FINAL
PRE- AND POST-CONSTRUCTION WATER QUALITY MONITORING REPORT

City of Long Beach

Colorado Lagoon Improvements Water Quality Monitoring Program

Grant Agreement Numbers:
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PREPARED FOR:

City of Long Beach

PREPARED BY:

KINNETIC LABORATORIES INCORPORATED

5225 Avenida Encinas, Suite H
Carlsbad, CA 92008

MOFFATT & NICHOL

3780 KILROY AIRPORT WAY, SUITE 600
LONG BEACH, CA 90806

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CALIFORNIA

Water Boards

STATE WATER RESOURCES CONTROL BOARD

REGIONAL WATER QUALITY CONTROL BOARDS

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CITY OF LONG BEACH

PRE- AND POST-CONSTRUCTION WATER QUALITY REPORT

COLORADO LAGOON IMPROVEMENTS
WATER QUALITY MONITORING PROGRAM

Grant Agreements Number 06-266-550-0 and ARRA 08-300-550-1

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ACRONYMS AND ABBREVIATIONS LIST

ASTM - American Society for Testing and Materials
BMP - Best Management Practice
CCC – Criterion Continuous Concentration
CTR - California Toxics Rule
DDD - dichloro (p-chlorophenyl)ethane
DDE - dichloro (p-chlorophenyl)ethylene
DDT - dichlorodiphenyl trichloroethane
DL - Detection Limit (considered the same as RL)
DO - Dissolved Oxygen
ICP-MS - Inductively Coupled Plasma-Mass Spectrometry
KLI - Kinnetic Laboratories, Inc.
MPN- Most Probable Number
PCB - Polychlorinated biphenyls
ppb - Parts per Billion
ppt – Parts per Thousand
QA/QC - Quality Assurance/Quality Control
RL - Reporting Limit (considered the same as DL)
RPD - Relative Percent Difference
SM- Standard Methods for the Examination of Water and Wastewater
SRM - Standard Reference Material
SWRCB-State Water Resource Control Board
TKN - Total Kjeldahl Nitrogen
TSS – Total Suspended Solids
USEPA - U.S. Environmental Protection Agency
WQO - Water Quality Objective
WQS - Water Quality Standard

EXECUTIVE SUMMARY

Colorado Lagoon has been designated as an impaired water body based upon metals, PAHs, organochlorine pesticides and elevated fecal indicator bacteria. Since 2004, the City has been actively engaged in addressing these issues. Grant funding was obtained to clean out the existing culvert connecting to Marine Stadium, install low flow diversions and trash traps in storm drains discharging to the Lagoon, and install a bioswale to treat localized runoff into the Lagoon. In addition, plans have been developed and a contractor selected to remove contaminated sediments that have accumulated since the Lagoon was first constructed. This monitoring study was designed to document changes that occurred since completion of the initial improvements. Surveys were conducted for a period of four months prior to initiating construction and again for a period of seven to ten months after completion of construction.

The monitoring effort focused on documentation of changes in the tidal flushing, water quality (nutrients, dissolved oxygen, toxic metals and organic compounds, suspended sediment, fecal indicator bacteria), and litter.

Major findings of the pre- and post-construction efforts included the following:

- Cleaning of the culvert increased the extent of the low tide by approximately 1.6 feet and reduced the time lag in tidal response.
- Litter in Colorado Lagoon was dramatically reduced. Average counts of litter and debris decreased by 86% at the culvert trash rack and nearly 97% along the south shoreline.
- Bacterial water quality during the summer of 2011 was the best that has been recorded in the last six years. Compliance with single sample criteria was achieved 90% of the time. Compliance with 30-day geometric mean criteria was achieved 100% of the time.
- Average water clarity increased by 24-32% at the three sample locations subsequent to the culvert cleaning and other improvements. Due to high variability, statistical significance could not be applied to this change.
- Nutrient concentrations were generally low and did not change substantially between the pre- and post-construction monitoring efforts.

In summary, the monitoring program indicates that the Colorado Lagoon constructed improvements (culvert cleaning, storm drain treatments and diversions, and bioswale) have resulted in improvements to tidal range, litter amount, bacteria, and water clarity. These water quality improvements in turn enhance both the recreational and habitat value of the lagoon.

INTRODUCTION AND BACKGROUND

The Los Angeles Regional Water Quality Control Board (Los Angeles RWQCB) 2006 303(d) list identifies Colorado Lagoon as impaired due to lead, zinc, chlordane, PAHs and toxicity 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. Bacteria were first added to the Colorado Lagoon 303(d) list by USEPA in 2006 as a result of frequent beach advisories due to elevated bacteria concentrations.

Since 2004, the City has completed several studies to: a) synthesize existing data on contaminants in Colorado Lagoon sediment, water and biota, b) develop additional data necessary to identify the full range of pollutants of concern and their distribution in the lagoon, and c) develop various restoration alternatives. Based upon these investigations, the City of Long Beach obtained funding to implement improvements recommended to improve conditions in Colorado Lagoon and lead towards eventually delisting the Lagoon as an impaired water body. The improvements consisted of:

- cleaning out the existing underground culvert to improve tidal water exchange with Marine Stadium,
- storm drain treatments and diversions, and
- design and construction of bioswales.

Photographs of the construction process are provided in Appendix F. Each improvement was anticipated to contribute incrementally to improved water quality in Colorado Lagoon. Storm drain treatments and diversions were expected to substantially reduce loads of legacy contaminants, litter, sediment and bacteria that originate in the highly urbanized watershed. Cleaning out the existing culvert between Colorado Lagoon and Marine Stadium was expected to enhance tidal exchange and thus further result in improvements in overall water quality, especially with respect to fecal indicator bacteria, water clarity, and reduced incidence of algal blooms. The bioswales were expected to reduce both sediment and nutrient loads from the adjacent golf course.

Water quality monitoring was conducted: a) prior to construction of these improvements to provide a contemporary baseline and b) immediately after construction to evaluate changes in water quality.

The following sections more fully describe the function and location of each Project improvement. The location of each improvement is shown in Figure 1 in relationship to all Project monitoring locations.

CULVERT CLEANING

The Lagoon is connected to Marine Stadium via a 900-feet-long underground box culvert. The culvert had not been cleaned since it was built in the 1960s. Because of this, the culvert was impeded by sediment that had accumulated on the bottom, and extensive marine growth that had accumulated on the sides and ceiling. Additionally, on the Marine Stadium side, there was a rock basin sill at the entrance of the culvert. The rocks were up to 3.5 feet above the invert (bottom) of the culvert thus muting the low tide.

These impedances were limiting the tidal exchange between the Marine Stadium and the Lagoon. Measured tide data prior to the culvert cleaning showed that the spring low tides in the Lagoon were perched above those of Marine Stadium and the ocean by approximately three feet, i.e. the Lagoon's tide range was significantly muted by the culvert.

Hydraulics modeling prior to the culvert cleaning indicated that culvert cleaning would improve by 1.4 feet and correspondingly circulation and residence time within the lagoon would also improve.

The culvert cleaning was conducted from 12 July 2010 to 29 July 2010.

STORM DRAIN TREATMENTS

Three of the major storm drains that discharge into the Lagoon were treated with low flow diversion systems and trash removal devices. The remaining major storm drain is planned to be treated via a separate project. Low flows that were previously discharged directly into the Lagoon from these three storm drains are now diverted instead into a common holding/storage area (wet well) and then pumped into the sanitary sewer treatment system at night when the treatment plant has added capacity.

Pollutants in these low flow discharges include bacteria. Previous sampling of the storm drain dry weather discharges indicated high concentrations of bacteria, as would be expected. Diverting these dry weather (low flow) discharges away from the Lagoon should prevent bacteria (and other pollutants) from entering the Lagoon. Although the three storm drains do not directly discharge into the swimming area of the Lagoon, the discharges from these storm drains would eventually circulate through the swimming area due to ebb and flood tide hydraulics.

The low flow diversion system was turned on 19 January 2011. However, there was only one day (20 January 2011) of diversion/discharge into the sewer system during the period of 19 January 2011 to 1 February 2011 because of some technical issues. From 2 February 2011 to 15 April 2011, only half of the system was operational. Since 15 April 2011, the low flow diversion has been in full operational mode.

Trash removal devices were installed within each of the storm drains just upstream of the diversion device in September/October 2010. Trash removal now occurs during both storm and dry weather flows. Trash removal is necessary to meet the requirements imposed by the sanitary sewer system and serves to reduce litter and media upon which bacteria can enter the Lagoon.

BIOSWALES

In addition to the major storm drain outfalls addressed above, there are several smaller/local storm drains that discharge into the Lagoon. There is also direct runoff from the adjacent golf course. In order to address the latter, a vegetated bioswale was installed along the shoreline of the west arm of the Lagoon. Groundbreaking on the bioswale occurred on September 1, 2009 and work was completed by mid-December 2009. A large amount of the flow to be treated is from the golf course. Pollutants in runoff typically produced by these land uses include bacteria, nutrients, trash, oxygen-demanding substances, oil and grease, and pesticides. The bioswale provides filtration to remove pollutants and sediment prior to discharge into the Lagoon thus improving water quality.

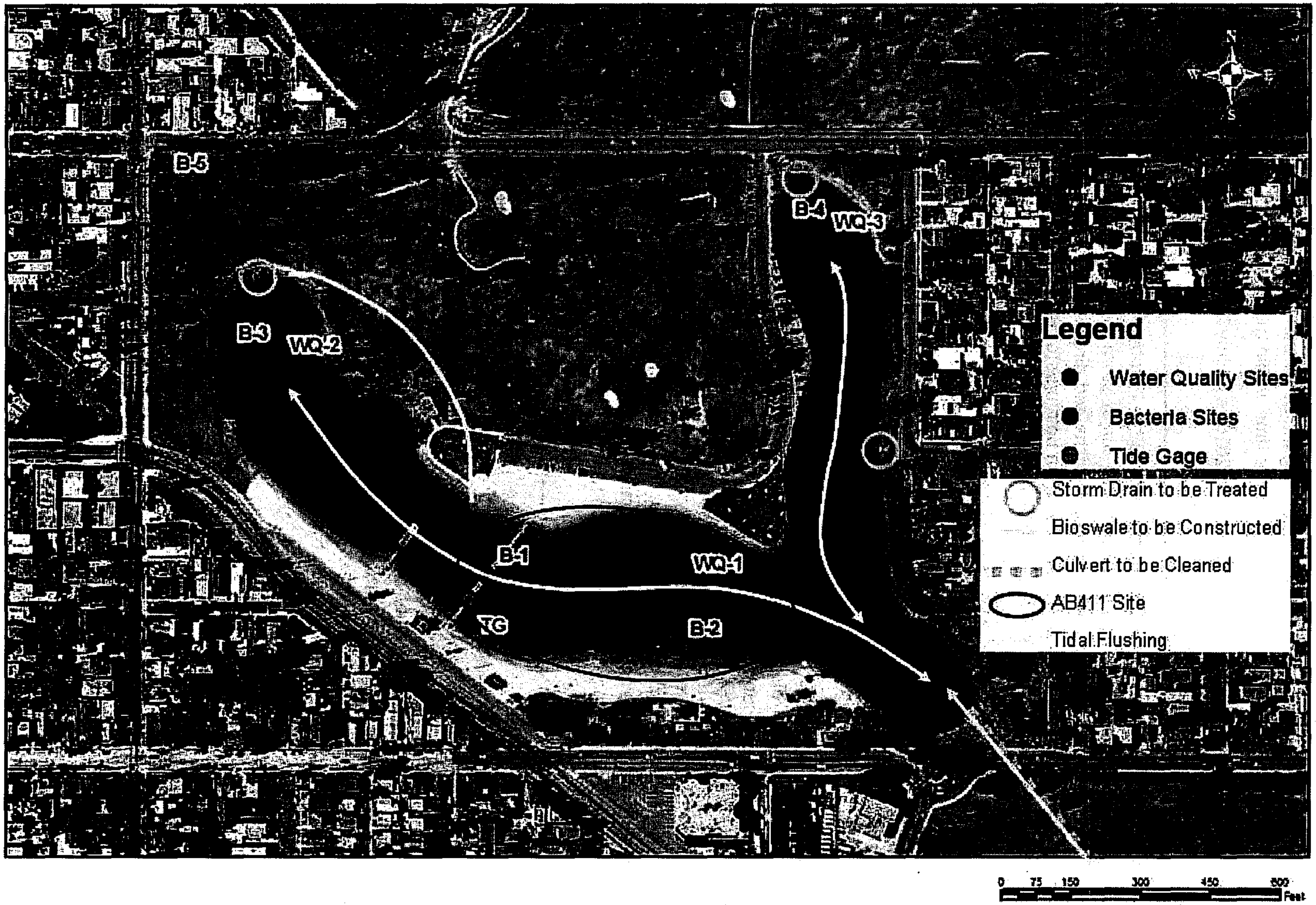


Figure 1. Locations of Project Improvements and their Relationship to Monitoring Sites.

METHODS

Colorado Lagoon was monitored for a period of four months prior to construction and again, for a seven-month period, following completion of Lagoon improvements. Identical methodology and analytical parameters were used during both monitoring periods. As listed in Table 5, the parameters monitored included:

Field Monitoring:

- Tidal Range
- Dissolved Oxygen (DO)
- Water Clarity (Turbidity)
- Algal Blooms
- Litter

Laboratory Analyses:

- Nutrients (Ammonia-N, TKN, Nitrate-N, Dissolved Orthophosphate-P, Total P)
- Total Suspended Solids (TSS)
- Fecal Indicator Bacteria (Total coliform, E. coli, and enterococcus)
- Total and Dissolved Trace Metals
- Organochlorine Pesticides/PCBs

FIELD MONITORING PROCEDURES

Several monitoring activities were based upon measurements taken in the field or by visual observation and documentation. These included deployment of a tide gage to measure the impacts of the culvert cleaning operation on tides, measurement of both dissolved oxygen and water clarity, and field assessments of algal blooms and litter. The following sections describe the approaches used for each element.

Tidal Range

A tide gage was deployed in Colorado Lagoon before and after the construction/culvert cleaning period. The initial (pre-construction) deployment period was from November 7, 2008 to December 14, 2008. The second (post-construction) period was from January 27, 2011 to April 20, 2011. Both periods met the plan requirement of a minimum of 30 days of recording.

The tide gage was to record the changes in the lagoon water levels expected as a result of the culvert cleaning and in comparison to open ocean tides. The tide gage was diver-mounted to a piling on the walk bridge in the lagoon and recorded water pressure every six minutes. During each deployment period, City of Long Beach survey staff recorded the water surface level from a local vertical benchmark at a specific date and time.

The recorded water pressure was converted to water elevation (relative to the NGVD29 vertical datum) using a pressure-depth equation and the surveyed water surface elevation at the specific date and time.

Dissolved Oxygen

Dissolved oxygen (DO) was measured at stations WQ-1, WQ-2, and WQ-3 (Figure 2) on a monthly basis during the 4 months of pre-construction monitoring and 7 months of post-construction monitoring. Measurements were taken by Moffatt & Nichol (M&N) staff, in conjunction with collection of water samples for laboratory analysis of nutrients, sediment, metals and organic compounds (Table 3).

DO was measured using a YSI Model 556 MPS multi-parameter system. Measurements were taken approximately 6 inches below the surface consistent with grab sampling conducted for nutrients and toxics. Calibration of the probe was checked on a daily basis prior to starting the sampling effort. The calibration process (saturated air) was performed as detailed in the YSI manual for this instrument.

Water Clarity and Algal Blooms

Water clarity and algal blooms were monitored by volunteers from Friends of Colorado Lagoon (FOCL) under direction of M&N (Table 1).

Table 1. Water Clarity and Algal Bloom Observation Dates

PRE-CONSTRUCTION SAMPLING DATES		POST-CONSTRUCTION SAMPLING DATES
29 August 2008	31 October 2008	28 February 2011
1 September 2008	7 November 2008	14 March 2011
6 September 2008	14 November 2008	30 March 2011
11 September 2008	21 November 2008	13 April 2011
12 September 2008	29 November 2008	14 May 2011
15 September 2008	5 December 2008	18 May 2011
18 September 2008	12 December 2008	5 June 2011
22 September 2008	19 December 2008	22 June 2011
26 September 2008	26 December 2008	6 July 2011
3 October 2008		22 July 2011
11 October 2008		3 August 2011
17 October 2008		16 August 2011*
24 October 2008		7 September 2011
		15 September 2011

* Water clarity not measured on this date.

Weekly algal bloom sampling was initiated when field crews conducting the weekly turbidity sampling observed any evidence of algal blooms developing. Algal monitoring was based upon visual observations. A black-and-white aerial photo of Colorado Lagoon was provided to the monitoring personnel. This person walked around the perimeter of the lagoon and visually observed areas where algae covered the water surface or accumulated along the banks. Prior to the commencement of the monitoring program, this person was educated on how to identify algae. The location(s) and spatial extent of the algal cover were drawn on the aerial photo. The monitoring personnel also took digital photographs of the areas covered by algae. Any general observations were also recorded on a form provided.

Water clarity was measured by use of a Secchi disk at WQ-1, WQ-2, and WQ-3 stations, from a boat. The disk was lowered into the water until the disk pattern could not be discerned. The water depth (in centimeters) at which this occurred was recorded.

