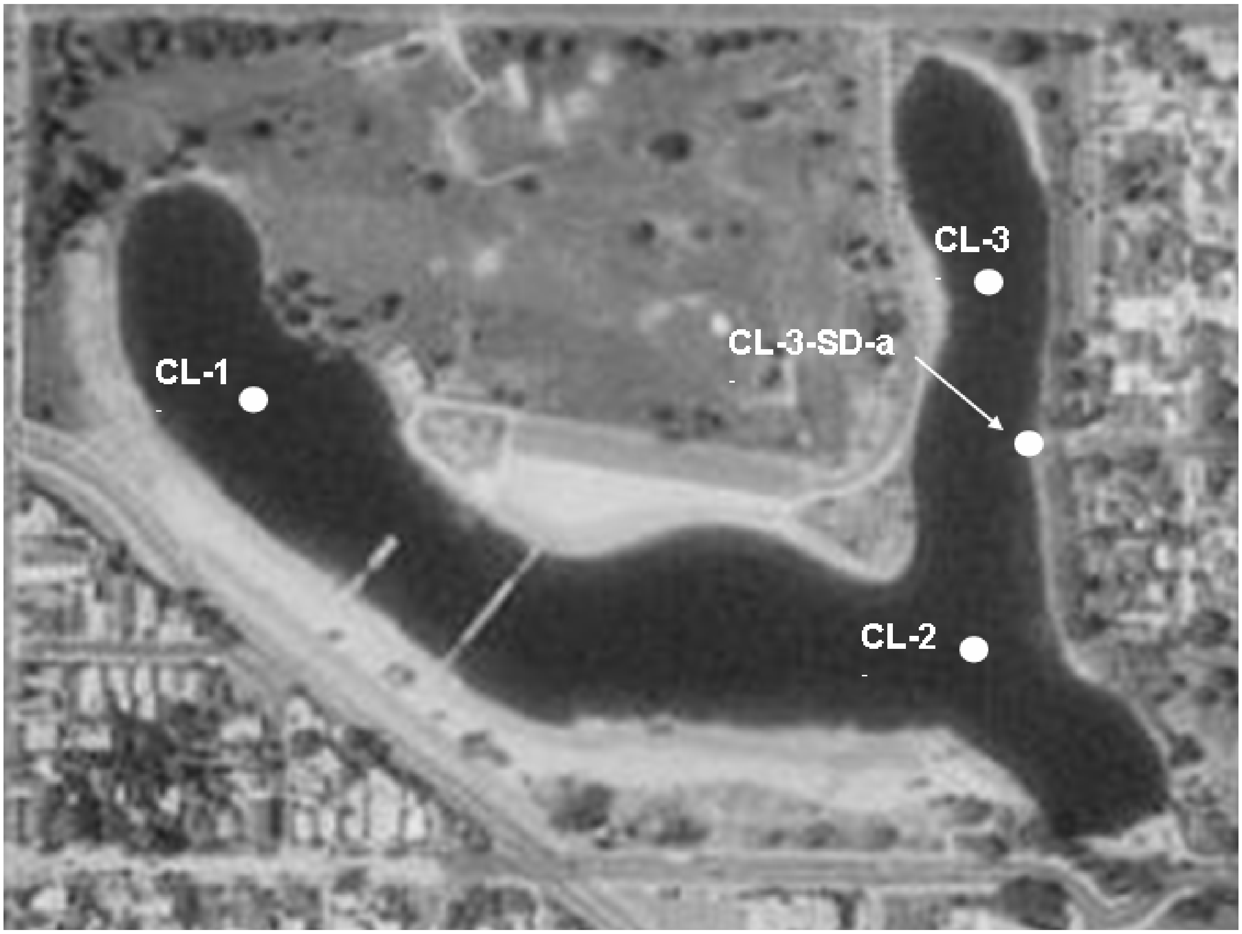


Figure 3-14 Location of Water Quality Sampling Sites

Table 3-6 Water Quality Testing Results, Colorado Lagoon, July 2004.

ANALYTE	Units	ML	Lab RL	CL-1-Wat	CL-2-Wat	CL-3-Wat	CL-3-SD-a
CONVENTIONAL PARAMETERS							
Orthophosphate-P	mg/L	0.01	0.01	0.050	0.039	0.041	0.93
Total Phosphorus	mg/L	0.05	0.01	0.061	0.043	0.035	1.0
Total Suspended Solids	mg/L	1.0	1.0	4.5	5.0	2.5	
Total Ammonia-Nitrogen	mg/L	0.1	0.1	0.10U	0.16	0.15	0.52
Total Kjeldahl Nitrogen	mg/L	0.1	0.1	0.86J	0.66J	0.79J	
Nitrate Nitrogen	mg/L	0.1	0.1	0.10U	0.10U	0.10U	1.8
Salinity	ppt		0.1				1.3
TOTAL METALS							
Aluminum	ug/L	25	50	50U	68.9	95	
Arsenic	ug/L	0.5	0.5	1.6	1.4	1.4	
Cadmium	ug/L	0.25	0.02	0.02U	0.02U	0.02U	
Chromium	ug/L	0.5	0.2	0.02U	0.02U	0.02U	
Copper	ug/L	0.5	0.1	0.9	0.9	0.9	
Iron	ug/L	25	20	137	181	211	
Lead	ug/L	0.5	0.0	1.28	0.95	1.02	
Nickel	ug/L	1	0.2	0.6	0.5	0.5	
Selenium	ug/L	1	1.0	1.0 U	1.0U	1.0U	
Silver	ug/L	0.25	0.02	0.06	0.03	0.02U	
Zinc	ug/L	1	0.5	4.1	2.8	3.4	
DISSOLVED METALS							
Aluminum	ug/L	25	50	50U	50U	50U	
Arsenic	ug/L	0.5	0.5	1.4	1.2	1.3	
Cadmium	ug/L	0.25	0.02	0.02U	0.02U	0.02U	
Chromium	ug/L	0.5	0.2	0.02U	0.02U	0.02U	
Copper	ug/L	0.5	0.1	0.9	0.9	0.9	
Iron	ug/L	25	20	48.6	37.9	38.6	
Lead	ug/L	0.5	0.0	0.07	0.5	0.11	
Nickel	ug/L	1	0.2	0.4	0.3	0.3	
Selenium	ug/L	1	1.0	1.0 U	1.0U	1.0U	
Silver	ug/L	0.25	0.02	0.03	0.11	0.03	
Zinc	ug/L	1	0.5	1.8	2.4	1.9	

