Machado Lake Nutrients and Toxics TMDL Lake Water Quality Management Plan

Final

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Acronyms

µg/L	micrograms per liter
µg/Kg	micrograms per kilogram
AOC	Administrative Oversight Committee
Basin Plan	Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties
BMP	Best Management Practice
BOE	Bureau of Engineering
BOS	Bureau of Sanitation
Caltrans	California Department of Transportation
CDFG	California Department of Fish and Game
CDS®	Continuous Deflection Separation
Cfs	cubic feet per second
City	City of Los Angeles
COAC	Citizens Oversight Advisory Committee
COC	chain-of-custody
County	County of Los Angeles
CSTR	continuously stirred tank reactor
CWA	Clean Water Act
DDT	Dichlorodiphenyltrichloroethane
DO	dissolved oxygen
ELAP	Environmental Laboratory Approval Program
EMC	Event Mean Concentrations
EMD	Environmental Monitoring Division
ET	Evapotranspiration
FOMA	Ferric Oxide Media Adsorption
HDSFR	high density single family residential
ICSD	Information Control Systems Division
KMHRP	Ken Malloy Harbor Regional Park
LA	Load Allocation
LACDPW	Los Angeles County Department of Public Works
LACFCD	Los Angeles County Flood Control District
LIMS	Laboratory Information Management System
LWQMP	Machado Lake Water Quality Management Plan
MF/RO	microfiltration/reverse osmosis
MFR	multi-family residential
mg/L	milligrams per liter
MOA	Memorandum of Agreement
MRP	Monitoring and Reporting Plan
MS4	Municipal Separate Storm Sewer System
MSDS	Material Safety Data Sheets

msl	mean sea level
NPDES	National Pollutant Discharge Elimination System
PCB	polychlorinated biphenyls
PCH	Pacific Coast Highway
PPE	personal protective equipment
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAP	City of Los Angeles, Department of Recreation and Parks
Regional Board	Los Angeles Regional Water Quality Control Board
SAA	Streambed Alteration Agreement
SEA	Significant Ecological Area
SOPS	Standard Operating Procedures
State Board	California State Water Resources Control Board
SUSMP	Standard Urban Stormwater Mitigation Plan
SWAMP	Surface Water Ambient Monitoring Program
TDS	total dissolved solids
TIN	total inorganic nitrogen
TIWRP	Terminal Island Water Reclamation Facility
TMDL	total maximum daily load
TSS	total suspended solids
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
WI DNR	Wisconsin Department of Natural Resources
WISARD	Wastewater Information System and Analytical Research Database
WLA	Waste Load Allocation
WPD	Watershed Protection Division

Section 1
Regulatory Background

1.1 Introduction

The Machado Lake Nutrients Total Maximum Daily Load (Nutrients TMDL) and Pesticides and PCBs TMDL (Toxics TMDL), developed by the Los Angeles Regional Water Quality Control Board (Regional Board), became effective on March 11, 2009 and March, 20 2012, respectively. These TMDLs establish numeric targets, load allocations (LAs), waste load allocations (WLAs), and implementation schedules that set forth the compliance requirements for each TMDL. The LA establishes a limit for the amount of each pollutant that can enter the lake from nonpoint sources. Nonpoint sources include nutrients entering Machado Lake from runoff flowing directly from Ken Malloy Harbor Regional Park (KMHRP), atmospheric deposition, and nutrients generated from internal nutrient loading in the lake itself. The WLA establishes a limit for the amount of each pollutant that can enter the lake from point sources, which includes storm drain discharges. A complete set of supporting documentation for each TMDL is available from the following sources:

Total Maximum Daily Load for Eutrophic, Algae, Ammonia, and Odors (Nutrients) in Machado Lake:
http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_64_2008-006_td.shtml

Total Maximum Daily Load for Pesticides and PCBs in Machado Lake:
http://www.waterboards.ca.gov/losangeles/board_decisions/basin_plan_amendments/technical_documents/bpa_79_R10-008_td.shtml

Responsible jurisdictions may either jointly prepare a Lake Water Quality Management Plan (LWQMP) with the parties responsible for the lake, or responsible jurisdictions can separately prepare TMDL Implementation Plans to illustrate compliance with their WLAs as measured in the storm drains. This distribution of water quality management responsibility is outlined in the adopting resolutions for each TMDL (Nutrients TMDL - Resolution No. R08-006; Toxics TMDL – Resolution No. R10-008)

The Nutrients and Toxics TMDLs identify the responsible jurisdictions for meeting LAs and WLAs. Meeting the WLA is the responsibility of the following jurisdictions: the Municipal Separate Storm Sewer System (MS4) Permittees (including Los Angeles County; Los Angeles County Flood Control District (LACFCD); the cities of Carson, Lomita, Los Angeles, Palos Verdes Estates, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, and Torrance); California Department of Transportation (Caltrans); and the National Pollutant Discharge Elimination System (NPDES) General Construction and Industrial Stormwater Permittees. Meeting the LA is the responsibility of the City of Los Angeles Department of Recreation and Parks.

This Machado Lake LWQMP has been prepared by two of the listed responsible agencies—the City of Los Angeles (City), Department of Recreation and Parks (RAP) and the City of Los Angeles Department of Public Works, Bureau of Sanitation (BOS).

The City has jurisdiction over 13 percent of the Machado Lake watershed. Therefore, the City acknowledges that compliance with the Nutrients and Toxics TMDLs depends on the cumulative reductions achieved through the commitments of the City and other responsible jurisdictions upstream of Machado Lake. This LWQMP has been prepared to summarize the best management practices (BMPs), specific monitoring program, and reporting requirements that the City will implement to demonstrate compliance within its portion of the Machado Lake watershed.

The assumption has been made that the other responsible jurisdictions will independently be in compliance with the WLAs, as required by the TMDL. The other responsible jurisdictions are required to prepare and submit separate TMDL Implementation Plans.

1.2 Objectives

The implementation of this LWQMP will achieve multiple objectives shared by the City and the Regional Board in their joint efforts to fulfill their responsibilities associated with improving water quality and enhancing the overall health of Machado Lake and the surrounding ecosystem. These objectives, which are defined to address the City's portion of the requirements under the Nutrients and Toxics TMDLs include:

1. Restore and maintain the beneficial uses of Machado Lake.

2. Attain the City's commitment to interim and final LAs and WLAs as applicable to the Nutrients and Toxics TMDLs.

3. Remove Machado Lake from the California Clean Water Act (CWA) §303(d) List on or before September 11, 2018 for nutrients and on or before September 30, 2019 for toxics.

4. Establish the tactical plan and implementation schedule between the City and the Regional Board for all implementation actions aimed at nutrient and toxics reductions within the portion of the Machado Lake watershed under the jurisdiction of the City.

5. Satisfy the requirements of Regional Board Resolution No. R08-006 and No. R10-008 and the Water Quality Control Policy for Addressing Impaired Waters: Regulatory Structure and Options (State Board Resolution 2005-0050) section 2 (c) (ii).

6. Implement an effective, long-term monitoring program that provides the data necessary to demonstrate compliance with numeric targets and provides sufficient data to identify when changes to implementation are necessary.

1.3 Regulatory Requirements

The purpose of this section is to summarize the regulatory requirements that drive the legal and technical underpinnings of the LWQMP. Regulatory requirements include a discussion of the regulatory background, adopted beneficial uses, and TMDL requirements. The detailed discussion on the components of the Nutrients and Toxics TMDLs can be found in Sections 1.4 and 1.5, respectively.

1.3.1 General

In California, water quality management programs are governed by the federal CWA and the State of California Porter-Cologne Water Quality Control Act. The regulatory hierarchy is illustrated in Figure 1-1.

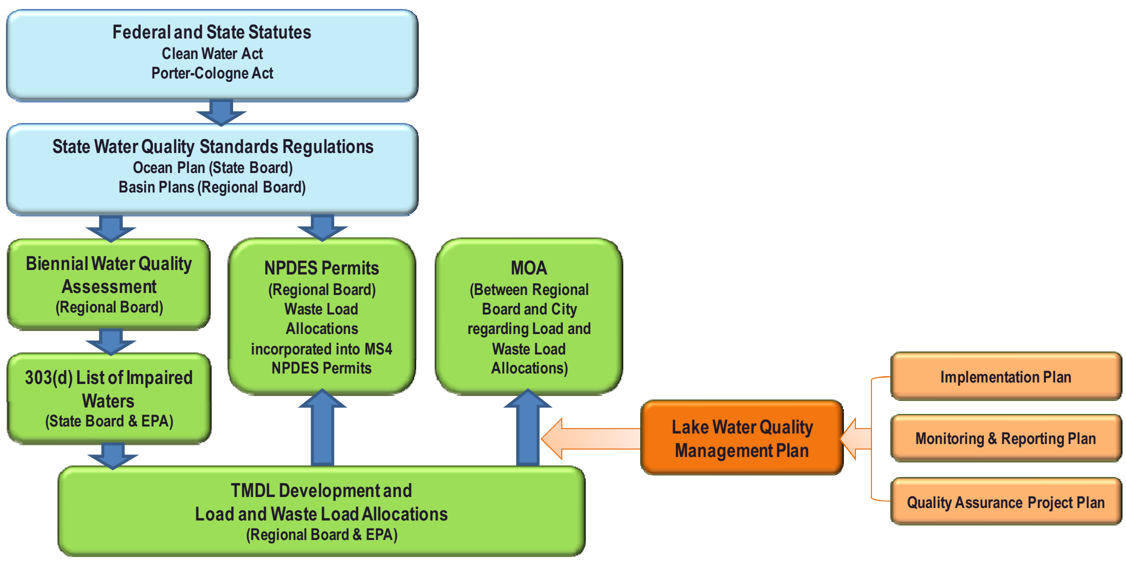

Figure 1-1
Regulatory Framework

The CWA provides the basis for the protection of all inland surface waters, estuaries, and coastal waters. The U.S. Environmental Protection Agency (USEPA) is responsible for ensuring the implementation of the CWA and its governing regulations. Authority for implementing the CWA has been delegated to the State of California. The state, at its own discretion, has in many instances established requirements that are more stringent than federal requirements.

California's primary statute governing water quality is the Porter-Cologne Water Quality Control Act of 1970 (Porter-Cologne Act). The Porter-Cologne Act grants the California State Water Resources Control Board (State Board) and nine California Regional Water Quality Control Boards broad powers to protect water quality and is the primary vehicle for implementation of California's responsibilities under the CWA. The governing regional board for the Los Angeles area watersheds is the Los Angeles Regional Water Quality Control Board. Through a formal rule-making process, the Regional Board has adopted surface water quality standards that establish the beneficial uses, numeric and narrative water quality criteria or objectives used to protect those uses, and an antidegradation policy. These water quality standards become a part of each region's Basin Plan, which locally is the *Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (Basin Plan 1994, as amended).

The CWA further requires entities that discharge to waters of the United States to receive a permit to do so as part of the NPDES permit program, and it is through this permitting program, which is regulated locally by the Regional Board, that water quality requirements are enforced. NPDES permitting requirements state that among other dischargers, any MS4 must also hold an NPDES permit. A municipal MS4 is essentially a municipality owned and operated network of storm drains that are not combined with sanitary sewers, which drain to a receiving waterbody rather than a wastewater treatment plant.

The City's storm drains are within the area covered by the County of Los Angeles (County) MS4 NPDES permit, which lists the County and 84 cities (all of the cities in the County with the exception of Long Beach) as the Permittees. This permit allows these agencies to discharge storm water to inland waterbodies and ultimately the Pacific Ocean. The permit was first issued in 1990 (Order No. 90-079) and was designed to prevent pollutants from being directly discharged into the MS4 or from being washed by runoff into the MS4 and subsequently discharged into local waterbodies. The most recent MS4 permit renewal was adopted on November 8, 2012 (Order No. R4-2012-0175) and became effective on December 28, 2012. This Permit is in effect for five years and incorporates the Machado Lake Nutrients and Toxics TMDL implementation requirements previously adopted by the Regional Board.

1.3.2 Beneficial Uses and Section 303d List of Impaired Waterbodies

The establishment of "beneficial uses" and the periodic evaluation of these uses are two fundamental programmatic requirements of the CWA that are used by the Regional Board and USEPA to evaluate water quality statewide.

Beneficial Uses

The Regional Board designates specific "beneficial uses" for each waterbody in a watershed. These uses are protected by the establishment of specific numeric or narrative criteria or water quality objectives. For example, waterbodies designated for water contact recreation (REC-1) have applicable bacterial water quality objectives to protect the health of swimmers from risks associated with ingestion of water.

The Regional Board established beneficial uses for Machado Lake (Table 1-1), which was formerly known as Bixby Slough and Harbor Lake, in the Basin Plan. The Basin Plan does not identify beneficial uses specifically for Wilmington Drain. Although no uses have been designated for the Drain, the CWA and state law require that discharges from Wilmington Drain to Machado Lake not cause a violation of the lake's water quality objectives.

Table 1-1
Beneficial Uses Identified for Machado Lake[1]

Use Category	Beneficial Use (Abbreviation)	Definition
Existing Uses		
Recreation Uses	Water Contact Recreation (REC-1)	Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs
	Non-Contact Water Recreation (REC-2)	Uses of water for recreational activities involving proximity to water, but not normally involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide-pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.
Habitat Related Uses	Wetland Habitat (WET)	Uses of water that support wetland ecosystems, including, but not limited to, preservation or enhancement of wetland habitats, vegetation, fish, shellfish, or wildlife, and other unique wetland functions which enhance water quality, such as providing flood and erosion control, stream bank stabilization, and filtration and purification of naturally occurring contaminants.
	Wildlife Habitat (WILD)	Uses of water that support terrestrial ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.
	Rare, Threatened, or Endangered Species (RARE)	Uses of water that support habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened, or endangered.
	Warm Freshwater Habitat (WARM)	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.
Potential Uses		
Municipal Supply	Municipal and Domestic Supply (MUN)	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.

Notes:
[1] Source: Los Angeles Region Basin Plan for the Coastal Watersheds of Los Angeles and Ventura Counties" (Basin Plan 1994, as amended)
[2] Machado Lake is listed in the Basin Plan as Bixby Slough and Harbor Lake.

303(d) List of Impaired Waters

Section 303(d) of the CWA requires states to identify waterbodies not supporting their beneficial uses even after all required effluent limitations have been implemented (e.g., through a discharge permit) [see Figure 1-1]. These waters are often referred to as "303(d) listed" or "impaired" waters. Water bodies that are on the §303(d) list require the development of TMDLs. The USEPA-approved §303(d) list for California was most recently updated in 2006. Both Machado Lake and Wilmington Drain are listed on the 2006 California §303(d) list of impaired water bodies. Table 1-2 presents the current §303(d) listings for Machado Lake and Wilmington Drain based on the 2008 California §303(d) list of impaired water bodies (Regional Board 2009). Once a TMDL is developed, for a specific pollutant that pollutant is removed from the 303(d) list of impairments.

Table 1-2
Current 303(d) Listings for Machado Lake and Wilmington Drain

Water Body	Pollutant / Stressor	TMDL Adoption
Machado Lake	Trash	March 2008
	Algae, ammonia, eutrophic, odor	March 2009
	Chlordane, DDT, dieldrin, PCBs	March 2012
Wilmington Drain	Coliform bacteria, copper, lead	To be determined

Source: State Board 2010 303(d) list:
http://www.waterboards.ca.gov/water_issues/programs/tmdl/2010state_ir_reports/category5_report.shtml

A TMDL for trash was approved by USEPA (March 6, 2008 effective date). With respect to the specific remaining impaired waters listings for Wilmington Drain (bacteria and metals), it is anticipated that when the Regional Board initiates development and adoption of TMDLs for these constituents, the emphasis for reduction and implementation will be targeted at the watersheds upstream rather than in the lower reach of the drain itself since it is the waterbody that requires protection. The Dominguez Watershed Master Plan prepared for Los Angeles County Department of Public Works (LACDPW) and the cities in the watershed was adopted in 2004. The plan identified a wide range of projects and activities through the watershed including the Wilmington Drain/Machado Lake portion of the watershed that will help address these listings.

1.3.3 TMDL Development

All waterbodies on the §303(d) list are subject to the development of a TMDL for the constituents listed (Figure 1-1). A TMDL establishes the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards. Depending on the nature of the pollutant, TMDL implementation requires a reduction of pollutant contributions from point sources (WLAs), nonpoint sources (LAs), or both.

The development of TMDLs affecting waters in the Los Angeles area watersheds is the responsibility of the Regional Board. Adoption of a TMDL requires an amendment to the Basin Plan and is subject to a substantial public review process. After the Regional Board adopts a TMDL as a Basin Plan amendment, it is submitted to the State Board for approval. Once the State Board approves a TMDL, it is submitted to USEPA Region 9 for final review and federal approval. A TMDL is not in effect until USEPA has issued its formal approval.

Once a TMDL is established, the numeric limits and LAs or WLAs become part of the Basin Plan. The following subsections describe the process that resulted in the establishment of the Nutrients and Toxics TMDLs.

Regulatory Components of the Nutrients TMDL

The Regional Board developed the Nutrients TMDL for Machado Lake in accordance with the TMDL schedule dictated in the consent decree (*Heal the Bay Inc., et al. v. Browner C 98-4825 SBA*) approved on March 22, 1999. The Regional Board amended the Basin Plan to incorporate the Nutrients TMDL, which was adopted on May 1, 2008 and approved by the State Board on December 2, 2008. The Nutrients TMDL became effective with USEPA approval on March 11, 2009 (see http://63.199.216.6/larwqcb_new/bpa/docs/2008-006/2008-006_RB_BPA.pdf).

Regulatory Components of the Toxics TMDL

The Regional Board developed the Toxics TMDL for Machado Lake in accordance with the TMDL schedule dictated in the consent decree (Heal the Bay Inc., et al. v. Browner C 98-4825 SBA) approved on March 22, 1999. The Regional Board amended the Basin Plan to incorporate the Toxics TMDL, which was adopted on September 2, 2010 and approved by the State Board on December 6, 2011. The Toxics TMDL became effective with USEPA approval on March 20, 2012 (http://63.199.216.6/larwqcb_new/bpa/docs/R10-008/R10-008_EPA_APV.pdf).

The Basin Plan amendments that incorporated the Nutrients and Toxics TMDLs are enforceable through the MS4 NPDES permit, which is the permit used to enforce water quality in discharges from the storm drains. City of Los Angeles storm drain discharges are managed by the BOS. Since both TMDLs include the RAP as a responsible jurisdiction, an entity not specifically regulated under the NPDES permit, a Memorandum of Agreement (MOA) was developed between the City and the Regional Board in April 2010 to include RAP, consistent with the requirements of the TMDLs. The MOA, which is included in Appendix A, and the TMDLs, stipulate the requirements for the City to prepare and submit to the Regional Board an LWQMP for review and approval.

The elements of this document pertaining to the Nutrients TMDL were previously approved by the Regional Board on February 14, 2011. This document has been amended to incorporate the Toxics TMDL requirements. This approach is consistent with the Toxics TMDL which allows for the submittal of one LWQMP to the Regional Board to address both the Nutrients and Toxics TMDL requirements. Sections 1.4 and 1.5 below describe the specific requirements applicable to each TMDL.

1.4 Machado Lake TMDL Components

This subsection discusses the components of the Machado Lake Nutrients and Toxics TMDLs.

1.4.1 Nutrient TMDL

Nutrient impairment in Machado Lake is a factor of both external pollutant loading and internal nutrient cycling, described as follows:

- **External Loading:** Phosphorus and nitrogen are introduced to the lake through urban runoff when the runoff transports nutrients and other contaminants to the lake.

Atmospheric deposition is also a nonpoint source of total nitrogen and phosphorus. External loading is a product of nutrient sources predominantly from permitted urban runoff discharges delivered from an approximately 22.6-square-mile (14,444-acre) watershed draining into the lake (see Figure 1-2). A small percentage of external pollutant loading originates from the park areas directly surrounding Machado Lake, which is considered non-permitted stormwater or a nonpoint source of pollution.

- **Internal Loading:** When oxygen is depleted at the sediment/water interface, anoxic conditions occur. Under these conditions, phosphorus and nitrogen can disassociate from the nutrient-rich sediment on the bottom of the lake and diffuse upward into the water column (James 2006), which contributes to algae growth and increased chlorophyll *a* concentrations (Wisconsin Department of Natural Resources [WI DNR] 2003). When oxygen levels are sufficiently high (i.e., greater than 2.0 milligrams per liter [mg/L]), phosphorus typically remains bound to the sediment.

Using existing available data, the Regional Board initiated the Nutrients TMDL in 2007 and selected the use of a steady-state Nutrient Numeric Endpoints BATHTUB spreadsheet tool as the modeling method for estimating nutrient loadings and establishing pollutant load and waste load allocations. Storm drain discharges (point sources) are required to meet the WLAs defined in the Nutrients TMDL, while the internal nutrient loading and nonpoint sources (specifically runoff from KMHRP) must meet the LAs defined in the Nutrients TMDL.

1.4.1.1 Numeric Targets

Adoption of TMDLs provides a formal process for setting numeric targets to ensure protection of all beneficial uses of surface waterbodies. The Machado Lake Nutrients TMDL established specific numeric targets to restore and maintain the beneficial uses assigned by the Regional Board under the Habitat Related Uses category. Table 1-3 summarizes the numeric targets, documented in the Nutrients TMDL. The use of multiple water quality targets for Machado Lake establishes a conservative approach for improving lake water quality and provides additional key indicators to track the symptoms of eutrophication.

Table 1-3
Numeric Targets for Nutrients TMDL

Indicator	Numeric Target
Total Phosphorus	0.1 mg/L monthly average
Total Nitrogen	1.0 mg/L monthly average
Ammonia	5.95 mg/L one hour average
Ammonia	2.15 mg/L 30 day average
Dissolved Oxygen	5 mg/L single sample minimum measured 0.3 meters above the sediments
Chlorophyll-*a*	20 µg/L monthly average

Source: Regional Board *Attachment A to Resolution No. R08-006*, Amendment to the Water Quality Control Plan Los Angeles Region.

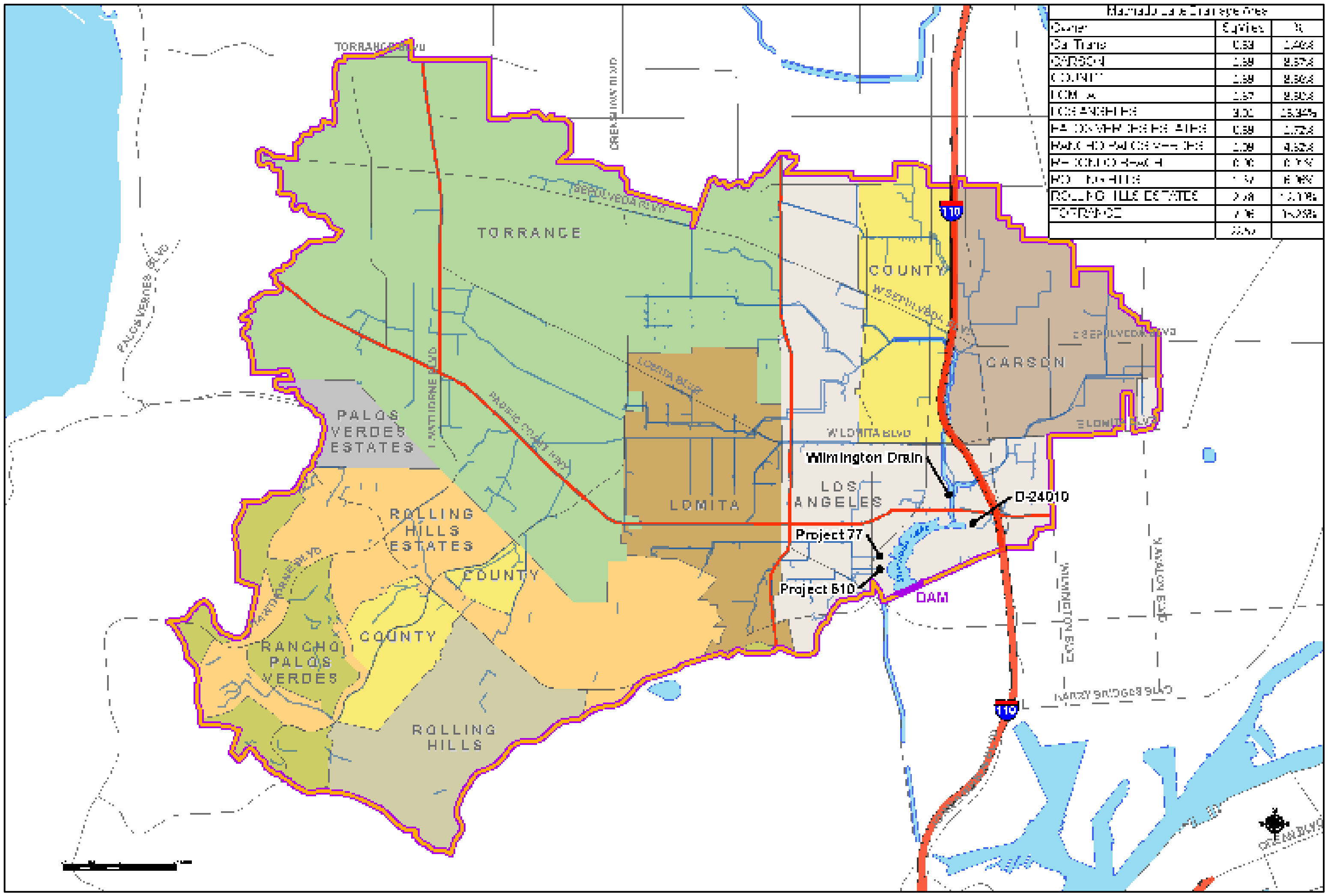

Figure 1-2
Machado Lake Watershed
Source: Machado Lake Nutrients TMDL Reference Guide

The Basin Plan Amendment documents that these impairments are caused by excessive loading of nutrients, including nitrogen and phosphorus in Machado Lake. Ammonia concentrations were found to be below toxicity levels, but still contributed to the total nitrogen loading.