Litter

Litter was monitored in two different areas of the Lagoon. One site was located along the south shore between the lifeguard station and the children's co-op pre-school. The second site was located at the Lagoon end of the culvert that connects with Marine Stadium. Monitoring staff collected all trash within each area using plastic trash bags. Collection of debris at the culvert required use of a pole/net to collect the litter accumulated within the culvert's trash rack. The trash bags were brought to a location where they were dumped onto a plastic tarp and the contents observed. The litter was sorted and categorized according to the following standard categories:

- Paper
- Cardboard/chipboard
- Moldable Plastic
- Plastic Film
- Styrofoam
- Wood Debris
- Metal
- Glass
- Cloth
- Cigarette Butts
- Other

Each piece of litter within each category was counted and a standardized form was filled in for each of the two areas. Collected litter was photographed prior to disposal in proper trash receptacles. Photographic documentation was also taken from three locations to record litter conditions throughout most of the Lagoon. Litter monitoring occurred once every other week (Table 2).

Table 2. Dates of Each Assessment of Litter Composition and Abundance in the Lagoon.

PRE-CONSTRUCTION SAMPLING DATES	POST-CONSTRUCTION SAMPLING DATES
1 September 2008	28 February 2011
15 September 2008	14 March 2011
3 October 2008	30 March 2011
17 October 2008	13 April 2011
31 October 2008	14 May 2011
14 November 2008	18 May 2011
29 November 2008	5 June 2011
16 December 2008	22 June 2011
26 December 2008	6 July 2011
	22 July 2011
	3 August 2011
	16 August 2011
	7 September 2011
	15 September 2011

Additional monitoring was conducted within 24-hours following a storm event and at least once for each of the periods before and after construction. Rainfall data from the Long Beach Daugherty Airport was used to characterize the general magnitude and antecedent conditions for each post storm monitoring event.

LABORATORY ANALYSES

The conventional, bacteriological, and chemical constituents selected for inclusion in this water quality program are presented in Table 5. Analytical method numbers, holding times, and reporting limits are also indicated for each analysis. Bacterial analyses were performed by the City of Long Beach Department of Health and Human Services. CRG Marine Laboratories conducted all chemical analyses associated with the pre-construction monitoring. Post-construction analyses were conducted by PHYSIS Analytical Laboratories.

Nutrients and Total Suspended Solids (TSS)

Collection of samples for nutrient and TSS analyses was conducted monthly during both pre- and post-construction monitoring periods (Table 3).

Table 3. Sample Collection Dates for Nutrient and TSS Analysis

PRE-CONSTRUCTION SAMPLING DATES	POST-CONSTRUCTION SAMPLING DATES
9 September 2008	24 February 2011
9 October 2008	28 March 2011
11 November 2008	27 April 2011
16 December 2008	23 May 2011
	21 June 2011
	17 July 2011
	23 August 2011

Metals, Organochlorine Pesticides, and PCBs

Additional samples were collected twice during the pre-construction monitoring period and twice during the post-construction monitoring period (Table 4) for analysis of total and dissolved metals, organochlorine pesticides, and PCBs at low detection limits. Due the matrix interferences associated with saline waters, analysis was performed by EPA1640 which involves chelation, extraction and concentration to achieve detection limits at levels relevant to water quality criteria.

Table 4. Sample Collection Dates for Metals, Organochlorine Pesticides and PCBs

PRE-CONSTRUCTION SAMPLING DATES	POST-CONSTRUCTION SAMPLING DATES
9 October 2008	27 April 2011
16 December 2008	17 July 2011

Table 5. Analytical Methods, Holding Times, and Reporting Limits

Analyte and Reporting Unit	Analytical Method	Holding Time	Target Reporting Limit
CONVENTIONAL PARAMETERS			
Orthophosphate-P (mg/L)	SM 4500-P E	48 hours	0.01
Total Phosphorus (mg/L)	SM 4500-P C	28 days	0.05
Total Ammonia-Nitrogen (mg/L)	SM 4500-NH3 F	28 days	0.03
Total Kjeldahl Nitrogen (mg/L)	SM 4500-N Org B	28 days	0.1
Nitrite Nitrogen (mg/L)	SM 4500-NO3 E	48 hours	0.1
Total Suspended Solids (mg/L)	SM 2540D	7 days	0.5
BACTERIA (MPN/100ml)			
Total Coliform	SM 9223	6 hours	10
Fecal Coliform	SM 9223	6 hours	10
Enterococcus	ASTM D6503-99	6 hours	10
TOTAL AND DISSOLVED METALS (µg/L)[1]			
Aluminum	EPA 1640(m)	180 days	6
Antimony	EPA 1640(m)	180 days	0.015
Arsenic	EPA 1640(m)	180 days	0.015
Beryllium	EPA 1640(m)	180 days	0.01
Cadmium	EPA 1640(m)	180 days	0.01
Chromium	EPA 1640(m)	180 days	0.05
Cobalt	EPA 1640(m)	180 days	0.01
Copper	EPA 1640(m)	180 days	0.02
Iron	EPA 1640(m)	180 days	1
Lead	EPA 1640(m)	180 days	0.01
Manganese	EPA 1640(m)	180 days	0.02
Molybdenum	EPA 1640(m)	180 days	0.01
Nickel	EPA 1640(m)	180 days	0.01
Selenium	EPA 1640(m)	180 days	0.015
Silver	EPA 1640(m)	180 days	0.04
Tin	EPA 1640(m)	180 days	0.01
Titanium	EPA 1640(m)	180 days	0.07
Vanadium	EPA 1640(m)	180 days	0.04
Zinc	EPA 1640(m)	180 days	0.01

1. Samples to be analyzed for dissolved metals are to be filtered within 48 hours.

Table 5. Analytical Methods, Holding Times, and Reporting Limits (continued)

Analyte and Reporting Unit	Analytical Method	Holding Time	Target Reporting Limit
CHLORINATED PESTICIDES (µg/L)			
Aldrin	EPA 625(m)	7 days	0.005
alpha-BHC	EPA 625(m)	7 days	0.005
beta-BHC	EPA 625(m)	7 days	0.005
delta-BHC	EPA 625(m)	7 days	0.005
gamma-BHC (lindane)	EPA 625(m)	7 days	0.005
alpha-Chlordane	EPA 625(m)	7 days	0.005
gamma-Chlordane	EPA 625(m)	7 days	0.005
DCPA (Dacthal)	EPA 625(m)	7 days	0.01
2,4'-DDD	EPA 625(m)	7 days	0.005
2,4'-DDE	EPA 625(m)	7 days	0.005
2,4'-DDT	EPA 625(m)	7 days	0.005
4,4'-DDD	EPA 625(m)	7 days	0.005
4,4'-DDE	EPA 625(m)	7 days	0.005
4,4'-DDT	EPA 625(m)	7 days	0.005
Dicofol	EPA 625(m)	7 days	0.1
Dieldrin	EPA 625(m)	7 days	0.005
Endosulfan I	EPA 625(m)	7 days	0.005
Endosulfan II	EPA 625(m)	7 days	0.005
Endosulfan sulfate	EPA 625(m)	7 days	0.005
Endrin	EPA 625(m)	7 days	0.005
Endrin Aldehyde	EPA 625(m)	7 days	0.005
Heptachlor	EPA 625(m)	7 days	0.005
Heptachlor Epoxide	EPA 625(m)	7 days	0.005
Hexachlorobenzene	EPA 625(m)	7 days	0.005
Methoxychlor	EPA 625(m)	7 days	0.005
Mirex	EPA 625(m)	7 days	0.005
cis-Nonachlor	EPA 625(m)	7 days	0.005
trans-Nonachlor	EPA 625(m)	7 days	0.005
Oxychlordane	EPA 625(m)	7 days	0.005
Perthane	EPA 625(m)	7 days	0.005
Toxaphene	EPA 625(m)	7 days	0.005
PCB CONGENERS (µg/L)	EPA 625(m)	7 days	0.005

Fecal Indicator Bacteria

Monitoring for Fecal Indicator Bacteria (FIBs) was conducted at four locations during the pre-construction period and five locations during the post-construction period. The locations were selected to be spatially representative and provide overlap with the AB411 program. One site (B-1) was sampled from the center of the walking bridge that crosses Colorado Lagoon. This is consistent with one of the three historical AB411 sites. A second site (B-2) was located in ankle-deep water at the swimming beach using AB411 sampling protocol. Two additional sites (B-3 and B-4) were sampled from shore, using a grab pole, to obtain water from approximately 10-feet offshore. A fifth site (B-5) was monitored within the wastewater storage well during the post-construction monitoring effort.

During dry weather periods, the objective was to conduct sampling during the time of day when peak dry weather flows occurred, however, prior dry weather flow monitoring in the watershed did not provide evidence of systematic daily fluctuations in flow rate. Monitoring was conducted as early as possible in the morning to obtain samples from the Lagoon concentrations in the receiving waters would have been expected to be highest.

Monitoring of FIBs was conducted on a weekly frequency during both the pre-construction and most of the post-construction monitoring periods (Table 8). Sampling events were classified as wet weather, wet weather impacted or dry weather. Samples were classified as wet weather if collected during a storm event. Samples collected within 72-hours of an event exceeding 0.1 inches are classified as wet weather impacted. Samples collected at all other times are considered dry weather sampling.

Table 6. Comparison of Site Designations used by the City's AB411 Program and those used for the Colorado Lagoon Construction Monitoring Effort

Colorado Lagoon Construction Monitoring Site Designations	Description of Site	AB411/Public Health Site Designations
Not monitored	North side shoreline	B-25[1]
B-1	Center of walking bridge	B-26
B-2	South side shoreline	B-24[1]
B-3	Western Arm	B-27
B-4	Northern (eastern) Arm	B-28
B-5	Sump of low flow diversion	B-29

1. B-24 and B-25 continue to be monitored as part of the Cities AB411 Program. B-26 was sampled in previous years but is no longer monitored.

Table 7. Fecal Indicator Bacteria (FIB) Criteria for both Single Samples and the 30-day Geometric Mean.

30-day Geometric Mean[1]	Single Sample Maximum[1]
• Total coliform density shall not exceed 1,000 per 100 ml; • Fecal coliform density shall not exceed 200 per 100 ml • Enterococcus density shall not exceed 35 per 100ml.	• Total coliform density shall not exceed 10,000 per 100 ml; • Fecal coliform density shall not exceed 400 per 100ml • Enterococcus density shall not exceed 104 per 100 ml • Total coliform density shall not exceed 1,000 per 100 ml when the fecal coliform/total coliform ratio exceeds 0.1

1. Criteria based upon the Los Angeles Regional Water Quality Control Board Basin Plan and State Health and Safety Code.

Figure 2. Monitoring Sites for Bacteria (B-1 through B-5), General Water Quality (WQ-1 through WQ-3, and Water Level (TG)

Table 8. Sample Collection Dates for Bacterial Analysis

PRE-CONSTRUCTION SAMPLING DATES		POST-CONSTRUCTION SAMPLING DATES	
25 August 2008 (D)	11 November 2008 (D)	10 January 2011 (D)	2 May 2011 (D)
2 September 2008 (D)	17 November 2008 (D)	18 January 2011 (D)	9 May 2011 (D)
8 September 2008 (D)	24 November 2008 (D)	24 January 2011 (D)	16 May 2011 (D)
16 September 2008 (D)	1 December 2008 (D)	31 January 2011 (W-I)	23 May 2011 (D)
22 September 2008 (D)	8 December 2008 (D)	8 February 2011 (D)	31May 2011 (D)
29 September 2008 (D)	15 December 2008 (W)	8 February 2011 (D)	8 June 2011 (D)
6 October 2008 (D)	16 December 2008 (W-I)	15 February 2011 (D)	22 June 2011 (D)
13 October 2008 (D)	22 December 2008 (D)	23 February 2011 (D)	29 June 2011 (D)
20 October 2008 (D)	29 December 2008 (D)	1 March 2011 (W)	13 July 2011 (D)
27 October 2008 (D)	5 January 2009 (D)	7 March 2011 (W-I)	19 July 2011 (D)
3 November 2008 (W-I)	12 January 2009 (D)	14 March 2011 (D)	12 September 2011 (D)
10 November 2008 (D)	20 January 2009 (D)	21 March 2011 (D)	19 September 2011 (D)
		28 March 2011 (D)	21 September 2011 (D)
		4 April 2011 (D)	26 September 2011 (D)
		13 April 2011 (D)	3 October 2011 (D)
		18 April 2011 (D)	10 October 2011 (D)
		25 April 2011 (D)	
		2 May 2011 (D)	

D=Indicates sampling conducted during dry weather conditions (<0.1 inches of rain during previous 72 hours)
W= Indicates rain occurred on the day of the sampling event.
W-I = Indicates >0.1inches of rainfall was measured during the previous 72 hours

Quality Assurance/Quality Control

The laboratory QA/QC activities provide information needed to assess potential laboratory contamination, analytical precision and accuracy, and representativeness. Analytical quality assurance for this program included the following:

- Employing analytical chemists trained in the procedures to be followed.
- Adherence to documented procedures, USEPA methods and written SOPs.
- Calibration of analytical instruments.
- Use of quality control samples, internal standards, surrogates and SRMs.
- Complete documentation of sample tracking and analysis.

Internal laboratory quality control checks included the use of internal standards, method blanks, matrix spike/spike duplicates, duplicates, laboratory control spikes and Standard Reference Materials (SRMs).

Data validation was performed in accordance with the USEPA Functional Guidelines for Low Level Concentration Organic Data Review (USEPA, 2001), USEPA Functional Guidelines for Inorganic Data Review (USEPA, 2002a), and Guidance on the Documentation and Evaluation of Trace Metals Data Collected for the Clean Water Act Compliance Monitoring-Draft (USEPA, 1996). Quality Assurance/Quality Control (QA/QC) activities associated with laboratory analyses are detailed in Appendix A.

RESULTS AND DISCUSSION

The following sections summarize the results of all pre- and post-construction monitoring activities.

Tidal Range

The Colorado Lagoon water levels, measured by the tide gage, are shown in Figure 3 and Figure 4 (as green lines), for the pre- and post-culvert-cleaning periods, respectively. It should be noted that the high water levels in the lagoon are affected by storm events, as the lagoon is a stormwater retention basin for a large watershed in east Long Beach. This is evident in the winter 2011 data where the lagoon water levels were periodically higher than the ocean high tides.

The maximum possible tide range in Colorado Lagoon would be the same as the tides experienced in the Marine Stadium on the other end of the culvert. Based on previous studies, the tides in Marine Stadium are known to match very close to those of the open ocean. Accordingly, it is appropriate to compare the tides of Colorado Lagoon to those of the open ocean. The nearest ocean tide station is the NOAA National Ocean Service Los Angeles Outer Harbor station (NOAA 2011). The tide data from this station is also plotted on Figure 3 and Figure 4 (as blue lines), for the pre- and post-culvert-cleaning periods, respectively. It is interesting to note the Japan tsunami effects (water level oscillations) in the March 11, 2011 timeframe.

Figure 5 presents a comparison of the pre- versus post-construction tides, based on two-week-window extracts of the recorded tide series. As expected, prior to the culvert cleaning, the tides within the lagoon were significantly muted in comparison to the ocean tides. Most notably, the lagoon's low tides were cut off by up to almost 3 feet and lagged, relative to ocean tides, during the period of record. The lagoon's high tides were also muted, although to a lesser extent than the low tides. This latest data is consistent with previous (2004) data which indicated the lagoon's Spring tide range was muted by up to 3.8 feet.

The post-construction period shows a dramatic improvement in the Colorado Lagoon tide range. As seen in Figure 5, the low tides in the lagoon are much closer to ocean tides, the lagoon high tides are only slightly muted, and the time lag is no longer present. The lagoon's low tides are cut off, relative to the ocean tides, worst case by only 1.2 feet during the period of record, i.e. the culvert cleaning resulted in a low tide improvement of approximately 1.6 feet. Previous studies predicted a spring tide range improvement of 1.4 feet upon cleaning of the culvert. Data from the post-construction deployment of the tide gauge demonstrated that the culvert cleaning met and even exceeded the expected improvements in tidal range.

FINDINGS:
Cleaning of the culvert increased the extent of the low tide by approximately 1.6 feet and reduced the time lag in tidal response.