Table 3-6 Water Quality Testing Results from Colorado Lagoon, July 2004. (continued)

ANALYTE	Units	ML	Lab RL	CL-1-Wat	CL-2-Wat	CL-3-Wat	CL-3-SD-a
CHLORINATED PESTICIDES							
4,4'-DDD	ug/L	0.05	0.05	0.05U	0.05U	0.05U	
4,4'-DDE	ug/L	0.05	0.05	0.05U	0.05U	0.05U	
4,4'-DDT	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Total DDT	ug/L	0.05	N/A	0.05U	0.05U	0.05U	
Aldrin	ug/L	0.01	0.005	0.005U	0.005U	0.005U	
alpha-BHC	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
beta-BHC	ug/L	0.01	0.005	0.005U	0.005U	0.005U	
delta-BHC	ug/L	0.01	0.005	0.005U	0.005U	0.005U	
gamma-BHC (lindane)	ug/L	0.02	0.02	0.02U	0.02U	0.02U	
Dieldrin	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Endosulfan I	ug/L	0.02	0.02	0.02U	0.02U	0.02U	
Endosulfan II	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Endosulfan sulfate	ug/L	0.05	0.05	0.05U	0.05U	0.05U	
Endrin	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Endrin Aldehyde	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Endrin ketone	ug/L	N/A	0.01	0.01U	0.01U	0.01U	
Methoxychlor	ug/L	N/A	0.05	0.05U	0.05U	0.05U	
Toxaphene	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
alpha-Chlordane	ug/L	0.1	0.1	0.1U	0.1U	0.1U	
gamma-Chlordane	ug/L	0.1	0.1	0.1U	0.1U	0.1U	
Heptachlor	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Heptachlor Epoxide	ug/L	0.01	0.01	0.01U	0.01U	0.01U	
Total Chlordane	ug/L	N/A	N/A	0.1U	0.1U	0.1U	
PCBs							
Aroclor-1016	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Aroclor-1221	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Aroclor-1232	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Aroclor-1242	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Aroclor-1248	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Aroclor-1254	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Aroclor-1260	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
Total PCBs	ug/L	0.5	0.5	0.5U	0.5U	0.5U	
ORGANOPHOSPHATE PESTICIDES							
Atrazine	ug/L	1.0	1.0	1.0U	1.0U	1.0U	
Chlorpyrifos (Dursban)	ug/L	0.05	0.05	0.05U	0.05U	0.05U	
Cyanazine	ug/L	1.0	1.0	1.0U	1.0U	1.0U	
Diazinon	ug/L	0.01	0.01	0.01	0.01	0.01	
Malathion	ug/L	1.0	1.0	1.0U	1.0U	1.0U	
Prometryn	ug/L	1.0	1.0	1.0U	1.0U	1.0U	
Simazine	ug/L	1.0	1.0	1.0U	1.0U	1.0U	

Table 3-7 Water Quality Profiles in Colorado Lagoon, June 29, 2004

Site	Time	Depth (m)	Temp(°C)	EC (mmhos/cm)	Salinity(g/kg)	pH	DO (mg/L)
CL-1	1315	1	23.9	49.2	32.2	7.9	7.3
	1319	2	23.7	49.3	32.3	7.8	6.2
	1320	3	23.3	49.5	32.4	7.6	3.2
	1320	4	23.1	49.6	32.5	7.6	2.8
CL-2	1205	1	23.4	49.6	32.4	7.8	6.9
	1206	2	22.9	49.5	32.4	7.7	4.8
	1207	3	22.6	49.5	32.4	7.7	4.8
	1208	3.75	22.5	49.6	32.5	7.7	4.8
CL-3	1409	1	24.4	49.6	32.5	7.9	8.0
	1410	2	24.0	49.6	32.5	7.9	7.4
	1411	3	23.4	49.7	32.5	7.8	5.6
	1416	4	22.7	49.7	32.5	7.8	4.6