1.4.1.2 Waste Load Allocations

As previously discussed, the Nutrients TMDL assigned WLAs to point sources that include the MS4 permitted stormwater discharges, Caltrans, and general construction and industrial discharges. Since there is no wastewater effluent discharged directly into Wilmington Drain or Machado Lake, the entire WLA, comprised of permitted stormwater, is incorporated into the applicable NPDES MS4 permits covering the Machado Lake watershed.

The Nutrients TMDL includes two interim compliance milestones in addition to the final compliance date. Table 1-4 summarizes the WLAs and associated interim and final compliance dates. The WLAs are expressed as concentrations of nutrients. The product of these concentrations and the annual average runoff volumes provides an equivalent estimate of allocated mass loads.

1.4.1.3 Load Allocations

LAs are defined as the portion of a receiving water's loading capacity that is attributed to existing or future nonpoint sources of pollution or to natural background sources (State Board 2005). Therefore, LAs in TMDLs are assigned to mitigate nonpoint sources of pollution. LAs can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. The primary nonpoint sources of nutrients to Machado Lake are sediment loading originating from storm drains including Wilmington Drain, internal nutrient loading from lake bottom sediments, atmospheric deposition, birds, wind re-suspension, bioturbation, and general surface runoff from KMHRP. Recreational and maintenance activities associated with the lake and KMHRP are the responsibility of RAP. Table 1-5 provides the LA established by the Nutrients TMDL.

1.4.1.4 Summary of Compliance Dates

Table 1-6 summarizes the compliance dates associated with the Nutrients TMDL.

1.4.2 Toxics TMDL

Machado Lake is impaired for toxics in fish tissue (chlordane, DDT, dieldrin, and PCBs) and sediment (chlordane, DDT, and PCBs). The physio-chemical properties of these toxics allows for a strong bond with particulate matter present in the lake, such as organic matter and fine-grained sediments, which allows for easy transport and accumulation in waterbodies, bioaccumulation in the food chain, and persistence in the environment for long periods of time.

Table 1-4
Interim and Final Waste Load Allocations for Total Phosphorus and Total Nitrogen

Waste Load Allocations	Compliance Date	Interim Total Phosphorus WLAs (mg/L)	Interim Total Nitrogen[2] WLAs (mg/L)
MS4 Permittees[1], Caltrans, General Construction and Industrial Stormwater permits	Interim - March 11, 2009	1.25	3.50
	2nd Interim – March 11, 2014	1.25	2.45
	Final – September 11, 2018[3]	0.10	1.00

Source: Regional Board Attachment A to Resolution No. R08-006, Amendment to the Water Quality Control Plan Los Angeles Region.

Notes:
[1] MS4 Permittees that are responsible for discharges to Machado Lake include: Los Angeles County, Los Angeles County Flood Control District, and the Cities of Carson, Lomita, Los Angeles, Palos Verdes Estates, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, and Torrance.
[2] Total nitrogen is TKN + NO_3-N + NO_2-N
[3] The compliance point for all year 5 interim and final WLAs is measured as specified in Implementation Plan Section II of the Basin Plan Amendment Table 7-29-1 of the Machado Lake Nutrients TMDL Staff Report, 2008.

Table 1-5
Interim and Final Load Allocations for Total Phosphorus and Total Nitrogen

Load Allocations	Compliance Date	Interim Total Phosphorus WLAs (mg/L)	Interim Total Nitrogen[1] WLAs (mg/L)
Nonpoint Source Nutrient Load (City of Los Angeles Department of Recreation and Parks)	Interim - March 11, 2009	1.25	3.50
	2nd Interim – March 11, 2014	1.25	2.45
	Final – September 11, 2018	0.10	1.00

Source: Regional Board *Attachment A to Resolution No. R08-006*, Amendment to the Water Quality Control Plan Los Angeles Region.

Notes:
[1] Total nitrogen is TKN + NO_3-N + NO_2-N.

Table 1-6
Compliance Deadlines for Load Allocation Requirements of the Nutrients TMDL

Compliance Date	TMDL Requirement
March 11, 2009	Meet 1st interim WLAs and LAs (see Table 1-4 and 1-5)
March 11, 2010	Enter into an MOA with the Regional Board to implement WLAs and LAs[1].
Sept. 11, 2010	Submit LWQMP to the Regional Board for approval.
60 days from date of LWQMP approval	Begin monitoring and implementation as outlined in the Monitoring and Reporting Plan (MRP) section of the LWQMP.
Annually from date of LWQMP approval	Submit annual monitoring reports.
March 11, 2014	Meet 2nd interim LAs (see Tables 1-4 and 1-5)
Sept. 11, 2016	TMDL re-opener period.
Sept. 11, 2018	Meet final LAs and numeric targets (see Table 1-4 and 1-5)

Source: Regional Board *Attachment A to Resolution No. R08-006*.

[1] The City of Los Angeles Department of Recreation and Parks is required to enter into the MOA as it is not regulated under the MS4 NPDES permit and the MOA will serve as the agreement to meet the TMDL load allocation requirements. However, since the City of Los Angeles Department of Public Works must meet the WLA, the two departments have jointly entered into the MOA with the Regional Board effective April 7, 2010 (Appendix A) and have collaborated in the preparation of this LWQMP.

External Loading

Toxics impairment in Machado Lake is a factor of historical external loading. These toxics were previously banned for use in the United States and there are no new sources introducing these toxics to the lake. Over time toxic contaminated sediments have accumulated in the lake resulting in exposure to aquatic organisms. Only one of the toxics, PCBs is still in use in equipment manufactured prior to 1979. However, there is no evidence that would suggest PCB activities in the watershed contribute to impairments at Machado Lake based on a review of the US EPA PCB Activity Report and US EPA PCB Transformer Registration databases conducted by the Regional Board.

Additional toxics loading into the lake is attributed to erosion of toxic contaminated sediments higher in the watershed and atmospheric deposition. Contaminated sediments are currently transported into Machado Lake from multiple storm drains and Wilmington Drain. A sediment characterization study conducted for Wilmington Drain indicates exceedances for Total DDT, chlordane, and PCB. This sediment would be a significant source of toxics if it is conveyed into Machado Lake.

A small percentage of external loading is attributed to atmospheric deposition of the contaminants related to historical usage. Pollutants are either volatilized and/or resuspended as particulates at which time they can be atmospherically deposited in water bodies or washed from surfaces and deposited in waterbodies during storm events.

Internal Loading

Machado Lake acts as a reservoir for toxics that are received from the watershed; minimal discharge of the contaminants occurs to downstream waterbodies. Additional constituent losses occur through natural breakdown, albeit at a slow pace. As the toxics accumulate in the lake, the toxics migrate into the water column and ultimately benthic organisms. From benthic organisms the toxics move up the food chain contributing to fish tissue impairment.

Conceptual Model
Using existing available data, the Regional Board initiated preparation of the Toxics TMDL and developed a conceptual model for quantifying internal and external toxics loadings and establishing pollutant load and WLAs. Storm drain discharges (point sources) are required to meet the WLAs associated with suspended sediment defined in the Toxics TMDL, while the internal toxics loading and nonpoint sources must meet the LAs defined in the Toxics TMDL.

1.4.2.1 Numeric Targets

Adoption of TMDLs provides a formal process for setting numeric targets to ensure protection of all beneficial uses of surface waterbodies. The Machado Lake Toxics TMDL established specific numeric targets to restore and maintain the beneficial uses assigned by the Regional Board. Impaired beneficial uses of the lake attributed to toxics include:

- Aquatic life (WARM, WILD, RARE, and WET);
- Recreation, including fishing (REC-1 and REC-2).

Tables 1-7 and 1-8 summarize the numeric targets for the water column, sediment, and fish tissue, documented in the Toxics TMDL. The water column targets are based on the California Toxics Rule (40 CFR section 131.38) for human health criteria and will protect both human health and aquatic life, as human health criteria are more rigorous than aquatic life criteria. Sediment numeric targets are derived from the freshwater Threshold Effect Concentration guidelines developed by the National Oceanic and Atmospheric Administration (NOAA). The fish tissue numeric targets are from the Office of Environmental Health Hazard Assessment Fish Contaminant Goals.

The Basin Plan Amendment (TMDL) documents that the major nonpoint source of these toxics is internal lake sediments contaminated from historic PCB and pesticide use in the watershed.

1.4.2.2 Waste Load Allocations

The Toxics TMDL assigned WLAs to point sources that include the MS4 permitted stormwater discharges, Caltrans, and general construction, and industrial discharges in both wet and dry weather. Since there is no wastewater effluent discharged directly into Wilmington Drain or Machado Lake, the entire WLA, comprised of permitted stormwater, is incorporated into the applicable NPDES MS4 permits covering the Machado Lake watershed.

Table 1-7
Water Column Numeric Targets for Toxics TMDL

Pollutant	Numeric Target (µg/L)
Total PCB's	0.00017
4,4' DDT	0.00059
4,4' DDE	0.00059
4,4' DDD	0.00084
Chlordane	0.00059
Dieldrin	0.00014

Source: Regional Board *Attachment A to Resolution No. R10-008*, Amendment to the Water Quality Control Plan Los Angeles Region.

Table 1-8
Sediment and Fish Tissue Numeric Targets for Toxics TMDL

Pollutant	Sediment Target (µg/kg dry weight)	Fish Tissue Target (ng/g wet weight)
Total PCB's	59.8	3.6
DDT (all congeners)	4.16	No target
DDE (all cogneners)	3.16	No target
DDD (all cogneners)	4.88	No target
Total DDT	5.28	21.0
Chlordane	3.24	5.6
Dieldrin	1.9	0.46

Source: Regional Board *Attachment A to Resolution No. R10-008*, Amendment to the Water Quality Control Plan Los Angeles Region.

Table 1-9 summarizes the WLAs by responsible party, pollutants, and dry weights in micrograms (µg) per kilogram (kg). Compliance by the responsible parties must be met over a three-year averaging period.

1.4.2.3 Load Allocations

LAs are defined as the portion of a receiving water's loading capacity that is attributed to existing or future nonpoint sources of pollution or to natural background sources (State Board 2005). Therefore, LAs in TMDLs are assigned to mitigate nonpoint sources of pollution. LAs can range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting the loading. Pesticides and PCBs contained within Machado Lake sediments are attributed to historical uses in the watershed that no longer occur. The sediments act as a reservoir for the pollutants. Bioturbation, fish feeding practices, and other disturbances results in uptake in benthic organisms and allowing the toxics to bioaccumulate in each successive level of the food chain impairing fish tissue. Recreational and maintenance activities associated with the lake are the responsibility of RAP.

Table 1-9
Toxics TMDL Waste Load Allocations

Responsible Party	Pollutant	WLA for Suspended Sediments – Associated Contaminants (µg/kg dry weight)[2]
MS4 Permittees[1], Caltrans, General Construction and Industrial Stormwater Permittees, Other Non-Stormwater NPDES Permittees	Total PCBs	59.8
	DDT (all congeners)	4.16
	DDE (all congeners)	3.16
	DDD (all congeners)	4.88
	Total DDT	5.28
	Chlordane	3.24
	Dieldrin	1.9

Source: Regional Board Attachment A to Resolution No. R10-008, Amendment to the Water Quality Control Plan Los Angeles Region.

Notes:
[1] MS4 Permittees that are responsible for discharges to Machado Lake include: Los Angeles County, Los Angeles County Flood Control District, and the Cities of Carson, Lomita, Los Angeles, Palos Verdes Estates, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, and Torrance.
[2] WLAs are applied with a 3-year averaging period.

Multiple uncertainties are associated with the Toxics TMDL. Uncertainties include:

- Limited data regarding the volume of pesticides and PCBs in lake sediments;
- Limited data on additional pesticides and PCBs entering the lake;
- Volume of the active sediment layer is estimated;
- Watershed sediment deposition rate is estimated; and

Estimated values for constant bulk density, sediment density, and sediment porosity used for calculating loads associated with sediment deposits.

As a result of the uncertainties, the LAs were set to meet the lake loading capacity, inclusive of a 10% margin of safety. Table 1-10 provides the LAs by pollutant established by the Toxics TMDL. The responsible party shall be responsible for nonpoint sources of the pesticides and PCBs (toxics) load.

Table 1-10
Load Allocations for Toxics TMDL

Responsible Party	Pollutant	Load Allocation (grams)
Nonpoint Source Nutrient Load (City of Los Angeles Department of Recreation and Parks)	Chlordane	1,147
	Total DDT	1,870
	Dieldrin	467
	PCBs	12,644

Source: Regional Board *Attachment A to Resolution No. R10-008*, Amendment to the Water Quality Control Plan Los Angeles Region.

1.4.2.4 Summary of Compliance Dates

Table 1-11 summarizes the LA compliance dates associated with the Toxics TMDL that are the responsibility of the RAP.

Table 1-11
Compliance Deadlines for Load Allocation Requirements of Toxics TMDL

Compliance Date	TMDL Requirement
March 20, 2013	Enter into an MOA with the Regional Board to implement the LAs[1] or amend MOA for Nutrient TMDL to address Toxics TMDL
September 20, 2013	Submit LWQMP, MRP Plan, and QAPP for Regional Board approval or amend applicable documents for Nutrient TMDL to address Toxics TMDL
60 days from date of LWQMP approval	Begin implementation as outlined in the MRP section of the LWQMP.
September 30, 2019	Meet LAs for Pesticides and PCBs (Table 1-9) and assess numeric targets

Source: Regional Board *Attachment A to Resolution No. R10-008.*

[1] The City of Los Angeles Department of Recreation and Parks is required to enter into the MOA as it is not regulated under the MS4 NPDES permit and the MOA will serve as the agreement to meet the TMDL load allocation requirements. However, since the City of Los Angeles Department of Public Works must meet the WLA, the two departments have collaborated in the preparation of this LWQMP and have previously jointly entered into an MOA with the Regional Board to address nutrients (effective April 7, 2010, Appendix A). This MOA will be amended as appropriate to incorporate elements applicable to toxics.

Table 1-12 summarizes the WLA requirements for the Toxics TMDL. Parties responsible for implementation are Caltrans, MS4 Permittees previously identified, and General Construction and Industrial Stormwater Permittees.

Table 1-12
Compliance Deadlines for Waste Load Allocation Requirements of Toxics TMDL

Compliance Date	TMDL Requirement
September 20, 2013[1]	Submit MRP Plan and QAPP for Regional Board approval
60 days from date of LWQMP approval	Begin monitoring as outlined in the MRP and QAPP section of the LWQMP.
2 years monitoring period	Conduct Phase 1 monitoring
Draft 6 months from completion of Phase 1 Monitoring Final 1 year from completion of Phase 1 Monitoring	Submit implementation plan to attain WLAs or document WLAs obtained
60 days from date of implementation plan approval	Begin implementation actions to attain WLAs as needed
September 30, 2019	Meet WLAs for pesticides and PCBs

Source: Regional Board *Attachment A to Resolution No. R10-008.*

[1] The deadline for responsible parties who are not assigned both WLAs and LAs is September 20, 2012.

1.4.3 Waste Load and Load Allocation Implementation

Compliance with the WLA, LA, and nutrient and toxics targets will require the implementation of BMPs that reduce external loadings to Machado Lake and reduce in-lake concentrations of nutrients and toxics in sediment. A variety of BMPs to address external and internal nutrient and toxics loading were identified in the Nutrient and Toxics TMDLs, which along with other BMPs were evaluated during the design of the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project.* The recommended BMPs summarized in Section 3 of this LWQMP are being implemented to restore water quality and improve the health of Machado Lake. This LWQMP is the summary of the action items and commitments that will be implemented to achieve compliance with the Nutrients and Toxics TMDLs.

1.5 Components of the LWQMP

Based on the regulatory requirements described previously, the Machado Lake LWQMP is organized to meet the elements stipulated by the Regional Board in the MOA and the Nutrients and Toxics TMDLs. The LWQMP includes the following components:

- Implementation Plan and Compliance Analysis
- Monitoring and Reporting Plan (MRP)
- Quality Assurance Project Plan (QAPP)

Collectively, Sections 1 through 6 and the Appendices in this LWQMP provide a detailed plan describing the commitments and management strategies necessary to attain the interim and final LAs and WLAs set forth in the Nutrients and Toxics TMDLs. This LWQMP focuses only on the portion of the Machado Lake watershed within the City's jurisdiction. This LWQMP addresses both point and nonpoint sources contributing to nutrient and toxics loading in Machado Lake. The LWQMP also provides a summary of how existing data and a lake water quality models are used to demonstrate compliance over time with the water quality targets and compliance schedules set forth in the Nutrients and Toxics TMDL.

1.5.1 Implementation Plan and Compliance Analysis

The implementation plan presented in Section 3 of this LWQMP describes the integration of actions and strategies that the City will take towards meeting the objectives and requirements of the Nutrients and Toxics TMDLs and other local, regional, and federal water quality management programs. The compliance analysis presented in Section 5 provides a summary of how existing data and lake water quality models are used to demonstrate the City's compliance with its portion of the LAs and WLAs of the Nutrients and Toxics TMDLs. Other programs that are advanced through the implementation of this LWQMP include the California Nonpoint Source Management Program, the rules and regulations administered by the California Department of Fish and Game (CDFG), and the City of Los Angeles Watershed Protection Division's Water Quality Compliance Master Plan for Urban Runoff (May 2009), as well as actions by other MS4 Permittees in the watershed.

1.5.2 Monitoring and Reporting Plan

Section 4 of this LWQMP provides a MRP, which is the City's strategic approach for collecting data and information to evaluate, summarize, and report on the monitoring results, changes in water quality, and progress toward achieving interim and final LAs and WLAs for Machado Lake. Other responsible agencies are responsible for preparation of separate MRPs for their portion of the watershed. The MRP, developed in accordance with California's Surface Water Ambient Monitoring Program (SWAMP) guidance, defines the City's monitoring program commitments necessary to meet the requirements stipulated in the Nutrients and Toxics TMDLs. To achieve these monitoring requirements, the MRP includes well defined data quality objectives that are critical to ensure appropriate data are collected to demonstrate compliance with interim and long-term nutrient and toxics targets as measured in the lake. The MRP also outlines the health and safety principles the City adheres to in conducting business to protect the well-being of its employees.

1.5.3 Quality Assurance Project Plan

As required by the MOA, and in accordance with the City's comprehensive water quality monitoring program, a QAPP is provided in Appendix B. The QAPP includes the protocols for sample collection, standard analytical procedures, laboratory certification, and corrective action measures all of which adhere to the California SWAMP guidance. The purpose of the QAPP is to ensure that data quality objectives are met and the monitoring program produces consistent, reliable data that meet the project's overall goals. The QAPP is necessary to effectively implement the MRP found in Section 4.

Section 2
Watershed Characteristics and Baseline Conditions for Water Quality Modeling

This section serves to illustrate the existing conditions within Machado Lake and the upstream watershed. These baseline conditions form the foundation from which improvements to the lake are based.

Described here are the watershed's current and historic conditions, followed by a summary of the baseline water quality from the upstream watershed as well as the water quality in the lake. Based upon these baseline conditions in the lake and watershed, Lake Water Quality Models were developed to evaluate the effectiveness of various BMPs (which are described in Section 3) at reducing nutrient and toxics concentrations in the lake. The Lake Water Quality Models are summarized in Section 2.3.3 and Appendix C. Future BMPs are described in Section 3.

2.1 Watershed Description

Wilmington Drain accounts for approximately 88 percent of the portion of the Machado Lake subwatershed that drains to the lake. The remaining 12 percent comes from five additional storm drains, of which Project 77 has the largest drainage area, and sheet flow from the KMHRP that surrounds Machado Lake. After the runoff passes through Machado Lake and the downstream Freshwater Marsh, it flows directly to the West Basin of the Los Angeles Harbor.

The Machado Lake and Wilmington Drain ecosystem, which includes Machado Lake, KMHRP, and the half-mile long soft bottom section of Wilmington Drain between Pacific Coast Highway (PCH) and the I-110 freeway, is one of the largest remaining coastal wetland ecosystems in Southern California (CDM and Parsons 2008). The KMHRP, a 291-acre park that is owned, operated, and maintained by the RAP, is located in the Wilmington and Harbor City communities of the City of Los Angeles, approximately 15 miles south of downtown Los Angeles. The Wilmington Drain section is located north of the lake in the Cities of Carson, Lomita, and Los Angeles and unincorporated Los Angeles County, and is operated by LACFCD.

Harbor Park Golf Course borders the northeast banks of Machado Lake and the Los Angeles Harbor College borders the Freshwater Marsh located south of Machado Lake. PCH and residential development borders KMHRP to the north, Vermont Avenue and a Kaiser Permanente facility borders KMHRP to the west, and Anaheim Street and Conoco-Phillips Oil Refinery are located to the south of the KMHRP (Figure 2-1). The dominant land use in the Machado Lake subwatershed is high density single family residential, which accounts for approximately 45 percent of the total land use (Regional Board 2008).

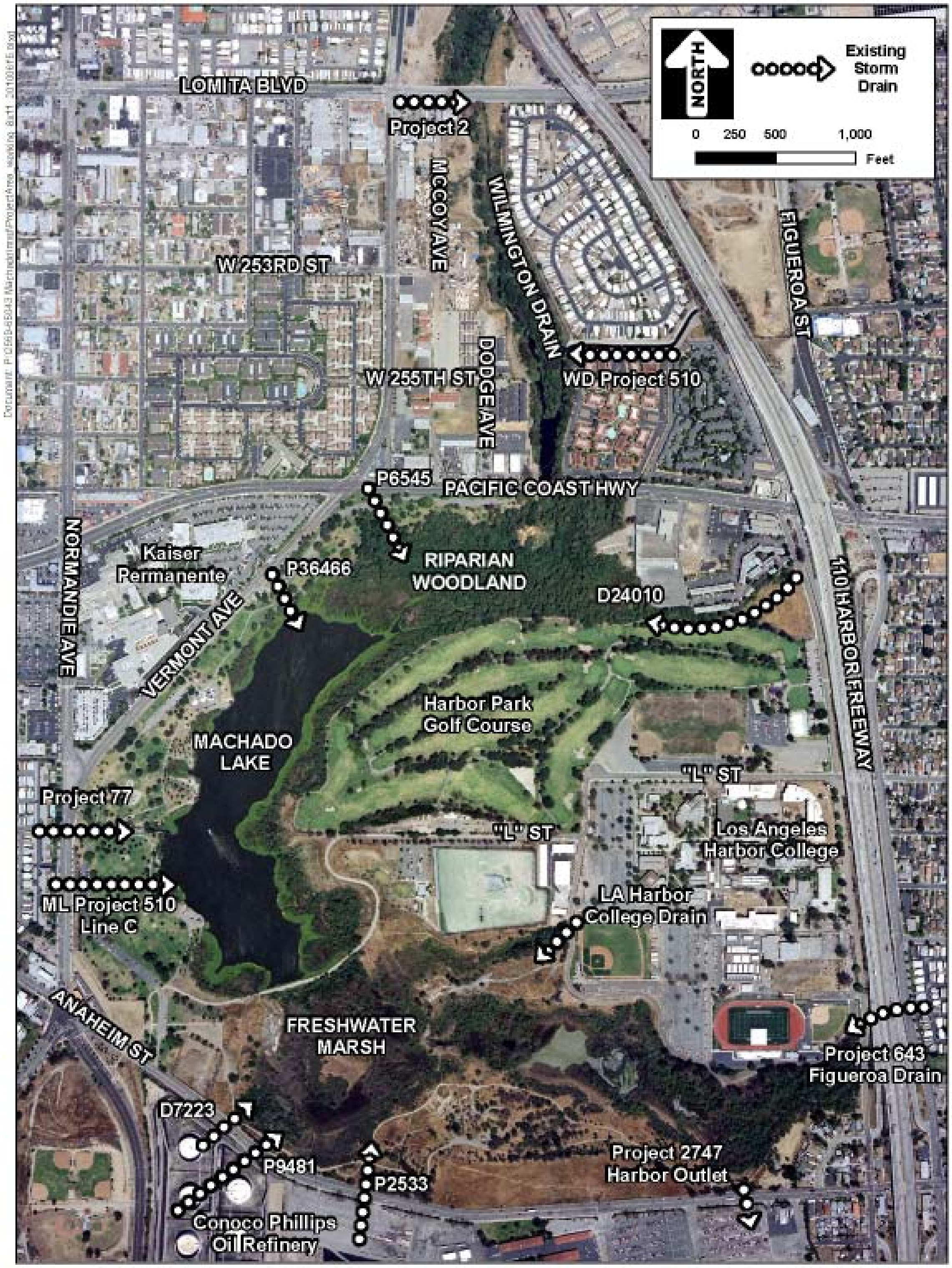

Figure 2-1
KMHRP and Wilmington Drain Location Map

2.1.1 Wilmington Drain

Wilmington Drain looking downstream from Lomita Boulevard

Wilmington Drain is a LACFCD facility managed by the LACDPW. It is characterized by an approximately 150-foot wide soft bottom channel, coastal sage scrub plant communities, non-native plants, urban litter, and riprap-filled gabions. From PCH to Lomita Boulevard, the Wilmington Drain is bordered on both sides by residential development. North of Lomita Boulevard, the western bank provides habitat for the endangered least Bell's Vireo and other native species, while north of I-110 the channel is concrete lined. Wilmington Drain collects stormwater runoff from a 19-square-mile watershed consisting of residential and industrial development. Wilmington Drain conveys stormwater to Machado Lake and also functions as a sedimentation basin.