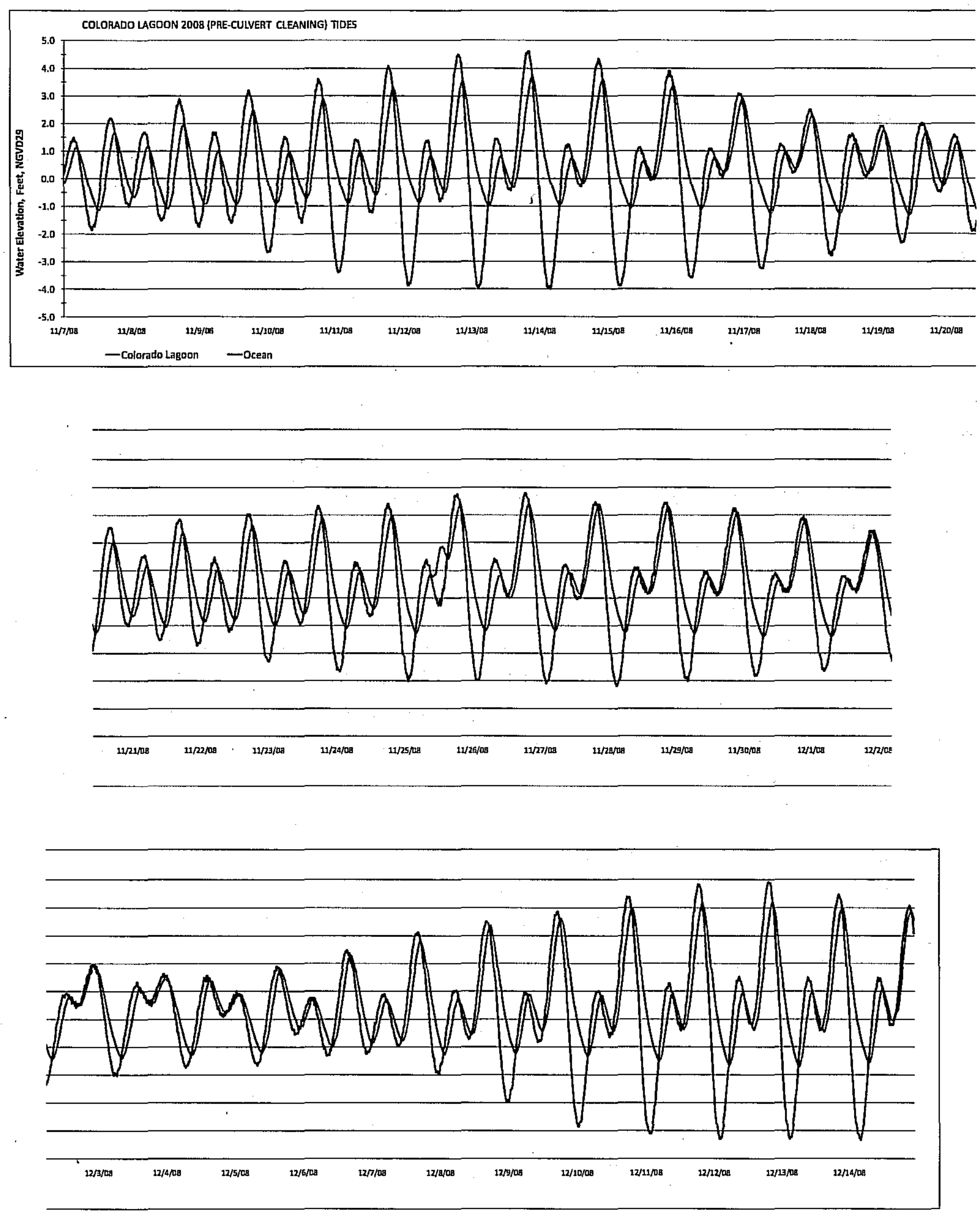


Figure 3. Complete 2008 Tide Series (Colorado Lagoon in Green, Ocean in Blue)

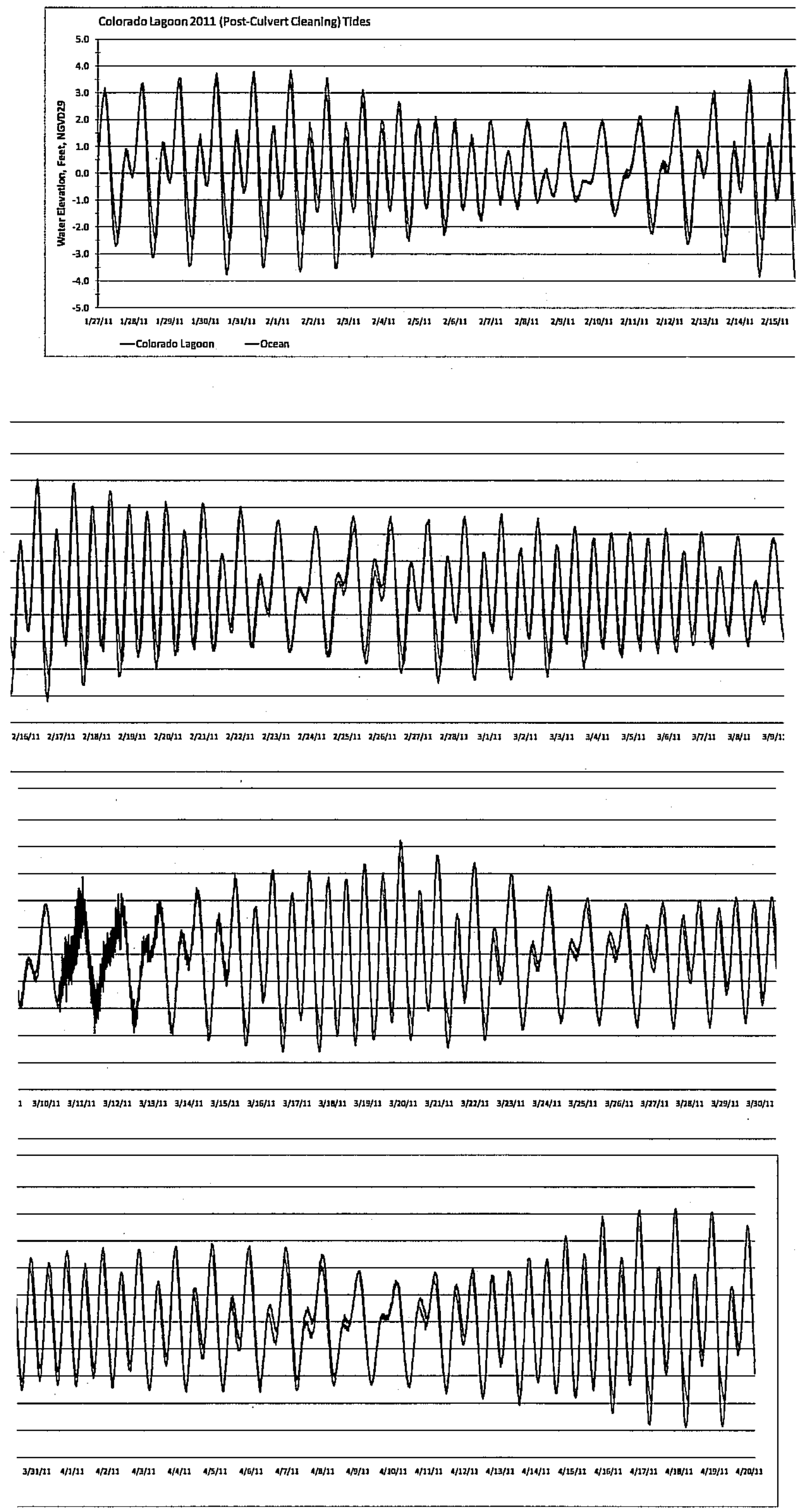
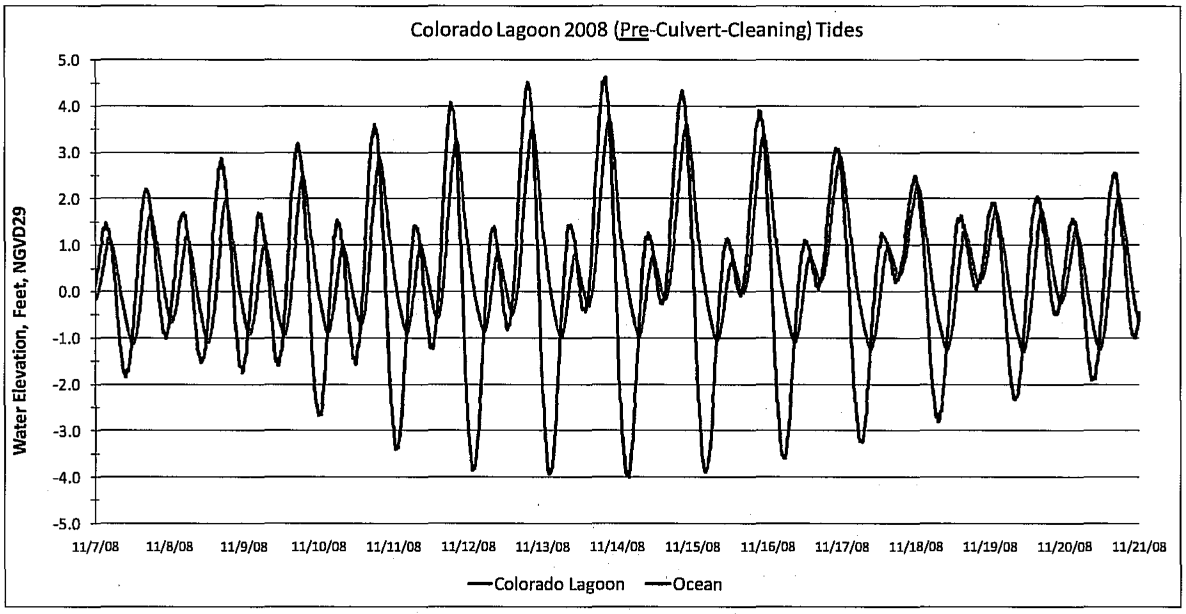


Figure 4. Complete 2011 Tide Series (Colorado Lagoon in Green, Ocean in Blue)



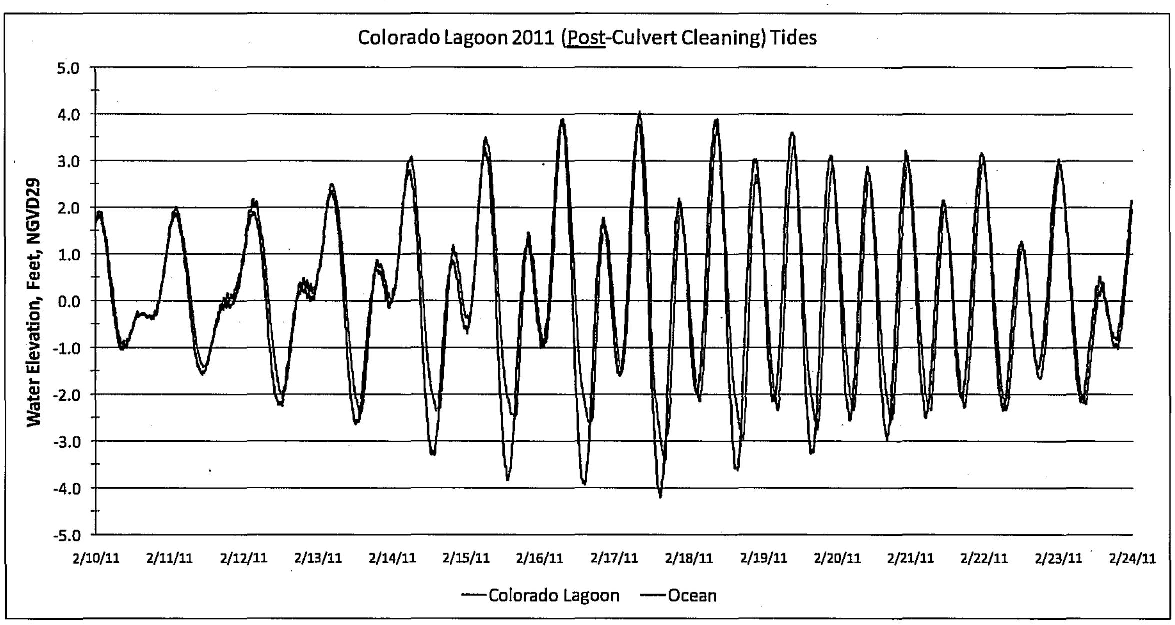


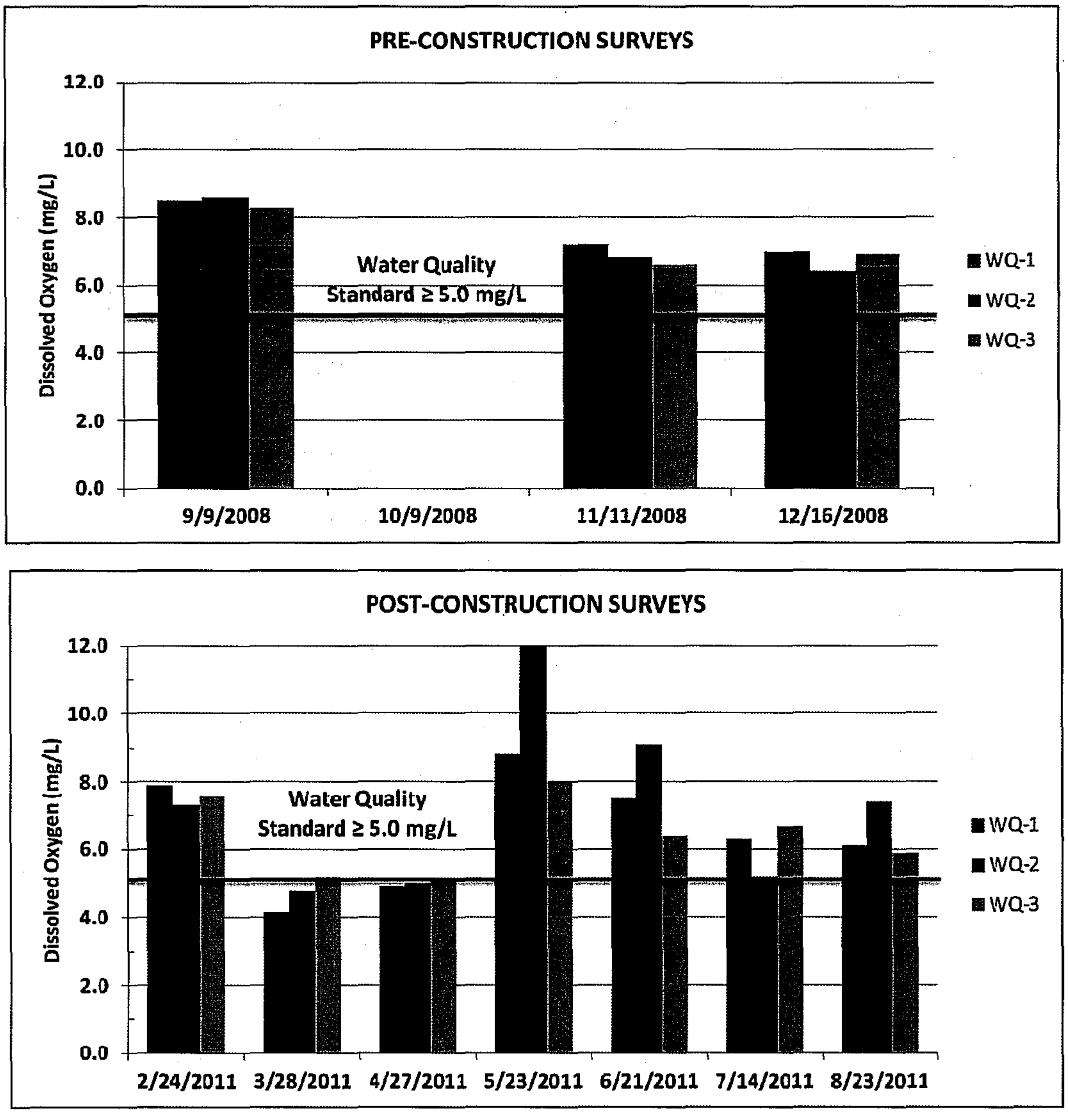
Figure 5. Pre- Versus Post-Culvert-Cleaning Tides (Colorado Lagoon in Green, Ocean in Blue)

Dissolved Oxygen

Dissolved oxygen was measured during each pre and post-construction survey. Data are tabulated along with other conventional analytes in Table 15 and Table 16. Dissolved oxygen data taken in association with the second pre-construction survey was rejected after determining that the meter was malfunctioning.

Monitoring associated with the pre-construction surveys (Figure 6) indicated that oxygen concentrations were consistently greater than 6.0 mg/L and did not drop below the minimum of 5 mg/L established in the Basin Plan (Los Angeles RWQCB, 1994). Greater variability was noted during the post construction surveys. Measured concentrations ranged from 4 to 12 mg/L with the lowest concentrations being encountered during the March 28, 2011 survey that followed the day after a 0.1 inch rainfall event.

FINDINGS:
Measurements of dissolved oxygen did not show strong evidence of any changes in response to project improvements completed to date.



Dissolved oxygen concentrations should be maintained at levels equal to or greater than 5.0 mg/L at all times.