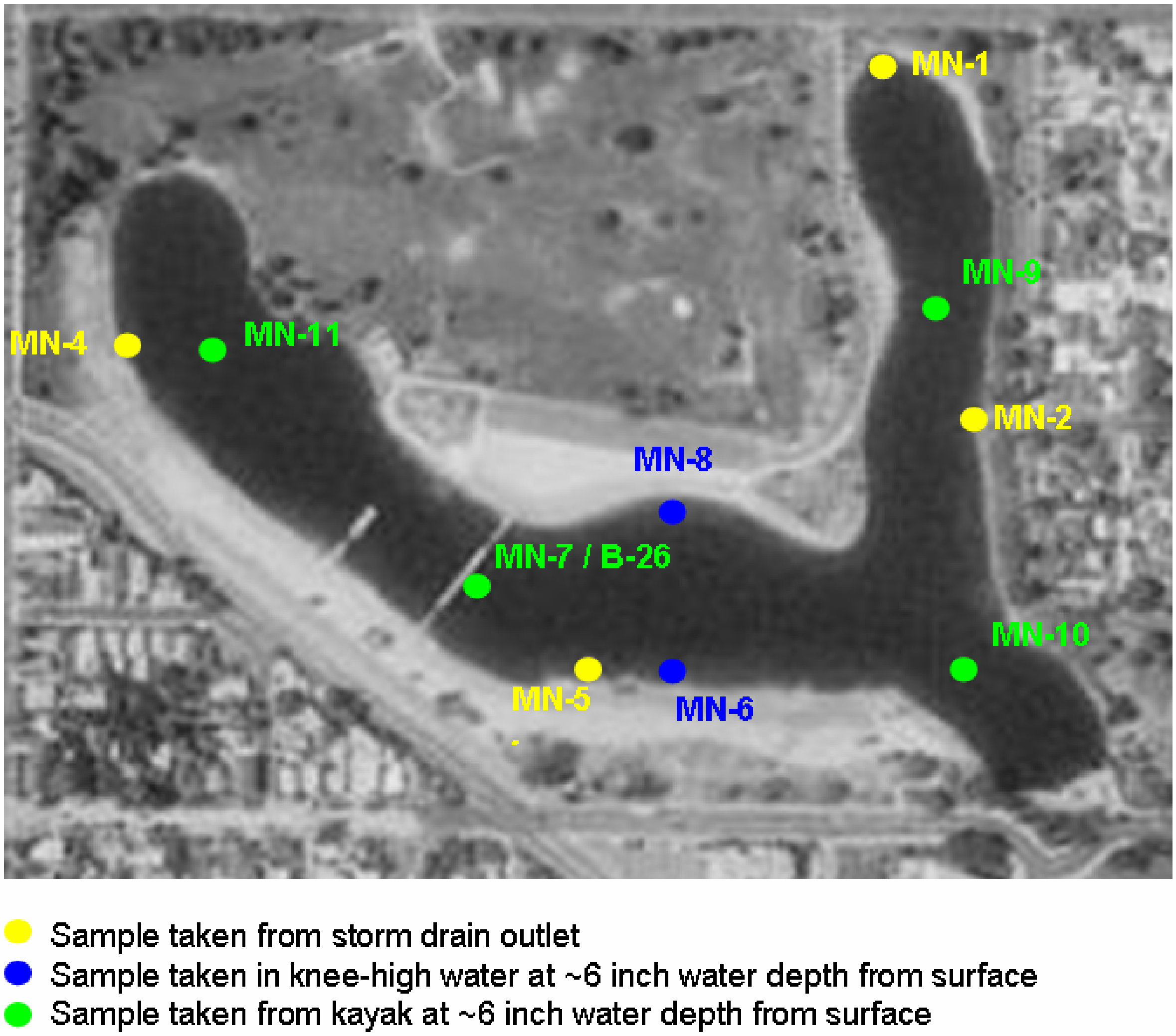


Figure 3-15 Bacteria Sampling Locations, August 2, 2004

Table 3-8 Concentrations of Bacteria (MPN/100 ml) measured in Storm Drains and Receiving Waters in Colorado Lagoon on August 2, 2004.[1]

Site	Total Coliform	E. coli	Enterococcus
Storm Drains – 0700			
MN-1	155310	2380	7701
MN-2	>241920	41060	3968
MN-4	129970	2560	4884
MN-5	16530	2400	74
Receiving Water Sites - 0700			
MN-6	2178	388	41
MN-7	1430	132	>24192
MN-8	1989	41	<10
MN-9	19863	221	313
MN-10	644	63	10
MN-11	>24192	4106	31
Receiving Water Sites - 1200			
MN-6	520	148	41
MN-7	294	66	<10
MN-8	1145	84	<10
MN-9	465	52	<10
MN-10	907	345	<10
MN-11	780	158	10
Receiving Water Sites - 1700			
MN-6	865	181	<10
MN-7	450	52	<10
MN-8	884	63	<10
MN-9	768	61	<10
MN-10	573	98	<10
MN-11	2187	288	<10

1. Water samples taken at 0700, 1200 and 1700 to examine changes over the course of a day.

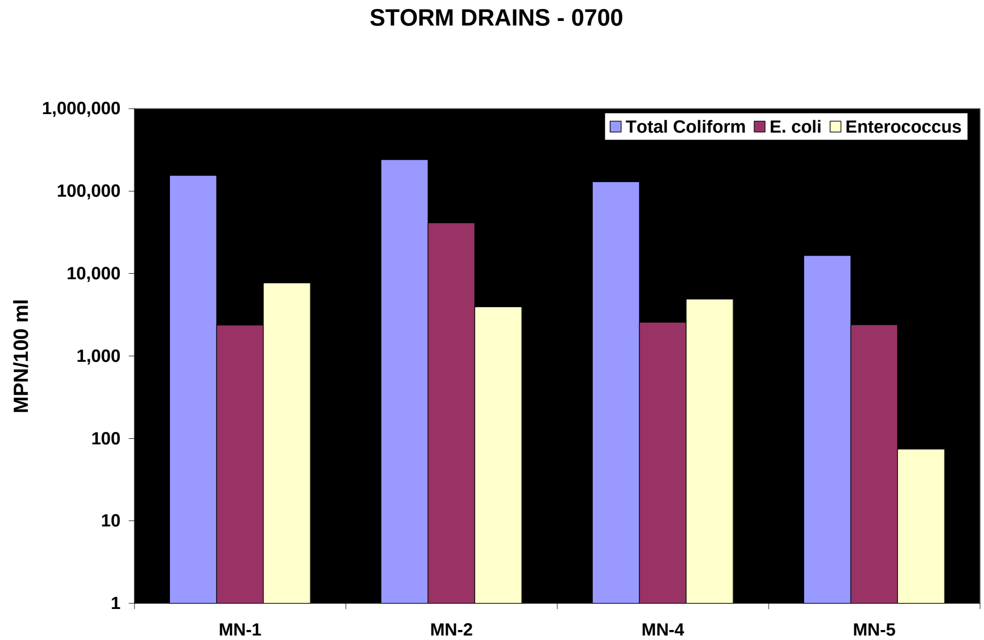


Figure 3-16 Bacteria Concentrations in Dry Weather Discharges from Colorado Lagoon Storm Drains at 0700 on August 2, 2004

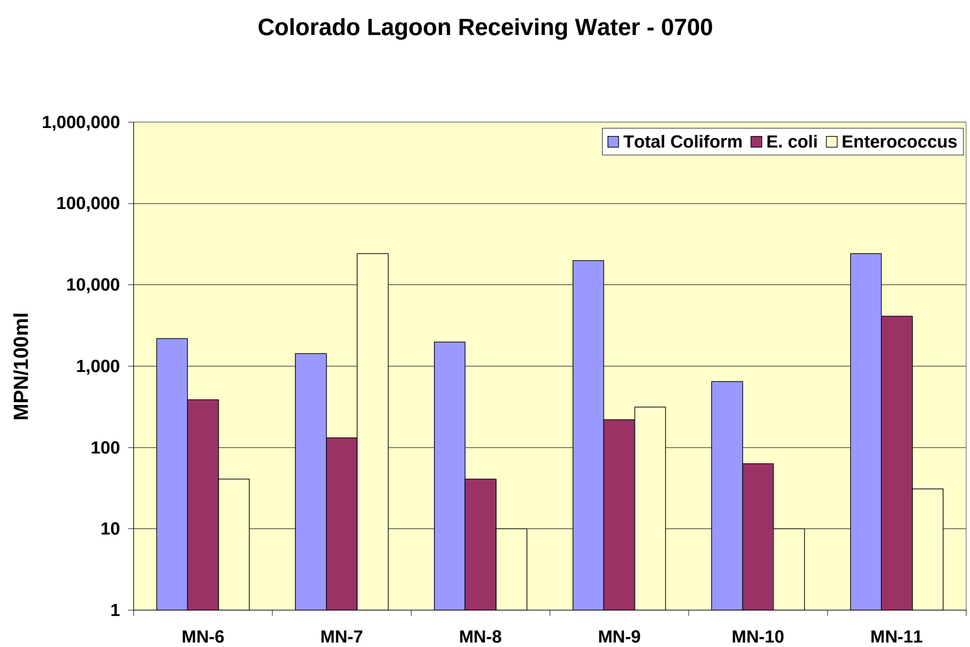


Figure 3-17 Bacteria Concentrations in Colorado Lagoon Receiving Waters at 0700 on August 2, 2004.