2.1.2 Machado Lake and Ken Malloy Harbor Regional Park

KMHRP is one of the largest parks in the City, and has one of the most diverse habitats in the region, including the 40-acre Machado Lake, a 63-acre seasonal freshwater marsh, and a riparian woodland. Because of these resources KMHRP has been designated as a Significant Ecological Area (SEA) by Los Angeles County Regional Planning. To Harbor and South Bay residents, Machado Lake and the KMHRP are recreational and natural resources in the park-poor urban Harbor City area. They are a popular recreation destination for local residents who enjoy the picnic spaces, fishing, bird watching, and hiking.

KMHRP Open Space Park Area

Machado Lake was formed either as a small canyon at the mouth of a former path of the Los Angeles River and/or by land subsidence, possibly following an earthquake. It was first reported in its original characteristic horseshoe shape with two upper arms in 1873 and was shown as either a lake or wetland as early as 1784.

Machado Lake

In the 1920 to 1930 period the lake was partially de-watered to allow surface mining of drilling clay and used as a site of multiple oil well drilling platforms, which had numerous oil spills. During World War II the lake was a disposal site for Los Angeles harbor dredge spoils.

Above-average wet years caused the lake to expand north and south, causing flooding to highways as they were constructed near the lake in the 1930s and '40s. This resulted in construction of flood control structures in 1955 that lowered the average lake level as much as 5 feet. The earthen dam was designed to maintain the level of the lake at a maximum of 10 feet mean sea level (msl). During almost all but possibly very minor storm events, water flows over the dam into the lower basin and ultimately to the Harbor Outfall at the southeastern corner of the park, where it is discharged to the West Channel of the Los Angeles Harbor.

The upper quarter of the original lake was lost by 1964 due to a combination of lowered lake level, high rates of sediment inflow, and invasion by willows. It is now a riparian woodland. The lower section of the lake, below the dam was lost about the same time. Some of the original lake in this area remains as isolated pools and wetlands. The 40-acre remaining lake is thus shallower and smaller, perhaps about half of its original size.

Today Machado Lake has a very high ratio of watershed to lake surface area, at 389:1 acres. Typical watershed to lake ratios are less than 100:1. Ratios greater than 40:1, and certainly greater than 100:1, indicate eutrophic conditions (Horne & Goldman 1994).

Conversion of most of the watershed from open plains or farmland to urban conditions increased inflow so that the lake water residence time in winter falls to a very short 5 days, or 0.0014 years. This is a very low water residence time, since a typical water residence time for natural lakes is 3 to 100 years.

Eutrophication of Machado Lake and the accumulation of toxic sediment has damaged habitat, degraded water quality, and negatively impacted recreational uses such as boating. Warning signs about the dangers of eating fish from the lake are now posted. In the mid-1980's, a portion of the lake was dredged.

2.2 Historic Lake Conditions as Determined from Sediment Analysis

In 2009, a paleolimnological study was conducted to investigate the historic conditions at Machado Lake through analysis of sediment (Horne 2010). This section includes a summary of the results of this report related to sedimentation rates and the nutrients and algae grown in the lake.

Paleo-Dating of Core Samples

Sixteen samples were taken from two cores in Machado Lake in August 2009. Since the depth of the lake was not known, assuming a typical urban sedimentation rate of 0.5 inches per year (1 foot per 24 years), a 5-foot deep sample was expected to be 120 years old, which would have been a sufficiently aged sample that would be representative of a period of time prior to substantial development in the area. Based on the expected sedimentation rates, a core from the lake bed surface to about 12 feet deep was taken at one site in the northern part of the lake, which would presumably represent almost 300 years of sediment record. Another sediment core was taken in the central part of the lake to a depth of approximately 7 feet, but this location may have been affected by dredging in the mid-1980s.

The results of the paleo-dating show sedimentation rates, measured at the north and central sections of the current lake using the isotopes of lead (210Pb) and cesium (137Cs), were much more rapid than expected in both cores, especially the northern core. For this site the deepest sample at almost 12 feet was dated using 210Pb at only 66 years old, or from 1943. This date indicates an extremely high annual sedimentation rate of 2.1 inches/year (11.6 feet or 139.2 inches/66 years from 1943 to 2009). Thus sedimentation rates were over four times rates anticipated based on other studies on urban water bodies. For the central core, which although possibly dredged in the 1980s, the deepest core sample at 6.7 feet was dated by 208Pb at 1914. The preliminary sedimentation rate was thus a more typical 0.85 inches/year (6.7 feet or 80.4 inches/95 years). However, previous dredging activities may have affected this sample.

Further study of the samples indicated that the annual rates of sedimentation accumulation have been increasing in Machado Lake since 1914. The sedimentation at both Machado sites showed two periods—a high but not unexpected 0.6 inches/year at the central site and 1.9 inches/year at the northern site between 1914 or 1943 and approximately 1996, with rates greatly increasing over the last 12 years. The reason for this increase is not clear but may be due to increased soil erosion and scouring in the storm drain channels as more water is discharged from developing urban land with more impervious surfaces.

Therefore, as shown, Machado Lake has had high sedimentation rates over the past 66 to 95 years, and rates have been increasing even more over the past 12 years.

Paleolimnology Study

Using the samples from the north section of Machado Lake, a paleolimnology study was also conducted (Horne, 2010). The purpose of the study was to determine if any changes in algae had occurred and if so, could the changes be attributed to increases in nutrients or other pollutants over the last 66 years (from 1943 to 2009).

The "fossil" remains of algae from these core samples were analyzed for species composition and abundance. Only diatoms with their glass-like silica frustules (cell walls or cases) are well preserved in sediment. Thirty-seven species of diatoms were found commonly (top 10 by abundance) out of a total of over 100 kinds. The most common were phytoplankton diatoms that grow in the open water but benthic forms that live in the mud were also present.

Surprisingly, given the large amount of development and drainage changes in this densely populated area, five centric (pill-box or barrel-shaped) diatoms species dominated the lake phytoplankton over the 66-year record. These species had in common an ability to tolerate a wide range of salinity (euryhaline) such as naturally occurred in the past and still occurs to some degree today (though limited by the dam). Looking at the abundance ranking of the five most common centric diatoms in Machado Lake sediments between 1943 and 2009 showed that no change in abundance is apparent.

The five most common diatoms formed two super-groups. Since the two super-groups dominated the phytoplankton for all of the 66 year record, it can be concluded that the waters of Machado Lake have been mesotrophic to eutrophic over this time and no change in trophic state can be determined from the kinds of algae present. The conclusion that can be made from this is that no change in trophic state has occurred since 1943. It is likely that such a small shallow lake with a large drainage basin and natural salinity stress would have few dominant species and ample nutrients even in 1700. To determine conditions prior to European settlement, deeper cores would be required. However, those conditions would not be comparable with current conditions since at that time Machado Lake was either part of the Los Angeles River, a fully tidal estuary or some combination of these alternatives.

Although many diatoms are indicators of trophic states, all of the members of super-groups 1 and 2 could be expected to be found in association with high nutrients due to their size. The individual cells and chains of all of super-groups 1 and 2 were quite large. Large cells have a smaller ratio of cell surface (where uptake of nutrients occurs) to cell volume (where nutrients are used to make biomass) than small algae. Although not all of the individual members of these first two groups are described specifically as being indicators of high nutrients or tolerant of pollution, they will normally be found in waters with relatively high nutrients. Machado Lake currently has high levels of most nutrients during the spring through fall growth season so the members of super-groups 1 and 2 were by definition at least tolerant of high nutrients.

A separate examination was done using a strict numerical ranking, which unlike the ranking of the top few species (described above as super-groups) where individuals were almost always in the top 10 (species of diatoms, top 10 by abundance), the numerical ranking tracks algae that were less common as well as those not found in all or most of the sediment depths sampled.

Examination of the top 20 species showed the presence of 8 species of the pennate benthic diatom *Nitzschia*. These species of *Nitzschia* in the top 20 have been described as favored by high nutrient concentrations or tolerant of "heavy pollution." This indicates that over this 53 year period, high nutrient concentrations are concluded to have been present.

The composite rankings for the three most common *Nitzschia* species showed clearly that the numbers of the three most common species of nutrient or heavy pollution tolerant *Nitzschia* increased about 25 percent (approximately 3 to 4.1) over the period of about 53 years (1953-2006). A larger increase of about 150 percent is seen between 1953 and 2009 but the later year may be an anomaly due to the very low water level which greatly increased the mud and submerged plant habitat for benthic species such as *Nitzschia* just as it decreased the habitat for the planktonic species like *Aulacoseira*.

The results of the paleolimnology study indicate that Machado Lake has been mesotrophic to eutrophic over the 66 year record, with high nutrients concentrations indicated over the 53 year record.

2.3 Baseline Loads and the Lake Water Quality Models

2.3.1 Baseline Nutrient Loads

BOS conducted in-lake water quality monitoring in Machado Lake at two in-lake locations from June 2006 to September 2008. Table 2-1 presents a summary of the data collected.

Table 2-1
Machado Lake In-Lake Water Quality[1] Storm Drain Water Quality and Field Collected Monitoring Data (June 2006 – September 2008)

Constituent	Units	Minimum	Average	Maximum
Total Phosphorus (P)	mg/L	0.3	0.8	1.4
Total Nitrogen (N)	mg/L	0.3	1.8	4.6
Chlorophyll a	µg/L	3.4	72.6	337.7
Ammonia-N	mg/L	0.03	0.04	0.6
Dissolved Oxygen (lake bottom)	mg/L	0.5	4.7	16.5

[1] Lake grab samples were taken at two in-lake locations from June 2006 to September 2008. Most in-lake water quality samples were collected during dry weather periods with low base flow in the drains. No samples were collected during wet weather; however, a few samples were collected one or two days after wet weather events. Minimum and maximum values shown are the minimum and maximum values of all the four sampling locations (not averages of minimum/maximum, but actual minimum/maximum measured values).

The in-lake nutrient concentrations presented here are the result of two types of nutrient loading processes (Figure 2-2):

- **External Loading:** phosphorus and nitrogen are introduced to the lake through urban runoff when the runoff transports nutrients and other contaminants to the lake. Additionally, atmospheric deposition is a source of total nitrogen.

- **Internal Loading:** When oxygen is depleted at the sediment/water interface anoxic (low oxygen) conditions occur. Under these conditions, phosphorus can disassociate from the nutrient rich sediment on the bottom of the lake and diffuse upward in the water toward the lake surface (James 2006), which contributes to algae growth and increased chlorophyll-*a* concentrations (WI DNR 2003). When oxygen levels are sufficiently high (i.e., greater than 2.0 mg/L), phosphorus typically remains bound to the sediment.

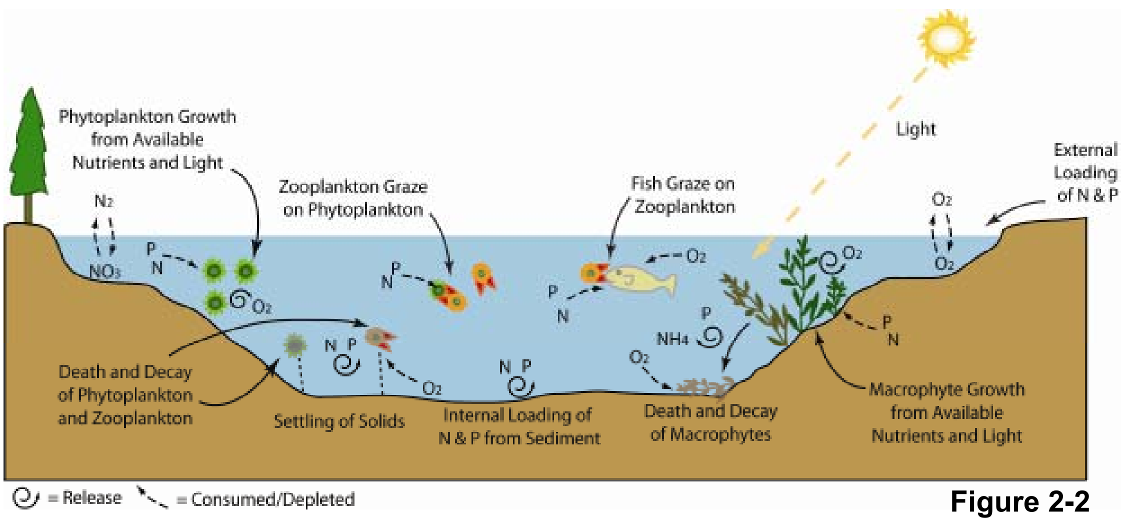

Figure 2-2
Phosphorus and Nitrogen Cycles in Lakes

Mass balance summaries were developed for the existing condition (see Sections 2.3.1 and 2.3.2) to provide insight to the systems' water quality drivers. Mass balance calculations, in terms of total nutrient loadings, were performed for both the entire water year (October through September) and for the dry season only (April through September). Results of these calculations are provided in Table 2-2. As shown, on an annual basis, nutrient loadings are dominated by wet weather runoff. However, in terms of the summer critical low water period, internal loadings from sediment are the predominant source of both N and P. Note that the "start season load" shown in the dry season graphs refers to the nutrient mass in the lake water column at the start of the dry season (residual from wet season loads).

Table 2-2
Internal vs. External Nutrient Load at Machado Lake

Source	Annual Load (kg)		Dry Season Load (kg)	
	Total P	Total N	Total P	Total N
External Load	7,840	31,509	256	968
Internal Load	288	1,997	276	1,006
Total Annual Load	8,128	33,506	532	1,974

Source: lake water quality model calibration

The external and internal nutrient loadings are used in the Lake Water Quality Model to estimate future nutrient concentrations in the lake. This dynamic model uses Machado Lake specific monitoring data and study results as inputs to the model. As such, the external and internal loadings are described in subsections 2.3.1 and 2.3.2, respectively.

2.3.1.1 Baseline External Pollutant Loads

External loading is a product of nutrient sources predominantly from permitted urban runoff discharges delivered from an approximately 22.6-square-mile (14,444-acre) watershed draining into the lake. Additional external pollutant loads from permitted stormwater discharges are delivered directly to Machado Lake or the upper riparian woodland area from the following storm drains listed in Table 2-3. Wilmington Drain, Project 77, and Project 510 Line C are Los Angeles County-owned storm drains, while the D24010, P6545, and P36466 drains are Los Angeles City-owned storm drains. The sheet flow to Machado Lake comes from KMRHP and the golf course adjacent to Machado Lake.

Table 2-3
Characteristics of Storm Drains to Machado Lake

Subwatershed	Area (acres)	Description
Wilmington Drain	12,097	Concrete Lined Open Channel
Project 77 Drain	1,604	102-inch RCP Drain
Project 510 Line C	81	72-inch RCP Drain
D24010	158	78-inch RCP Drain
P6545	71	36-inch RCP Drain
P36466	37	36-inch RCP Drain
Sheet Flow to Machado Lake	108	NA
Total	**14,156**	**NA**

Note: an additional 1,337 acres of the Machado Lake Watershed are tributary to the areas below the lake (freshwater marsh) and are therefore excluded from this table. As such, only the area tributary to Machado Lake is shown here.

Historical water quality monitoring data was compiled and compared to establish the most appropriate data set to use as input to the Lake Water Quality Model.

The data sets that were reviewed include the following:

- BOS, Watershed Protection Division (WPD) water quality monitoring data from 2006-2008

- LACDPW water quality monitoring data from 1987-1995
- LACDPW Regional Event Mean Concentrations (EMCs) derived from data collected from 1994-2000

City of Los Angeles, Bureau of Sanitation Watershed Protection Division, Water Quality Monitoring Data from 2006-2008

Water quality monitoring of inflows to the lake was conducted by the BOS WPD in three storm drains that discharge to Machado Lake. The storm drain samples were taken from June 2007 through September 2008. Table 2-4 summarizes the data collected (refer to Appendix C for additional information). For dry weather, 102 samples were taken during this period. However, during wet weather only a limited number of samples were taken (nine were taken during a rain event, and another nine were taken between one and three days following a rain event).

Table 2-4
Machado Lake Storm Drain Water Quality and Field Collected Monitoring Data (June 2007 – September 2008)[1]

Constituent	Units	Minimum	Average	Maximum
Total Phosphorus (P)				
Dry Weather	mg/L	0.03	0.6	4.66
Wet Weather	mg/L	0.13	0.6	1.99
Total Nitrogen (N)				
Dry Weather	mg/L	1.29	2.7	18.42
Wet Weather	mg/L	1.77	2.8	5.71
Organic N				
Dry Weather	mg/L	0.42	1.6	15.4
Wet Weather	mg/L	0.76	1.1	2.3
Ammonia-N				
Dry Weather	mg/L	0.03	0.3	1.44
Wet Weather	mg/L	0.14	0.5	0.86
Total Suspended Solids (TSS)				
Dry Weather	mg/L	0.5	12	181
Wet Weather	mg/L	7	96	311
Total Hardness as $CaCO_3$				
Dry Weather	mg/L	134	360	1,000
Wet Weather	mg/L	15	120	264
Turbidity (dry and wet)	NTU	0[2]	6.93	131.20
Temperature (dry and wet)	Deg C	9.24	18.04	23.60
pH (dry and wet)	SU	7.53	8.09	9.09

Notes:
[1] Storm Drain samples were taken at three storm drain outfalls (Wilmington Drain above Lomita Blvd, Project 77 storm drain on the west side of Machado Lake, Project 510-Line C storm drain outfall on the west side of Machado Lake). The storm drain samples were taken from June 2007 through September 2008.
[2] Rounded to zero from a negative reading.

Additional wet weather sampling was performed for the City (CDM & Parsons 2010) during seven wet weather days from October 2009 through January 2010. Two samples were taken at each location for each rain event. A summary of the average at each of the three sampling locations is presented in Table 2-5.

Table 2-5
Machado Lake Wet Weather Sampling (2009 –2010 Wet Season)

Location	Total P (mg/L)	Dissolved Ortho-phosphate as P (mg/L)	Total N (mg/L)	Ammonia as N (mg/L)	Nitrate + Nitrite (mg/L)	Suspended Solids (mg/L)
Wilmington Drain	0.83	0.31	4.77	1.12	1.05	102.05
Project 77	0.82	0.53	5.77	1.26	1.5	104.27
Machado Lake Dam	0.53	0.28	1.48	2.82	0.33	101.49

Notes:
Samples were taken during the 2009-2010 wet season as part of a State Coastal Conservancy Grant for the City of Los Angeles. Seven rain events were sampled, with generally two samples taken per rain event per location. Sampling locations include Wilmington Drain south of PCH, at the Project 77 drain, at the Machado Lake dam.

Los Angeles County Department of Public Works, Water Quality Monitoring Data from 1987-1995

The LACDPW collected water quality samples at several locations within the Dominguez Watershed from 1987 through 1995. One sampling location was in the Machado Lake subwatershed, located in Wilmington Drain upstream of the PCH. These data are presented in the Dominguez Watershed Management Master Plan (LACDPW 2004) and below in Table 2-6. It is assumed that these data were collected during wet weather events based on the placement of the table within the Master Plan (within a subsection titled stormwater monitoring) but that is not stated explicitly.

Table 2-6
LACDPW Sampling Results for Wilmington Drain Sampling Location, 1987-1995

Pollutant	Units	Sample Results[1, 2]		
		Minimum	Average	Maximum
TSS	mg/L	13	225.2	1,143
Total P	mg/L	0.08	0.3	1.3
Ammonia-N	mg/L	0	1.0	15
(Nitrate+Nitrite)-N	mg/L	0	1.1	10.83

Notes:
[1] Average concentrations presented in the Dominguez Watershed Management Master Plan in Table 2.3-24 Summary of historic water quality data for the Dominguez Watershed.
[2] Presented are the Wilmington Drain sampling location results. From 1994-2000 there were 72 composite samples and 4 grab samples collected at another Dominguez Channel monitoring location but the number of samples taken at the Wilmington Drain monitoring location are not stated.

Los Angeles County Department of Public Works Regional Event Mean Concentration Monitoring Results Derived from Data Collected from 1994-2000

LACDPW maintains a data set of land use-based EMCs that were derived from the Los Angeles County's 1994-2000 monitoring data (LACDPW 2006). For the Los Angeles area as a whole, this data set is considered the most extensive, locally-derived data for a variety of land use types. The City of Los Angeles maintains a pollutant load model that utilizes these EMCs to simultaneously calculate loads and concentrations for each of the constituents of concern based on watershed land use and historical rainfall. The average wet weather water quality concentrations were calculated by the pollutant load model for the land use mix within the Wilmington Drain subwatersheds. These values are presented in Table 2-7.

Table 2-7
Comparison of Actual and Theoretical Wet Weather Pollutant Load Concentrations

Pollutant	Units	Sample Results			(Column D) Pollutant Load Model-Derived Concentrations[4]	(Column E) Average of Columns A-C
		(Column A) LA BOS 2006-2008[1]	(Column B) LACDWP 1987-1995[2]	(Column C) CDM & Parsons 2009-2010[3]		
Total P	mg/L	0.62	0.3	0.82	0.36	0.58
Dissolved P	mg/L	NA[5]	NA	0.42	0.27	0.42
Total N	mg/L	2.76	NA	5.27	3.77	4.02
Organic N	mg/L	1.14	NA	NA	2.22	1.14
Ammonia-N	mg/L	0.52	1.0	1.19	0.49	0.90

Notes:
[1] See Tables 2-4. Total P, dissolved-P, all nitrogen species, and TSS data are average concentrations of these constituents sampled at Wilmington Drain above Lomita Boulevard, Project 77, and Project 510 Line C under wet weather conditions. Data provided by WPD on December 1, 2008.
[2] See Table 2-6. Average concentrations presented in Table 2.3-24. Summary of historic water quality data for the Dominguez Watershed, in the Dominguez Watershed Management Master Plan.
[3] See Table 2-5. Average concentrations of storm drain samples at Wilmington Drain and Project 77 outfall under wet weather conditions.
[4] Using the City of Los Angeles pollutant load model that is based on LA County derived land use based event mean concentrations (EMCs), the land use in the Machado Lake watershed and historical rainfall. Does not account for possible load removed from Walteria Lake subwatershed, which usually retains stormwater after rain events. This practice could remove 50-60% of TSS and up to 40% of metals from the fraction of flow that is detained/retained. Walteria Lake is 25% of the tributary area to Machado Lake, so this would translate to loads to Machado Lake potentially being on the order of 10-15 percent lower than predicted.
[5] NA – not analyzed

Wet Weather Data Set Used in Lake Water Quality Model

Table 2-7 presents the average wet weather sampling data for Machado Lake and Wilmington Drain collected by BOS, LACDPW, and CDM & Parsons (from Tables 2-4, 2-5 and 2-6) as well as the predicted wet weather concentrations derived by the pollutant load model using the Los Angeles County EMC data. Column E is the average of the three actual wet weather sampling data sets. Following is a summary of the comparison of these three sets of data:

- In general, analytical results from the sampling programs are of a similar order of magnitude as the values derived using the area-wide EMC data in the pollutant load model.
- Total phosphorous estimated by the pollutant load model (Column D) is somewhat lower compared to the average of the three data sets (Column E).
- Total nitrogen estimated by the pollutant load model (Column D) is slightly higher compared to the average of the three data sets (Column E).

Since the data set for the measured wet weather monitored data (columns A, B and C) is representative of current conditions, it was used calibrate the lake water quality model. However, it was determined that the pollutant load model results (Column D) would be used in the Lake Water Quality Model to represent future conditions since the area-wide EMC data set used in the pollutant load model is considered more representative of long-term wet weather nutrient concentrations. Also, due to the upstream BMPs, including public education and outreach the future runoff to the lake is expected to have relatively lower total nitrogen and total phosphorus values.