Figure 6. Concentrations of Dissolved Oxygen Measured during Pre-and Post-Construction Surveys

Water Clarity

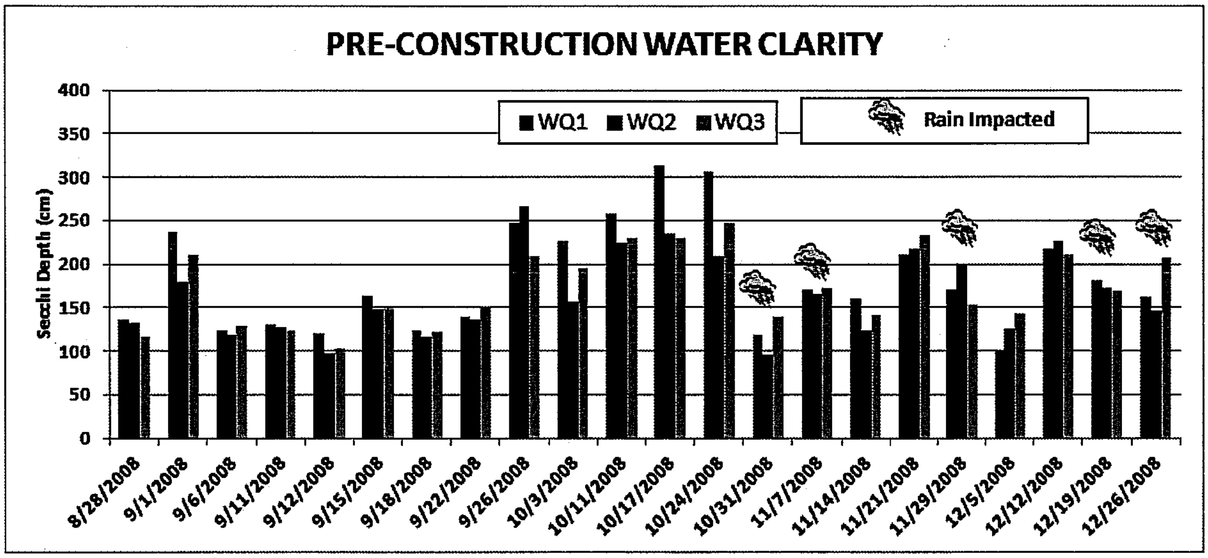
Secchi disk measurements used to assess water clarity are presented in Table 9 and graphically in Figure 7 and Figure 8. Five of the pre-construction surveys and one post-construction survey were influenced by rain in excess of 0.1 inches over the three days prior to the sampling events. Overcast and cloudy conditions also influence the water clarity. Water clarity associated with rain events was often notably impacted. The box plots in Figure 8 summarize the distributional characteristics of water clarity both by including all data and eliminating events that were considered potential impacted by rainfall. When comparing only dry conditions, water clarity during the pre-construction surveys ranged from 167 to 189 centimeters at the three sites, with highest clarity evident at WQ-1 which is located closest to the culvert. During post-construction surveys, water clarity ranged from 208 to 225 centimeters again with highest water clarity typically found at WQ-1. Although the average water clarity at each site increased by 19 to 25 percent in the post-construction surveys, the difference would not be considered to be statistically different due to the high variability as best shown in Figure 8. In addition, direct statistical comparison may not be appropriate due to the seasonal differences in timing of the two surveys.

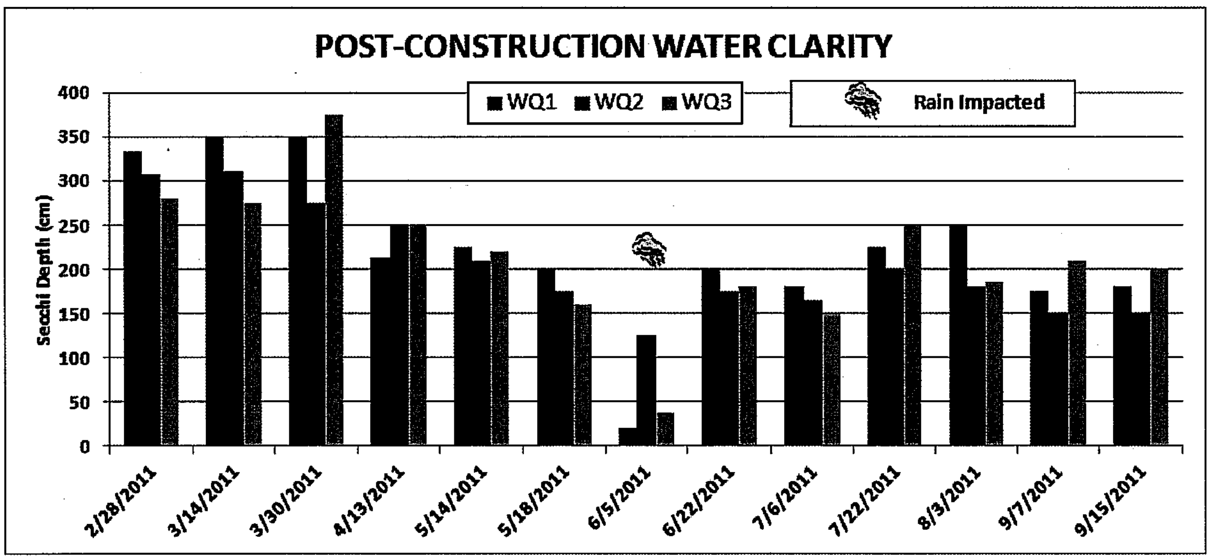
FINDINGS:
Average water clarity increased by 19-25% at the three sample locations subsequent to the culvert cleaning and other improvements. Due to high variability, statistical significance could not be applied to this change.

Table 9. Pre- and Post-Construction Secchi Depth Measurements in Centimeters.

Date	WQ-1	WQ-2	WQ-3	Rain Impacted?
Pre-Construction				
8/29/2008	136.5	132.5	117	
9/1/2008	237	180	210	
9/6/2008	124	118	128	
9/11/2008	131	127	124	
9/12/2008	120	98	102	
9/15/2008	163	148	150	
9/18/2008	124	117	121	
9/22/2008	140	136	151	
9/26/2008	247	267	208	
10/3/2008	226	156	195	Cloudy
10/11/2008	257	224	229	
10/17/2008	313	235	230	
10/24/2008	307	208	247	
10/31/2008	119	95	140	**R**
11/7/2008	170	166	173	**R**
11/14/2008	160	124	141	
11/21/2008	210	217	233	
11/29/2008	171	200	153	**R**
12/5/2008	100	126	143	
12/12/2008	217	226	210	
12/19/2008	181	173	169	**R**
12/26/2008	162	147	207	**R**
Post-Construction				
2/28/2011	333	307	280	**R**
3/14/2011	350	310	275	
3/30/2011	350	275	375	
4/13/2011	212.5	250	250	
5/14/2011	225	210	220	Overcast
5/18/2011	200	175	160	**R**
6/5/2011*	20	125	37.5	
6/22/2011	200	175	180	Overcast
7/6/2011	180	165	150	
7/22/2011	225	200	250	
8/3/2011	250	180	185	
9/7/2011*	175	150	210	
9/15/2011*	180	150	200	Overcast

*Measurements taken late in day (later than other measurements)





Rain impacted surveys identified by the "cloud"

Figure 7. Column Plots of Water Clarity measured during Pre- and Post-Construction Surveys.

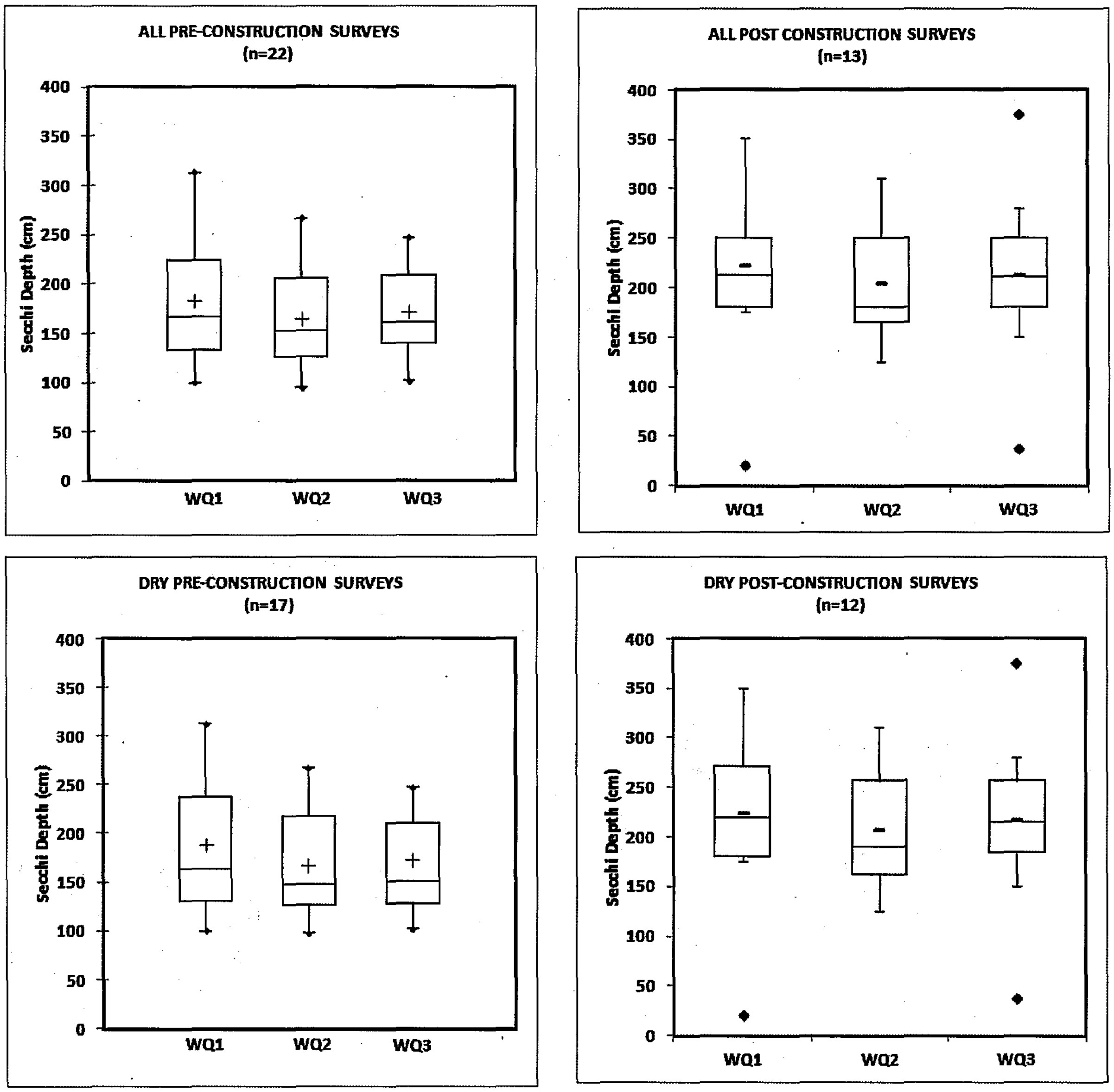


Figure 8. Box Plots of Secchi Depth Measurements (All data and only dry weather data) measured at each site during Pre- and Post-Construction Surveys.

Macroalgal Blooms

Observations on the presence or absence of algal blooms in Colorado Lagoon were undertaken weekly or biweekly during the four month monitoring period prior to construction and the seven month monitoring period following construction. The following information was gathered at each event by the Friends of Colorado Lagoon under the supervision of Moffatt and Nichol: date, time, notes on tide and weather, a map with macroalgal blooms along the shoreline marked, and notes including the presence of free-floating algal blooms in the lagoon. Estimates on % of algal blooms along the shoreline were made from this information for comparative purposes.

Algae were observed along 0% to 50% of the lagoon shoreline during the pre-construction monitoring period of 29 August 2008 to 19 December 2008 (Table 10). No algal were observed in 8 out of the 19 pre-construction monitoring events. The highest observances of macroalgae occurred in October 2008 and November 2008. During this time period, 4 out of the 7 observations noted that macroalgae occurred along 40% to 50% of the shoreline. Free-floating macroalgae also were observed three times during this period (3, 24, and 31 October 2008). During the remaining pre-construction monitoring efforts, macroalgae were found along less than 5% of the shoreline.

During the post-construction monitoring period of 28 February 2011 to 15 September 2011, macroalgae were observed along 0% to 100% of the lagoon shoreline (Table 10). However, the only period when algae were totally absent was during the two surveys conducted in August 2011. Both surveys were considered compromised because of high tides that impacted visibility at the shoreline. If these two compromised observations are removed from the post-construction monitoring effort, macroalgae covered from 10% to 100% of the lagoon shoreline in the post-construction monitoring period. Free-floating macroalgae were only observed once (22 June 2011) during the post-construction monitoring period. It is common for mats of benthic macroalgae to float to the surface after a period of high growth.

During the pre-construction monitoring period, macroalgae were observed an average of 11% of the perimeter of Colorado Lagoon, while during the post-construction monitoring period they were observed to occupy an average of 45% of the perimeter of the lagoon. It is important to note that the pre-construction period was during the fall-winter months when algae blooms are less likely to occur, whereas the post-construction period was during the spring-summer months when algae blooms tend to be in their maximum condition. This timing of the pre-and post-construction periods was controlled by the construction activities and grant funding availability.

FINDINGS:
Observations of macroalgae did not show strong evidence of any changes in response to project improvements completed to date. However, macroalgal abundances are highly influenced by season. The timing of the pre and post-construction periods limited the ability to evaluate macroalgal changes that were related to project improvements.

Table 10. Pre- and Post-Construction Macroalgae Observations

Date	Time	% of Shoreline with Macroalgae	Free-Floating Algae Observed?
Pre-Construction			
08/29/08	12:00	5	N
09/01/08	10:30	0	N
09/06/08	14:45	1	N
09/11/08	13:00	0	N
09/12/08	10:00	0	N
09/15/08	11:00	5	N
09/22/08	8:30	0	N
09/26/08	14:30	0	N
10/03/08	10:45	0	Y
10/11/08	14:20	40	N
10/17/08	11:05	45	N
10/24/08	12:05	10	Y
10/31/08	14:10	5	Y
11/07/08	9:00	40	N
11/21/08	10:00	5	N
11/29/08	11:00	50	N
12/05/08	9:00	5	N
12/12/08	10:00	0	N
12/19/08	9:30	0	N
Post-Construction			
02/28/11	16:00	100	N
03/14/11	13:00	100	N
03/30/11	11:00	90	N
04/13/11	14:17	60	N
05/14/11	14:50	40	N
05/18/11	10:01	35	N
06/05/11	16:06	30	N
06/22/11	9:45	55	Y
07/06/11	14:30	10	N
07/22/11	8:00	80	N
08/03/11	13:00	0	N
08/16/11	10:00	0	N
09/07/11	14:15	10	N
09/15/11	17:41	20	N

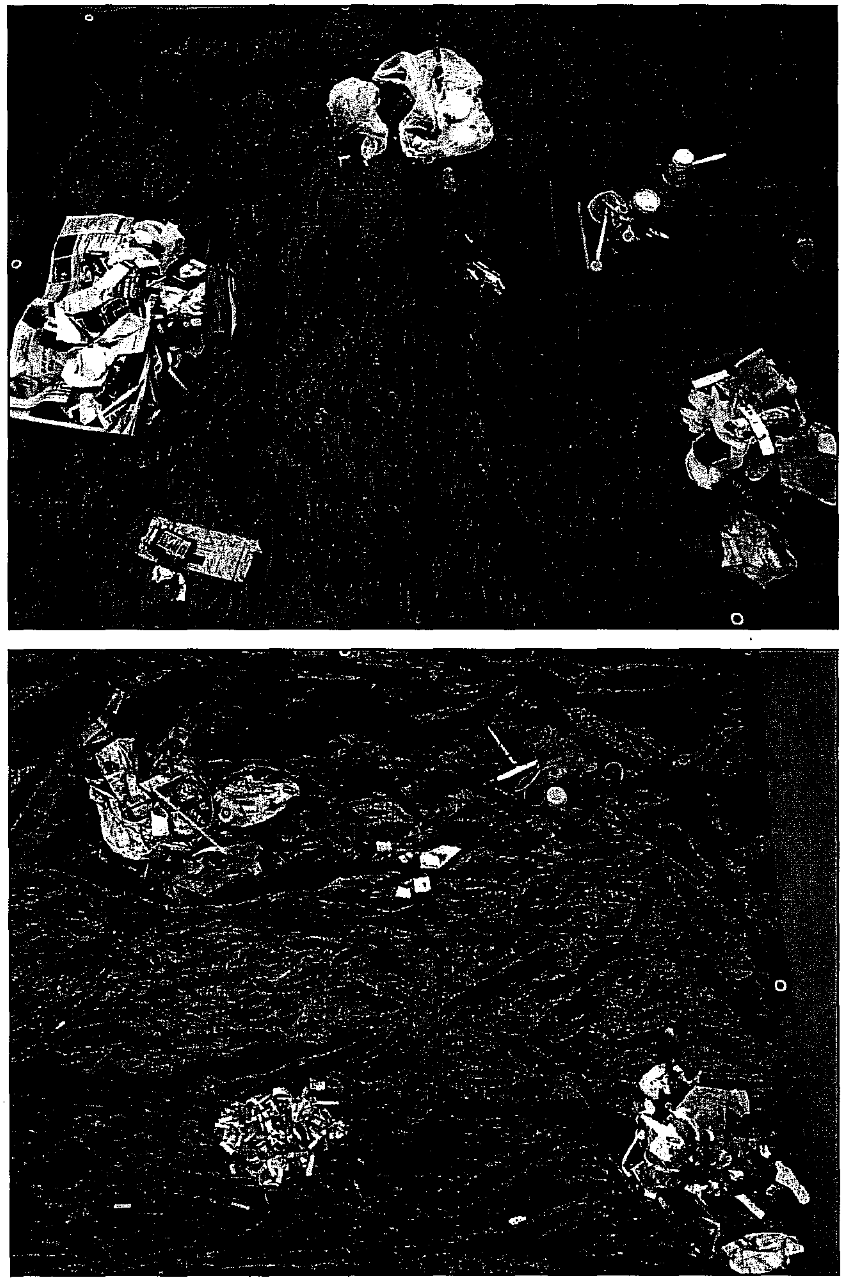
Litter

Litter was monitored biweekly by the Friends of Colorado Lagoon in two different areas of the Colorado Lagoon. The first area evaluated for litter was the lagoon end of the culvert that connects with Marine Stadium. The second area evaluated for litter was along the south shore between lifeguard station and the children's co-op pre-school. Figure 9 illustrates sorted litter and debris from each site after collection and quantification. Large accumulations of litter and debris associated with a pre-construction storm event are shown in Figure 10. Figure 11 shows litter and debris intercepted by the Fresh Creek trash nets installed in the storm drains as part of the improvements. Significant reductions in the pieces of litter were found between pre- and post-construction monitoring at both sites (Figure 12 and Figure 13). Specifically, litter counts in the following categories were measurably reduced post-construction: paper, moldable plastic, plastic film, Styrofoam, glass, and cigarette butts.