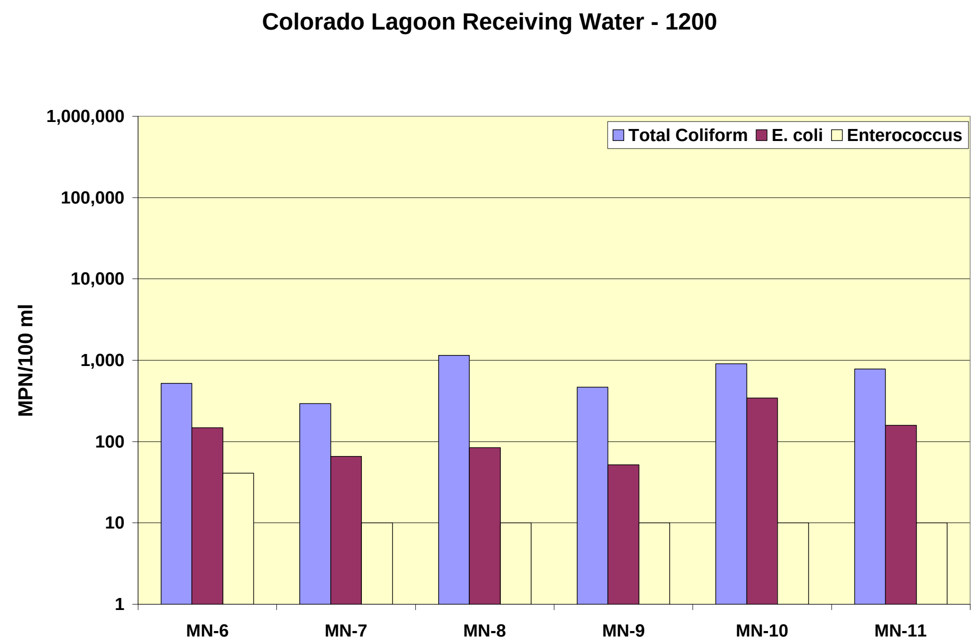
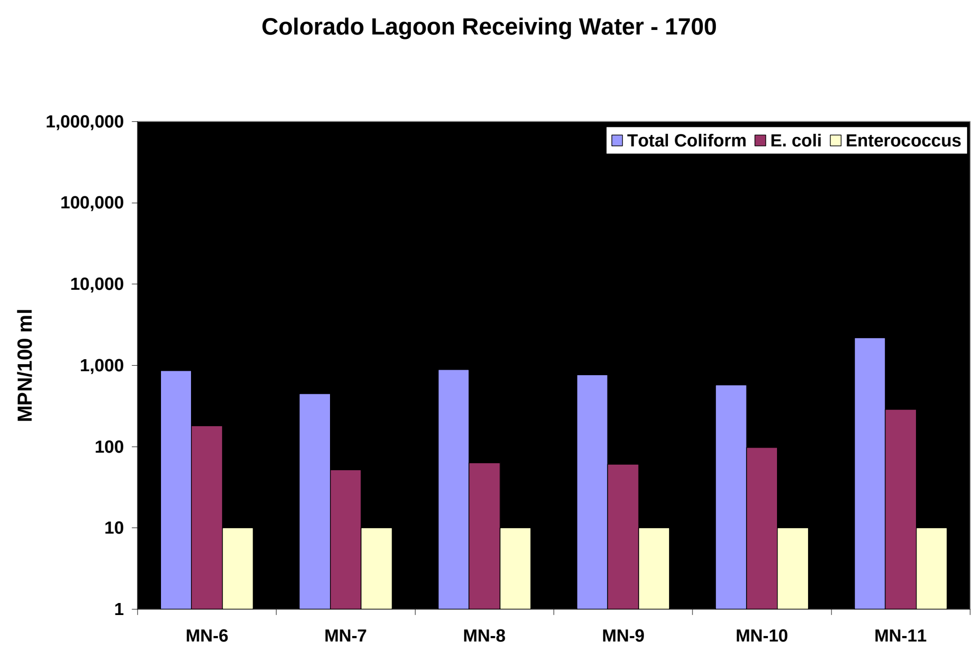


Figure 3-18 Bacteria Concentrations in Colorado Lagoon Receiving Waters at 1200 on August 2,



2004

Figure 3-19 Bacteria Concentrations in Colorado Lagoon Receiving Waters at 1700 on August 2, 2004.

4.0 BIOACCUMULATION DATA

Data describing the concentrations of contaminants in resident or transplanted biota from Colorado Lagoon are relatively rare. The California Department of Fish and Game's State Mussel Watch provides some of the only information on tissue burdens from biota in the Lagoon. Despite the fact that these data are now approximately 20 years old, they still provide some value especially when used with data from sediment cores taken as part of this assessment. Both provide a glance into the past and the contaminants that have accumulated over time in the Lagoon.

4.1 California Department of Fish and Game (CDF&G) Mussel Watch

CDF&G collected resident mussels from Colorado Lagoon in the early to mid '80s (Table 4-1) California mussels were transplanted to Colorado Lagoon for a 4-month period in 1986.

Data from these surveys are summarized in Table 4-2 and 4-3. Comparisons are made to the EDL85s for resident bivalves and transplanted bivalves that were developed based upon 20 years of data from 1977 through 1997. The EDL85 is simply the 85 percentile for each contaminant

In the case of metals (Table 4-2), lead was the only element that was consistently elevated. Initial levels of lead in resident bivalves were reported as high as 8.73 mg/Kg-wet but declined to 2.91 mg/Kg-wet in 1985. Similar trends are evident for total chlordane and DDT compounds (Table 4-3). Most chlordane compounds in resident bivalves remained at levels above the EDL85 during the 1985 survey. They also tended to exceed these levels in the mussels transplanted to Colorado Lagoon in 1986.