Dry Weather Data Set Used in Lake Water Quality Model

For dry weather conditions, available water quality data for key parameters in dry weather urban runoff were reviewed. Based on the limited data sets available, it was determined that the most appropriate data set to use was the monitored data from the City of Los Angeles BOS water quality monitoring program, which is presented in Table 2-4. As such, this data set was used as the dry weather baseline concentrations input into the Lake Water Quality Model.

2.3.1.2 Internal Nutrient Load Determination

To establish the internal nutrient loading in Machado Lake, a study was conducted in 2009 for Machado Lake that estimated the flux of nutrients in the lake (Horne 2009). The laboratory study used undisturbed sediment cores and natural lake water contained in flux chambers to provide experimental values for the flux of nutrients from surface sediment layers. The results from the nutrient flux study were used to estimate baseline internal loading of nutrients in the lake from the sediment water interface. This data was used in the development of the baseline conditions in the Lake Water Quality Model.

In the laboratory study, sediment flux chambers were used to simulate the conditions in the lake. For several days the sediment flux chambers were maintained with gentle air bubbles to simulate aeration in the lake, followed by several days where the chambers were maintained at anoxic conditions via gentle nitrogen bubbling to simulate anoxic conditions that can occur in the summer and in the upper sediments. Following anoxic conditions, air was again bubbled in the chambers. A typical suite of nutrient measurements were made at each stage. A brief summary of the results are presented in Table 2-8.

Table 2-8
Nutrient Flux Results[1]

Parameter	Soluble Phosphate (mg/L)	Ammonia-N (mg/L)	Nitrate+ Nitrite-N (mg/L)	TIN[2] (mg/L)
Aeration (air, 2 days)	0.36 (0.40)	0.5 (0.43)	0.05	0.55
Anoxic (N_2 gas, 4 days)	(1.26)	(4.0)	0.05	4.8
Re-aeration (air; 15 days)	(1.1)	0.3 (0.02)	3.3	3.3

Note:
[1] Values not shown in parenthesis are from a certified lab; values in parentheses from a Hach kit.
[2] TIN = total inorganic nitrogen; (nitrate + nitrite + ammonia).

2.3.2 Baseline Toxic Loads

A limited set of site specific measured toxics data were available to determine baseline toxic loads. Baseline toxic loads were determined by analyzing sediment data sets collected at multiple points in time by multiple agencies as listed in Table 2-9.

Table 2-9
Summary of Machado Lake Sediment Data Sets

Source	Sample Date
City of Los Angeles, Machado Lake Watershed Management Plan	May 14 & 15, 2001
SWAMP	August 4, 2003
City of Los Angeles	October 22, 2008
Regional Board	January 14, 2009

Source: Regional Board *Machado Lake Pesticides and PCBs TMDL.*

Of relevance to this study are measured watershed runoff concentrations of sediment-bound pollutants obtained in 2008 and in-lake shallow sediment pollutant concentrations obtained in 2003 and 2009 as summarized in Table 2-10. Measured lake water column concentrations of the targeted toxic pollutants were not available.

Table 2-10
Machado Lake Water Sediment Toxics Data

Lake Region	Sample Date	Sample Depth (cm)	Constituents of Concern (µg/kg)			
			Total Chlordane	Total DDT	Dieldrin	PCBs
North Lake	May 14-15 2001	20- composite	5.8	5.8	ND	No data
Mid North Lake	May 14-15 2001	20- composite	1.4	4.4	ND	No data
Mid Lake	May 14-15 2001	20- composite	2	2	ND	No data
Mid Lake South	May 14-15 2001	20- composite	7	ND	ND	No data
South Lake	May 14-15 2001	20- composite	3	2	ND	No data
North Lake	August 4, 2003	2	39.75	64.22	ND	94.1
Mid North Lake	August 4, 2003	2	60.73	76.13	ND	115.8
Mid Lake	August 4, 2003	2	40.93	57.13	ND	119.3
Mid Lake South	August 4, 2003	2	82.29	80.14	1.54	87.5
South Lake	August 4, 2003	2	64.01	57.35	1.1	75.2
North Lake	October 22, 2008	15	No data	4.69	No data	No data
North Lake	October 22, 2008	76	No data	8.38	No data	No data
Mid Lake (west side)	October 22, 2008	15	No data	10.04	No data	No data
Mid Lake (west side)	October 22, 2008	76	No data	8.7	No data	No data
North Lake	January 14, 2009	2	98.5	ND	ND	16.6
Mid Lake	January 14, 2009	2	56.4	34.8	ND	35.2
South Lake	January 14, 2009	2	60.7	19.8	ND	22.7
South Lake	January 14, 2009	2	67.1	51.9	ND	68.6

Notes:
ND = Non Detect
Detection limit is 1 µg/dry kg
Source: Regional Board *Machado Lake Pesticides and PCBs TMDL*

The in-lake toxic concentrations presented here are the result of two types of toxic loading processes:

- **External Loading:** Toxics impairment in Machado Lake is a factor of historical external loading as the toxics were previously banned from use in the US. Additional toxics loading into the lake is attributed to erosion of toxic contaminated sediments higher in the watershed and atmospheric deposition. A small percentage of external loading is attributed to atmospheric deposition of the contaminants related to historical usage.

  External loading is a product of historical external loading predominantly from permitted urban runoff discharges delivered from an approximately 22.6-square-mile (14,444-acre) watershed draining into the lake. External pollutant loads from permitted stormwater discharges are delivered directly to Machado Lake or the upper riparian woodland area from the multiple storm drains previously listed in Table 2-3.

  A small number of toxics samples were obtained in December 2008 from both Wilmington Drain and the Project 77 drainage basin (CRWQCB 2010) as provided in Table 2-11. No pollutants were detected in the Project 510 Drain. Therefore, event mean concentrations were only developed for Wilmington Drain and Project 77.

Table 2-11
Observed External Concentration of Toxics at Machado Lake

Pollutant	Observed Concentrations (µg/kg)		
	Wilmington Drain	Project 77	Project 510
Chlordane	25.4	6.7	ND
Total DDT	18.5	1.5	ND
Dieldrin	19.2	ND	ND

Notes:
ND = Non Detect
Detection limit is 1 µg/dry kg
Source: Regional Board *Machado Lake Pesticides and PCBs TMDL*

- **Internal Loading:** Machado Lake acts as a reservoir for the toxics with minimal discharge of the contaminants to downstream waterbodies. Additional constituent losses occur through natural breakdown, albeit at a slow pace. As the toxics accumulate in the lake, the toxics migrate into the water column and ultimately benthic organisms. From benthic organisms the toxics move up the food chain contributing to fish tissue impairment. Almost all toxics loading in the lake is attributed to internal loading.

2.3.3 Lake Water Quality Model

The Lake Water Quality Model is a numerical model that was constructed to evaluate the complex dynamics within the lake, including internal and external loading of nutrients and toxics. As such, the model is based on in-lake dynamics, historic pollutant loading (see Sections 2.3.1 and 2.3.2), and the nutrient flux study performed for Machado Lake (see Section 2.3.1.2). Initially the model was developed to simulate nutrients and was subsequently adapted to additionally simulate toxics. The Lake Water Quality Model for nutrients and toxics is described in detail in Appendix C and summarized here.

2.3.3.1 Nutrients Model Development

The lake water column is simulated as a fully mixed system, also termed a "continuously stirred tank reactor," or CSTR. This assumption is known to approximate lake dynamics for small, shallow lakes, such as Machado Lake, where mixing (e.g., diffusion, wind turbulence) dominates over advection (e.g., transport of pollutants by the motion of flowing water). Lake volumes are assumed steady on a daily basis (outflow = inflow) but can be varied monthly to account for summer losses (e.g., evapotranspiration [ET]). The model targets the key parameters of this eutrophic lake: phytoplankton (as chl-*a*), phosphorus (P), and nitrogen (N). The model was constructed in Microsoft *Excel* to allow for easy adaptation of code to address various potential rehabilitation options and alternatives.

Internal loads of N and P, released by the sediments back to the water column, are calculated with a separate module. For these calculations, a second vertical layer was added to the fully mixed water column to represent surface, biologically-active sediments. The size of this layer is defined by a user-specified depth (d) and porosity (ρ). Within the sediment layer, the following sediment nutrient dynamics are simulated:

- Lumped nutrient mineralization (of organic particulate nutrients) and desorption (of sediment-bound nutrients)

- Nutrient adsorption (from pore water to sediments)

Note that the model requires both oxic and anoxic rate constants for defining these two processes, where the extent of surface sediment anoxia (by percentage of lake bottom) is specified on a monthly basis by the user.

A conceptual depiction of the model mechanics is provided in Figure 2-3. The model simulates total phosphorus and total nitrogen on a daily timestep. Particulate and dissolved fractions are estimated based on user-input constant particulate fractions. Simulated external sources of phosphorus and nitrogen include: wet weather runoff, dry weather baseflow, and supplemental "make-up" water pumped into the lake during summer months. Other potential external sources of nutrients, including wildlife and atmospheric deposition of nitrogen, are not explicitly included in the model.

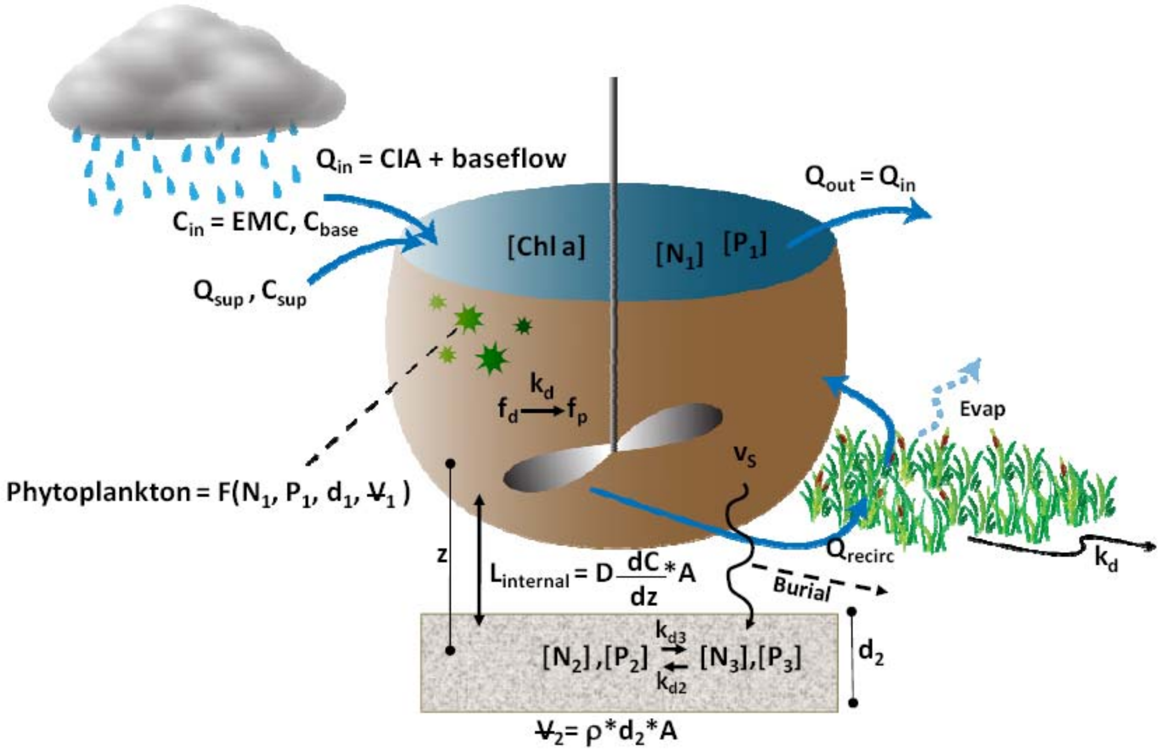

Figure 2-3 Machado Lake Water Quality Model for Nutrients

Internal processes included in the model are:

- N and P settling (particulate fractions only),
- First-order assimilation of N and P (dissolved fractions only), and
- Internal loading of dissolved N and P from the sediment to the water column.

First-Order Assimilation of N and P

Dissolved nutrient removal (uptake) from the water column, parameterized by k_d, is included as an inflow load to the particulate nutrient pool. In other words, this process is a transformation of nutrient forms (from dissolved to particulate), rather than a complete removal of dissolved nutrients. This captures the dynamic of phytoplankton uptake, which is believed to be driving water column nutrient assimilation during the summer, and also facilitates the coupling between water column and sediment layer calculations. The importance of this phenomenon to the lake nutrient cycle is supported by historical measured in-lake particulate fractions of both N and P.

Both k_d (first order removal rate constant for water column) and v_s (particulate fraction settling rate) are allowed to vary seasonally. This is done to capture the seasonal dynamics of phytoplankton in the lake. Uptake is believed to be highest during the summer months, while net settling rates are believed to be lower during the summer when live phytoplankton, rather than sediment, dominates the particulate nutrient pool.

Internal Loading of N and P

Internal loads of N and P, released by the sediment back to the water column, are calculated with a separate module. For these calculations, a second vertical layer was added to the fully mixed water column to represent surface, biologically-active, sediment (Figure 2-3). The size of this layer is defined by a user-specified depth (d) and porosity (ρ). Both sediment-bound and porewater nutrient concentrations are calculated within this layer based on standard formulations found in the literature (e.g., Cerco & Cole 1993; Pollman 2000). Sediment-bound nutrients are replenished via settling of particulate fraction nutrients in the water column. Movement from the sediment-bound nutrient pool to the porewater pool occurs via a first order lumped mineralization/desorption rate. Movement in the opposite direction (porewater to sediment) occurs via a first order adsorption rate. Both rates are variable depending on the oxic state of the sediment. Transport of nutrients from the sediment porewater to the lake water column, and at times vice versa, is calculated following a standard Fickian diffusion formula.

Based on this model, predicted nutrient concentrations in the lake after the implementation of the various in-lake BMPs (see Section 3) is summarized in the compliance analysis section (see Section 5). Refer to Appendix C for a detailed discussion on the Lake Water Quality Model for Nutrients.

2.3.3.2 Toxics Model Development

The Lake Water Quality Model described above was adapted to simulate toxics rather than nutrients, in Machado Lake. As described previously, the Lake Water Quality Model simulates a well-mixed water column coupled with a shallow sediment pollutant module that includes dynamic interactions between sediment-bound pollutants, sediment porewater pollutants, and overlying water column pollutants. The toxics model focuses on only those in-lake processes and mechanisms relevant to toxic pollutants. These include flushing, settling of sediment-bound pollutants, accumulation in shallow sediments, and subsequent re-release in dissolved form.

The toxic pollutants included in the adapted model are PCBs and three pesticides: chlordane, DDT, and dieldrin. All four pollutants are assumed to be conservative in the model; i.e. the model assumes no decay, volatilization, or chemical transformations. This is believed to be an approximately valid assumption given the known persistence in the environmental of these legacy pollutants. However, as with nutrients, a certain fraction of settled pollutants are “buried” in deeper sediments and assumed unavailable for subsequent re-release. This effectively removes a portion of the settled pollutant load from the system. All four pollutants are also known to have a high affinity for sediment binding and low water solubility (CRWQCB 2010). Consequently, the fraction particulate for incoming and suspended pollutants was assigned to 1.0 in the model.

The key dynamic processes included in the toxics model (Figure 2-4) are:

- External loading from watershed runoff and dry weather baseflow

- Flushing of pollutants entrained in the water column
- Settling of sediment-bound pollutants, and
- Adsorption and desorption of pollutants in the shallow sediment layer.

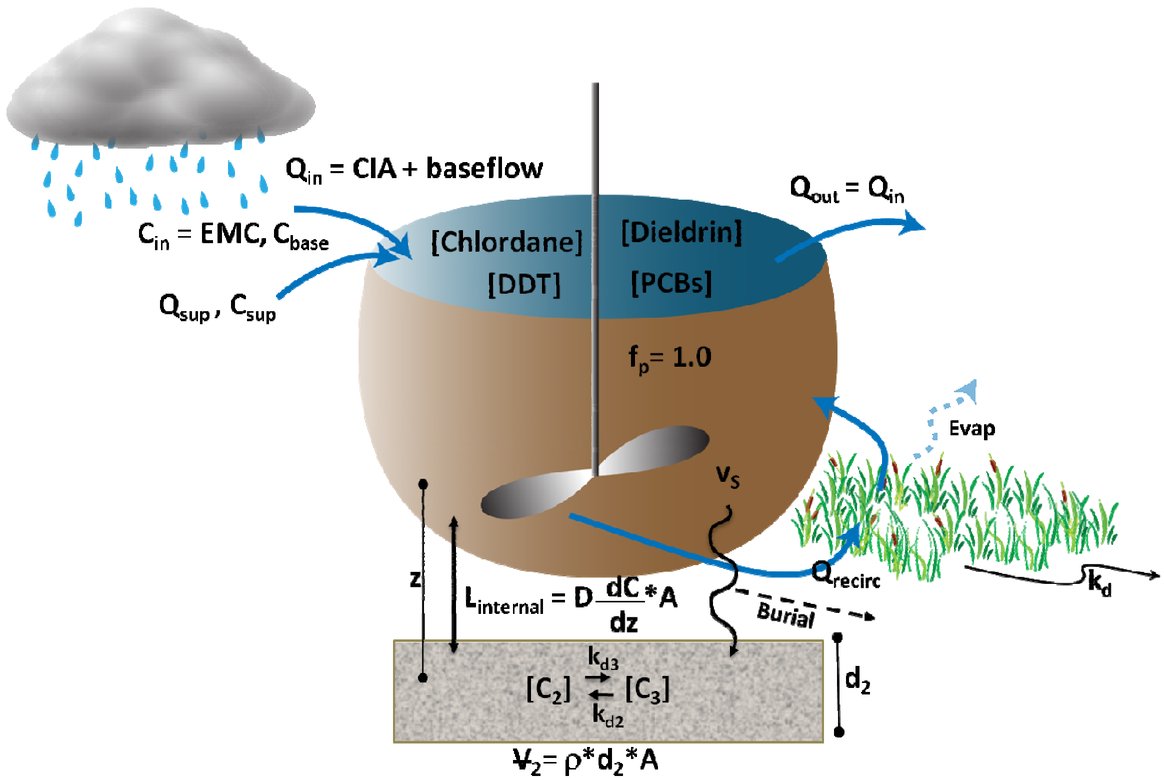

Figure 2-4
Machado Lake Water Quality Model for Toxics

Key inputs specific to the toxics model include: watershed runoff and baseflow pollutant concentrations, sediment-bound pollutant settling rates and burial fraction, and sediment layer adsorption (k_{d3}) and desorption rates (k_{d2}). Model outputs used in this study are daily water column and shallow sediment-bound pollutant concentrations. All other model parameters, including the physical characteristics of the shallow sediment layer, the lake water column, and the watershed, were retained from the previously-parameterized nutrient water quality model.

Based on this model, predicted toxic concentrations in the lake after the implementation of the various in-lake BMPs (see Section 3) is summarized in the compliance analysis section (see Section 5). Refer to Appendix C for a detailed discussion on the Lake Water Quality Model for Toxics.

Section 3
Implementation Plan

Residents of Los Angeles approved Proposition O, a $500-million bond measure, in 2004 to improve water quality for water bodies within the City. The City prepared Concept Reports for both the Machado Lake and Wilmington Drain projects in December 2006, identifying the funding needed for design and construction. Based on the Citizens Oversight Advisory Committee (COAC) and Administrative Oversight Committee (AOC) recommendation, City Council authorized $117 million of Proposition O funding for the two projects. The project, now a combination of the two and referred to as the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project*, is currently in the bid phase, and the construction phase will involve installation of a number of BMPs that will restore water quality and comply with TMDL targets for Machado Lake.

The Implementation Plan component of the LWQMP describes the specific BMPs that will be constructed by the City within Wilmington Drain and the portion of the KMHRP from PCH to the Machado Lake dam that are necessary to meet the City's TMDL responsibilities to restore water quality in Machado Lake. The cumulative effect of the BMPs selected for construction will enhance Machado Lake water quality, achieve ecosystem restoration objectives, and mitigate the City's contribution of nutrient and toxic loading to Machado Lake.

3.1 Implementation Plan Approach

The planning, design, and construction of the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project* was guided by four main objectives outlined in Proposition O—1) water quality improvement,; 2) flood control, 3) ecosystem restoration, and 4) recreation enhancement. The management strategies (i.e., the integrated group of recommended BMPs) selected for Wilmington Drain acknowledge the function of the channel as a sedimentation basin, and those selected for Machado Lake acknowledge the cumulative impacts of external loading and internal lake loading. Selecting the most effective suite of BMPs evolved through a detailed evaluation, ranking, and prioritization process that was driven by the over-arching goal of restoring lake water quality and meeting the regulatory requirements set forth in the Nutrients and Toxics TMDLs. The final design solution derived after a thorough evaluation of three different alternatives for Wilmington Drain and six different alternatives for Machado Lake will serve as the foundation of the Implementation Plan for this LWQMP. Construction of the final design of the two projects is slated to begin in 2013. The integration of the management strategies summarized below will achieve the City's Proposition O objectives, Most of the BMPs provide some pollutant load reduction (some more quantifiable than others) necessary to meet the LA and WLA established for the City in the Nutrients and Toxics TMDLs.

3.1.1 Description of Management Strategies

Table 3-1 provides the comprehensive list of management strategies that are being constructed to accomplish the necessary reductions in pollutant loads to Machado Lake and to achieve the objectives of the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project*. Table 3-1 also lists the partner agencies within the Machado Lake watershed responsible for implementation. The management strategies, which focus on reducing external or internal nutrient and toxic loads, are organized into two general categories—1) nonpoint source BMPs, and 2) point source BMPs. Nonpoint source BMPs include strategies that are designed to achieve LAs; point source BMPs are targeted to achieve WLAs.

Table 3-1
Management Strategies to Reduce Nutrient and Toxics Loading In Machado Lake

Management Strategy	Location	Implementation Lead
Nonpoint Source BMPs		
Lake Dredging	Machado Lake	LA City
Add Supplemental Water During Summer Dry Season– microfiltration/reverse osmosis	Machado Lake	LA City
Oxygenation System[1]	Machado Lake	LA City
Off-line Treatment Wetland	Machado Lake	LA City
Phosphorus Removal System[1]	Machado Lake	LA City
Aquatic Plant Management and Littoral Zone Enhancements, including Ludwigia Removal	Machado Lake	LA City
Shoreline Erosion Control (Lake Edge) Treatments	Machado Lake	LA City
Golf Course Maintenance Yard Site BMPs	KMHRP	LA City
KMHRP Design Improvements (WQ benefits), including Southern Tarplant enhancement	Wilmington Drain, Machado Lake	LA City
Point Source BMPs		
In-Lake Sediment Basin – North (captures inflows from Drain P6545, Drain D24010, and Wilmington Drain)	Machado Lake	LA City
Re-grade entire Wilmington Drain channel bottom	Wilmington Drain	LACDPW
Clean box culverts at Lomita Blvd.	Wilmington Drain	LACDPW
Clearing and annual maintenance of channel vegetation	Wilmington Drain	LACDPW
CDS at D24010 Drain	KMHRP	LA City
Bioengineered swale at Project 77 Drain (dry weather treatment)	KMHRP	LA City
Bioengineered swale at Project 510 Line C Drain (dry weather treatment)	KMHRP	LA City
Graded channels between D24010 and Machado Lake	KMHRP and Machado Lake	LA City
Graded channels between Figueroa Drain and Harbor Outlet	KMHRP and Machado Lake	LA City
Trash Nets at Wilmington Drain/110 Fwy; Project 510 (Pine Creek) Channel	Wilmington Drain, Machado Lake	LA City
CDS at Figueroa Drain	KMHRP	LA City
CDS at Project 77 Storm Drain	KMHRP	LA City

[1] The oxygenation system and phosphorus removal system may be removed from the project if it is decided to utilize microfiltration/reverse osmosis water beyond the dry season.

The collective integration of all BMPs coupled with long-term operation and maintenance activities is necessary to meet the water quality objectives of Nutrients and Toxics TMDLs. Therefore, inter-agency and inter-departmental collaboration are essential to advancing stewardship, implementation, maintenance, water quality monitoring, and the evaluation of progress. The construction and operation of these management strategies is necessary to meet the City's commitment toward TMDL implementation.

Table 3-2 lists other voluntary strategies that are important design components of the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project*.

Table 3-2
Additional Management Strategies for Machado Lake Ecosystem Restoration

Management Strategy	Location	Implementation Lead
Wilmington Drain Pocket Park	Wilmington Drain	City
Dam Improvements	Machado Lake	City
Invasive Plant Removal - Riparian Woodland and Freshwater Marsh	KMHRP	City

Figure 3-1 on the following page displays the general location of the various BMPs that are listed in Table 3-1 and Table 3-2. Descriptions of each management strategy are provided in the following subsections.