The number of pieces of trash collected each monitoring day at each site were added and then averaged by pre- and post-construction efforts. At the site near the culvert, litter items collected post-construction (22 items average) were observed to be 85% lower than recorded during pre-construction surveys (147 items average) (Table 11). Along the south shore, litter items collected post-construction (10 items average) were observed were nearly 97% lower than during pre-construction (299 items average) (Table 13).

With a post-construction decrease in litter came redistributions within the litter categories for both sites. Generally speaking, moldable plastics percent volume went down while plastic film and cigarette butts went up at the both sites (Figure 14 and Figure 15; Table 13 and Table 14). Additionally, the south shore site had pre-construction litter in the categories of cardboard, wood debris, glass, and cloth that were not observed in the post-construction assessments.

FINDINGS:
Litter monitoring provided documentation of dramatic reductions in the litter. Average counts of litter and debris decreased by 85% at the culvert trash rack and nearly 97% along the south shoreline.

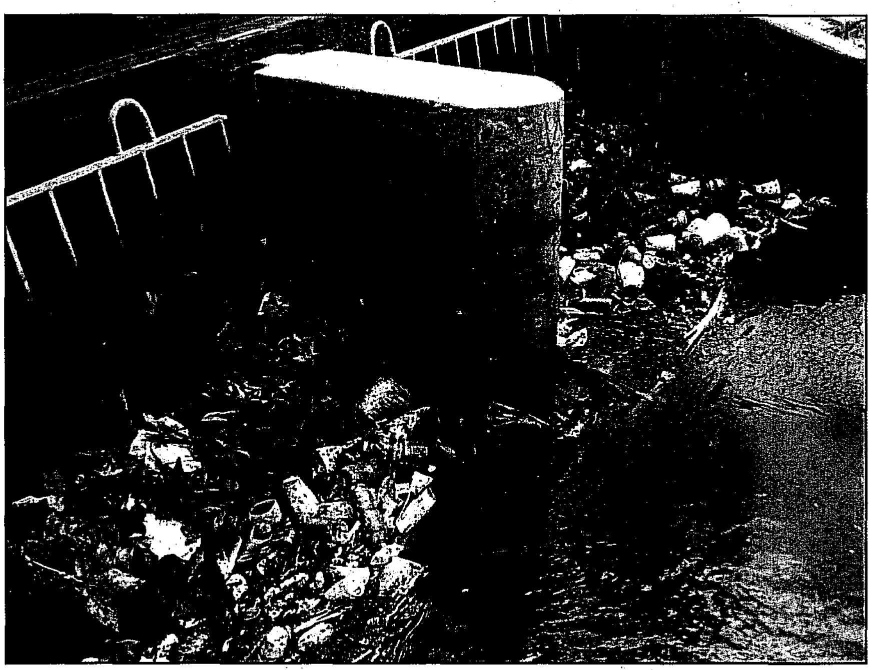


Sorted Litter from South Shoreline

Sorted Litter from Culvert

Figure 9. Sorted Debris and Litter collecting during the 9-15-08 Field Assessment along the South Shoreline and at the Culvert.

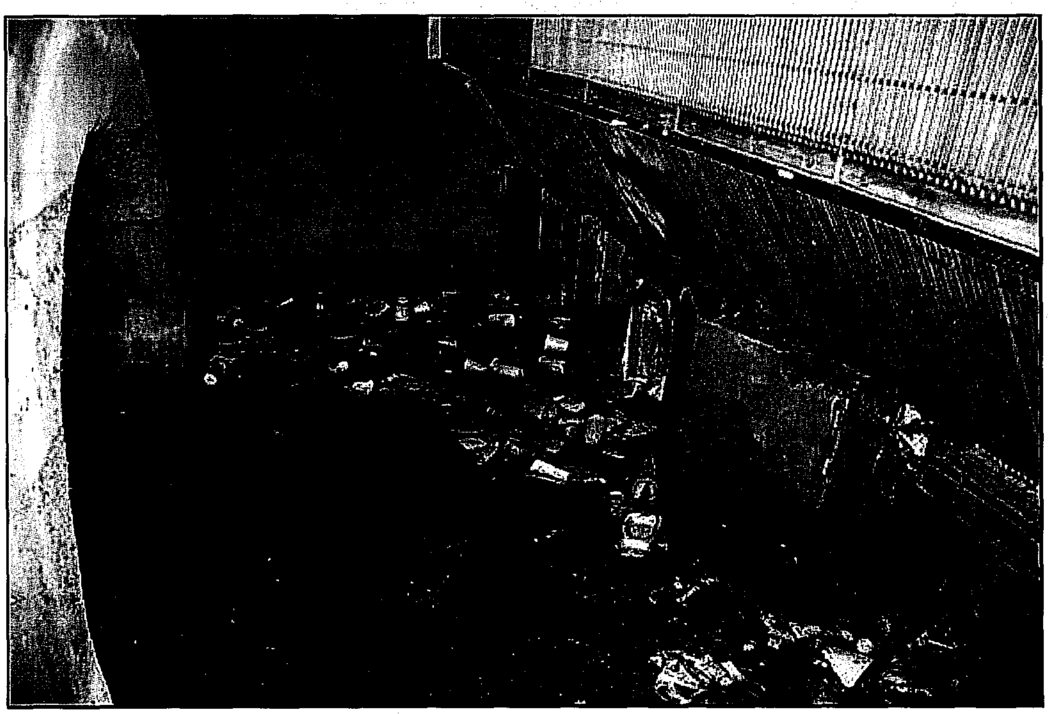
Litter from South Shoreline



Litter at the Culvert

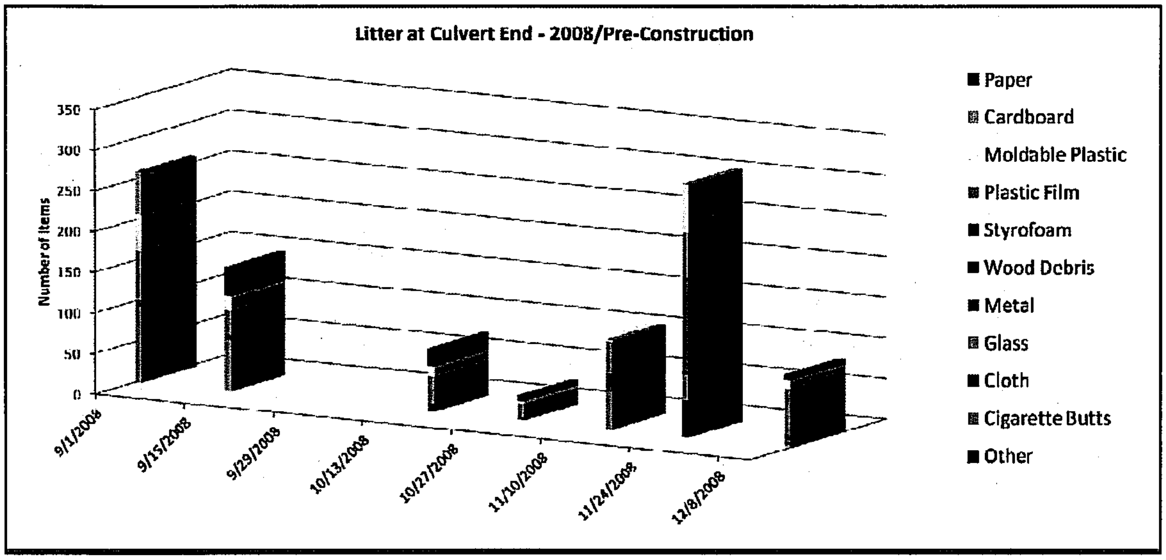
Figure 10. Debris and Litter Collected during the 11-26-08 Post Storm Field Assessment along the South Shoreline and at the Culvert.

a) **Downstream view with bags approximately half full.**



b) **Upstream view showing trash entering the trap nets.** *Photos courtesy of Dave Pirazzi.*

Figure 11. Litter and Debris in Storm Drain Trash Net (Downstream and Upstream Views)



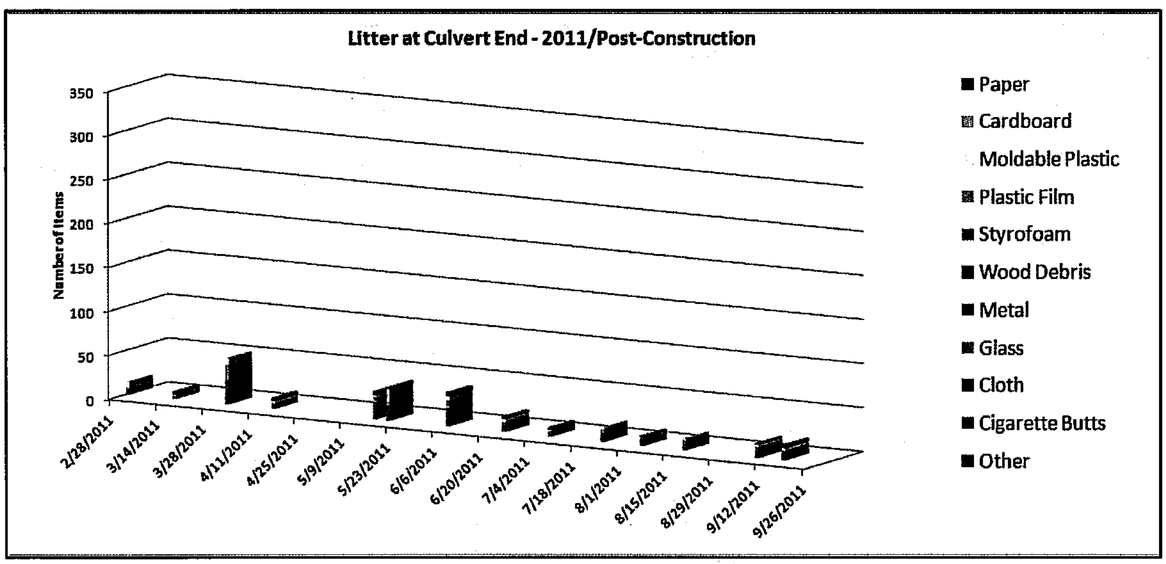
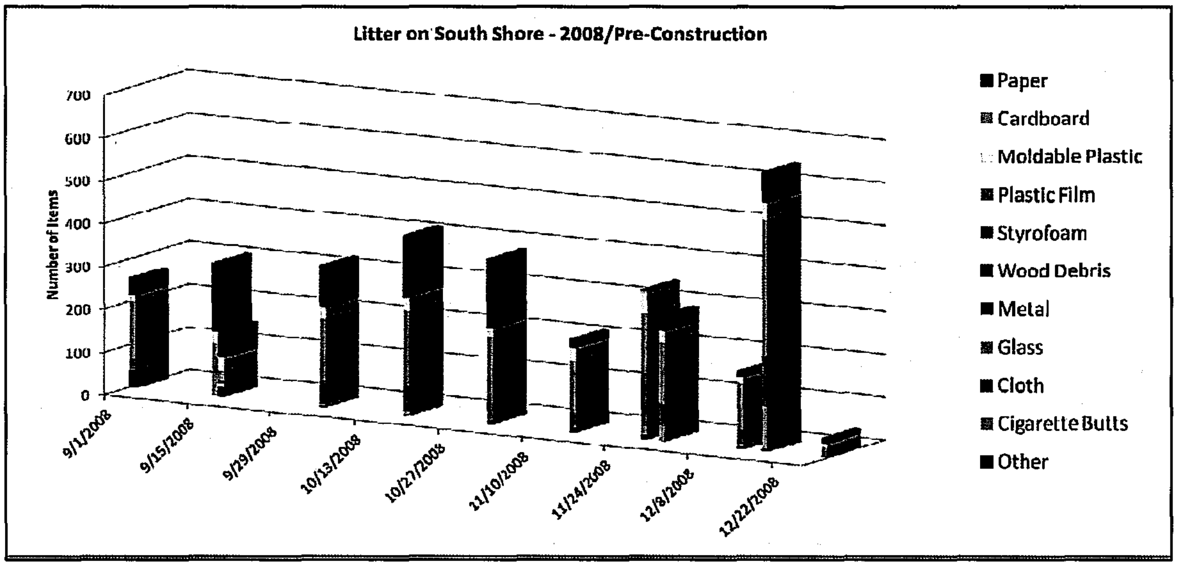


Figure 12. Counts of each Litter Category collected at the Trash Racks for the Culvert connecting to Marine Stadium during Pre- and Post-Construction Monitoring.



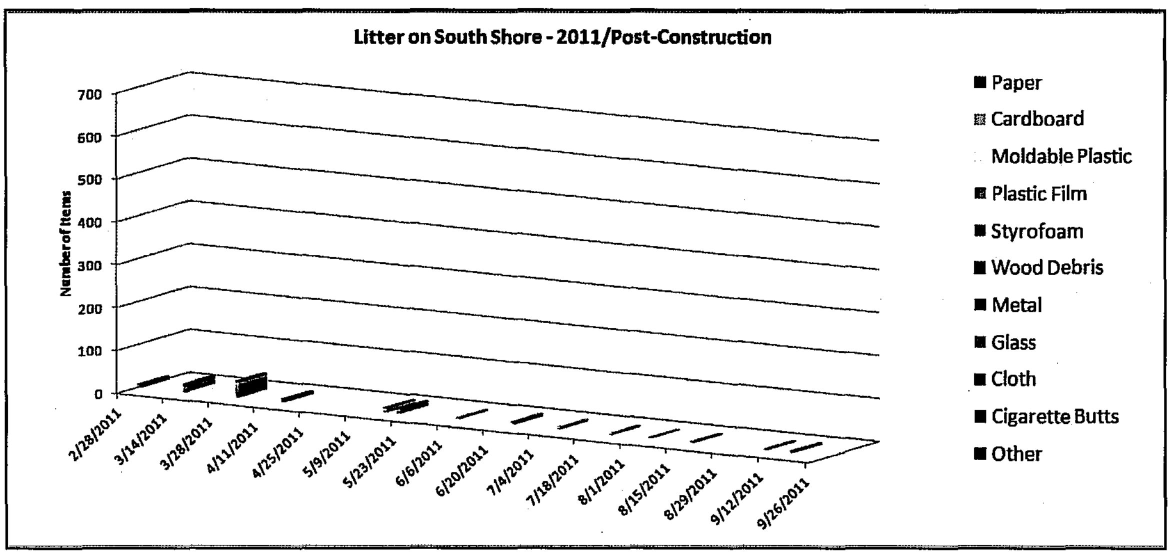
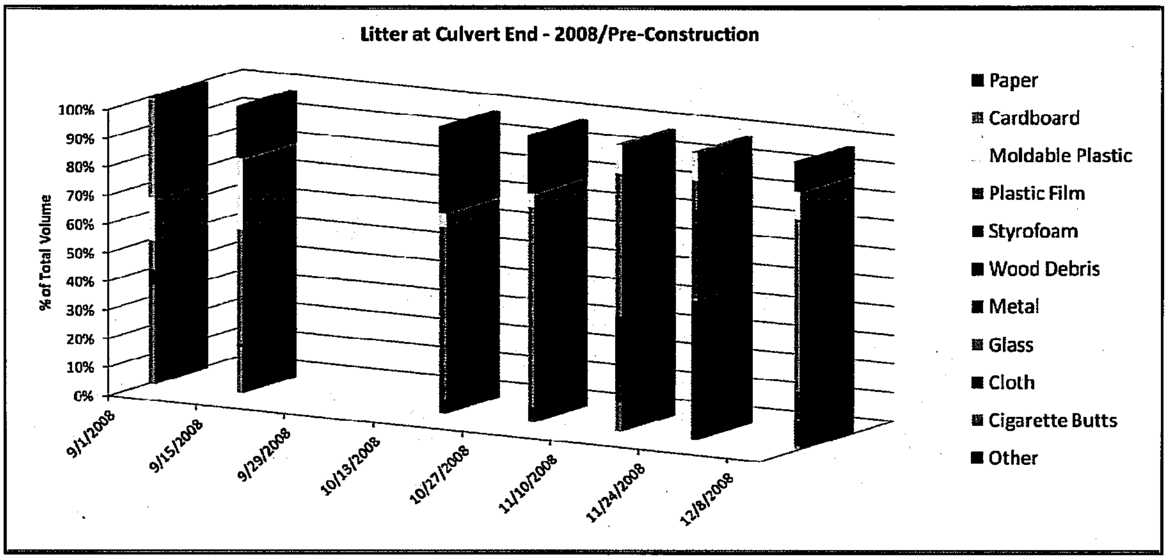


Figure 13. Counts of each Litter Category collected along the South Shoreline (Swimming Beach) during Pre- and Post-Construction Monitoring.