Table 4-1 Mussel Watch Sample Data for Colorado Lagoon

Station Number	701.0	701.0	701.0	701.2
Station Name	Colorado Lagoon/West	Colorado Lagoon/West	Colorado Lagoon/West	Colorado Lagoon/East
Collection Date	1/11/1982	1/24/1985	12/23/1985	12/24/1986
Year	82	85	86	87
Species	RBM[1]	RBM	RBM	TCM[2]
Deployment (months)	n/a	n/a	n/a	4
% Moisture-Metals	86.8	88.8	84.5	82
% Moisture Organics	85.5	88.8	84.3	79.8
Mean Length (mm)-Metals		54.9	47	63
Mean Length (mm)-Organics	57	61	47	65
% Lipid	1.6	0.53	1.07	1.28

n/a = not applicable

1. RBM = Resident Bay Mussel
2. TCM = Transplanted California Mussels

Table 4-2 Trace Metals in Mussels from Colorado Lagoon (mg/Kg-wet)

Element	**Station/Year RBM[1] 701.0 82**	**701.0 85**	**701.0 86**	**RBM EDL85[2]**	**Station/Year TCM[3] 701.2 87**	**TCM EDL85**
Ag	0.005	0.008	0.013	0.05	0.019	0.09
Al	37.8	77.3	33.9	170	16.2	138
Cd	0.26	0.22	0.17	0.99	0.67	1.59
Cr	0.13	0.2	0.13	0.73	0.25	0.73
Cu	1.18	1.14	1.27	2.28	0.75	5.30
Hg	0.0267	**0.0669**	0.0412	0.05	0.041	0.06
Mn	1.53	2.73	2.14	5.11	1.15	4.60
Pb	**8.73**	**4.17**	**2.91**	1.61	**3.19**	1.57
Zn	14	20.1	17.2	42.9	21.8	55.8

1. RBM = Resident Bay Mussel
2. EDL85 = 85th percentile for samples from 1977-1997 by species
3. TCM = Transplanted California Mussels

Table 4-3 Synthetic Organic Contaminants in Mussels from Colorado Lagoon (ug/Kg-wet)

Element	Station/Year RBM[1]			RBM EDL85[2]	Station/Year TCM[3]	TCM EDL85
	701.0	**701.0**	**701.0**		**701.2**	
	82	**85**	**86**		**87**	
aldrin	ND	ND	0.3	ND	ND	ND
chlorbenside	**42**	ND	ND	ND	3	ND
alpha-chlordene		**1.1**	**1.9**	0.4	2.2	0.4
cis-chlordane	**79.8**	**14.6**	**17.3**	11.8	**26**	6.9
gamma-chlordene		1.1	1.4	0.4	0.9	0.2
trans-chlordane	**69.6**	**16.8**	**14.1**	12.3	**24**	5.6
cis-nonachlor	**6.2**	**5.4**	**6.9**	2.5	ND	2.1
trans-nonachlor	**62.3**	**16.8**	**15.1**	10.6	**10.2**	4.9
oxychlordane	**3.9**	**0.6**	**0.9**	0.5	**1.6**	0.4
total chlordane	**221.9**	**56.4**	**57.5**	37.7	**64.9**	20.0
chlorpyrifos	ND	**1.1**	ND	ND	**1.5**	0.6
dacthal	0.5	ND	ND	7.4	ND	0.6
o,p'-DDD	5.7	1.3	1.9	11.7	**7.2**	5.7
p,p'-DDD	40.6	6	7.8	44.2	12.5	22.7
o,p'-DDE	**33.3**	1.6	2.5	7.4	1.3	5.9
p,p'-DDE	66.7	22.4	22	167	20	94.7
p,p'-DDMS	ND	ND	ND	7.0	**4.4**	2.1
p,p'-DDMU	6.2	1.5	4.1	31.8	1.8	7.6
o,p'-DDT	ND	ND	0.9	3.1	**11.2**	3.4
p,p'-DDT	**13.6**	4.4	3.8	7.0	1.6	6.4
total DDT	166.2	37.2	43	233.6	59.9	145.1
diazinon	ND	ND	ND	ND	ND	ND
dieldrin	9.7	3.4	3.8	10.5	18.2	5.7
endosulfan I	ND	1.3	ND	89.8	0.5	1.0
endosulfan II			ND	48.2	ND	ND
endosulfan sulfate			ND	46.8	ND	1.3
total endosulfan	ND	1.3	ND	102.5	0.5	1.3
endrin	ND	ND	ND	2.2	ND	ND
alpha HCH	0.6	0.3	0.2	0.4	0.5	0.6
beta HCH	ND	ND	ND	ND	ND	ND
delta HCH	ND	ND	ND	ND	ND	ND
gamma HCH	0.7	0.4	0.5	0.3	**1.6**	0.4
heptachlor	2.2	0.2	ND	0.3	ND	ND
heptachlor epoxide	ND	0.4	0.4	0.2	**1.9**	0.1
hexachlorobenzene	ND	ND	ND	0.1	ND	ND

Table 4-3 Synthetic Organic Contaminants in Mussels from Colorado Lagoon (ug/Kg-wet) (continued)

Element	Station/Year RBM[1] 701.0			RBM EDL85[2]	Station/Year TCM[3] 701.2	TCM EDL85
	701.0 82	701.0 85	701.0 86		701.2 87	
methoxychlor	ND	ND	ND	ND	ND	ND
ethylparathion	ND	ND	ND	ND	ND	ND
methylparathion	ND	ND	ND	ND	ND	ND
ronel	ND	ND		ND		ND
tetradifon	ND	ND	ND	ND	ND	ND
toxaphene	17.4	ND	ND	82.1	ND	ND
chlordene		ND	ND	ND	ND	
PCB 1248	ND	ND	ND	ND	ND	ND
PCB 1254	110.2	35.8	48.7	127	42	161.9
PCB 1260	ND	ND	ND	ND	ND	ND
total PCBs	110.2	35.8	48.7	128.7	42	171.3

1. RBM = Resident Bay Mussel
2. EDL85 = 85th percentile for samples from 1977-1997 by species
3. TCM = Transplanted California Mussels

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5.0 POLLUTANT SOURCE EVALUATION

Pollutant sources were previously addressed in KLI/M&N (2004). Contaminants of concern and evaluation of the potential sources of these compounds remain unchanged after a complete evaluation additional pollutant data associated with water and biota. The spatial distribution of contaminants in Colorado Lagoon sediments clearly show that the major contaminants of concern (COCs) are introduced into the western reach. Portions of the watershed that contribute to loads in the northern reach of the Lagoon appear to contribute relatively minor loads of COCs. The subbasin that contributes to the northern arm of the Lagoon is half the size of the subbasin the drains to the western arm. In addition, the subbasin for the northern arm consists of two primary land use categories. Land use in this area is roughly 1/3 park lands/golf course and 2/3 residential. The subbasin that drains to the western arm of the Lagoon is a mix of residential, commercial, transportation corridors, institutional and park lands/golf course land use activities.