3.1.2 Strategies to Meet Load Allocations

Management strategies necessary to achieve the LA consist of BMPs that are designed to specifically target in-lake nutrient loads, toxics in sediment loads, and nutrients associated with nonpoint source runoff transported from KMHRP to Machado Lake via overland flow. The nonpoint source BMPs provide specific reductions in nutrient loads and toxics by removing a large amount of nutrient-rich lake-bottom sediments, reducing sediments and nutrients transported to Machado Lake from the golf course and KMHRP, and reducing suspended sediments containing toxics. Some of the BMPs indirectly address related water quality issues and can provide additional reasonable assurances that compliance with lake nutrient and toxics targets can be achieved. The strategies designed to meet the LA are the direct responsibility of BOS and RAP. The list of in-lake nonpoint source BMPs that will be implemented to achieve the nutrients and toxics LAs are summarized below.

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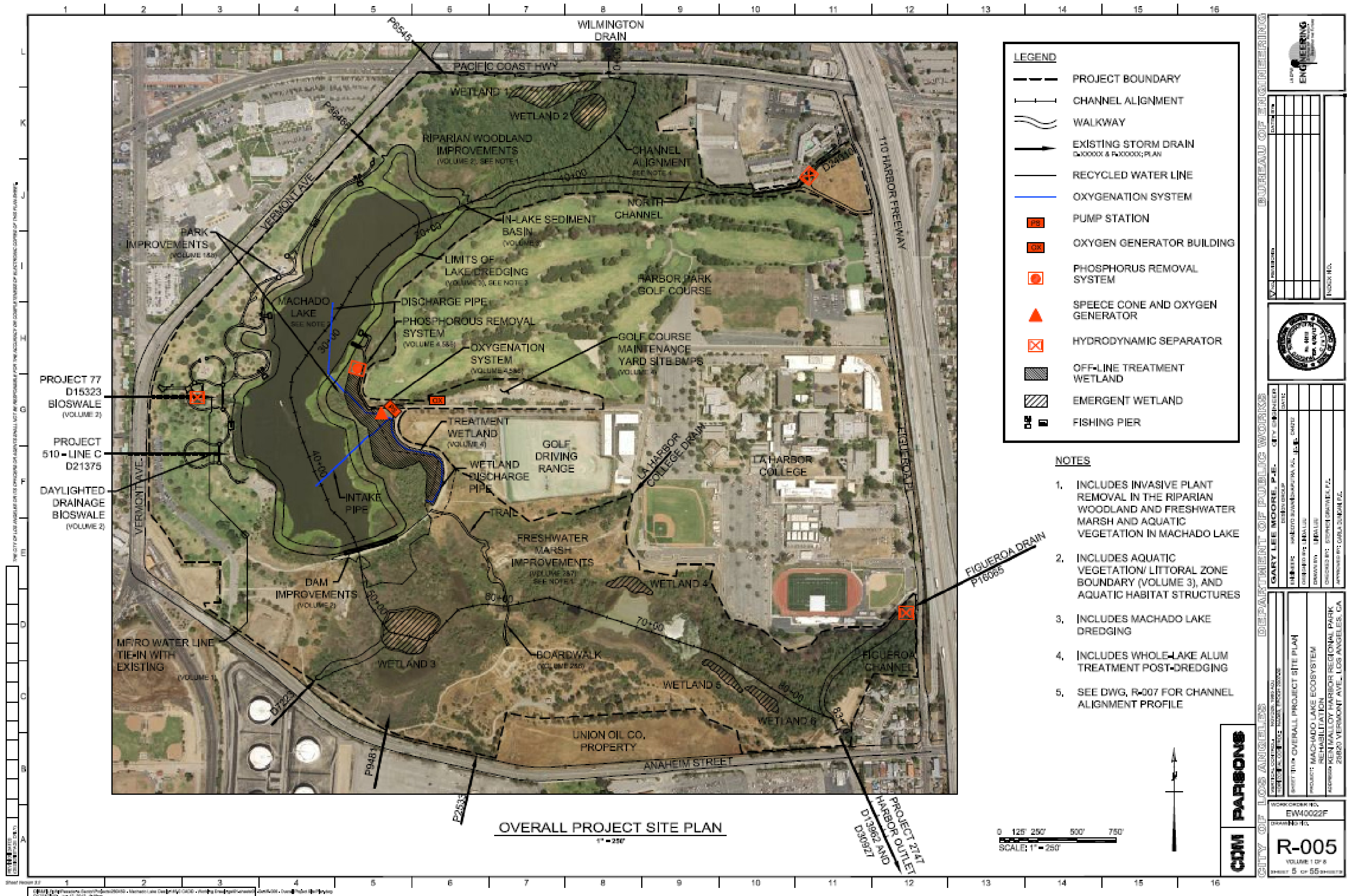

Figure 3-1
Schematic Layout of Management Strategies

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3.1.2.1 In-Lake BMPs

An integrated suite of lake rehabilitation strategies will be implemented to address recycling of in–lake nutrient loads and suspension of toxics in sediments. Key components include dredging to an average depth of 6 feet and maintaining a constant lake water surface elevation by using a supplemental water source. Recycled microfiltration/reverse osmosis (MF/RO) water will be used for lake augmentation purposes to maintain full lake levels in the summer. An offline-treatment wetland, an aeration system, and phosphorus removal system will also help satisfy the water quality objectives of the project. The phosphorous removal system and aeration systems may be removed from the project if it is decided to utilize MF/RO water beyond lake augmentation purposes. Each strategy must be implemented in concert with the others to meet water quality objectives and goals. The Regional Board approved sediment dredging to a water depth of 6 feet for a proposed Machado Lake Ecosystem Rehabilitation Project on August 29, 2013 (401 Certification File No. 12-054). In addition, underwater capping with Aquablok® and a minimum 6-inch layer of clean, non-saline, loamy-sand will be provided for aquatic habitat on the lake bottom.

Details of the suite of in-lake rehabilitation strategies include:

- **Hydraulic dredging to remove nutrient-rich lakebed, toxics in sediment, and lake edge sediment**. Sediment is a two-fold problem in Machado Lake: (1) Sediment accumulation decreases the lake depth, which over time allows increased macrophyte and algae growth; and (2) internal nutrient loading from lakebed sediment into the water column is believed to be a major contributor to water quality degradation in Machado Lake. Lake edge dredging will primarily focus on reshaping the east and west banks to diversify the lake edge configuration and environment. Dredging activities will create a shallow, contoured underwater shelf or terrace in these areas suitable for establishing a littoral zone with desirable aquatic vegetation. Lake edge improvements include re-contouring portions of the lake that have been highly impacted by elevated levels of sediment inflow in ways that will benefit water quality and habitat and stabilize lake edges by removing soft sediment down to a more firm substrate layer. Implementation of this BMP requires the removal of approximately 216,700 cubic yards of sediment from Machado Lake. This volume may increase if bid costs are less than anticipated. It is the most costly in-lake sediment management option; however, because of the additional benefits received by dredging, including increasing/creating recreational opportunities, removing toxics in sediment, and improving aquatic habitat, it is considered cost-effective for Machado Lake.

- **Supplemental water (low-nutrient) to maintain lake levels** during the dry season. Field data from Machado Lake has shown that the lake loses approximately 2 feet of water due to evaporation during each summer dry season (RWQCB 2008). Additionally, water quality analysis results reveal that nutrient levels in the lake tend to increase during the dry season due mainly to evaporation and conditions of the lake that promote internal nutrient recycling as a result of the lack of inflow from any source (City of Los Angeles 2004). This decrease in water depth contributes to the overall water quality problem in the lake. Recycled MF/RO water from Terminal Island Water Reclamation Facility (TIWRP) will be piped as the source of supplemental water for Machado Lake.

- **An oxygenation system** will supplement dissolved oxygen (DO) to enhance water quality and mitigate the potential for eutrophication and odor. The water quality model demonstrates that significant water quality improvements can be achieved through oxygenation, particularly during the hot, dry months from May through October, when DO in the water column is most critical. The Speece Cone, Downflow Bubble Contact Oxygenator, is the recommended oxygenation system for Machado Lake. The system directly targets the sediment/water interface for the delivery of oxygen. This is accomplished by taking water near the bottom of the south end of the lake, where the temperature is lowest and the water most dense, pumping the water through the Speece Cone, and then discharging the oxygenated water again near the bottom of the north end of the lake. While the capital costs are higher than air-based systems, the Speece Cone itself has no moving parts, which minimizes maintenance requirements. The Speece Cone will be located on the east side of the lake adjacent to the treatment wetland and phosphorous removal system. The oxygenation system may be removed from the project if it is decided to utilize MF/RO beyond levels required to sustain the lake level in the dry season.

- Construction of an **off-line treatment wetland** that circulates lake water through a nutrient and sediment removal wetland to further reduce nutrients within the lake, remove potentially toxic laden sediment, and improve water quality. To implement this BMP, a treatment wetland will be constructed along the east side of Machado Lake to provide a means of long-term, nutrient and sediment removal.

- Construction of a **phosphorus removal system using Media Adsorption**. The concept of a Media Adsorption method involves pumping lake water continuously through a set of pressure rated treatment vessels containing an industry approved adsorption media. Water is pumped either directly from the lake in winter months or from the end of the re-circulating treatment wetland in summer months. Water entering the treatment system is conditioned with an in-line carbon dioxide gas diffusion to lower pH to optimal levels (~7.4) for phosphorus adsorption. Water then continues through two treatment vessels in a lead-lag configuration to first remove the bulk of phosphorus from the water in the first tank and then polish any remaining phosphorus out of the water in the second tank. Water exiting the second tank is discharged directly back to the lake. The media used in the treatment system has a limited lifetime dependent upon phosphorus concentrations and the levels of other constituents in the water. After a period of time, some media may lose its ability to adsorb phosphorus resulting in the need for periodic maintenance. At this point, the media can be regenerated with a caustic backwash to remove bound phosphorus, other constituents, and clogging particulates. The media will typically be able to undergo three regeneration cycles before needing to be replaced with fresh media. Caustic backwash solution is conveyed to the site for use during backwash events and removed from the site when backwashing is complete, eliminating the need to store caustic solution. Spent media can be disposed of as non-hazardous material at a standard landfill. The phosphorous removal system may be removed from the project if it is decided to utilize MF/RO beyond levels required to sustain the lake level in the dry season.

- **Aquatic plant management**, including macrophyte management and littoral zone modifications/enhancements that would improve overall water quality and reduce vector breeding grounds. Aquatic plant management refers to controlling nuisance species (i.e., primarily *Ludwigia*, but to a lesser extent, also tules and cattails), to maximizing beneficial aspects of plants in water bodies, and to restructure plant communities. Management activities will emphasize the establishment of diverse native macrophyte communities (emergent and submerged) along an underwater shelf (e.g., terrace) as well as the removal of selected invasive macrophytes. Implementation of this BMP also provides secondary benefits through periodic removal of nutrient rich and potentially toxic laden sediments along the lake shoreline.

- **Shoreline stabilization** to enhance aquatic and riparian habitat and limit nutrients and sediment entering the lake from lake shore erosion. This BMP incorporates highly refined design elements that seek to restore the entire edge of the lake with appropriate slopes and aquatic vegetation species that will prolong the ability of the littoral zone to uptake nutrients. Shoreline stabilization will be implemented in conjunction with the aquatic plant management activities.

3.1.2.2 Park BMPs

Additional BMPs will target nonpoint source nutrient loading that originates from the riparian woodland area upstream of Machado Lake and the portion of KMHRP that surrounds Machado Lake. These BMPs may also potentially reduce conveyance of sediment containing toxics. Although the expected pollutant load reductions attributable to these BMPs cannot be quantified, these management strategies will improve stewardship of the Machado Lake ecosystem, provide additional potential nonpoint source reductions, and offer additional efforts toward achieving a healthier Machado Lake. The BMPs targeting nonpoint source runoff assigned to the LA include:

- **Habitat and Park Design**—An intensive program of invasive plant species removal will take place throughout KMHRP. Invasive species like *Ludwigia* will be removed, while the Southern Tarplant and the Coastal Sage Scrub will be replanted to enhance habitat. The design elements of the new park design will enhance the recreational benefits of the project and promote ecosystem restoration and nonpoint source pollution abatement and education.

- **BMPs to mitigate storm water runoff from City Golf Course Maintenance Yard.** Several improvements are proposed to the existing Golf Course maintenance yard, including a new vehicle wash rack, expanded improved bulk storage bins, and BMPs to treat runoff. The existing wash rack will be demolished to construct a 47-foot by 28-foot, roofed structure. The wash rack will be sloped to direct flows into a catch basin that captures grass clippings and large debris and can be manually cleaned. From the catch basin, runoff will flow into an underground clarifier before discharging into the sanitary sewer line. The existing bulk storage bins will be demolished to build larger bins with higher walls, which will completely contain the stored material. Tarps will be provided to cover stored materials. A small berm at the exterior of the storage bins will direct runoff to the west into a dry well structure designed for Standard Urban Stormwater Mitigation Plan (SUSMP) storm. During larger storm events, the dry well will overflow into an earthen swale that will also capture runoff from the entire west portion of the maintenance yard. The swale will discharge into an infiltration basin designed to capture the SUSMP storm. Treated runoff will then be drained to the lake.

- **Wetlands—In addition to the offline treatment wetland adjacent to the lake** (**see abov**e), emergent wetland improvements will also be made in the riparian woodland and lower freshwater marsh. The objectives of the wetland improvements are to provide additional filtration of storm water runoff from Wilmington Drain, D24010 Drain, and other storm water drains that discharge into these areas as well as providing new and better quality wetland habitat for wildlife associated with these areas. The emergent wetlands will be planted with southern bulrush, which is recognized for its sediment retention and water quality improvement capabilities. The riparian woodland areas north of the lake will be planted with willow, cottonwood, and other woody species to help keep trash and other coarse debris from entering the lake during major storm runoff events.

3.1.3 Strategies to Meet Waste Load Allocation

Other BMPs that will be constructed are specifically designed to mitigate point source loading from upstream permitted stormwater discharges. These BMPs will contribute to improving the health of Machado Lake and achieving compliance with the nutrient and toxics water quality targets set by the WLAs. These BMPs will provide positive benefits to the water quality in Machado Lake by reducing the long-term build-up of sediments in the lake and thereby maintaining deeper lake levels which is a one of the key implementation strategies for improving lake water quality. BMPs will focus on reducing pollutant loads conveyed from Wilmington Drain and three major storm drain outfalls—D24010, Project 510 Line C Drain, and Project 77 Drain. The BMPs targeted for Wilmington Drain focus on increasing the hydraulic capacity of the channel as well as the sediment storage capacity thereby decreasing the sediment loads transported to Machado Lake. Wilmington Drain BMPs include:

- **Re-grade the Wilmington Drain channel bottom** creating an in-channel sediment basin at the south end, immediately north of PCH. The flat channel bottom will result in the removal of more than 30,000 cubic yards of sediment. This will remove accumulated sediment that currently hampers stormwater conveyance and provide significant future sediment storage capacity.

- **Clean out box culverts** under Lomita Boulevard and PCH and re-grade transition zone in channel above and below box culverts as necessary. This will also diminish the amount of sediment available for transport downstream to each culvert.

- **Clear vegetation from the channel bottom** and selectively remove invasive plant species on channel banks on an annual basis. This will improve the hydraulic storage capacity of Wilmington Drain.

Re-grading Wilmington Drain and removing approximately 30,000 cubic yards of sediment provides significant additional needed sediment storage capacity. The clearing and excavation of the channel does not impact the island north of PCH or other documented sensitive habitat.

Other BMPs that will address stormwater discharges to Machado Lake include:

- **Installation of hydrodynamic separation devices at storm drains D24010, Project 77, and the Figueroa Drain**, the Continuous Deflection Separation (CDS®) system manufactured by Contech Construction Products Inc. A CDS® is a widely-used structural BMP device designed to capture pollutants such as trash and sediments in storm drain systems. This technology typically consists of flow-through structures that use the passive energy of the flow to separate the solids from liquid through a non-blocking, non-mechanical screening chamber and settles the pollutants into a sump for storage and eventual collection. The primary benefit of this BMP is derived from its ability to remove sediment loads that would be transported to Machado Lake. This is another BMP that aims to reduce the amount of sediment deposition occurring in Machado Lake.

- **In-lake sediment trap** to improve water quality by localizing sediment deposition to facilitate more frequent removal and thereby extend the timeframe for a deeper lake. In-lake sediment traps are depressions created at storm drain outfalls. At the north edge of the lake, the lake would be graded a few feet deeper than the surrounding lakebed and lined with a structural material to reinforce the bottom. The intent is to create a submerged stilling basin at the drain outfall that will collect sediment in a defined, localized area that can be easily accessed for removal. Material used to protect the basin structure includes interlocking articulated open-cell or closed-cell varieties of concrete blocks and should extend the full length of the basin. An access road will be constructed to allow equipment to reach these areas of the lake for long-term maintenance.

- **Construction of bioengineered swales at the stormwater outfalls of Project 510 Line C and Project 77 Drain**, which are effective at reducing nutrient levels from dry weather flows delivered to Machado Lake.

- **Trash Nets at Wilmington Drain/110 Freeway and Project 510 (Pine Creek) Channel** are not designed to specifically reduce sediment or nutrient loading to Machado Lake. However, they are an important BMP that will allow the City to advance the goal of a healthy lake and achieve other water quality program requirements. Characteristics of each trash net include:

- ***Wilmington Drain @ 110 Freeway*** - The trash net structure will be an in-line, 22-net system as manufactured by Fresh Creek Technologies, Inc. The trash net structure would be located within Wilmington Drain just downstream of the concrete channel discharge under the 110 Freeway. The system will use the passive energy of the influent stream to drive the trash/floatables into the disposable nets. The nets will collectively treat a design flow rate of 764 cfs with an anticipated head loss of approximately 3 inches. The nets will have the capability to collapse to pass the higher storm events (peak flow rate of 5,028 cfs) in order to minimize system head loss while still retaining previously captured trash. The nets will be serviceable from the south side of the structure with a truck-mounted crane and several dump trucks.

- ***Project 510 (Pine Creek) Channel*** - The trash net structure will be an in-line, 3-net system as manufactured by Fresh Creek Technologies, Inc. The trash net structure will be located within the Project 510 trapezoidal concrete channel just east of Wilmington Drain. The system will use the passive energy of the influent stream to drive the trash/floatables into the disposable nets. The nets will collectively treat a design flow rate of 133 cfs with an anticipated head loss of approximately 0.1 inches. The system will have the capability to pass the higher storm events (peak flow rate of 638 cfs) in order to minimize system head loss while still retaining previously captured trash. The nets will be serviceable from the south bank of the trapezoidal channel with a truck-mounted crane and a dump truck.

3.1.4 Miscellaneous Design Components

Other design elements that are incorporated into the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project,* which support the Proposition O ecosystem restoration and recreation goals, are summarized below. While these BMPs do not have a direct effect on the health of Machado Lake they are important components of the overall project design and do advance environmental improvement.

- **Construct park on west side of Wilmington Drain, south of Lomita Boulevard** to advance education and outreach on ecosystem restoration. Site specific BMPs will be incorporated to capture runoff from the park and pet waste disposal bags will also be provided in the park.

- **Dam modifications for operational flexibility and public safety.** Several design features are proposed to improve the lake level control, safety, and the visual appearance of the Machado Lake Dam. To provide the maximum flexibility for regulating lake water levels, a combination of a high level box culvert system and a low level pump system will be incorporated as part of the Machado Lake Dam improvements. The high level culverts can lower the lake level to 9 feet msl for maintenance purposes or in advance of small storms. With the addition of the pumps, it is possible to draw the entire lake water surface to elevation 7 feet msl (or below). The dam crest will be overlain with 4 inches of decorative concrete and a decorative guard rail will be added to the upstream face for safety considerations. As part of the improvements, water levels will be monitored in Machado Lake. The operational flexibility created by these dam modifications can provided added benefits such as additional flow during dry seasons to maintain wetland functions in the freshwater marsh below the dam and allow for necessary maintenance of in-lake sediment basins and vegetation terraces.

- **Invasive plant removal from riparian areas.** Restoration and enhancement of the habitat in the riparian woodlands includes managing a number of nonnative plant species that are cumulatively contributing to a degraded community. These species include salt cedar, giant reed, ash, Himalayan blackberry, Brazilian pepper tree, passion flower, blue gum, and others. Nonnative species will be selectively removed throughout KMHRP and replaced with native plant species typically observed in riparian habitats. Landscape plantings associated with both the Wilmington Drain Pocket Park and KMHRP will also be selected from an appropriate list of native species. An adaptive management approach will be used to cultivate a more robust riparian habitat that will benefit the overall function, health, and diversity of the plant and wildlife community of the Wilmington Drain and Machado Lake ecosystem.

3.2 Implementation Plan Schedule

The implementation schedule consists of construction, monitoring, and compliance/ reporting phases. The implementation plan begins with the construction of the *Wilmington Drain Multi-use Project* and the *Machado Lake Ecosystem Rehabilitation Project*.

Construction activities for *Wilmington Drain Multi-use* and *Machado Lake Ecosystem Rehabilitation Projects* are tentatively scheduled to begin in late Spring 2013 and conclude in Spring 2016.. The monitoring requirements of the implementation plans will begin 60 days after approval of the respective MRPs and QAPPs provided in this LWQMP. The water quality monitoring outlined in Section 3 is an ongoing program commitment of the City. The compliance and reporting phase of implementation began in 2012 for the Nutrients TMDL and will begin in 2014 for the Toxics TMDL. Compliance monitoring for nutrients will be interrupted in 2013 during installation of BMPs and dredging associated with the Machado Lake Ecosystem Rehabilitation Project. Compliance and reporting is also an ongoing commitment of the City. Figure 3-2 provides an estimated project time line for implementation of the requirements outlined in this LWQMP.

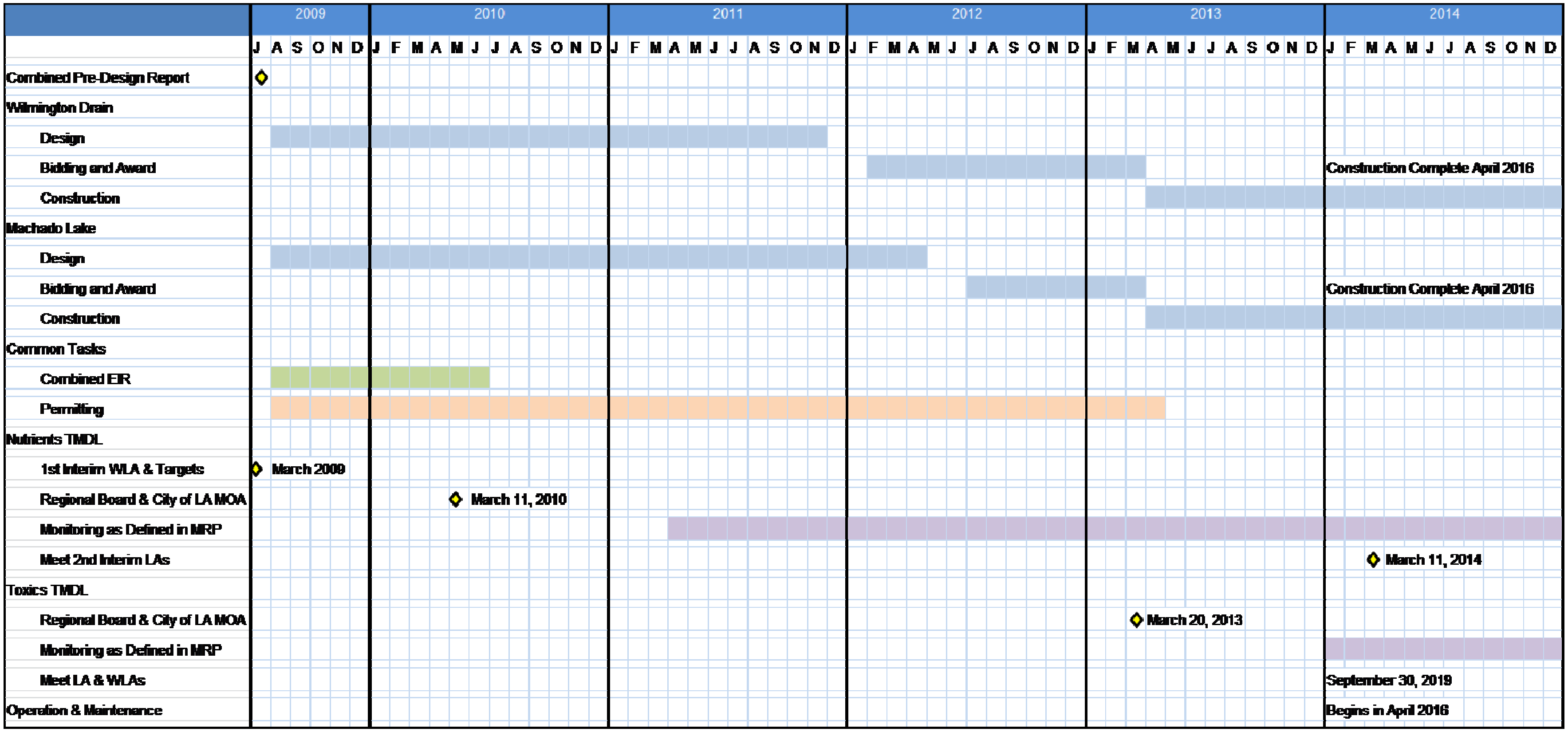

Figure 3-2
Implementation Plan Schedule

Section 4
Monitoring and Reporting Plan

4.1 Sampling Procedures and Analytical Methods

4.1.1 Monitoring Sites

For the Nutrients TMDL water samples and *in-situ* measurements will be collected from two mid-lake monitoring sites, ML-1 and ML-2, respectively (Figure 4-1). As specified in the Basin Plan Amendment, ML-1 and ML-2) are located in the open water portion of the lake with one in the northern portion and one in the southern portion of the lake. Buoys will be used to identify and mark both sampling locations.. The GPS coordinates for ML-1 and ML-2 are listed in Table 4-1. The average of these two sampling locations shall be used to determine compliance with the LAs and attainment of numeric targets listed in the Nutrients TMDL.