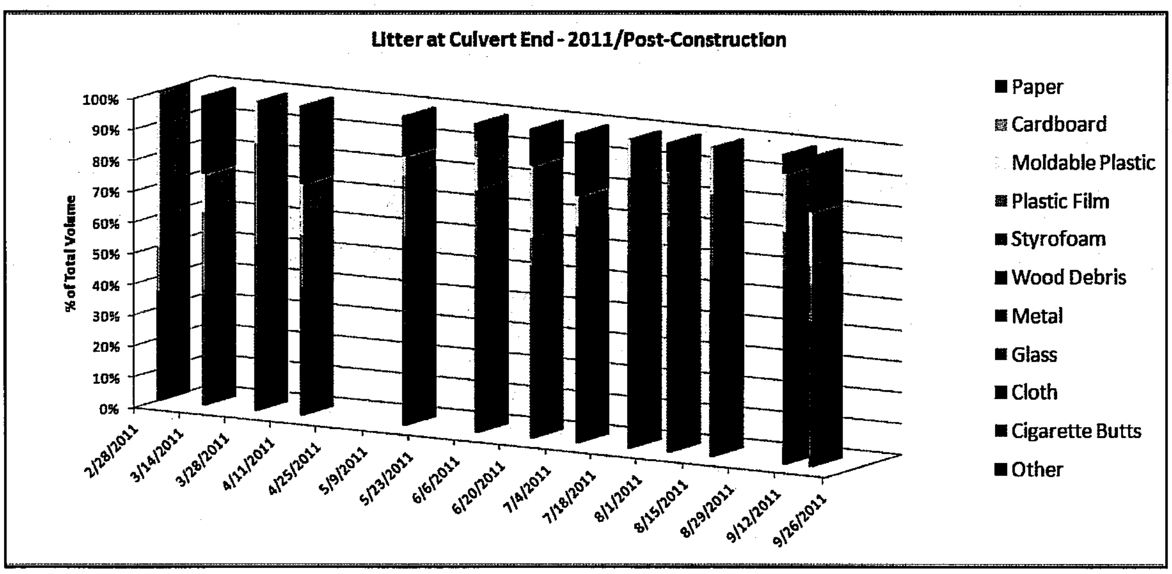
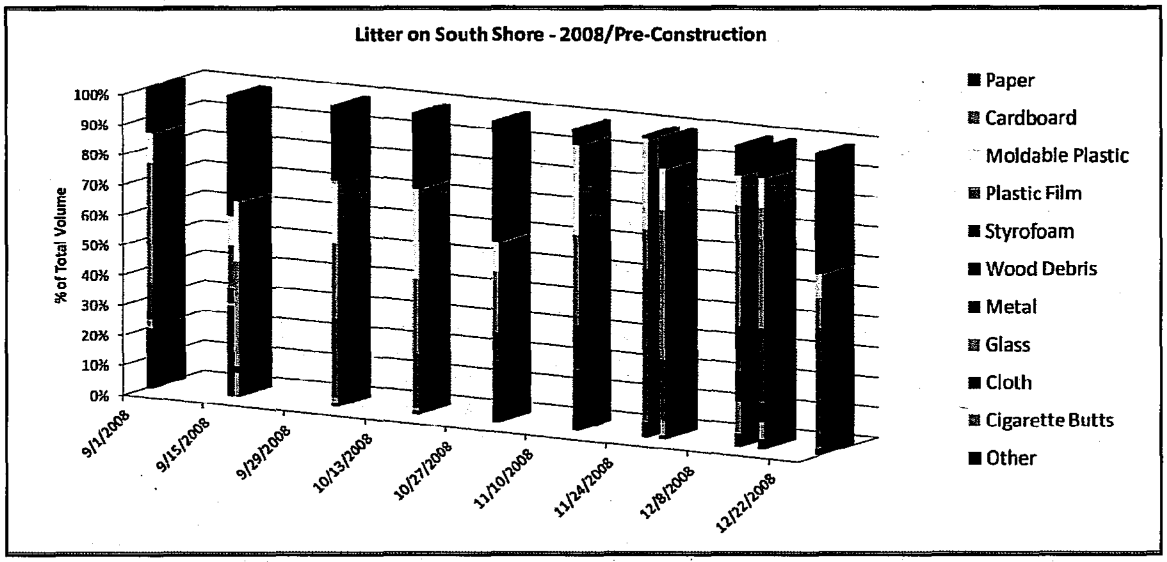


Figure 14. Percent Volume of each Litter Category collected at the Trash Racks for the Culvert connecting to Marine Stadium during Pre- and Post-Construction Monitoring.



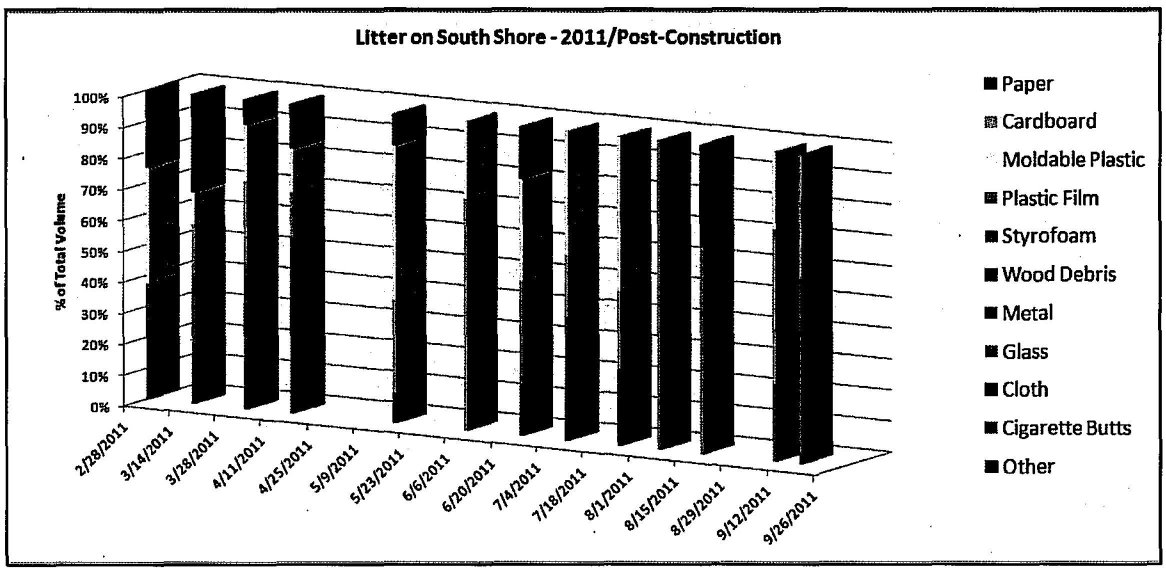


Figure 15. Percent Volume of each Litter Category collected along the South Shoreline (Swimming Beach) during Pre- and Post-Construction Monitoring.

Table 11. Counts of Pre and Post-Construction Trash collected near the Culvert connecting with Marine Stadium during Pre- and Post-Construction Surveys.

	Paper	Cardboard	Moldable Plastic	Plastic Film	Styrofoam	Wood Debris	Metal	Glass	Cloth	Cigarette Butts	Other
PRE-CONSTRUCTION											
9/1/2008		53	44	61	9					92	
9/15/2008	35		18	30	6			3		60	
10/17/2008	21		13	34	9						
10/31/2008	6		4	16	2					2	
11/14/2008			2	39	22					47	
11/26/2008			60	55	115	2	2	2		30	45
12/12/2008	6		11	57	9	1	2			3	
POST-CONSTRUCTION											
2/28/2011			7		2		1			4	
3/14/2011	2		1	2	3						
3/30/2011			7	17	15					13	
4/13/2011	3		2	2			1			4	
5/14/2011	4		2	6			2			17	
5/18/2011	1			15	4		4			11	2
6/5/2011	3	2	4	8			1			20	
6/22/2011	2		4	2	2					7	
7/6/2011	2		1	2	1					4	
7/22/2011			2	4	3					7	
8/3/2011	1			2	1					7	
8/16/2011			2	3	2					6	
9/7/2011	1		3	2	2		1			6	1
9/15/2011	3		3	1	2					8	

Table 12. Counts of Pre and Post-Construction Trash collected along the South Shoreline.

	Paper	Cardboard	Moldable Plastic	Plastic Film	Styrofoam	Wood Debris	Metal	Glass	Cloth	Cigarette Butts	Other
PRE-CONSTRUCTION											
9/1/2008	40		16	134	19		2	4			41
9/15/2008	160		27	110		1				12	
9/16/2008	62		30	23		1	3		2	12	20
10/3/2008	96	4	23	146	49		4	4			3
10/17/2008	143		32	174	61			7			2
10/31/2008	162		20	153	41	2	2				4
11/14/2008	19		31	120	35	4	4		1		2
11/26/2008	3	4	48	140	121		2			20	10
11/29/2008	36		25	143	52					35	1
12/12/2008	14		12	110	28	3	3	3		2	6
12/16/2008	70		40	320	110	1	4	1		100	4
12/26/2008	12		8	9	14						2
POST-CONSTRUCTION											
2/28/2011	2		3		1					2	
3/14/2011	6		2	3	5					3	
3/30/2011	3		7	10	5		1			11	1
4/13/2011	1		1	1			1			3	
5/14/2011	1		5	3						1	
5/18/2011	1			6			1			3	
6/5/2011			1	3							
6/22/2011	1		2	2	1						
7/6/2011			2	1	1					1	
7/22/2011			2	1						1	
8/3/2011				2							
8/16/2011	1			2							
9/7/2011			1	2	1						
9/15/2011				2	3						

Table 13. Percent Volume of Trash collected near the Culvert connecting with Marine Stadium during Pre- and Post-Construction Surveys.

	Paper	Cardboard	Moldable Plastic	Plastic Film	Styrofoam	Wood Debris	Metal	Glass	Cloth	Cigarette Butts	Other
PRE-CONSTRUCTION											
9/1/2008		35.0	15.0	10.0	5.0					35.0	
9/15/2008	18.0		25.0	40.0	1.0			1.0		15.0	
10/17/2008	30.0		5.0	60.0	5.0						
10/31/2008	20.0		5.0	70.0	4.0					1.0	
11/14/2008			10.0	50.0	30.0					10.0	
11/26/2008			10.0	10.0	30.0	0.5	0.5	0.5		0.5	48.0
12/12/2008	10.0		10.0	60.0	10.0	5.0	4.0			1.0	
POST-CONSTRUCTION											
2/28/2011			50.0	14.3		7.1				28.6	
3/14/2011	25.0		12.5	25.0	37.5						
3/30/2011			13.5	32.7	28.9					25.0	
4/13/2011	25.0		16.7	16.7			8.3			33.3	
5/14/2011	12.9		6.5	19.4			6.5			54.8	
6/5/2011	8.1	5.4	10.8	21.6			2.7			51.4	
6/22/2011	11.8		23.5	11.8	11.8					41.2	
7/6/2011	20.0		10.0	20.0	10.0					40.0	
7/22/2011			12.5	25.0	18.8					43.8	
8/3/2011	9.1			18.2	9.1					63.6	
8/16/2011			15.4	23.1	15.4					46.2	
9/7/2011	6.3		18.8	12.5	12.5		6.3			37.5	6.3
9/15/2011	17.6		17.6	5.9	11.8					47.1	

Table 14. Percent Volume of Trash collected along the South Shoreline during Pre- and Post-Construction Surveys.

	Paper	Cardboard	Moldable Plastic	Plastic Film	Styrofoam	Wood Debris	Metal	Glass	Cloth	Cigarette Butts	Other
PRE-CONSTRUCTION											
9/1/2008	15.0		10.0	40.0	10.0		2.0	3.0			20.0
9/15/2008	40.0		10.0	14.0		1.0	2.0		2.0	1.0	30.0
9/16/2008	35.0		20.0	35.0		2.0				8.0	
10/3/2008	25.0	1.0	20.0	25.0	25.0		1.0	1.0		1.0	1.0
10/17/2008	25.0		30.0	25.0	18.0			1.0			1.0
10/31/2008	40.0		10.0	20.0	10.0	10.0	5.0				5.0
11/14/2008	5.0		30.0	30.0	15.0	10.0	5.0		3.0		2.0
11/26/2008	0.5	0.5	30.0	13.0	50.0		0.5			0.5	5.0
11/29/2008	10.0		14.0	50.0	20.0					5.0	1.0
12/12/2008	10.0		10.0	40.0	15.0	5.0	5.0	10.0		1.0	4.0
12/16/2008	10.0		10.0	40.0	25.0	1.0	5.0	1.0		5.0	3.0
12/26/2008	40.0		8.0	10.0	40.0						2.0
POST-CONSTRUCTION											
2/28/2011	25.0		37.5		12.5					25.0	
3/14/2011	31.6		10.5	15.8	26.3					15.8	
3/30/2011	7.9		18.4	26.3	13.2		2.6			29.0	2.6
4/13/2011	14.3		14.3	14.3			14.3			42.8	
5/14/2011	10.0		50.0	30.0						10.0	
6/5/2011			25.0	75.0							
6/22/2011	16.7		33.3	33.3	16.7						
7/6/2011			40.0	20.0	20.0					20.0	
7/22/2011			50.0	25.0						25.0	
8/3/2011				100.0							
8/16/2011	33.0			67.0							
9/7/2011			25.0	50.0	25.0						
9/15/2011				40.0	60.0						

Nutrients and TSS

Pre- and post construction surveys of nutrients, TSS and other conventional water quality characteristics are summarized in Table 15 and Table 16. Overall, concentrations of nutrients and suspended solids were relatively low with many of the target nutrients being reported either below or near project detection limits. One unique characteristic was the dominance of organic nitrogen (Figure 16). Organic nitrogen was calculated as the difference between TKN and ammonia-N. Organic nitrogen was the dominant form of nitrogen in all surveys. Nitrate-N was either not detected or measured at concentrations of less than 0.1 mg/L in all but a few water samples. Low concentrations such as this are also typical of Newport Bay (Orange County, 2005).

One case of nitrate-N reaching a concentration of 0.62 mg/L at WQ-2 (post construction monitoring, 27 April 2011) is suspected as being caused by localized sources since the other two sites had concentrations of just 0.03J and 0.06 mg/L of nitrate-N. Concentrations of total P (0.184 mg/L) were also elevated at WQ-2 during that survey while the remaining two sites had total P concentrations ranging from below the detection limit (0.05 mg/L) to 0.092 mg/L.

The typically low concentrations of total P were consistent with the high water clarity and lack of suspended sediment. Total P tends to associate with particulates. TSS measured during the pre-construction surveys varied from 1.7J mg/L to 5.2 mg/L. Similar concentrations were encountered during the post-construction surveys with the exception of sampling conducted on 23 May 2011 when values ranged from 10.3 to 16.3 mg/L.

Unique conditions were noted during the post-construction survey conducted on 21 June 2011. Water in the northern arm of the Lagoon appeared slightly brown and murky. Dissolved oxygen was elevated at this site (9.1 mg/L) relative to the other two locations. Results of testing indicated higher TSS at this location and depletion of all nutrients except organic nitrogen. The concentration of organic nitrogen was 1.5 mg/L which was among the higher concentrations measured during both pre- and post-construction monitoring. This appears to have been the result of a localized plankton bloom although water samples were not analyzed for chlorophyll or phytoplankton to confirm.

FINDINGS:

Concentrations of nutrients (nitrogen and phosphorus) were low in both pre- and post-construction surveys. Measured concentrations were often below detection limits. Nitrogen compounds were strongly dominated by organic nitrogen that was frequently more than an order of magnitude higher than inorganic forms. Despite the relative dominance of organic nitrogen, concentrations of this form rarely exceeded 1 mg/L.

Concentrations of TSS were typically low throughout the two monitoring periods and were consistent with the periods of high water clarity recorded in the Lagoon.

Table 15. Conventional Analytes measured in Surface Waters of Colorado Lagoon during Pre -Construction Surveys.

	09-September-2008			09-October-2008			11-November-2008			16-December-2008		
Pre Construction Events 1-4	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**
Conventionals (mg/L unless otherwise noted)												
Temperature (Deg C)							17.6	17.8	17.2	13.7	14.3	14.2
Dissolved Oxygen	8.5	8.6	8.3				7.2	6.8	6.6	7	6.4	6.9
Total Ammonia (as N)	0.03U	0.03U	0.03U	0.07	0.05	0.06	0.04	0.05	0.06	0.25	0.22	0.24
Nitrate (as N)	0.05U	0.01	0.05U	0.02J	0.03J	0.02J	0.02J	0.02J	0.02J	0.21	0.21	0.19
Total Kjeldahl Nitrogen	0.5U	0.5U	0.56	1.5	1.7	1.5	1.1	1.1	0.98	0.98	1.3	1.1
Orthophosphate (as P)	0.01U	0.01U	0.01U	0.02	0.02	0.02	0.02	0.03	0.03	0.11	0.12	0.11
Total Phosphorus	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05UJ-	0.05UJ-	0.05UJ-	0.05U	0.05U	0.053J
Total Suspended Solids	4	2.7J	1.7J	2.5J	1.7J	3J	4.3J	2.7J	4J	5	5.2	4J

Table 16. Conventional Analytes measured in Surface Waters of Colorado Lagoon during Post -Construction Surveys.