Based upon a review of contaminants reported in sediments, water and biota of Colorado Lagoon, the primary COCs identified in the lagoon are lead and the three groups of organochlorine pesticides (DDT compounds, chlordane and dieldrin). Each of these primary COCs tend to have low solubility in water and to be strongly associated with sediments. All of these compounds are not only present in the sediments but have been reported at high levels in tissues of in resident bivalves. The organochlorine pesticides are not only persistent but will bioaccumulate and biomagnify in biota.

Secondary COCs include PCBs and a number of metals including cadmium, copper, mercury, silver and zinc. The primary source of lead in urban drainages is typically historical use of leaded gasoline. Although today lead content in gasoline has been greatly reduced, gasoline still contains lead and continues to be a source of lead in the environment. The organochlorine pesticides are considered legacy contaminants in that manufacturing and use of the compounds has been prohibited for many years. Due to the persistence of these compounds, they are still found in soils and storm drain systems. Recent surveys in the San Francisco Bay area (Kinnetic Laboratories, Inc./EOA Inc., 2002) have demonstrated that these compounds are still found in relatively high concentrations in sediments in stormdrains and catchbasins. These contaminants are strongly associated with the fine grained sediments.

Although, concentrations of these substances are rarely detected in stormwater runoff (except for lead), these contaminants are commonly encountered in areas where sediments transported by stormwater runoff settle and accumulate over time.

The adjacent golf course contributes runoff to both the western and northern reaches of the Lagoon. The largest contributions from the golf course would be expected to enter the northern reach where it comprises at least 1/3 of the total area of the subbasin. The golf course also contributes runoff to the western arm of the Lagoon but it comprises only a small portion of the total area of the subbasin. The much higher quality of sediments in the northern reach may indicate that the golf course is not now and has not historically been a major source of metals, organochlorine pesticides or PAHs.

6.0 PRELIMINARY WATER QUALITY IMPROVEMENT OPTIONS

There are two facets to improving water quality in the lagoon: 1) eliminating pollutant sources and 2) increasing circulation.

6.1 Elimination of Pollutant Sources

Elimination of pollutant sources is via either upstream watershed management, diversion of flows away from the lagoon, treatment options, or local protocals. The previously delivered “Colorado Lagoon Watershed Impacts Report” provided Best Management Practice (BMP) recommendations for improving the watershed:

- Construction Activities - improve sediment capture
- Commercial Parking Area Wash Down - educate and/or enforce
- Over-watering - educate and/or enforce
- Pesticide/Herbicide Use – educate, require management plans, enforce
- Pathogens – educate

Other watershed improvement alternatives discussed in the Watershed Impacts Report include: a) installation of curb inlet screens at selected locations to prevent litter and sediments from entering the storm drain system, b) water diversion structures or covers for drop inlets within Recreation Park Golf Course to prevent pesticides/herbicides/fertilizers from lawn overwatering from entering storm drain system, 3) berms around Recreation Park Dog Park to prevent contaminated sediment from entering storm drain system.

There are three concepts available for diverting flows (that potentially contain contaminants) away from the lagoon: 1) reduce the number of stormwater drains entering the lagoon, 2) divert dry weather runoff, and 3) divert first flush stormwater. The first concept is to decrease the number of storm drains that enter the lagoon. There are currently eleven drains into the lagoon (four major drains and seven local drains); see attached Figure 6.1. A significant improvement would be implementation of the County of Los Angeles Termino Avenue Drain Project (TADP) alternative to divert one of the major storm drains (at the western tip of the lagoon western arm) away from the lagoon and into the Marine Stadium. This storm drain serves approximately 25% of the Colorado Lagoon watershed area and thus elimination of this drain would greatly reduce the amount of stormwater and dry weather runoff that enters the lagoon. There is a 24-inch diameter pipe drain on the southern shore which enters the lagoon in the designated swimming area; an opportunity exists to reroute this drain into the proposed TADP Marine Stadium drain which is aligned in the same area, (although it would be downstream of the CDS unit and sewer diversion point). There is also a large (63-inch) storm drain (owned by the County) in the northern portion of the western arm which serves approximately 36% of the lagoon’s watershed area; there would be a significant improvement to the lagoon water quality if this drain was also rerouted so as to be included in the County's proposed TADP drain system into the Marine Stadium. These options would have to be developed jointly with the County of Los Angeles and the feasibility of these options is therefore uncertain.

Figure 6-1 Locations of Storm Drain Outfalls into Colorado Lagoon

The City of Long Beach Local Coastal Program (LCP) report (1980) states: "the major storm drains presently emptying into the west and north arms of the Lagoon should be diverted to the ocean or the San Gabriel River". Construction of new storm drain conveyances to the ocean (approximately 1 mile away) is not practical based on cost and disruption to the affected neighborhoods. It would not be feasible to do this option without pumping due to a local higher elevation in the area just south of the lagoon and lack of an appropriate gravity gradient. Also a new coastal structure would have to be constructed so as to be able to discharge the storm drain water beyond the surfzone; this would require California Coastal Commission approval. Construction of new storm drains to the San Gabriel River (approximately two miles away) would also be extremely expensive (estimate upwards of $25M). This would require a very large pump station, (probably bigger than any currently built in L.A. County) and an inverted siphon to bypass under the Cerritos Channel in order to get to the San Gabriel River. Other issues include a very large above-ground structure adjacent to the lagoon and potential Cal Trans right-of-way conflicts. It is recommended that these options not be further studied. However, there is a potential for some of the drains to be diverted into the proposed new County drain, as discussed above; this would have essentially the same benefit as diverting storm drains into the ocean or the San Gabriel River. The LCP also discusses the golf course polluting the lagoon by “seepage of contaminants to ground-water”. This problem would be mitigated via the golf course BMPs recommended in the Watershed Characterization Report.