For the Toxics TMDL, Waste Load Allocation (WLA) Compliance Monitoring will be conducted at the major sub-watersheds that discharge to the lake. Monitoring sites have been selected at the following drains: Wilmington Drain (WD-1), Project 77 Drain (P-77), and Project 510 (P-510) (Figure 4-1). The GPS coordinates for these sites are listed in Table 4-1.

The Toxics TMDL also requires Load Allocation Compliance and Numeric Target Assessment Monitoring. This includes sampling at the northern end, mid point, and southern end of Machado Lake as well as the capture of fish for tissue analysis. Sediment samples will be collected at all three stations: ML-1, ML-2, and ML-3 (Figure 4-1). The water column samples will be collected only at ML-3 (mid point of the lake). Fish will be captured wherever they can be obtained throughout the lake.

Sometimes safety and access issues are problematic when conducting field sampling, such as adverse weather conditions and/or lake management activities. In the case of any unforeseen event, every effort will be made to collect another representative sample in a timely manner. If possible, sample collection will move to a nearby location if the sample can still be considered "representative" of lake conditions. Otherwise, the site will be reported as "inaccessible" and sampling will be skipped at that site until the next scheduled sampling event.

Table 4-1
List of Monitoring Sites for the Machado Lake Nutrient TMDL and Toxics TMDL

Monitoring Site ID	Description	GPS Coordinates		Program	Type
		Lat	Lon		
ML-1	Machado Lake (Northern End)	33.787913	-118.292661	Nutrient TMDL (biweekly)	Water Column (grab)
				Toxics TMDL (1x/3yrs)	Sediment
ML-2	Machado Lake (Southern End)	33.783196	-118.293571	Nutrient TMDL (biweekly)	Water Column (grab)
				Toxics TMDL (1x/3yrs)	Sediment
ML-3	Machado Lake (Mid Point)	33.785630	-118.294339	Toxics TMDL (1x/3yrs)	Water Column (grab)
					Sediment
WD-1	Wilmington Drain	33.790864	-118.287574	Toxics TMDL Phase 1 (3x/yr) Phase 2 (1x/2yrs)	Suspended Solids
P-77	Project-77 Drain	33.785122	-118.296629	Toxics TMDL Phase 1 (3x/yr) Phase 2 (1x/2yrs)	Suspended Solids
P-510	Project-510 Drain	33.784079	-118.296661	Toxics TMDL Phase 1 (3x/yr) Phase 2 (1x/2yrs)	Suspended Solids

Figure 4-1
Mid-lake Sampling Locations

4.1.2 Sample Types and Sampling Frequency

For the Nutrient TMDL monitoring will be conducted bi-weekly, on a year-round basis, resulting in 26 sample events per year. For consistency purposes, sample collection will typically be conducted on the same time and day of the week. However, depending upon operational needs, sample collection may occur earlier or later during the designated sampling week.

Grab samples will be collected at each site and analyzed for the following parameters:

- Total Nitrogen (sum of Organic-N + Ammonia-N + Nitrate/Nitrite-N)
- Total Phosphorus
- Ortho-Phosphorus (PO_4)
- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Chlorophyll-*a*
- Turbidity

In addition, the following general water chemistry parameters will be measured *in-situ*, at the time of sample collection:

- Temperature
- pH
- Specific conductivity
- Dissolved oxygen
- Secchi depth
- Lake elevation (using a staff gauge)

For the Toxics TMDL, WLA Compliance Monitoring will be in two phases. Phase 1 monitoring will be conducted over a two-year period. Samples will be collected during three wet weather events each year. The first large storm event of the season shall be included as one of the monitoring events. Phase 2 monitoring will commence once Phase 1 monitoring has been completed. Samples will be collected during one wet weather event every other year.

Samples will be analyzed for total suspended solids (sometimes referred to as “storm-borne sediments”). Sampling will be conducted with autosamplers or by hand, so that sufficient volumes of suspended solids are obtained to allow for analysis of the following pollutants in the bulk sediment:

- Total Organic Carbon
- Total PCBs
- DDT and Derivatives
- Dieldrin
- Total Chlordane
- Total Suspended Solids (of the water sample, so that sediment load can be calculated)

In addition, general water chemistry (temperature, pH, specific conductivity, and dissolved oxygen) will be analyzed in the composite sample (or grab sample, if collected manually) immediately following sample collection. A flow measurement will be taken at the time of sample collection. This will be accomplished either by means of a handheld flow meter or a permanently installed flow meter, depending on feasibility and site conditions.

For the Toxics TMDL, Load Allocation Compliance and Numeric Target Assessment Monitoring will commence following remediation of lake sediments as presented in this LWQMP. Lake sediments will be collected from ML-1, ML-2, and ML-3 immediately following remediation of lake sediments; samples will be collected at a frequency appropriate to assess post-remediation conditions and demonstrate compliance with LAs. Thereafter, samples will be collected every three years to assess attainment of numeric targets. The sediment samples shall be analyzed for:

- Total Organic Carbon
- Total PCBs
- DDT and Derivatives
- Dieldrin
- Total Chlordane

A water sample will be collected every three years from site ML-3 (midpoint of the lake). The sample is to be associated with wet-weather conditions. As such, it will be collected within 72 hours of a significant rainfall. The unfiltered sample will be analyzed for:

- Total PCBs
- DDT and Derivatives
- Dieldrin
- Total Chlordane

Fish shall be collected for tissue analysis once every 3 years. Fish tissue samples will be analyzed for:

- Total PCBs
- DDT and Derivatives
- Dieldrin
- Total Chlordane

In addition to the parameters above, whenever samples (i.e., sediment, water, or fish) are collected, general water chemistry (temperature, pH, Dissolved Oxygen, and specific conductivity) will be measured at the lake.

4.1.3 Sample Collection and Delivery Procedures

In-lake water samples will be collected from a boat. The motor will be turned off prior to reaching the sampling location, allowing the boat to coast to the anchoring point. This will be done to prevent contamination of the water sample by motor exhaust and to avoid agitation of benthic sediments by the propeller. Once the boat has reached the sampling location, the boat will be tethered to the monitoring buoy to keep the boat from drifting offsite while measurements are recorded and the samples are collected.

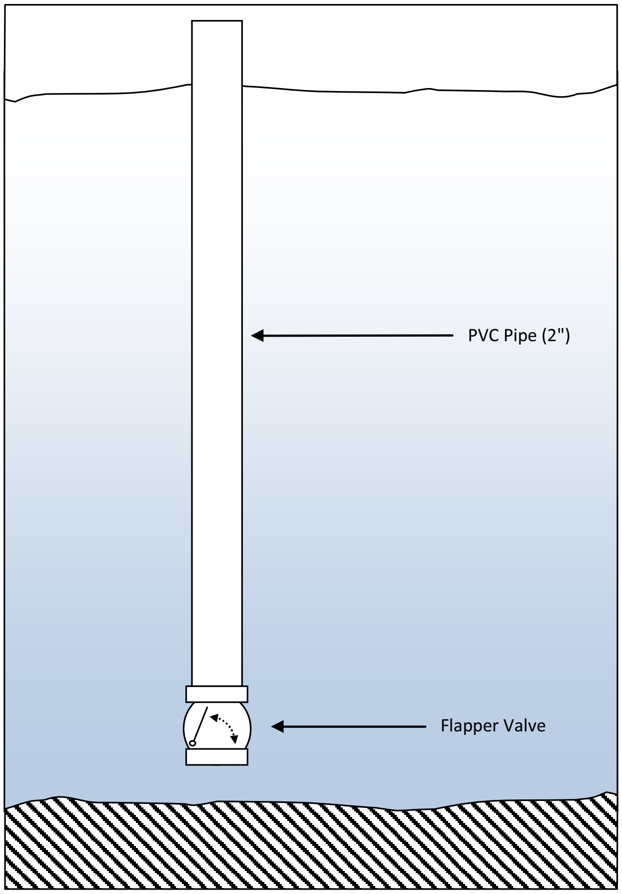

Figure 4-2
Depth Integrated Sampler with Flapper Valve

To account for stratification of the water column, samples will be depth-integrated. A custom-made sampling device will be used for this procedure. The device consists of a polyvinyl chloride (PVC) pipe (2-inch diameter) with a "flapper valve" attached to the lower end (Figure 4-2). As the sampler is lowered vertically into the lake, water fills the PVC pipe, such that the entire water column is represented in the sample. As the device is lifted out of the water, the flapper valve closes and retains the sample within the PVC pipe. The sampler can be configured with various lengths of PVC pipe to match the depth of the water at each sampling station. Under typical conditions at Machado Lake, the depth integrated sampler will collect about 2 liters of sample each time it is lowered into the water. To collect sufficient volume for all of the laboratory-analyzed parameters, the sampler must be lowered multiple times at each station. To ensure consistency of the sample, the samples from each "plunge" are poured into a clean bucket where they are mixed and composited. Once sufficient volume is collected in the compositing bucket, the water sample is poured into the appropriate bottles for the analyses being requested. Refer to Table 4-2 for the types of bottles to be used for each analysis, along with handling requirements. The date and time of sample collection, field measurements, and ambient conditions will be recorded. Additionally, field staff will measure the changes in lake elevation by recording the water level on a staff gauge that will be installed at an appropriate location in the lake.

Table 4-2
Sample Types, Required Volume, and Handling Requirements

Constituents	Sample Volume	Containers (#, size and type)	Preservation	Holding Time
Total Suspended Solids	1000 mL	(1) 1000 mL Plastic Bottle	Store Cool at 4ºC	7 days
Total Dissolved Solids	1000 mL	(1) 1000 mL Plastic Bottle	Store Cool at 4ºC	7 days
Total Ammonia (NH_3-N) Total Nitrogen Total Phosphorus	500 mL	(1) 500 mL Plastic Bottle	Store Cool at 4ºC Add sulfuric acid, pH < 2	28 days
Nitrate (NO_3-N) Ortho-Phosphorus (PO_4)	500 mL	(1) 500 mL Plastic Bottle	Store Cool at 4ºC	7 days
Chlorophyll-*a*	1000 mL	(1) 1000 mL Brown Plastic Bottle	Filter and then freeze at 0ºC	14 days
Turbidity	125 mL	(1) 125 mL Plastic Bottle	Store Cool at 4ºC	48 hours
PCBs, DDTs, Chlordane, Dieldrin *(water column)*	5 Liters	(5) 1-L Amber Glass Bottles, Hexane rinsed	Store Cool at 4ºC	7 days
DDTs, Chlordane, Dieldrin (*Lake Sediment, Fish Tissue and Suspended Solids*)	30 grams	4oz Amber Glass Jar, Hexane rinsed	Store Cool at 4ºC or Freeze	14 days or 6 months
PCBs *(Lake Sediment, Fish Tissue and Suspended Solids)*	30 grams	4oz Amber Glass Jar, Hexane rinsed	Store Cool at 4ºC	7 days
Total Organic Carbon (sediment)	100 mL	(1) 100 mL Glass Jar	Store Cool at 4ºC	3-6 months

For *in-situ* measurements of water quality parameters, staff will utilize a multi-parameter sonde (e.g., YSI model 6600), or comparable instruments to measure temperature, DO, pH, and specific conductivity. Field measurements will be made after sample collection is complete unless the measurements can be made in a way that will not contaminate or influence the samples. To determine attainment of numeric targets for DO concentrations, readings must be taken 0.3 meters above the bottom of the lake. Prior to lowering the DO sensor in the water, field staff will measure the depth of the water to determine how far the sensor should be lowered. Once the desired depth is obtained, field staff will lower the probe to the appropriate depth, and allow the instrument to stabilize before recording the DO reading.

In addition to the DO reading at 0.3 meters above the bottom of the lake, staff will submerge the sonde slowly into the lake to measure each of the parameters throughout the entire water column. Once the data are obtained throughout the entire water column, the median value of each parameter will be reported for every 0.5 meter depth interval. In addition to these water quality measurements with the sonde, field staff will also determine Secchi depth, using a standard 8-inch diameter Secchi disc with alternating black and white quadrants, to gauge the turbidity and clarity of the water.

Suspended solids samples are proposed to be collected from sites WD-1, P-77, and P-510 during wet weather conditions, although the sample site may change. If it is feasible to install an autosampler and flow meter, the sampler will be programmed to collect composite samples when the flow rate in the storm drain reaches a certain threshold. The ideal composite sample will consist of multiple sample aliquots that are collected over the duration of the targeted storm event. An additional goal is to collect a sufficient volume of water so that an adequate amount of suspended solids can be isolated for analysis of the pollutant concentrations in the bulk sediment. A flow-weighted composite sample is thought to be the best approximation of the "event mean concentration" of pollutants in a given storm event. Depending on site conditions, it may not be possible to accurately measure flow with a permanently installed flow metering device. If that is the case, then the autosamplers may be programmed to collect time-paced composites, whereby aliquots are collected at a constant time interval (e.g. every 15 minutes). If it is not feasible to use an autosampler, then grab samples will suffice. Grab samples should be collected during wet weather conditions, whereby the flow is clearly generated by rainfall in that particular sub-watershed. The volume of water needed to obtain sufficient quantities of suspended solids will depend on the concentration of suspended solids in the runoff that is sampled. This can vary significantly from storm to storm, and also among sites. Based on previous experience, it may require as much as 40 Liters of water to obtain the necessary amount of solids. If the quantity of suspended solids is not adequate to perform the full suite of analyses, then subsequent storms will be sampled, and suspended solids will be composited among storms. There is currently no standardized method for obtaining suspended solids (also referred to as "storm-borne sediments") for analysis of pollutant concentrations. Several other TMDL monitoring programs in the Los Angeles Region are currently developing methods for obtaining storm-borne sediments. If a standardized approach is developed, it may be adopted into this MRP.

The collection of lake sediment samples will follow the SWAMP SOP "Field Collection Procedures for Bed-Sediment Samples". The SWAMP SOP allows for the use of a sediment coring device or a sediment grab device (e.g. Van Veen grab). Field Teams will explore both options. When the most effective method is chosen, that method will be used for the duration of this monitoring program.

The collection of fish for tissue analysis will be conducted in a manner consistent with the US EPA document titled, "*Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories: Volume 1 Fish Sampling and Analysis (EPA 923-B-00-0007)*". Field teams will either use fishing gear (hook and line) or a seine (net) to capture fish. If deviations from these guidelines are used, they will be noted when the data are reported.

Water column samples for analysis of pesticides and PCBs will be collected in the same manner that the nutrient samples are collected—using the depth integrated sampling device. General water quality parameters (pH, DO, temperature and conductivity) will also be measured at the time of sampling.

After samples are collected, they must be stored on ice in a cooler with the lid closed during transport to the laboratory. Suspended solid samples require further processing before they are to be submitted to the lab for analysis of the bulk sediment. These samples must be decanted and centrifuged in order to isolate the solids. This method is described in further detail in WPD's SOP titled "*Procedures for Collecting Storm-borne Sediments*".

Chain-of-custody (COC) forms are completed by the sampler for all samples, placed in a plastic envelope, and kept inside the cooler with the samples. Upon delivery to the laboratory, the laboratory staff inspects the condition of the samples, signs the COC, and reconciles the label information to the COC form. Time of sample collection is noted, and the samples are stored at the appropriate temperature until analysis is begun, always within the holding time limitation. At this point, the laboratory becomes responsible for sample custody. Samples may be disposed of when analysis is complete and all analytical quality assurance/quality control procedures are reviewed and accepted.

To ensure the accuracy and thoroughness of the dataset, field duplicates will be collected at one of the monitoring sites, along with field blanks for each of the analytes being tested. Note that it is not possible to prepare field blanks for lake sediment samples, fish tissue samples, and suspended solid samples. When preparing the field duplicates, water from a single sampling vessel is to be split into two identical bottles (one for the regular sample and one as the duplicate). The sample will be well-mixed before splitting. For reporting purposes, only the data for the regular sample will be used, whereas the data for the duplicate will be used for quality assurance purposes. Field sampling staff will record the location where the duplicate samples were taken, but this information will not be shared with the laboratory until after the results have been provided. Given the foreseeable difficulty of obtaining sufficient suspended solids for testing during storm events, it may not be feasible to provide a Field Duplicate for these samples.

4.1.4 Analytical Methods

All samples samples will be analyzed by Environmental Monitoring Division (EMD). Laboratory will be ELAP certified for each of the methods. All lab samples will be analyzed in accordance with SWAMP-approved (or comparable) analytical methods (Table 4-3). However, if alternate methods are chosen, the Regional Board will be notified before any analyses are performed. If the constituents of concern have numeric targets that are lower than the readily available detection limits, the City shall incorporate new method detection limits in the MRP and QAPP as analytical methods and detection limits continue to improve (i.e., development of lower detection limits) and become more environmentally relevant.

4.2 Data Quality Objectives

4.2.1 Quality Assurance Project Plan

A QAPP is included in this document and is meant to supplement this Monitoring and Reporting Plan (see Appendix B). The purpose of the QAPP is to ensure that the monitoring program produces consistent, reliable data that meet the project's overall goals, and data quality objectives are met. Data quality objectives are discussed in detail in the QAPP. In general, the QAPP will ensure that methods for sample collection and laboratory analysis are consistent with guidelines established by the State of California's SWAMP. The QAPP also specifies the corrective actions to be taken when data quality objectives are not being met.

Table 4-3
Laboratory Analytical Methods and Detection Limits

Parameter	Lab	Analytical Method	ML Limit[1]	MDL Limit[2]
Total Suspended Solids	EMD	SM 20th ed. 2540 D		1.0 mg/L
Total Dissolved Solids	EMD	SM 20th ed. 2540 D		28 mg/L
Organic Nitrogen	EMD	EPA 351.2	0.1 mg/L	0.1 mg/L
Total Ammonia (NH_3-N)	EMD	EPA 350.1	0.1 mg/L	0.05 mg/L
Nitrate/Nitrite	EMD	EPA 300.0	0.1 mg/L	0.02 mg/L
Total Nitrogen	EMD	Sum of NH3, NO3, NO2, and Organic-N.		
Ortho-Phosphorous	EMD	SM 4500-PE	0.1 mg/L[3]	0.05 mg/L
Total Phosphorous	EMD	SM 4500-PE	0.1 mg/L[3]	0.05 mg/L
Chlorophyll-*a*	EMD	SM 20th ed. 10200 H	10 µg/L	6 µg/L
Turbidity	EMD	SM 20th ed. 2130 B	3.0 NTU	0.3 NTU
DDT & derivatives *(Solids)*	EMD	EPA 8081	1.0 µg/Kg	0.21-0.86 µg/Kg
Total Chlordane *(Solids)*			10.0 µg/Kg	2.6 µg/Kg
Dieldrin *(Solids)*			1.0 µg/Kg	0.22 µg/Kg
PCB *(Solids)*	EMD	EPA 8082	50.0 µg/kg	3.0-11.0 µg/Kg
PCBs *(Water)*	EMD	EPA 608	50.0 µg/L	0.023-0.050 µg/L
DDT & derivatives *(Water)*			0.5-5.0 µg/L	0.002-0.007 µg/L
Total Chlordane *(Water)*			10 µg/L	0.056 µg/L
Dieldrin *(Water)*			1.0 µg/L	0.005 µg/L

[1] **Minimum Level** (ML) means the concentration at which the entire analytical system must give a recognizable signal and an acceptable calibration point. The ML is the concentration in a sample that is equivalent to the concentration of the lowest calibration standard analyzed by a specific analytical procedure, assuming all the method-specified sample weights, volumes and processing steps have been followed (EPA 1991).

[2] **Method Detection Limit** (MDL) means the minimum concentration of a substance (analyte) that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte (40 CFR136 Appendix B)

[3] While EMD's ML for this constituent is currently 0.1 mg/L, the laboratory can lower this value as needed to be less than the WLA by adding additional calibration standards at lower concentrations.

4.3 Data Management and Reporting

4.3.1 Database Management

Data management will be a collaborative effort involving field staff from the WPD, as well as laboratory staff from the EMD. WPD will record and maintain all field data collected during sampling events. A field log sheet will be used to register all information during a particular sampling event, such as date, time, name of field personnel, sampling location, sample ID, name of sampling program, and visual inspection of the site as well as additional comments that may be relevant to the project. All field data will be entered into an electronic database following each sampling event. Autosampler and flow data will be maintained in a database by WPD. WPD currently uses Flowlink 5.1 software to manage these types of data. EMD will record and log all samples that are analyzed at the laboratory, and all laboratory data will be entered into EMD's Laboratory Information Management System (LIMS). Upon validation from each respective laboratory supervisor, EMD will upload the validated data into the Bureau of Sanitation's Wastewater Information System and Analytical Research Database (WISARD). Likewise, WPD field staff will upload the required *in-situ* measurements and other pertinent field observations into WISARD. The WISARD database is maintained by the Information Control Systems Division (ICSD) and is used extensively by the Bureau of Sanitation for legal reporting of data for various NPDES and TMDL monitoring programs. Custom report templates will be developed for the Nutrients and Toxics TMDLs, so that data are reported in a timely, consistent manner, with systems in place to maintain the integrity of the data. Data within WISARD can only be edited with administrative approval, and will have an access log showing activities and changes made to the file. WISARD files are stored on a secure server, and are backed up on a daily basis.

In addition, hard copies of the Field log sheets and laboratory results will be filed in project specific folders at WPD and EMD, respectively. All electronic data files, at WPD and EMD, are saved on a network drive and are backed-up in an archive. Records will be maintained for a minimum of 5 years after submission of the data to the Regional Board. However, it is the practice of the Bureau of Sanitation (including WPD and EMD) to maintain monitoring records indefinitely.

4.3.2 Reporting Guidelines and Distribution

As specified in the Nutrients TMDL, data for this monitoring program must be reported to the Regional Board on an annual basis. For the Toxics TMDL, Phase 1 of WLA Compliance monitoring shall also be reported on an annual basis. Phase 2 of WLA Compliance monitoring shall be reported biennially (i.e., once every two years). LA Compliance and Numeric Target Assessment Monitoring results will be reported annually until compliance with LAs and numeric targets has been demonstrated. Following the demonstration of compliance, LA Compliance and Numeric Target Assessment monitoring will be reported every three years. Monitoring shall begin within 60 days following final approval of this plan by the Regional Board's Executive Officer. An the Annual Monitoring Report, including results from both the Nutrients TMDL and Toxics TMDL, shall be submitted on or before June 30th of each year. In the case of the Nutrients TMDL, the Annual Monitoring Report will include any data collected from January 1st through December 31st, from the preceding year. For certain elements of the Toxics TMDL (e.g. WLA Compliance Monitoring), the data will be reported according to the timeframe of the storm season. Therefore, the Annual Monitoring Report may include monitoring results from October (of the previous year) through April (of the current year). If it is not feasible to report the Toxics data at the same time as the Nutrient TMDL data, then the Toxics data will be provided as an Addendum to the Annual Monitoring Report, and an explanation will be provided in the Addendum as to why the data are being reported separately. Furthermore, some elements of the Toxics TMDL (e.g., in-lake sampling for LA Compliance Monitoring and Numeric Target Assessment) is only required on a triennial basis. Therefore, there will be many years in which the Annual Monitoring Report will have nothing to report for these elements of the MRP.

The Legal Reporting Unit of the EMD will be responsible for compiling the required data for each Annual Monitoring Report. Data templates will be set up in the WISARD database, so that compiling the data will be an automated process, ensuring that data transcription errors are eliminated at this step in the reporting process. Since WPD staff is responsible for the *in-situ* measurements and the collection of samples, a preliminary draft of the compiled data tables will be provided to WPD for review. Any discrepancies identified in the data tables will be discussed and resolved through a coordinated effort by WPD and EMD staff. Upon approval of the data, WPD will be responsible for writing the narrative portion of the Annual Monitoring Report in which WPD will interpret and summarize the findings for the given time period of that report. The Division Managers of WPD and EMD will certify the integrity of the laboratory results, and the Technical Leader from WPD will send a hard copy of the finalized Annual Monitoring Report (with approval signatures) to the Executive Officer of the Regional Board. Electronic copies of the report will also be sent to various stakeholders, and technical staff at the Regional Board. An email distribution list will be created for this purpose, and interested parties can request to be included on this list by contacting the Division Manager at WPD. The Technical Leader at WPD (this person is identified in the attached QAPP) will be responsible for maintaining the distribution list, and for sending out the electronic copies of the finalized Annual Monitoring Report. To begin with, the email distribution list will include individuals that are listed on the distribution list for the attached QAPP (see Table 1 in Appendix B).