	24-February-2011			28-March-2011			27-April-2011			23-May-2011		
Post Construction Events 1-4	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**
Conventionals (mg/L unless otherwise noted)												
Temperature (Deg C)	15.2	15.4	15.2	17.1	16.9	15.2	19.8	20.5	19.4	19.9	21.0	20.3
Dissolved Oxygen	7.9	7.3	7.57	4.15	4.76	5.19	4.9	5.0	5.1	8.83	12	8.03
Total Ammonia (as N)	0.03U	0.03U	0.03U	0.1	0.15	0.14	0.03U	0.03U	0.03U	0.18J	0.06J	0.06J
Nitrate (as N)	0.029J	0.065	0.113	0.09	0.25	0.08	0.03J	0.62J	0.06J	0.03J	0.03J	0.31J
Total Kjeldahl Nitrogen	0.5	0.63	0.36J	1.07	0.93	0.66	0.5	0.56	0.5	0.84	0.84	1.2
Orthophosphate (as P)	0.01UJ	0.01UJ	0.01UJ	0.24J	0.01UJ	0.01UJ	0.01U	0.01U	0.01U	0.01U	0.012	0.021
Total Phosphorus	0.04	0.2364J	0.683	0.05U	0.05U	0.107J	0.05U	0.184	0.092	0.134	0.05U	0.327
Total Suspended Solids	1.1J	1.4J	2.2J	1.6J	1.8J	2.1J	3.6J	3.8J	1.8J	10.3	15.8	16
	21-June-2011			**14-July-2011**			**23-August-2011**					
Post Construction Events 5-7	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**	**WQ-1**	**WQ-2**	**WQ-3**			
Conventionals (mg/L unless otherwise noted)												
Temperature (Deg C)	21.3	21.5	21.2	21.8	22.2	22	23	23.4	22.9			
Dissolved Oxygen	7.5	9.1	6.4	6.3	5.2	6.7	6.1	7.4	5.9			
Total Ammonia (as N)	0.03U	0.03U	0.07	0.04	0.03U	0.03U	0.03U	0.03U	0.03U			
Nitrate (as N)	0.01J	0.05U	0.05U	0.01J	0.02J	0.05U	0.05U	0.04J	0.02J			
Total Kjeldahl Nitrogen	0.73	1.53	0.88	0.58	0.56	0.66	0.28	0.15	0.17			
Orthophosphate (as P)	0.01U	0.01U	0.01U	0.0523	0.0496	0.0733	0.043	0.0344	0.0368			
Total Phosphorus	0.045J	0.05U	0.058	0.05U	0.089	0.118	0.05U	0.129	0.05U			
Total Suspended Solids	2.9J	7	3.6J	4.7J	2.7J	1.7J	1.5J	2.6J	3.3J			

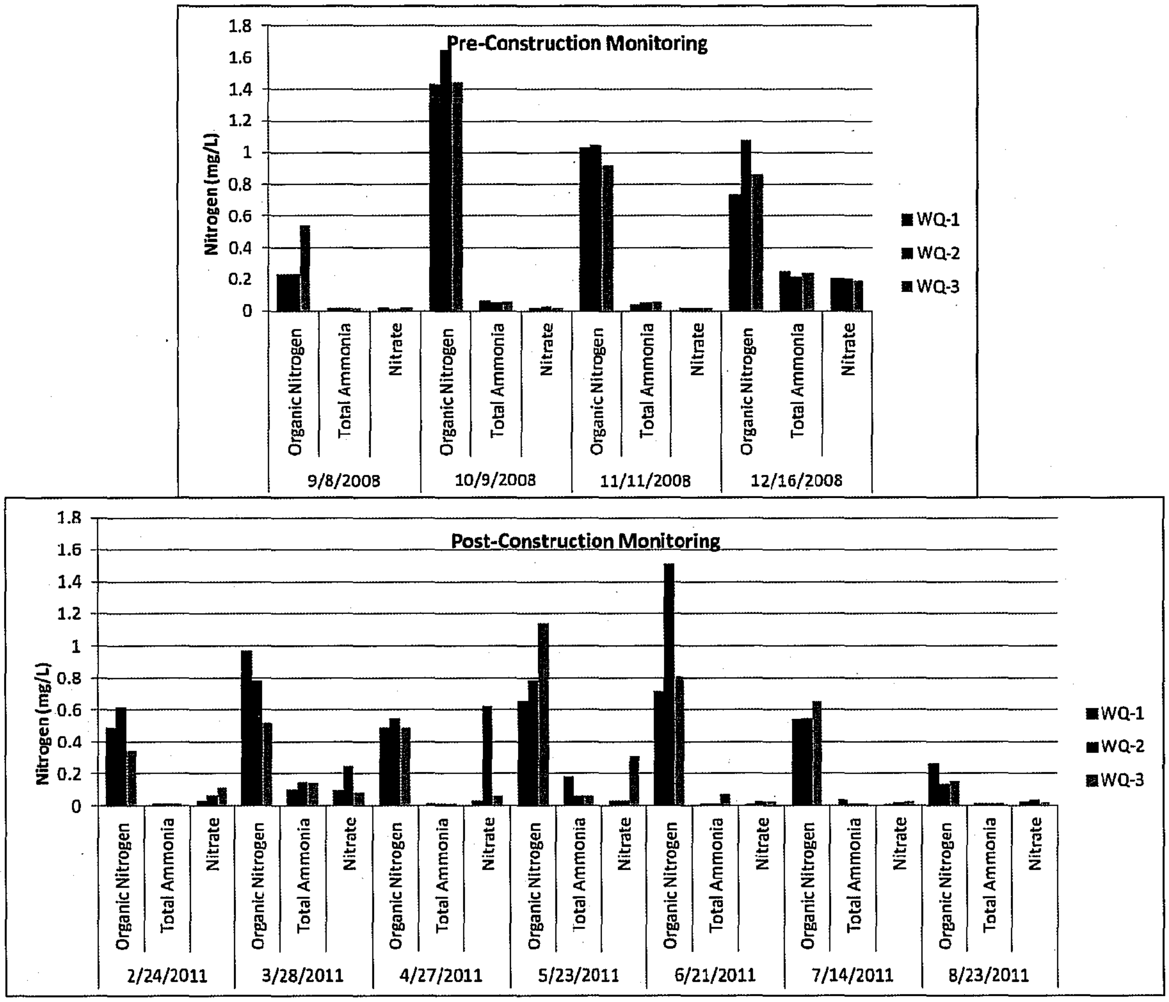


Figure 16. Nitrogen Compounds Measured in Surface Water Samples during Pre- and Post-Construction Monitoring

Fecal Indicator Bacteria (FIB)

Fecal Indicator Bacteria measured at the Colorado Lagoon monitoring sites during pre-and post-construction time periods are summarized in Table 17 through Table 19. Data include weekly AB-411 sampling conducted at B-24 (equals B-2 in the Colorado Lagoon Construction Monitoring Project) by the City of Long Beach Department of Health and Human Services.

Both the pre- and post-construction surveys were impacted by rain at various times. Rain influence was defined as more than 0.1 inches during the previous 72 hours. In most cases, these monitoring surveys were characterized by concentrations of FIBs in excess of water quality standards. Recreational users are routinely advised to avoid all beaches impacted by runoff during such times.

Fecal coliform summarized in Table 18 may have a high bias relative to other measurements reported from both Los Angeles and Ventura County. Long Beach and these two county programs all use Colilert® to measure *E. coli*. The City of Long Beach estimates fecal coliform by multiplying the *E. coli* results by a factor of 1.3. Both Los Angeles and Ventura County report the *E. coli* results as equivalent to fecal coliform. Los Angeles County performed site specific study comparisons that suggested that differences between *E. coli* and fecal coliform were not sufficient to be considered statistically significant. The City of Long Beach has not yet conducted such studies and therefore has continued to use the default factor of 1.3.

Site B-5 (sump of the low-flow diversion) was sampled during post-construction monitoring to assess the potential benefits resulting from diversion of low flows during dry weather. Although concentrations of FIBs were often higher than measured in the receiving waters, surprisingly they were not as high as expected based upon measurements taken in other storm drains in the City during dry weather conditions. Typical dry weather flows have concentrations of *E.coli* and *Enterococcus* ranging between 10^3 and 10^4 MPN/100ml (Kinnetic Laboratories, Inc. 2009). The extremely low bacterial concentrations measured in the sump during the last seven surveys are highly unusual and the cause is not understood. Water could not be collected from the sump during seven of the post-construction surveys.

The seasonal differences in timing of the pre- and post-construction surveys impact the ability to make direct comparisons (Table 17 through Table 19) but the concentrations of all three FIBs clearly decreased at the monitoring sites after completion of all major improvements. In order to make a better comparison, AB411 monitoring data were analyzed for the summer season (Memorial Day to Labor Day) starting in 2006. Percent compliance was examined during these time periods for both the single sample (SS) criterion for the three indicator bacteria and the 30-day geometric mean (GM) criteria as listed in Table 7. The percentage that receiving waters met all single sample criteria or geometric mean criteria during the summer periods is summarized in Figure 17. Dramatic improvements were documented in compliance with both the single sample (SS) and the 30-day geometric mean (GM) bacterial water quality criteria. Compliance with the single sample criteria for the summer 2011 period was 90%. During the five previous summers, compliance with the single sample criteria ranged from 48% to 85%. Similarly, compliance with the 30-day geometric mean criteria was 100% for the summer of 2011 compared to 2% to 62% in the previous years.

Although it is impossible to conclude that these very substantial improvements were a result of the improvements, they do show promise that the improvements will have the long-lasting effects on water quality that were intended.

FINDINGS:
Water quality during the summer of 2011 was the best that has been recorded in the last six years. Compliance with single sample criteria was achieved 90% of the time. Compliance with 30-day geometric mean criteria was achieved 100% of the time

Table 17. Concentrations of Total Coliform (MPN/100 ml) measured at each Site during the Pre- and Post-Construction Surveys.

PRE-CONSTRUCTION						POST-CONSTRUCTION						
	B-2	**B-1**	**B-3**	**B-4**	**Rain?**		**B-2**	**B-1**	**B-3**	**B-4**	**B-5**	**Rain?**
8/25/2008	497	657	1274	8664		1/3/2011	**24196**					**R**
9/2/2008	**15531**	867	3649	19863		1/10/2011	393	368	2909	1076	4884	
9/3/2008	869					1/11/2011	**12997**					
9/8/2008	4106	459	**19863**	**12033**		1/12/2011	1850					
9/16/2008	911	307	1050	1056		1/18/2011	905	857	657	723	1169	
9/22/2008	8164	738	3873	708		1/24/2011	231	109	246	156	9208	**R**
9/23/2008	**1317**					1/31/2011	3076	5172	7701	4611	6131	
9/24/2008	414					2/8/2011	145	63	213	73	97	
9/29/2008	414	231	1408	368		2/15/2011	373	605	199	355	323	
10/6/2008	**26000**	156	3448	2224		2/23/2011	754	855	504	583	**24196**	
10/7/2008	708					3/1/2011	6488	**24196**	539	**24196**	**24196**	**R**
10/13/2008	**19863**	**12997**	**26000**	**26000**		3/7/2011	**24196**	**24196**	**19863**	816	**24196**	
10/14/2008	657	**1904**				3/14/2011	324	487	336	144		**R**
10/15/2008	74	528				3/21/2011	**24196**	**24196**	**24196**	**24196**	**24196**	
10/20/2008	695	431	288	253		3/28/2011	8664	8164	7270	9804	**24196**	
10/27/2008	86	471	1576	521		4/4/2011	565	521	345	748	420	
11/3/2008	**26000**	**26000**	**26000**	**26000**	**R**	4/12/2011	31					
11/10/2008	1850	3441	1045	1137		4/18/2011	262	305	195	288	169	
11/17/2008	959	657	697	763		4/25/2011	**24196**	**24196**	**24196**	2755	2851	**R**
11/24/2008	2723	631	862	7270		4/26/2011	331					
12/1/2008	**10462**	5794	6867	8164		5/2/2011	10	10	20	30		
12/2/2008	**24196**	7701				5/9/2011	20	10	20	63		
12/3/2008	2481	4611				5/16/2011	n/a					**R**
12/8/2008	3282	794	776	862		5/23/2011	107	52	63	31		
12/9/2008	**5172**					5/31/2011	98	110	<10	10		
12/10/2008	**2481**					6/7/2011	63					
12/11/2008	1385					6/8/2011	31	20	<10	41	72	
12/15/2008	**26000**	**26000**	**26000**	**26000**	**R**	6/21/2011	20					
12/16/2008	**26000**	**26000**	**26000**	**26000**	**R**	6/22/2011	30	41	10	31	97	
12/22/2008	1515	5794	5794	1223	**R**	6/28/2011	62					
12/29/2008	960	836	749	563		6/29/2011	109	84	107	74	30	
1/5/2009	6488	669	**17329**	160		7/6/2011	20					
1/12/2009	813	374	473	84		7/12/2011	591					
1/20/2009	30	332	1421	173		7/13/2011	74	109	96	175	169	
1/26/2009	**24196**	**24196**			**R**	7/18/2011	**2603**					
						7/19/2011	820	228	1034	1785		
						7/25/2011	650					
						8/2/2011	148					
						8/9/2011	364					
						8/16/2011	181					
						9/12/2011	20	31	85	20		
						9/19/2011	110	197	62	228		
						9/21/2011					**24196**	
						9/26/2011	52	31	31	10	183	
						10/3/2011	496	605	826	1842	1059	
						10/10/2011	275	295	171	250	259	

Notes: Values highlighted and bolded in **red** exceeded the 10,000 MPN/100ml single sample water quality criterion for recreational bathing use or the 1000 MPN/100ml criterion when fecal coliform exceeds 10% of the total coliform. **"R"** indicates a rain advisory was in effect. B5 is sampled in the sump of the low flow bypass.

Table 18. Concentrations of Fecal Coliform (MPN/100 ml) measured at each Site during the Pre- and Post-Construction Surveys.

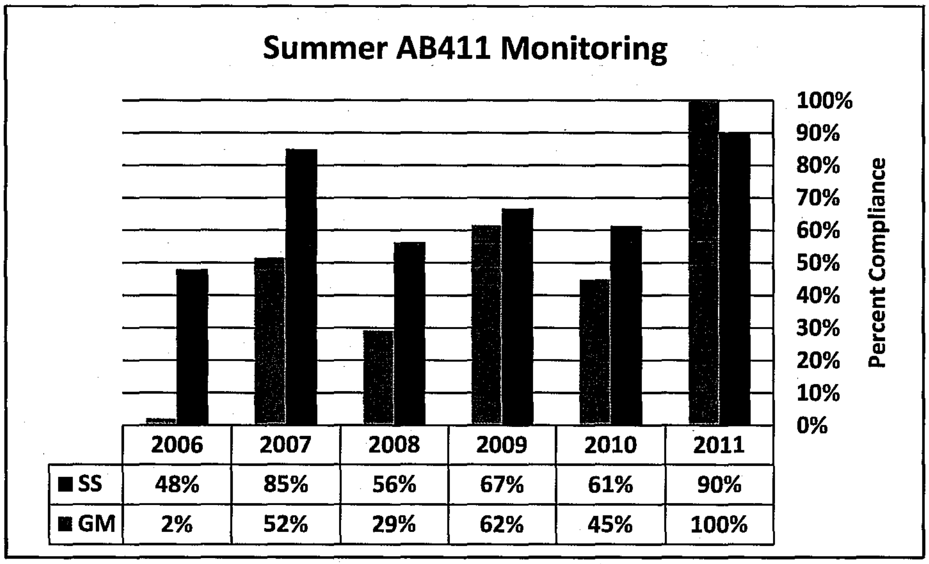
PRE-CONSTRUCTION						POST-CONSTRUCTION						
	B-2	B-1	B-3	B-4	Rain?		B-2	B-1	B-3	B-4	B-5	Rain?
8/25/2008	40	109	325	82		1/3/2011	**3540**					R
9/2/2008	203	125	53	66		1/10/2011	296	10	13	5	5	
9/3/2008	98					1/11/2011	68					
9/8/2008	341	40	136	142		1/12/2011	112					
9/16/2008	235	53	135	170		1/18/2011	159	142	112	240	96	
9/22/2008	157	53	82	110		1/24/2011	26	5	13	26	218	
9/23/2008	**490**					1/31/2011	169	274	337	127	**624**	R
9/24/2008	53					2/8/2011	68	40	127	5	5	
9/29/2008	40	26	68	5		2/15/2011	174	53	109	98	112	
10/6/2008	**462**	40	**549**	209		2/23/2011	40	53	13	5	159	
10/7/2008	225					3/1/2011	140	82	5	40	68	
10/13/2008	**2967**	**3067**	**3397**	**5035**		3/7/2011	**546**	**633**	**485**	13	**7532**	R
10/14/2008	126	378				3/14/2011	53	5	26	5		
10/15/2008	26	112				3/21/2011	**5994**	**7118**	**6349**	**8927**	**24196**	R
10/20/2008	142	26	13	68		3/28/2011	53	26	13	13	**3999**	
10/27/2008	40	68	53	68		4/4/2011	5	26	5	26	13	
11/3/2008	**4232**	**20190**	**10613**	**6349**	R	4/12/2011	13					
11/10/2008	354	329	53	26		4/13/2011						
11/17/2008	**448**	222	94	208		4/18/2011	40	53	53	26	26	
11/24/2008	316	208	143	**504**		4/25/2011	**1247**	**3067**	26	13	68	R
12/1/2008	**645**	281	109	205		4/26/2011	10					
12/2/2008	40	96				5/2/2011	5	5	5	5		
12/3/2008	13	220				5/9/2011	13	5	13	5		
12/8/2008	243	112	13	96		5/16/2011	**ns**	**ns**	**ns**	**ns**	**ns**	R
12/9/2008	**829**					5/23/2011	5	13	13	5		
12/10/2008	**2481**					5/31/2011	5	5	5	5		
12/11/2008	96					6/7/2011	10					
12/15/2008	**7118**	**10613**	**11263**	**6724**	R	6/8/2011	5	5	5	26	5	
12/16/2008	**5338**	**5658**	**8434**	**5035**	R	6/21/2011	10					
12/22/2008	26	296	81	5	R	6/22/2011	5	5	5	5	5	
12/29/2008	157	157	98	109		6/28/2011	53					
1/5/2009	370	26	**734**	110		6/29/2011	13	5	13	5	13	
1/12/2009	159	98	13	5		7/6/2011	10					
1/20/2009	5	40	**953**	13		7/12/2011	174					
1/26/2009	**24196**	**24196**			R	7/13/2011	26	5	5	5	5	
						7/18/2011	**538**					
						7/19/2011	380	68	**402**	**820**		
						7/25/2011	40					
						8/2/2011	53					
						8/9/2011	68					
						8/16/2011	10					
						9/12/2011	10	10	10	10		
						9/19/2011	13	10	26	13		
						9/21/2011					159	
						9/26/2011	13	10	13	10	10	
						10/3/2011	53	40	82	26	40	
						10/10/2011	10	13	10	40	13	

Notes: Values highlighted and bolded in **red** exceeded the 400 MPN/100ml single sample water quality criterion for recreational bathing use. **"R"** indicates a rain advisory was in effect. B5 is sampled in the sump of the low flow bypass.