The County’s TADP also includes low flow diversion for the Termino Avenue drain watershed area, (approximately 25% of the lagoon’s total watershed area). The diversion concept is included in both the Colorado Lagoon and Marine Stadium drain alternatives. The proposed storm drain system includes a diversion to direct dry-weather flows into a nearby existing sanitary sewer line and to the County Sanitation District sewage treatment plant. In addition, the proposed plan includes construction of an in-line trash screening device (Continuous Deflective Separator) to remove solids and flotsam from urban runoff and light storm flows prior to discharging into the lagoon or Marine Stadium. In the County’s alternative to discharge stormwater into the Colorado Lagoon, dry weather runoff would be diverted to the Marine Stadium.

Boyle Engineering Corporation performed an investigative study of Colorado Lagoon water quality for the City of Long Beach in 2003. Diversion of storm drains to the sewage treatment plant was one of the options evaluated. Their sewer diversion study included diversion of the three remaining Colorado Lagoon major drains; the Termino Avenue drain was also assumed to be diverted as part of the County’s project. However, it was noted that due to pumping limits imposed by the Los Angeles County Sanitation District (LACSD) and utilization of a major portion of the capacity by the TADP, only about one-half of the dry weather discharge of the three drains’ watershed areas could be pumped into the sewer system each day (although there is possibly a misunderstanding or discrepancy in the watershed area calculations). This suggests that either the City work with the LACSD to increase the capacity allocation to the Colorado Lagoon or they pursue sewer diversion for only one or two of the remaining lagoon drains. Selection of these drains would be based on understanding which drain(s) contributes the greatest pollutants to the lagoon. Alternatively, all drains could be treated, but for only approximately one-half of the daily discharge; this was the approach estimated for costs in the Boyle study.

The study also noted that the LACSD requires pumping and on-site wet well storage for collection of low flows prior to connection into the regional sewer mains. This in turn necessitates construction of diversion structures for each storm drain outlet to divert dry weather runoff to the sewers. The potential for diverting dry weather low flows for the three (non-TADP) major storm drains will be further evaluated as part of the restoration alternatives development task. (Note: if the 63-inch storm drain at the northern tip of the western arm was diverted into the County's proposed TADP drain system, then there would only be two other major storm drains to address).

The third diversion option is for diverting first flush stormwater. Based on our initial assessment, the County's sewage treatment plant does not have the capacity to handle the first flush stormwater draining into the lagoon.

Treatment options include inline trash/solids collection devices, disinfection treatment facilities and bio-swales. The 2003 Boyle study evaluated installation of in-line solids removal/trash separator devices on several of the Colorado Lagoon storm drain outlets. This was a relatively high cost item for both construction and maintenance. Based on observation, most of the trash seems to be coming from the park and beach areas immediately adjacent to the lagoon and not through the storm drains. At this time, there does not seem to be a major need that would justify installation of trash collection devices in the Colorado Lagoon storm drain outlets. Trash management protocals (discussed in the next paragraph) and installation of filtering devices at each of the street catch basins would be a less costly approach to prevent trash and solids from entering the lagoon. Disinfection treatment facilities were identified in the Boyle study, but it is recommended that this option <u>not</u> be pursued due to the cost, infeasibility, and lack of data for disinfection treatment facilities. The bio-swale option (vegetated swales and berms) to collect direct runoff from the golf course before it enters the lagoon is a worthwhile option and will be further evaluated in the alternatives development task.

Two other options exist to reduce pollutant contributions to the lagoon including management of birds and trash at the lagoon. An option to reduce bacteria inputs is to manage waterfowl by removing and prohibiting release of domestic birds such as ducks and geese. These birds excrete sufficient volumes to pollute lagoon waters when their resident numbers are high as quantified by the University of California, Irvine in a study done regarding water quality at Huntington Beach (2001). The bird population at the lagoon does not appear to be problematic at this time, but should be qualitatively monitored by lifeguards or other City personnel to identify if their numbers are increasing over time. Other municipalities have installed signs discouraging feeding domestic waterfowl to reduce duck populations and their excretions. They have also enacted local laws prohibiting release of domestic birds to such locations. Results have been successful in Fullerton, for example, where domestic bird populations have declined from over 200 to less than 100 within the last two years. Managing other inputs from pollution such as trash could be improved around the lagoon perimeter by increasing resources directed to collecting trash at the lagoon beaches and park. More frequent and effect trash management will reduce flotsam at the Lagoon. Local residents have identified trash management as a needed approach to improving environmental quality at the site.

6.2 Increasing Circulation

6.2.1 Culvert Evaluation for Water Quality Impacts

The City benefits from being able to qualitatively compare and contrast water quality at Colorado Lagoon with that of nearby Marine Stadium. Visual inspection of the water conditions at both the lagoon and Marine Stadium show dramatic differences in water clarity, turbidity, algal growth, and submerged aquatic plant growth. These qualitative indicators suggest that the Lagoon experiences poorer circulation than nearby Marine Stadium and impaired water quality. Both seawater basins receive water from Alamitos Bay, are located very close to one another (within 1,000 feet), and reach approximately 15 feet deep. The difference between the sites is caused by the existence of a culvert from Marine Stadium to Colorado Lagoon, and the Lagoon is therefore experiences an indirect connection to the ocean (Alamitos Bay) while Marine Stadium experiences a direct connection. The culvert to Colorado Lagoon affects water quality by restricting tidal exchange between the lagoon and Marine Stadium, leading to less flushing of resident seawater from previous tide cycles, and of inputs from storm drains. Accumulation of aging seawater and inputs from storm drains at the lagoon results in higher concentrations of nutrients, bacteria and chemicals, and lower dissolved oxygen

The Colorado Lagoon Hydrology/Hydraulics Study identified muting of tides in the Lagoon caused by the culvert. The muting essentially limits the tidal exchange to and from the Lagoon and flushing of the lagoon that would occur if muting were minimized. Tide data measured at the Lagoon and at Marine Stadium show the Lagoon reaches the same high tide elevations as Marine Stadium and the ocean, but the low tide in the Lagoon is perched above those of Marine Stadium and the ocean by approximately 2 feet, representing a reduction from the full ocean tide range by approximately 33% (2 feet of muting divided by the 6 foot full ocean tide range). Also, tidal elevation changes at the Lagoon lag in time behind those of Marine Stadium by up to 3 hours. The lag adds to the muting by causing an offset in the time of high and low tides at the Lagoon from the ocean. As the Lagoon drains during an ebbing (outgoing) tide, its drainage is delayed by 3 hours so it never completely drains before the tide begins to rise again at Marine Stadium. This stops the Lagoon drainage and reinitiates tidal inflow to the Lagoon from the Stadium, so the quantity of water drained from the Lagoon each tide cycle is reduced and a build-up of aging seawater occurs. Water quality parameters at the Lagoon are negatively affected by this process.