4.3.3 Annual Report Content

For both the Nutrient TMDL and the Toxics TMDL, the annual reports will contain a complete listing of the data collected as well as a narrative report that interprets the data and summarizes the findings.

Standard data report templates will be designed to query the laboratory and field data contained in WISARD so that the data tables are generated automatically. The report format will include the appropriate calculations to compare sampling results to the numeric targets and interim/final load allocations listed in the Basin Plan Amendments. For example, some of the numeric targets and limits require hourly-, 30-day-, and monthly-averages to be computed.

4.3.4 Unofficial Reports

In addition to the required annual reports, WPD and/or EMD may develop other standardized reports that summarize monitoring data more frequently (e.g., monthly reports). These reports will be for the purpose managing and assessing the data, as well as providing essential information for lake water quality management. These data would be available to employees in the Bureau of Sanitation who possess a WISARD login ID. For those unable to acquire a WISARD login ID, the data could be emailed to a distribution list set up by the Legal Reporting Unit at EMD. It should be noted, that these reports would be considered "unofficial results" since they will not be certified by WPD and EMD Division Managers, and the data contained would still be subject to review with respect to Data Quality Objectives.

4.4 Health and Safety Plan

In an effort to improve employee safety, health awareness, and prevent occupational-related injuries and illness, participating laboratories and field sampling groups must have a safety program that satisfies applicable federal, state, and local regulations. It is the policy of the City to have a safe working environment for all of their employees and that all field and laboratory work be performed in a manner that provides the maximum level of safety for the protection of every employee.

4.4.1 Health and Safety Plans

EMD maintains its own chemical hygiene plan for its employees, and this plan is deemed sufficient for the protection of EMD staff when handling, analyzing, and disposing of samples.

WPD also maintains its own Health and Safety Plan, including safety considerations that are unique to conducting field work at Machado Lake. A dedicated binder has been established, that holds pertinent information related to the sampling locations for this monitoring program. The binder will be updated as more information is discovered. The Health and Safety Binder will reside at WPD offices, and relevant parts will be reproduced for each field crew before the first sampling event. The binder will contain the following types of items:

- Maps showing nearest hospitals and quickest routes from key locations
- Map showing location of Police headquarters, Fire Departments, and other emergency resources
- All contact information of emergency resources
- Map showing areas of concern or potential hazards as gleaned in the reconnaissance activities and updated over time
- Checklists: vehicle safety, Personal Protective Equipment (PPE), etc.
- Material Safety Data Sheets (MSDS) of chemicals used in the field or calibration room
- Instructions for chemical spill, automotive accident and personal injury response

4.4.2 Sampling Constraints

The health and safety of field and laboratory staff is always the primary concern when conducting monitoring activities. If a sample location is inaccessible or deemed to be unsafe, no sample is required to be collected and comments should be noted on the field log sheet. During wet weather, safety considerations may preclude collection of a sample. In the case of an unforeseen event, every effort will be made to collect another representative sample in a timely manner. Furthermore, certain management practices and/or rehabilitation activities may cause samples from the lake to be "non-representative" of true conditions. If this is deemed to be the case, sampling may be postponed or cancelled until the conditions return to equilibrium.

Section 5
TMDL Compliance Analysis

5.1 Overview

This section describes the anticipated ability of the City to achieve compliance with its responsibilities under the Nutrients and Toxics TMDLs based on the implementation of the BMPs described in Section 3 and utilizing information obtained from the monitoring and reporting plan described in Section 4. As discussed in Section 1, compliance with the TMDLs involves the implementation of the following two components:

- **Load allocation (LA)** – TMDL limit applicable to nonpoint sources. At Machado Lake nonpoint sources include nutrients entering the lake from overland flows from the surrounding parkland as well as nutrients and toxics generated from internal loading in the lake itself. The agency responsible for nonpoint sources of pollutants is identified in the TMDL as the City of Los Angeles, Department of Recreation and Parks.

- **Waste load allocation (WLA)** – TMDL limits applicable to each point source, including storm drain discharges. The WLA is the responsibility of the following jurisdictions: the MS4 Permittees (including Los Angeles County; LACFCD; the Cities of Carson, Lomita, Los Angeles, Palos Verdes Estates, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, and Torrance); Caltrans; and the NPDES General Construction and Industrial Stormwater Permittees.

As previously discussed, this LWQMP has been prepared by the City to address actions taken by two of the listed responsible agencies: RAP and BOS. The other responsible jurisdictions will submit separate plans. As such, the compliance analysis detailed here serves to illustrate how the City will comply with its responsibilities under the Nutrients and Toxics TMDLs. It should be noted that this compliance analysis assumes the other responsible jurisdictions will independently be in compliance with the WLAs, as required by the TMDLs.

5.2 Compliance Analysis

The City will be implementing a wide range of strategies and BMPs that will work toward reducing nutrient and toxics loads in the lake and in the case of nutrients from the surrounding land within KMHRP as well as reducing sediment loads in runoff from surrounding watersheds. Upper watershed cities and agencies outside of the City's jurisdiction are responsible for implementing measures to meet targets established in the nutrients and toxics TMDLs at the endpoint of their jurisdictional boundaries. Implementation of these measures in the upper watershed would reduce sediments conveyed to the post-dredged Machado Lake. The analysis contained in this section is based on representing current in-lake and post-BMP in-lake conditions as predicted by the Lake Water Quality Model (see Section 2 and Appendix C).

5.2.1 Nutrient TMDL Compliance

As allowed by the Nutrients TMDL supporting documentation, compliance with the City's commitment to WLAs and LAs under the TMDL can be demonstrated by a combination of documentation of BMPs being implemented and analysis of improvements in lake water quality expected to be achieved by these BMPs. As such, since the nutrient LAs and WLAs have the same numeric values as the nutrients in-lake numeric water quality targets, overall compliance with targets will be demonstrated through predicting and monitoring concentrations of nutrients within the lake.

5.2.1.1 Interim Compliance

The TMDL includes two interim compliance dates with corresponding interim compliance LAs and WLAs. These dates are March 11, 2009, and March 11, 2014. The final LAs and WLAs must be met by September 11, 2018. Table 5-1 summarizes current water quality conditions as compared to the two interim and one final LAs and WLAs.

Currently, in-lake water quality conditions meet the two interim compliance LAs and WLAs for Total P and Total N as shown in Table 5-1, while there are no interim compliance targets for chlorophyll-*a*, or ammonia-N. Therefore, BMPs that will be implemented are intended to achieve compliance with the final LAs and WLAs.

Table 5-1
Current Conditions Compared to Load Allocations and Waste Load Allocations

Constituent	Current Measured Conditions (average)[1]	Compliance Date and Load/Waste Load Allocations (mg/L)[2]		
		Interim: March 11, 2009	Interim: March 11, 2014	Final: Sept. 11, 2018
Total Phosphorus (mg/L)	0.8	1.25	1.25	0.10
Total Nitrogen (mg/L)	1.8	3.5	2.45	1.0
Chlorophyll-*a* (µg/L)	73	NA	NA	20
Ammonia-N (mg/L)	0.04[3]	NA	NA	5.95 (1-hr)[4] 2.15 (30-day)[4]
Dissolved Oxygen (mg/L)	4.7[5]	NA	NA	5[6]

Current conditions: In-Lake samples were taken at four in-lake locations from June 2006 to September 2008. Note that in-lake measurements include phosphorus concentrations from both internal and external loads.

Notes:

[1] See Table 2-1 in Section 2. City of Los Angeles, Watershed Protection Division sampling program. Monthly Average of water quality samples taken at four in-lake locations from June 2006 to September 2008 Most in-lake water quality samples were collected during dry weather periods with low base flow in the drains. No samples were collected during wet weather; however, a few samples were collected one or two days after wet weather events.

[2] TMDL Load Allocations as presented in the Amendment to the Water Quality Control Plan – Los Angeles Region to Incorporate the TMDL for Nutrients in Machado Lake.

[3] Overall Ammonia-N Average (Table 2-1). Note that the maximum is 0.58 mg/L, also below the load allocations.

[4] One hour average and 30 day average, 5.95 mg/L and 2.15 mg/L respectively.

[5] The average concentration of oxygen at the bottom depth is 4.7 mg/L, while the minimum measured is 0.46 mg/L.

[6] Single sample minimum measured 0.3 meters above the sediment.

5.2.1.2 Final Compliance Analysis

Currently the concentrations of total nitrogen, total phosphorus and chlorophyll-*a* in the lake exceed the final numeric targets (Table 5-1). Concentrations for ammonia-N are far below the final numeric targets and average values of dissolved oxygen are slightly below the final numeric target. In order to reduce sources and loadings of nutrients and sediment and improve in-lake conditions that will contribute to achieving the targets, the City will implement the following BMPs (see Section 3 for more detailed BMP descriptions):

Non-Point Source:

1. Lake Dredging
2. Add Supplemental Water - Recycled
3. Oxygenation System
4. Off-line treatment wetland
5. Phosphorus removal system
6. Aquatic Plant Management and Littoral Zone Enhancements
7. Shoreline Erosion Control (Lake Edge) Treatments
8. Golf Course Maintenance Yard Site BMPs
9. KMHRP Design Improvements (WQ benefits), including Southern Tarplant enhancement

Point Source:

10. In-Lake Sediment Basin - North
11. Re-grade Entire Wilmington Drain Channel Bottom
12. Clean box culverts at Lomita Blvd.
13. Clearing and Annual Maintenance for Channel Vegetation
14. CDS at D24010 Drain
15. CDS at Project 77
16. CDS at Figueroa Drain
17. Bioengineered swale at Project 77 Drain (dry weather treatment)
18. Bioengineered swale at Project 510 Line C Drain (dry weather treatment)

Other:

19. Public Education and Outreach

BMPs Included in the Lake Water Quality Model

The Lake Water Quality Model was developed to estimate nutrient concentrations in Machado Lake after the installation of the first five BMPs listed above (lake dredging, addition of supplemental water, oxygenation system, off-line treatment wetland, and a phosphorus removal system). The nutrient removal potential resulting from these BMPs are included directly in the model because of the substantial amount of data that exists to support their performance, as well as the significant amount of studies done specifically at Machado Lake to establish input assumptions (see Section 2 and Appendix C for a discussion on the model).

The potential contributions to nutrient uptake and removal from the remaining 14 BMPs, numbers 6 through 19 above, were included in the model in two ways.

- **In Lake BMPs:** BMPs 6 through 9 as well as number 19 (public education and outreach) are expected to reduce the internal loading of nutrients in the lake. Since sufficient supporting documentation does not exist to individually quantify the reduction associated with these BMPs, no further reduction was directly accounted for in the model. In affect this adds a minor, though not quantifiable factor of safety to the interpretation of the results.

- **Watershed BMPs:** BMPs 10 through 18 are expected to reduce the concentration of nutrients in the runoff from the upstream watershed. As with the in lake BMPs discussed above, each of these BMPs could not be simulated individually due to insufficient supporting documentation. Again, no overt reduction was taken to account for these BMPs. However, the previously discussed use of long-term average EMC values rather than the short term monitoring data to represent runoff from the upstream watersheds also accounts for miscellaneous upstream BMPs that are part of the project as well as good source control measures that the City will continue to implement within its portion of the watershed.

The following sections describe the predicted post-BMP nutrient concentrations in the lake based on the benefits that can be quantified from the first five BMPs listed above.

Predicted In-Lake Nutrient Concentrations after BMP Implementation

The Lake Water Quality Model (Section 2 and Appendix C) was used to simulate the water quality results of implementing these BMPs. Table 5-2 presents predictions of the mean summer water quality conditions expected in 2014, 2018 and 2024, representing one year, five years, and ten years, respectively, after the implementation of the BMPs described in Section 5.2.2 above. The 2014 and 2018 dates also serve as predictions of the second interim and final compliance milestones. Table 5-3 presents the monthly concentrations of total phosphorus, total nitrogen, and chlorophyll-*a* after implementation of all of the BMPs. Summer (May to September) represents the critical period with respect to sustained elevated nutrient concentrations and phytoplankton growth. However, as shown, increases in monthly nutrient concentration can occur during the winter months due to large spikes in loading from rain events.

Table 5-2
Predicted In-Lake Nutrient Concentrations with Current Runoff Concentrations

Constituent	TMDL Numeric Targets (Final Compliance)[1]	Model Predictions[2]		
		2014 Mean Summer	2018 Mean Summer	2024 Mean Summer
Total Phosphorus (mg/L)	0.1[3]	0.12	0.15	0.16
Total Nitrogen (mg/L)	1.0[3]	1.19	1.21	1.22
Chlorophyll-*a* (µg/L)	20[3]	17	18	19
Ammonia-N (mg/L)	5.95 (1-hr)[4] 2.15 (30-day)[4]	NA[5]	NA[5]	NA[5]
Dissolved Oxygen (mg/L)	5[6]	NA[7]	NA[7]	NA[7]

Notes:
[1] TMDL Load Allocations: Nutrients TMDL.
[2] Predicted concentrations: Machado Lake Lake Water Quality Model described in Appendix C. Assumes that BMPs are installed by 2013. 2014 is therefore 1 year post BMP installation, and 2018 is 5 years post BMP installation, and 2024 is 10 years after BMP installation.
[3] Monthly Average
[4] One hour average and 30 day average, 5.95 mg/L and 2.15 mg/L respectively.
[5] The model does not predict ammonia. BMPs included in Machado Lake Rehabilitation Project are expected to directly decrease ammonia levels in the lake as discussed in Section 5.2.2.4.
[6] Single sample minimum measured 0.3 meters above the sediment.
[7] The model does not predict dissolved oxygen. BMPs included in the Machado Lake Rehabilitation Project directly increase oxygen levels in the lake as discussed in Section 5.2.2.3.

Table 5-3
Modeled Monthly Nutrient Concentrations After Implementation of BMPs

Month	Monthly mean[1, 2, 3] 2014			Monthly mean[1, 2, 3] 2018			Monthly mean[1, 2, 3] 2024		
	TP (mg/L)	TN (mg/L)	Chl-*a* (µg/L)	TP (mg/L)	TN (mg/L)	Chl-*a* (µg/L)	TP (mg/L)	TN (mg/L)	Chl-*a* (µg/L)
April	0.13	0.58	9	0.15	0.60	9	0.16	0.63	10
May	0.12	0.90	13	0.14	0.84	12	0.15	0.75	11
June	0.17	1.73	23	0.19	1.76	24	0.21	1.81	25
July	0.14	1.62	22	0.17	1.65	23	0.19	1.69	24
Aug	0.13	1.48	20	0.15	1.51	21	0.17	1.54	22
Sept	0.08	0.88	12	0.10	1.14	16	0.12	0.90	14
Oct	0.13	0.74	-	0.13	0.70		0.12	0.64	
Nov	0.11	0.34	-	0.12	0.27		0.14	0.32	
Dec	0.24	1.33	-	0.24	1.36		0.23	1.25	
Jan	0.26	1.72	-	0.25	1.52		0.25	1.37	
Feb	0.26	1.61	-	0.26	1.63		0.27	1.70	
March	0.20	0.94	-	0.22	1.15		0.24	1.32	

Note:
[1] Predicted concentrations: Machado Lake Lake Water Quality Model described in Appendix C. Assumes that BMPs are installed by 2013. 2014 is therefore 1 year post BMP installation, 2018 is 5 years post BMP installation, and 2024 is 10 years after BMP installation.
[2] Summer months are the worst case with respect to sustained elevated nutrient concentrations and phytoplankton growth. However, increases in nutrient concentrations can occur during the winter months due to large spikes in loading from rain events. These become more pronounced in the model as summer internal loads are addressed with dredging. Additionally the model assumes that the wetlands only operate during the summer.
[3] The model does not simulate winter phytoplankton. The empirical formulation is intended for summer mean concentration. It is assumed that winter phytoplankton is not the concern due to lower temperatures

and sunlight.

Based on the in-lake and other BMPs that the City will be implementing to address nutrient loadings, it is predicted that the lake will meet the chlorophyll-*a* load on a summer time average and may only very slightly exceed the average in a few peak summer months. Implementation of the BMPs is also predicted to substantially reduce the nutrient concentrations in the lake below the current conditions. Phosphorus is predicted to be reduced from a current mean summer value of 0.8 mg/L to a mean summer value of 0.12 mg/L (85 percent reduction) in the first year, while nitrogen is predicted to be reduced from a current mean of 1.8 mg/L to a summer mean of 1.19 mg/L (34 percent reduction) (see Tables 5-1 and 5-2). However, the mean phosphorus and nitrogen concentrations are still predicted to exceed the in-lake numeric targets. Chlorophyll-*a* is predicted to be reduced from its current average concentration of 73 µg/L to 17 µg/L, a 77 percent reduction.

Treatment of External Load to meet Nutrients Load and Waste Load Allocations
As shown in Table 2-4 in Section 2, water quality monitoring in the storm drains indicates that phosphorus concentrations in runoff from the watershed may average 0.6 mg/L during both dry and wet weather, and nitrogen concentrations average 2.7 mg/L for dry weather and 2.8 mg/L for wet weather, values that exceed the LAs and WLAs. The tributary area to Machado Lake is approximately 14,156 acres, which is approximately 389 times the surface area of the lake (see Figure 1-2 in Section 1), resulting in substantial runoff loads entering the lake predominantly from wet weather urban runoff. Since the external load of nutrients is substantial, and there is a large tributary area compared to the lake area, the external load will have to be significantly reduced prior to discharge to the lake in order for the lake to consistently attain the nitrogen and phosphorus numeric targets established for the lake. It should also be noted that it is the high external load that causes the elevated internal load to occur during the summer months. As the nutrients are brought to the lake via the urban runoff, they settle within the lake and re-suspend during the summer months. The high load during the winter months is due to spikes in nutrient loads during rain events, which are directly related to the nutrient load in the runoff.

The City of Los Angeles' upstream portion of the watershed is 1,800 acres, or 13 percent of the total watershed. Therefore, 87 percent of the watershed is not within the City of Los Angeles' jurisdiction. As stated previously, since the other upstream jurisdictions are not participating in the activities and BMPs described in this LWQMP, they are required to separately meet their TMDL WLAs by reducing the nutrient concentrations in the runoff from their areas. If the quality of the runoff from the portion of the upstream watershed that is attributed to these responsible jurisdictions were to be reduced through various BMP approaches to achieve the TMDL WLAs of 0.1 mg/L – P and 1.0 mg/L – N, then the external load to Machado Lake would be substantially reduced.

Table 5-4 presents the 2014 summer average concentrations of total phosphorus, total nitrogen, and chlorophyll-*a* assuming in-lake BMPs are installed by 2013. Table 5-4 also presents the model results for 2018 and 2024, which further assumes that by 2018 the other responsible jurisdictions will be meeting their final TMDL WLAs.

Table 5-4
Predicted In-Lake Nutrient Concentrations with Upstream Jurisdictions Meeting the TMDL Waste Load Allocations

Constituent	TMDL Numeric Targets (Final Compliance by 2018)[1]	Model Predictions[2]		
		2014 Mean Summer	2018 Mean Summer	2024 Mean Summer
Total Phosphorus (mg/L)	0.1[3]	0.12	0.08	0.08
Total Nitrogen (mg/L)	1.0[3]	1.19	0.58	0.57
Chlorophyll-*a* (µg/L)	20[3]	17	8	8
Ammonia-N (mg/L)	5.95 (1-hr)[4] 2.15 (30-day)[4]	NA[5]	NA[5]	NA[5]
Dissolved Oxygen (mg/L)	5[6]	NA[7]	NA[6]	NA[6]

Notes:
[1]TMDL Load Allocations: Nutrients TMDL. Final compliance targets are shown, which must be met by 2018. Interim compliance targets are presented in Table 5-1.
[2] Predicted concentrations: Machado Lake Lake Water Quality Model described in Appendix C. Assumes that BMPs are installed by 2013. 2014 is therefore 1 year post BMP installation, and 2018 is 5 years post BMP installation, and 2024 is 10 years after BMP installation. It is assumed that the other responsible jurisdictions, which account for 87 percent of the tributary drainage area, are in compliance with their WLA starting in 2018.
[3] Monthly Average
[4] One hour average and 30 day average, 5.95 mg/L and 2.15 mg/L respectively.
[5] The model does not predict ammonia. BMPs included in Machado Lake Rehabilitation Project are expected to directly decrease ammonia levels in the lake as discussed in Section 5.2.2.4.
[6] Single sample minimum measured 0.3 meters above the sediment.
[7] The model does not predict dissolved oxygen. BMPs included in the Machado Lake Rehabilitation Project directly increase oxygen levels in the lake as discussed in Section 5.2.2.3.

Table 5-5 presents the 2014, 2018 and 2024 monthly concentrations (one year, five years, and ten years after BMP implementation) of total phosphorus, total nitrogen, and chlorophyll-*a* also assuming the in-lake BMPs are installed by 2013 in addition to the other responsible jurisdictions meeting their TMDL WLAs by 2018.

Assuming that these other upstream responsible jurisdictions were to fully meet the TMDL WLAs in runoff reaching the lake, the model predicts the in-lake nutrient concentrations will be consistently at or below the total phosphorus, total nitrogen and chlorophyll-*a* targets throughout the year.

Table 5-5
Modeled Monthly Nutrient Concentrations Based on In-Lake BMPs and Assuming Other Jurisdictions Meeting TMDL WLAs

Month	Monthly mean[1, 2, 3] 2014			Monthly mean[1, 2, 3] 2018			Monthly mean[1, 2, 3] 2024		
	TP (mg/L)	TN (mg/L)	Chl-*a* (µg/L)	TP (mg/L)	TN (mg/L)	Chl-*a* (µg/L)	TP (mg/L)	TN (mg/L)	Chl-*a* (µg/L)
April	0.13	0.58	9	0.07	0.25	2	0.07	0.25	2
May	0.12	0.90	13	0.07	0.39	4	0.07	0.35	3
June	0.17	1.73	23	0.09	0.76	11	0.09	0.76	11
July	0.14	1.62	22	0.09	0.78	12	0.09	0.78	12
Aug	0.13	1.48	20	0.09	0.78	12	0.09	0.78	12
Sept	0.08	0.88	12	0.07	0.50	6	0.07	0.49	6
Oct	0.13	0.74	-	0.07	0.34	-	0.05	0.27	-
Nov	0.11	0.34	-	0.06	0.14	-	0.06	0.13	-
Dec	0.24	1.33	-	0.09	0.50	-	0.09	0.46	-
Jan	0.26	1.72	-	0.10	0.59	-	0.10	0.50	-
Feb	0.26	1.61	-	0.10	0.60	-	0.10	0.62	-
March	0.20	0.94	-	0.09	0.39	-	0.09	0.47	-

Note:
[1] Predicted concentrations: Machado Lake Lake Water Quality Model described in Appendix C. Assumes that BMPs are installed by 2013. 2014 is therefore 1 year post BMP installation, and 2018 is 5 years post BMP installation, and 2024 is 10 years after BMP installation. It is assumed that the other responsible jurisdictions, which account for 87 percent of the tributary drainage area, are in compliance with their WLA starting in 2018.
[2] Summer months are considered the worst case with respect to sustained elevated nutrient concentrations and phytoplankton growth. However, increases in nutrient concentrations can occur during the winter months due to large spikes in loading from rain events. These become more pronounced in the model as summer internal loads are addressed with dredging. Additionally the model assumes that the wetlands only operate during the summer.
[3] The model does not simulate winter phytoplankton. The empirical formulation is intended for summer mean concentration. It is assumed that winter phytoplankton is not the concern due to lower temperatures and sunlight.

Dissolved Oxygen Numeric Target

The TMDL also sets a minimum concentration of DO in the lake at 5 mg/L, measured 0.3 meters above the sediment. As shown in Table 2-1 in Section 2, the current minimum observed DO concentration is 0.5 mg/L, while the current average is 4.7 mg/L on the bottom of the lake. While the Lake Water Quality Model does not predict the concentration of DO in the lake, the Machado Lake Rehabilitation Project includes installation of an oxygenation system which will increase DO levels in the lake. The oxygenation system will inject pure oxygen into the lake through a Speece cone. The Speece cone involves a downflow bubble contactor that will extract water from the bottom of the lake and inject pure oxygen at the top of the device. This will create a "bubble swarm" in the center of the cone, which will achieve a 95 percent transfer of oxygen to the water. Through a pipe with increasing diameter (allowing the velocity to slow as the water flows downward) the water will be re-injected back into the bottom of the lake. This system will be used primarily during the period of March through November when the oxygen levels are lower. The system will be designed to be able to maintain DO concentrations at or above 5 mg/L.

Ammonia Numeric Target

The TMDL also sets a minimum concentration of ammonia (NH4) in the lake as both a 1-hour average limit of 5.95 mg/L and a 30-day average of 2.15 mg/L. As shown in Table 2-1 in Section 2, the current monitoring data shows that the average in-lake measurement was 0.04 mg/L NH4, which is substantially below the numeric targets.