Table 19. Concentrations of Enterococcus (MPN/100 ml) measured at each Site during the Pre- and Post-Construction Surveys.

PRE-CONSTRUCTION						POST-CONSTRUCTION						
	B-2	B-1	B-3	B-4	Rain?		B-2	B-1	B-3	B-4	B-5	Rain?
8/25/2008	31	5	10	5		1/3/2011	**2100**					R
9/2/2008	**531**	10	10	10		1/10/2011	**254**	5	150	42	**364**	
9/3/2008	5					1/11/2011	**124**					
9/8/2008	10	5	**192**	53		1/12/2011	87					
9/16/2008	31	31	5	5		1/18/2011	99	42	5	10	59	
9/22/2008	**306**	10	5	5		1/24/2011	20	5	10	31	**945**	
9/23/2008	5					1/31/2011	87	**164**	**254**	87	**364**	R
9/24/2008	5					2/8/2011	10	10	20	5	5	
9/29/2008	5	5	10	20		2/15/2011	5	20	10	10	5	
10/6/2008	**254**	5	87	64		2/23/2011	5	20	5	10	945	
10/7/2008	10					3/1/2011	64	**254**	31	42	**406**	
10/13/2008	**1091**	**831**	**1298**	**1445**		3/7/2011	288	271	207	10	**2005**	R
10/14/2008	20	5				3/14/2011	20	5	5	5		
10/15/2008	5	53				3/21/2011	**2005**	**2005**	**2005**	**2005**	**2005**	R
10/20/2008	5	5	10	42		3/28/2011	64	20	10	20	**2005**	
10/27/2008	42	53	**324**	**137**		4/4/2011	5	20	20	10	64	
11/3/2008	**2005**	**2005**	**2005**	**2005**	R	4/12/2011	42					
11/10/2008	**124**	**111**	**192**	87		4/13/2011						
11/17/2008	**945**	75	53	**137**		4/18/2011	5	10	5	5	20	
11/24/2008	**222**	31	64	20		4/25/2011	192	**591**	5	31	5	R
12/1/2008	**453**	**344**	**504**	99		4/26/2011	5					
12/2/2008	**164**	**111**				5/2/2011	5	5	5	10		
12/3/2008	10	64				5/9/2011	5	5	20	10		
12/8/2008	**238**	64	87	31		5/16/2011						R
12/9/2008	**178**					5/23/2011	5	5	5	5		
12/10/2008	**254**					5/31/2011	5	5	5	5		
12/11/2008	**124**					6/7/2011	5					
12/15/2008	**2005**	**2005**	**2005**	**2005**	R	6/8/2011	5	5	5	10	31	
12/16/2008	**2005**	**2005**	**2005**	**2005**	R	6/21/2011	5					
12/22/2008	20	**137**	**124**	42	R	6/22/2011	5	5	5	5	5	
12/29/2008	53	53	75	20		6/28/2011	5					
1/5/2009	**782**	5	**1298**	10		6/29/2011	5	5	5	10	31	
1/12/2009	75	10	31	10		7/6/2011	5					
1/20/2009	5	20	53	5		7/12/2011	**384**					
1/26/2009	**124**	**111**			R	7/13/2011	10	5	20	5	5	
						7/18/2011	20					
						7/19/2011	5	5	5	5		
						7/25/2011	20					
						8/2/2011	10					
						8/9/2011	5					
						8/16/2011	5					
						9/12/2011	10	10	10	10		
						9/19/2011	10	10	10	10		
						9/21/2011					**306**	
						9/26/2011	10	10	10	10	10	
						10/3/2011	31	42	10	31	53	
						10/10/2011	20	10	10	10	10	

Notes: Values highlighted and bolded in **red** exceeded the 104 MPN/100ml single sample water quality criterion for recreational bathing use. **"R"** indicates a rain advisory was in effect. B5 is sampled in the sump of the low flow bypass.



SS = Compliance with Single Sample Criterion for any one of the FIBs
GM = Compliance with 30-day geometric mean for any one of the FIBs

Figure 17. Summary of AB411 Monitoring during the Summer Months (2006-2011).

Metals, Organochlorine Pesticides and PCBs

Both pre- and post-construction monitoring results for trace metals are summarized in Table 20. Results of water samples analyzed for chlorinate pesticides are summarized in Table 21 and PCBs are summarized in Table 22.

Concentrations of dissolved and total metals (Table 20) were generally low during all four surveys. The only metal that exceeded water quality criteria was dissolved copper. The California Toxics Rule (CTR) saltwater dissolved copper criterion of 3.1 ug/L was exceeded at two sites during the 16 December 2008 pre-construction survey. Dissolved copper concentrations were 3.72 ug/L at WQ-1 and 3.19 ug/L at WQ-2 thus exceedences were relatively minor. The highest concentration of dissolved copper measured in the first pre-construction survey and both post-construction surveys was 1.06 ug/L.

Survey results for total recoverable metals were compared with Ocean Plan criteria since they are listed as total recoverable criteria. Although they do not apply to Colorado Lagoon, they do provide a general benchmark for examining the data. The results of this comparison further confirm that trace metals remain well below these benchmarks during both the pre- and post-construction surveys.

All organics (Table 21 and Table 22) measured during the pre- and post-construction surveys were below very low detection limits established in the Monitoring Plan. This is consistent with the low concentrations of TSS present in the surface waters. Most of these organics tend to be associated with particulates and would be expected to enter the Lagoon during periodic storm events. As the suspended sediment settles, the associated organic compounds tend to accumulate in bottom sediments as noted in previous sediment surveys. The next stage of the improvements will involve removal of these sediments to improve benthic habitat.

FINDINGS:
Trace metals concentrations in Colorado Lagoon surface waters remain consistently low during dry weather periods. The chronic dissolved copper criterion was slightly exceeded during one pre-construction survey. None of the organic compounds (organochlorine pesticides and PCBs) were detected which is consistent with previous surveys.

Table 20. Dissolved and Total Recoverable Trace Metals measured in Surface Waters of Colorado Lagoon during Pre- and Post-Construction Surveys.

	Pre-Construction						Post-Construction						CTR[1] SALT CCC
	9 October 2008			16 December 2008			27 April 2011			17 July 2011			
	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	
Dissolved													
Al	6U	6U	6U	6U	6U	6U	4.4J	4.8J	5.2J	5.3J	3.5J	3.6J	
Sb	0.25	0.23	0.21	0.36	0.19								
As	1.1	1.2	1.2	1.3	1.2	1.1	1.0	1.4	1.1	1.2	1.3	1.4	**36**
Be	0.01U	0.01U	0.01U	0.01	0.01	0.012							
Cd	0.06	0.05	0.04	0.04	0.06	0.05	0.03	0.04	0.04	0.04	0.04	0.04	**9.3**
Cr	0.10	0.09	0.11	0.40	0.43	0.36	0.18	0.28	0.18	0.23	0.20	0.20	
Co	0.06	0.07	0.06	0.11	0.14	0.10							
Cu	0.65	1	0.62	3.72	3.19	2.86	0.92	1.06	1.04	1.02	0.93	0.9	**3.1**
Fe	1.5	3.4	0.8J	8.5	9.8								
Pb	0.06	0.08	0.11	0.19	0.23	0.11	0.16	0.16	0.17	0.20	0.20	0.17	**8.1**
Mg	4.9	8.9	6.7	11.8	14.5	12.2	6.2	28.7	9.6	20.9	12.8	15.6	
Mo	9.3	9.5	9.6	6.0	6.1								
Ni	0.28	0.35	0.30	0.90	1.13	1.03	0.44	0.70	0.48	0.57	0.56	0.42	**8.2**
Se	0.01J	0.02	0.02	0.02	0.02	0.04	0.015U	0.02	0.015U	0.015U	0.02	0.02	
Ag	0.04U	0.04U	0.04U	0.04U	0.04U	0.04U	0.05	0.05	0.05	0.06	0.04	0.04	
Tl	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U							
Sn	0.01	0.04	0.01U	0.12	0.009J	0.01U							**71**
Ti	0.074	0.098	0.133	0.134	0.122	0.075							
V	2.0	2.0	2.0	2.1	2.2	2.1							
Zn	0.1	1.1	8.0	23.6	28.2	16.9	6.9	8.0	7.3	7.6	6.3	5.6	**81**
Total Recoverable													**OP[2]**
Al	9	4J	24	132	151	128	34	26	42	30	22	87	
Sb	0.44	0.19	0.22	0.53	0.39	0.33							
As	1.3	1.4	1.3	1.3	1.2	1.3	1.2	1.6	1.3	1.3	0.6	1.5	**32**
Be	0.01U	0.01U	0.01U	0.014	0.017	0.015							
Cd	0.04	0.03	0.03	0.06	0.05	0.04	0.03	0.05	0.04	0.04	0.04	0.05	**4**
Cr	0.15	0.15	0.18	0.74	0.86	0.70	0.38	0.33	0.48	0.40	0.31	0.52	
Co	0.09	0.10	0.10	0.19	0.24	0.18							
Cu	0.7	0.7	0.8	4.2	5.5	4.0	1.3	1.4	1.4	1.3	1.3	1.6	**12**
Fe	44	39	55	187	208	176							
Pb	0.46	0.53	0.68	1.36	1.96	1.27	0.58	0.57	0.64	0.57	0.62	0.97	**8**
Mg	6	10	9	14	18	15	15	43	15	24	12	18	
Mo	9.1	9.3	9.6	5.3	5.4	6.0							
Ni	0.33	0.38	0.37	1.01	1.34	1.01	0.51	0.73	0.54	0.64	0.46	0.54	**20**
Se	0.01J	0.01J	0.01J	0.02	0.02	0.02	0.04	0.02	0.015U	0.01J	0.03	0.03	**60**
Ag	0.04U	0.04U	0.04U	0.04U	0.04U	0.04U	0.05	0.05	0.06	0.06	0.05	0.05	**2.8**
Tl	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U							
Sn	0.014	0.01U	0.01U	0.052	0.041	0.029							
Ti	1.3	0.9	2.3	9.2	10.1	9.0							
V	2.2	2.3	2.3	2.7	2.8	2.7							
Zn	7.3	3.0	19.5	23.4	32.4	19.0	7.3	7.8	7.4	7.1	8.1	6.9	**80**

1. CTR Saltwater Continuous Criteria Concentration for Dissolved Metals in Bays and Estuaries.
2. OP = Ocean Plan Instantaneous Max for Total Recoverable Metals
3. Shaded values exceed water quality criteria listed in far right column
4. J indicates analyte is present but considered to be an estimate when between the Method Detection Limit and the Reporting Limit.

Table 21. Chlorinated Pesticides measured in Surface Waters of Colorado Lagoon during Pre- and Post-Construction Surveys.

	Pre-Construction						Post Construction						
	9-October-2008			16-December-2008			27-April-2011			14-July-2011			
	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	Salt CCC
Chlorinated Pesticides													
2,4'-DDD	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
2,4'-DDE	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
2,4'-DDT	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
4,4'-DDD	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
4,4'-DDE	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
4,4'-DDT	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.001
Aldrin	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
alpha-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
alpha-Chlordane	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
beta-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
cis-Nonachlor	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
DCPA (Dacthal)	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U							
delta-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Dicofol	0.1U	0.1U	0.1U	0.1U	0.1U	0.1U							
Dieldrin	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.0019
Endosulfan I	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U				0.005U	0.005U	0.005U	0.0087
Endosulfan II	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U				0.005U	0.005U	0.005U	0.0087
Endosulfan sulfate	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Endrin	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.0023
Endrin aldehyde	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Endrin ketone	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
gamma-BHC	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
gamma-Chlordane	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Heptachlor	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.0036
Heptachlor epoxide	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.0036
Methoxychlor	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Mirex	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Oxychlordane	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
Perthane	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	
Toxaphene	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U				0.0002
trans-Nonachlor	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	

Table 22. PCB Congeners measured in Surface Waters of Colorado Lagoon during Pre- and Post-Construction Surveys.

	Pre-Construction						Post Construction						
	9-October-2008			16-December-2008			27-April-2011			14-July-2011			
	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	Salt CCC
PCB Congeners													
PCB003	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB008	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB018	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB028	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB031	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB033	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB037	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB044	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB049	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB052	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB056+060	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U							
PCB066	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB070	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB074	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB077	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB081	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB087	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB095	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB097	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB099	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB101	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB105	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB110	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB114	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB118	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB119	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB123	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB126	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB128	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	

Table22. PCB Congeners measured in Surface Waters of Colorado Lagoon during Pre- and Post-Construction Surveys. (continued)

	Pre-Construction						Post Construction						Salt CCC
	9-October-2008			16-December-2008			27-April-2011			14-July-2011			
	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	WQ-1	WQ-2	WQ-3	
PCB Congeners													
PCB138	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB141	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB149	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB151	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB153	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB156	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB157	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB158	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB167	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB168+132	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB169	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB170	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB174	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB177	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB180	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB183	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB187	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB189	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB194	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB195	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB200	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U							
PCB201	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB203	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U							
PCB206	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	
PCB209	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	

CONCLUSIONS

Colorado Lagoon monitoring was completed in compliance with the approved QAPP. Pre-construction monitoring was conducted for a period of four months in 2008 and post-construction monitoring was conducted for a period of seven months in 2011. A comparison of the pre- versus post-monitoring results indicates the following:

- Tidal range improved significantly - the low tides in the lagoon are now much closer to ocean tides, the lagoon high tides are only slightly muted, and the time lag is no longer present. The culvert cleaning resulted in a low tide improvement of approximately 1.6 feet during the period of monitoring.
- Litter items found on the south shore during post-construction surveys decreased by 97% relative to the pre-construction period. Litter items collected near the culvert decreased by 85% relative to pre-construction surveys.
- Substantial improvements in bacterial water quality were documented following full implementation of a functional low flow diversion system, trash traps and cleaning of the culvert. Dramatic improvements were documented in compliance with both the single sample (SS) and the 30-day geometric mean (GM) bacterial water quality criteria. Compliance with the single sample criteria for the summer 2011 period was 90%. During the five previous summers, compliance with the single sample criteria ranged from 48% to 85%. Similarly, compliance with the 30-day geometric mean criteria was 100% for the summer of 2011 compared to 2% to 62% in the previous years.
- Water clarity improved at all three monitoring locations, although a statistical significance could not be applied to this change.
- Low concentrations of most trace metals were measured in the water column during both pre- and post construction surveys. Dissolved copper slightly exceeded CTR water quality at two sites during one of the pre-construction surveys but levels were well below these criteria during all other surveys.
- Organochlorine Pesticides and PCBs were not detected in any of the pre- or post-construction surveys despite use of extremely low detection limits. This is consistent with previous surveys conducted in the Lagoon.
- Concentrations of nutrients (both nitrogen and phosphorus) were low during all pre- and post-construction surveys. Nitrogen was predominantly in the form of organic nitrogen.
- Concentrations of Total Suspended Solids (TSS) were consistently low in both the pre-construction (1.7 to 5.2 mg/L) and most post-construction surveys (1.1 to 7 mg/L). Slightly higher TSS (10.3 to 16 mg/L) was measured during the 23 May 2011 post construction survey. The low concentration of TSS in all samples is consistent with the high water clarity and low concentrations of total recoverable trace metals.
- There was not an apparent significant change in dissolved oxygen or algae blooms. Also, it is difficult to compare results because the monitoring periods were during different seasons of the year and algal blooms tend to occur seasonally.

In summary, the monitoring program indicates that the Colorado Lagoon constructed improvements (culvert cleaning, storm drain treatments and diversions, and bioswale) have resulted in improvements to tidal range, litter amount, bacteria, and water clarity. These water quality improvements in turn enhance both the recreational and habitat value of the lagoon.

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