Low tides at the Lagoon never drop to the levels in Marine Stadium because the culvert restricts flows sufficiently to prevent efficient hydraulic exchange between the two water bodies. Friction along the culvert interior over its relatively long length (approximately 1,000 feet) retards and slows flow through it. Also, extensive marine growth within the structure further impedes flow. Additionally, the culvert is fitted with tide gates that can be operated to further restrict the opening on the Lagoon end. The gates are usually left open, but are not currently able to open fully to their design capability and are sometimes closed when deemed appropriate by City staff.

The gates were closed during a study period in July of 2004 and the effect was to essentially cut tidal flow between the Lagoon and Marine Stadium.

The Lagoon is the collection point for drainage from the watershed. Limited flushing results in chemicals, bacteria, and nutrients remaining in the Lagoon longer than would otherwise be the case. The properties of Lagoon waters become and remain impaired as watershed inputs reside in the system and are not readily flushed to the sea.

6.2.2 Possible Improvements to the Culvert for Water Quality

Several opportunities exist to either improve the culvert connection, or modify the connection in some manner to improve tidal flushing and resultant water quality. The culvert is significantly infilled with marine growth since its construction nearly 40 years ago. The original culvert design includes removable access panels on the top that provide access for small bulldozers to be used to scrape the interior walls and floor. These access openings are large enough to allow small cleaning equipment to be lowered into the culvert by crane. Culvert cleaning should occur regularly, such as every 5 to 10 years to maximize the internal culvert cross-section for hydraulic flow and keep the flow path clear. Marine habitat that has grown within the culvert should be investigated as part of the Feasibility Study or subsequent environmental review to determine potential environmental impacts from this operation.

Also, the culvert tide gates could be opened to greatest physical extent to maximize the flow path and improve hydraulic efficiency. The gates have been opened partially, and are sometimes closed for certain reasons such as maintaining a constant water surface elevation throughout the day during the swimming season. City staff should consider opening the gates all the way and leaving them open all the time (unless a chemical spill within the Lagoon or watershed warrants their closure) to allow maximum tidal flushing to improve water quality.

Additionally, recent inspection by the engineer indicates that a rock or stone sill may exist at the culvert mouth at Marine Stadium end that lies above the culvert floor, impeding tidal flow. Also, debris may exist at the end of the culvert at Colorado Lagoon. The culvert should be inspected for the presence of a structural sill and debris, and consideration should be given to their removal.

Performing any of all of these actions will result in improved tidal circulation at the Lagoon and better water quality. The most dramatic improvement in water quality would come from removing the culvert and replacing it either with a larger culvert, or an open channel. Creating an open channel would result in minimal tidal muting and a reduced lag, and corresponding improvement in water quality. The channel would allow freer conveyance of seawater to the lagoon with much lower friction losses and greater hydraulic efficiency. Relatively short culvert sections would still be required to be placed under existing roads. These culverts could be larger in cross-section than the existing one, however, to more effectively convey the full ocean tide range. Several members of the public and the Citizens Advisory Group suggested removing the culvert and leaving an open channel. These options would definitely improve tidal hydraulics and water quality at the Lagoon, but would be more costly than cleaning and clearing the existing culvert. Costs to perform these actions will be estimated as part of analyzing restoration alternatives for the Lagoon in the remaining Feasibility Study.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based upon a review of contaminants reported in sediments, water and biota of Colorado Lagoon, the primary COCs identified in the lagoon are lead and the three groups of organochlorine pesticides (DDT compounds, chlordane and dieldrin). All of these compounds are not only present in the sediments but have been reported at high levels in tissues of in resident bivalves. The organochlorine pesticides are not only persistent but will bioaccumulate and biomagnify in biota.

Secondary COCs include PCBs and a number of metals including cadmium, copper, mercury, silver and zinc. The primary source of lead in urban drainages is typically historical use of leaded gasoline. Although today lead content in gasoline has been greatly reduced, gasoline still contains lead and continues to be a source of lead in the environment. The organochlorine pesticides are considered legacy contaminants in that manufacturing and use of the compounds has been prohibited for many years. Due to the persistence of these compounds, they are still found in soils and storm drain systems.

A one-time examination of indicator bacteria in dry weather discharges and receiving waters of Colorado Lagoon demonstrated high concentrations in the dry weather flows and in receiving waters at 0700. Concentrations measured in the receiving waters exceeded AB411 criteria. By noon when the City typically performs the AB411 survey, concentrations of indicator bacteria had declined and no longer exceeded criteria. Since UV radiation is known to cause dieoff of indicator bacteria, it is likely that the timing of the AB411 survey underestimates concentrations that are present earlier in the day.

Several potential options have been identified which would improve water quality in the lagoon; these include: a) implementation of upstream watershed BMPs, b) elimination of storm drain outlets into the Colorado Lagoon in coordination with the County's Termino Avenue Drain Project, c) dry weather diversion into the County sewage treatment plant for additional storm drains, d) construction of bio-swales and berms, e) installation of street catch basin filters, f) improvement of trash management protocols at the lagoon, g) bird management protocols, and i) improvements to the tidal culvert.

The culvert to Colorado Lagoon restricts tidal flushing of the Lagoon and, together with inputs from the watershed, results in impaired water quality conditions. Visual comparison between the Lagoon and nearby Marine Stadium, both connected to the ocean, shows Lagoon water quality to be degraded from the Bay. Lagoon water is more turbid and less clear, and contains algal blooms and submergent plant growth (indicative of excess nutrients in the system), while Alamitos Bay is relatively clear and contains no algal blooms and minimal submergent plant growth. The culvert is significantly filled in with marine growth since its construction nearly 40 years ago, and is partially restricted by tide gates at the Lagoon end, and by a sill on the Marine Stadium end. Debris may be present also partially blocking the Lagoon end. The effect of these restrictions is that tidal flushing is reduced and constituents in the Lagoon are not readily flushed to Marine Stadium, therefore accumulating in the lagoon and impairing the water quality. Solutions to the culvert restriction include cleaning and clearing the culvert, and opening the tide gates as much as possible to promote maximum tidal flow. Another option is to remove the culvert and replace it with an open channel. This option would generate maximum improvements to water quality but would also require significant costs that will be estimated as part of the Feasibility Study.

These options will be further investigated as part of this project's "Develop and Evaluate Restoration Alternatives" task.

8.0 REFERENCES

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APPENDIX A