Further, the ratio of NH4:TN is expected to remain consistent. The average ratios of NH4:TN (ammonia to total nitrogen) from historical measured data in the lake is 0.04 mg/L NH4 : 1.8 mg/L TN (average values presented in Table 2-1), which means that the TN concentration is 45 times the NH4 concentration. Since the future TN value following full implementation of the BMPs is predicted to be 0.6 mg/L (Table 5-4) then using the same ratio of NH4:TN, the NH4 concentration would be 45 times less than 0.6 mg/L TN, or 0.001 mg/L NH4. As this value is far below the numeric limit for NH4, it is expected that the ammonia concentration would meet the TMDL numeric target.

Moreover, the oxygenation system will increase the DO levels in the lake thus promoting greater nitrification; consequently, the ratio of NH4:TN will likely be even lower in the future.

5.2.1.3 Sensitivity Analysis

In order to assess the sensitivity of the lake water quality model to individual model input parameters, a "jack-knifing" procedure was employed. The term "jack-knifing" commonly refers to the process of varying individual model parameters, in isolation and within reasonable ranges, to assess model sensitivity. In general, the analysis shows moderate to low model sensitivity (within $\pm$ 25%) to the majority of input parameters for the given perturbation ranges, indicating a robust model. More importantly, for the specific application of the model presented in this document, none of the perturbations resulted in excursions above the TMDL targets for any of the three output variables. The analysis identified the greatest model sensitivity is related to lake depth, sediment nitrogen parameters, and wetland and water column nitrogen uptake rates. Details of the analysis are provided in Appendix C.

5.2.1.4 Uncertainty Analysis

The jack-knife analysis described above provides useful information on model sensitivities to individual parameters and also provides initial steps in quantifying model prediction uncertainty. As described in Appendix C, a moderate level of uncertainty in model predictions can be attributed to model parameterization, although this is lessened by the fact that the parameterization is supported by measured data, model calibration efforts, and sound engineering judgment and experience. However, an additional source of significant uncertainty in the model predictions is that associated with input parameters that we know to be "naturally" variable. In the lake water quality model, such parameters are generally linked to weather and hydrology, both of which introduce elements of randomness and unpredictability. To address this category of uncertainty, a stochastic version of the Machado Lake Water Quality model was developed.

The stochastic version of the Machado Lake Water Quality model was constructed using the @RISK software (*Palisade Corporation*), an add-in to Excel (*Microsoft)*. In this version of the model, selected model parameters were allowed to vary stochastically during model simulation, rather than assumed constant. Probability distribution functions were fit to available data for each stochastic variable. These probability distribution functions describe the expected variability of each stochastic variable using continuous functions. Model output (N, P, and Chl-a concentrations) are presented as cumulative probability distribution functions across a range of values, rather than as single concentrations. This type of output provides valuable insight into the risk of concentration target exceedances and the level of uncertainty associated with each output parameter due to natural random variability.

Results show that all of the calculated output concentration probability curves for the baseline (post-BMP) system are relatively flat, indicating limited sensitivity to the inflow concentration and flow variability modeled. It is also noteworthy that both the N and chl-a output curves lie fully below the TMDL targets, while the P curve extends slightly above the target only at approximately the 40% exceedance level. We can conclude from these results that, given the assumed effectiveness of in-lake and watershed mitigation efforts, the risk of exceeding TMDL targets as a result of randomness in weather and inflow concentration patterns is low. Further details of this analysis are provided in Appendix C.

5.2.2 Toxics TMDL Compliance

As specified in the Toxics TMDL, compliance will require elimination of toxic pollutant loading from external sources and clean-up of contaminated lake bed sediments. TMDL effectiveness will be determined through monitoring water, sediment, and fish tissue samples and comparing resultant data to the LA, WLA, and numeric targets.

5.2.2.1 Final Compliance Analysis

In order to reduce sources and loadings of toxics and sediment and improve in-lake conditions that will contribute to achieving the targets, the City will implement the following BMPs (see Section 3 for more detailed BMP descriptions):

Non-Point Source:

1. Lake Dredging
2. Add Supplemental Water - Recycled
3. Oxygenation System
4. Off-line treatment wetland
5. Phosphorus removal system
6. Aquatic Plant Management and Littoral Zone Enhancements
7. Shoreline Erosion Control (Lake Edge) Treatments
8. Golf Course Maintenance Yard Site BMPs
9. KMHRP Design Improvements (WQ benefits), including Southern Tarplant enhancement

Point Source:

10. In-Lake Sediment Basin - North
11. Re-grade Entire Wilmington Drain Channel Bottom
12. Clean box culverts at Lomita Blvd.
13. Clearing and Annual Maintenance for Channel Vegetation
14. CDS at D24010 Drain
15. CDS at Project 77
16. CDS at Figueroa Drain
17. Bioengineered swale at Project 77 Drain (dry weather treatment)
18. Bioengineered swale at Project 510 Line C Drain (dry weather treatment)

Other:

19. Public Education and Outreach

BMPs Included in the Lake Water Quality Model

As with the nutrient model, the toxics model was developed primarily to forecast long term concentrations of key toxic pollutants in the lake after installation of the proposed BMPs. The proposed BMPs that are included in the model, relevant to toxics, are: dredging (BMP 1), supplemental water (BMP 2), and re-circulating treatment wetlands (BMP 4).

The Lake Water Quality Model for toxics was developed to estimate toxic concentrations in Machado Lake after the installation of the aforementioned BMPs. The toxic removal potential resulting from these BMPs is included directly in the model because of the substantial amount of data that exists to support their performance, as well as the significant amount of studies done specifically at Machado Lake to establish input assumptions (see Section 2 and Appendix C for a discussion on the model).

The potential contributions to toxics removal of the remaining 16 BMPs, were not included in the model since sufficient supporting documentation does not exist to individually quantify the reduction associated with these BMPs. Although no further reduction was directly attributed to these BMPs in the model, in affect this adds a minor, though not quantifiable, factor of safety to the interpretation of the results.

The following sections describe the predicted post-BMP toxic concentrations in the lake based on the benefits that can be quantified from the three BMPs included in the model.

Predicted In-Lake Toxic Concentrations after BMP Implementation

The Lake Water Quality Model (Section 2 and Appendix C) was used to simulate the water quality results of implementing these BMPs. Table 5-6 presents current conditions, post BMP installation predictions, post BMP installation plus a reduction in watershed load reduction to loading capacity, and the TMDL numeric targets for lake water column concentrations for 2014 and 2024, representing one year and ten years, respectively, after the implementation of the BMPs described in Section 5.2.2.1 above.

Table 5-6
Model Results: Lake Water Column Concentrations

	2014 (Year 1) Annual Mean				2024 (Year 10) Annual Mean			
	Chlordane (µg/L)	**DDT (µg/L)**	**Dieldrin (µg/L)**	**PCBs (µg/L)**	**Chlordane (µg/L)**	**DDT (µg/L)**	**Dieldrin (µg/L)**	**PCBs (µg/L)**
Current Conditions	1×10^{-3}	1×10^{-3}	1×10^{-4}	2×10^{-4}	6×10^{-2}	7×10^{-2}	1×10^{-4}	3×10^{-4}
Post BMP Implementation[1]	9×10^{-5}	6×10^{-5}	1×10^{-5}	2×10^{-5}	7×10^{-4}	5×10^{-4}	5×10^{-5}	7×10^{-5}
Post BMP Implementation *Plus* watershed load reductions to Loading Capacity	4×10^{-6}	8×10^{-6}	1×10^{-5}	2×10^{-5}	3×10^{-5}	6×10^{-5}	5×10^{-5}	6×10^{-5}
TMDL Numeric Targets	*5.9×10^{-4}*	*5.9×10^{-4}*	*1.4×10^{-4}*	*1.7×10^{-4}*	*5.9×10^{-4}*	*5.9×10^{-4}*	*1.4×10^{-4}*	*1.7×10^{-4}*

Notes:
[1] BMPs include supplemental water, dredging, and recirculating treatment wetland.
[2] It is assumed that the other responsible jurisdictions throughout the watershed not participating in this LWQMP (e.g. all upstream responsible jurisdictions except the City of Los Angeles) will treat their wet weather and baseflow runoff prior to it entering Machado Lake.

Table 5-7 presents an analogous table for predicted shallow sediment concentrations.

Table 5-7
Model Results: Lake Shallow Sediment Concentrations

	2014 (Year 1) Annual Mean				2024 (Year 10) Annual Mean			
	Chlordane (µg/kg)	**DDT (µg/kg)**	**Dieldrin (µg/kg)**	**PCBs (µg/kg)**	**Chlordane (µg/kg)**	**DDT (µg/kg)**	**Dieldrin (µg/kg)**	**PCBs (µg/kg)**
Current Conditions	60	70	1	1	1	1	1	2
Post BMP Implementation[1]	7	5	0.2	5	80	50	0.8	60
Post BMP Implementation *Plus* watershed load reductions to Loading Capacity	0.3	0.6	0.1	4	3	6	0.7	60
TMDL Numeric Targets	*3.2*	*4.2*	*1.9*	*60*	*3.2*	*4.2*	*1.9*	*60*

Notes:
[1] BMPs include supplemental water, dredging, and recirculating treatment wetland.
[2] It is assumed that the other responsible jurisdictions throughout the watershed not participating in this LWQMP (e.g. all upstream responsible jurisdictions except the City of Los Angeles) will treat their wet weather and baseflow runoff prior to it entering Machado Lake.

As shown in Tables 5-6 and 5-7, even with planned in-lake BMPs, future exceedances of both sediment and water column are predicted. Water column chlordane and DDT are predicted to be just at the regulatory targets in ten years following in-lake BMP initiation without watershed load reductions. However, with load reductions down to the established loading capacity, water column chlordane and DDT are projected to be well below the target. Water column dieldrin and PCBs are predicted to be below regulatory targets throughout the projection period for either watershed scenario.

Sediment chlordane and DDT are predicted to be at or above targets at the end of the ten year projection period for either watershed loading scenario. Sediment PCBs are predicted to be at the regulatory target at the end of the ten year period for either watershed loading scenario. Sediment dieldrin is predicted to be below the target for all scenarios.

A key to reducing toxics concentrations in the lake is clearly the dredging of contaminated sediments as this is where the vast majority of the in-lake load resides. Modeling results indicate large immediate benefits from this action but, for some of the pollutants, these predicted benefits are not sustained into the future. This is particularly true if watershed loads continue as current. Therefore a useful modeling output is the predicted time before re-dredging is required.

Table 5-8 summarizes projected re-dredge times for the various scenarios. For this analysis, the date at which re-dredging is required is defined as the point at which sediment pollutant concentrations have increased to above regulatory targets. As can be seen, without watershed load reductions and assuming currently measured EMCs, the benefits of dredging are predicted to be very short-lived for chlordane and DDT. With watershed load reductions, the limiting pollutant is DDT, and the model predicts that the lake will need to be re-dredged in approximately 7 years to address this pollutant.

Table 5-8
Model Results: Projected Re-dredge Time Periods

	Chlordane (years)	DDT (years)	Dieldrin (years)	PCBs (years)
Current Conditions	NA	NA	NA	NA
Post BMP Implementation[1]	1	1	none required	10
Post BMP Implementation *Plus* watershed load reductions to Loading Capacity	12	7	none required	12

Treatment of External Load to meet Toxics Load and Waste Load Allocations
As shown in Table 2-11 in Section 2, water quality monitoring in the Wilmington Drain indicates chlordane, total DDT, and dieldrin exceed the applicable WLAs. Data for Project 510 indicates these toxics were not detected. Project 77 exceeded the WLA for chlordane only. As previously discussed, the water quality monitoring data for the storm drains is limited and it appears the majority of WLA exceedances are attributed to Wilmington Drain.

The tributary area to Machado Lake is approximately 14,156 acres, which is approximately 389 times the surface area of the lake (see Figure 1-2 in Section 1), resulting in runoff loads entering the lake predominantly from wet weather urban runoff. As discussed above reductions in external loading will assist with meeting the regulatory targets and narrowing the gap between projected concentrations and regulatory requirements. The external load of toxics is secondary to internal loading.

The City of Los Angeles' upstream portion of the watershed is 1,800 acres, or 13 percent of the total watershed. Therefore, 87 percent of the watershed is not within the City of Los Angeles' jurisdiction. As stated previously, since the other upstream jurisdictions are not participating in the activities and BMPs described in this LWQMP, they are required to separately meet their TMDL WLAs by reducing the toxic concentrations in the runoff from their areas. If the quality of the runoff from the portion of the upstream watershed that is attributed to these responsible jurisdictions were to be reduced through various BMP approaches to achieve the TMDL WLAs, then the external load to Machado Lake would be reduced.

5.2.2.2 Sensitivity Analysis

A sensitivity analysis was performed in order to assess model sensitivity to key parameters and to quantify a portion of the uncertainty in the model predictions. This exercise involved varying parameters independently within reasonable ranges and comparing output with baseline model output, a process often termed "jack knifing". For this work, the post BMP implementation model, without watershed load reductions, was selected as the "baseline". Model sensitivity was defined according to changes in the predicted Year 10 sediment concentrations of the four targeted pollutants.

Results are summarized in Table 5-9. Projected sediment-bound pollutant concentrations are shown to vary significantly (+100%, -75%) with adjustments to key parameters within reasonable ranges of uncertainty. The model shows greatest sensitivity to the prescribed burial fraction of settled sediment-bound pollutants. Year 10 pollutant concentrations are approximately doubled at the low end of the burial fraction range and approximately quartered at the high end. Moderate sensitivity is shown to settling velocities, desorption coefficients (k_{d2}) and wet weather EMCs; low sensitivity is shown to the vertical mixing length. The model is shown to be insensitive to the prescribed dry weather EMC, for all pollutants.

Table 5-9
Sensitivity Analysis Results, Post BMP Implementation Model

Parameter	Yr 10 Sediment Chlordane ($\mu g\ kg^{-1}$)	Yr 10 Sediment DDT ($\mu g\ kg^{-1}$)	Yr 10 Sediment Dieldrin ($\mu g\ kg^{-1}$)	Yr 10 Sediment PCBs ($\mu g\ kg^{-1}$)
baseline parameterization	80	50	0.8	60
burial fraction (0.1 - 0.9)	20-200	10-100	0.2 - 2	20-100
settling velocity (10 - 60 ft s^{-1})	40-90	30-60	0.5 - 0.9	40-70
k_{d2} (± 1 order of magnitude)	20-90	20-60	0.09 - 2	50-60
vertical mixing length (0.5 – 4 ft)	70-90	50-60	0.5 - 1	60-60
EMC wet (± 50%)	40 - 100	30 - 90	0.4 - 1	30 - 10
EMC dry (± 50%)	80 - 80	50 - 50	0.8 - 0.8	60 - 60

5.2.2.3 UncertaintyAnalysis

Modeling results were compared with compliance metrics provided in the lake toxics TMDL report developed by the Regional Board. Compliance targets include both water column and sediment concentration standards. As with any modeling exercise, there is inherent uncertainty in any predictions made by the model. This uncertainty can be reduced with the support of site-specific measured data (e.g. calibration and validation) and results of similar studies in the literature. While the key toxic pollutant mechanisms are believed to be well-represented in the model applied here, site specific data were limited. Levels of uncertainty associated with the modeling results presented here should therefore be viewed as relatively high – specifically, higher than those of the nutrient modeling which was well-supported by monitoring data.

Modeled watershed loads are largely based on a limited measured data set from recent sampling of Wilmington Drain and Project 77 wet and dry weather flows. The measured toxic pollutants were sediment-bound and clearly represent inputs from a “legacy” pool of toxics present in the soils and sediments of the drainage basins. Significant restrictions now exist regarding the use of these chemicals. Therefore, over time the legacy loads for these chemicals are expected to be significantly reduced in the watershed via periodic flushing events and natural degradation. The model does not account for these processes in the future scenario simulations presented here. Rather, it assumes that baseline “current condition” legacy loads remain steady into the future. This is a conservative assumption and therefore represents an additional implicit margin of safety in the model predictions.

5.3 Healthy Lake Goals for Nutrients

The historical trophic state of Machado Lake was investigated in the paleolimnologic study summarized in Section 2.2, which states that it is likely that the waters of Machado Lake have been mesotrophic to eutrophic for the past 66 years (1943 to 2009). Further, the diatoms that have persisted over this time period indicated that the lake has consistently had high nutrient concentrations.

Additionally, whereas typical lakes have lake to watershed ratios less than 1: 100, Machado Lake has a very high surface area to watershed area of 1: 389 acres, which is indicative of a lake that would have eutrophic conditions (Horne & Goldman, 1994).

These two pieces of information indicate that the lake not only has been eutrophic historically, but also that the nature of the drainage area nearly guarantees that the lake would be eutrophic.

Phosphorus and nitrogen are the key nutrients for photoplankton growth in lakes, and are responsible for the eutrophication of surface waters (Regional Board, 2008). However, ultimately the most direct measure of a healthy lake with respect to eutrophication is the concentration of algal biomass, as measured by chlorophyll-*a*. While N and P concentrations are primary drivers of algal growth, they are not the only drivers. Lake morphology, sunlight, and temperature are examples of other variables that impact algal concentrations. Consequently, N and P concentrations in the lake should be viewed as indirect measures of a healthy lake, with respect to eutrophication. The relationship between nutrient concentrations and chlorophyll-*a* concentrations varies by lake and is impossible to define exactly even with the most robust of models. Therefore, it is recommended that focus the water quality management be placed on the chlorophyll-*a* concentration reduction rather than N and P concentrations. The TMDL acknowledges that:

> "*If water quality improves and the numeric targets for chlorophyll a and dissolved oxygen are achieved and the allocations and/or numeric targets for nitrogen and phosphorus have not been achieved, the TMDL may be reconsidered to adjust the allocations and targets. Moreover, if nitrogen and phosphorus allocations and numeric targets are met and the chlorophyll a and dissolved oxygen numeric targets are exceeded, the TMDL may be reconsidered to adjust the allocations and targets.*"

The analysis conducted to support this LWQMP indicates that is it likely that with implementation of all the proposed BMPs and management activities, the targets for chlorophyll-*a* and dissolved oxygen can be achieved at Total-P and Total-N concentrations somewhat higher than the established numerical targets. It is anticipated that this condition can be consistently achieved and demonstrated through monitoring following completion and operation and maintenance of the BMPs, therefore reconsideration of targets and/or allocations in the TMDL would be warranted.

5.4 Summary

5.4.1 Nutrients Summary

The lake is currently in compliance with the LAs and WLAs for the two interim compliance dates for nutrients (see Table 5-1). The City is currently in the bid phase of the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project*, and the in-lake BMPs and other activities that are part of this project are predicted by the Lake Water Quality Model to reduce phosphorus concentrations in the lake by 85 percent and nitrogen concentrations by 34 percent. Chlorophyll-*a* is predicted to be reduced 77 percent, and effectively below the numeric target of the TMDL. Dissolved oxygen and ammonia are also predicted to maintain or achieve levels that will consistently meet the numeric targets of the TMDL.

The Machado Lake Water Quality Model for nutrients has illustrated that full implementation of the BMPs that the City of Los Angeles is committed to will not result in the lake consistently meeting the total phosphorus and total nitrogen targets in the TMDL due to the substantial external annual wet weather runoff loading of phosphorus and nitrogen to the lake. Therefore, if the nutrient targets are to be consistently met in addition to the chlorophyll-*a* targets, concentrations of phosphorus and nitrogen in the runoff of the entire watershed must be reduced prior to discharge to the lake.

Eighty-seven percent (87%) of the upstream portion of the watershed consists of land and other features that are outside of the City of Los Angeles' jurisdiction. The Lake Water Quality Model for nutrients shows that if the other responsible jurisdictions located upstream of the lake reduced nitrogen and phosphorous in the runoff to achieve the required TMDL WLAs prior to its discharge to the lake by 2018, the in-lake nutrient concentrations should be at or below the total phosphorus, total nitrogen and chlorophyll-*a* targets throughout the year. In the event that the targeted nutrient reductions in the upstream watersheds are not fully achieved by 2018, it should be noted that chlorophyll-*a* and dissolved oxygen targets could still be met, and if this is demonstrated through monitoring following completion and operation and maintenance of the BMPs, reconsideration of targets and/or allocations in the TMDL would be warranted.

5.4.2 Toxics Summary

Modeling results for toxics show large improvements in lake water quality as a result of planned in-lake BMPs. These improvements are characterized by lower toxic pollutant concentrations in both the water column and the shallow sediments. However, results also indicate that, depending on future watershed loads entering the lake, these improvements are not likely sustainable indefinitely:

- Results indicate that dieldrin will be fully addressed with currently planned in-lake BMPs. Neither water column nor sediment dieldrin concentrations are predicted to exceed regulatory targets following BMP implementation and into the foreseeable future.

- For chlordane and PCBs, the model projects an approximately ten year period following BMP implementation where water column and sediment concentrations will be below targets if watershed loads are reduced to quantified loading capacities as required by the TMDL. After approximately ten years, however, lake sediment pollutant concentrations are predicted to nearly return to current levels, and the lake may need to be re-dredged.

- For DDT, the model predicts the post-dredging period of compliance to be closer to seven years (see Tables C-28 and C-29 in Appendix C).

Note that, despite sediment quality concerns, water column concentrations for all four pollutants are predicted to be well below the regulatory targets, if watershed loads are reduced to meet applicable TMDL WLAs, throughout the ten year projection period and beyond.

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Section 6
Capital Costs and Long-Term Maintenance Requirements

A construction cost estimate based on the 100 percent design drawings prepared for the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project* is summarized in Section 6. A summary of general long-term maintenance strategies associated with the some of the BMPs outlined in Section 3 is also provided. Through the collaborative effort of the City and LACDPW the construction and long-term maintenance of BMPs will result in water quality compliance and ecosystem restoration.

6.1 Capital Costs for Construction

Detailed capital cost estimates for construction were developed according to City of Los Angeles Bureau of Engineering guidelines and Proposition O estimating procedures. These guidelines and procedures include using the following estimating factors:

- Mobilization allowance – 4 percent
- Permitting Allowances – 3 percent
- Other Allowances – 5 percent
- Estimating contingency – 20 percent
- Construction cost escalation – 6 percent per year (to mid-point of construction)
- Construction contingency – 10 percent (allows for construction change orders)

Table 6-1 provides costs for the construction of the management strategies presented in Section 3. Table 6-1 does not mimic line for line Tables 3-1 and 3-2 for costs because there are other necessary construction components or steps associated with various BMPs that were itemized in Table 6-1. These cost estimates are opinions of probable cost based on 100% design drawings.

The construction cost estimate shown in Table 6-1 is subdivided into three parts: City costs for construction of BMPs for Machado Lake, City costs for construction of BMPs for Wilmington Drain, and LACDPW costs for Wilmington Drain. For Wilmington Drain, the estimate assumes that a portion of the work will be funded by LACDPW, such as those features proposed to improve flood control capacity. All other costs are assumed to be funded through Proposition O and are shown as City costs. The cost allocated to the City is approximately $201.44 million. The cost allocated to LACDPW is approximately $6.26 million. The total estimated cost is approximately $207.7 million. This opinion of probable cost is provided to demonstrate the magnitude of the commitment from the City and LACDPW to water quality and ecosystem restoration.

Table 6-1 Cost Estimate for Wilmington Drain and Machado Lake Construction

Description	100% Design Estimate[1]	
MACHADO LAKE		
Lake Dredging and AquaBlok	$	58,210,000
Lake Edge Treatment Dredging	$	1,280,000
Subtotal	**$**	**59,490,000**
Storm Water BMPs		
D24010 Drain	$	313,000
Figuerora Drain	$	668,000
Project 77	$	610,000
Site Source Control	$	243,000
Bioengineered Swale @ Project 77	$	211,000
510 Swale and Headwall	$	101,000
Subtotal	**$**	**2,146,000**
Wetlands		
Riparian Area	$	422,000
Offline Recirculation Wetlands	$	1,571,000
Freshwater Marsh	$	470,000
Figuerora Drain Wetlands	$	295,000
Subtotal	**$**	**2,758,000**
Lake Rehabilitation		
Aeration	$	1,358,000
Alum Treatment	$	375,000
Phosphorous Removal	$	1,283,000
Lake Water Quality Monitoring System	$	228,000
Dam Improvements	$	466,000
Fish Habitat	$	288,000
Recycled Water Make-up	$	155,000
Park Components	$	6,655,000
Invasive Removal	$	1,226,000
Subtotal	**$**	**12,034,000**
Other		
Mobilization	$	3,057,000
Permit Allowance	$	2,293,000
Escalation to Mid-Point Construction	$	2,650,000
General Conditions	$	6,542,000
Contingency	$	8,832,000
Sales Tax, Insurance, Overhead and Profit	$	14,303,000
Subtotal	**$**	**37,677,000**
Total	**$**	**190,533,000**
Wilmington Drain		
City of Los Angeles		
Invasive/Exotic Plant Removal	$	594,000
Landscape	$	3,825,000
Landscape Maintenance	$	29,000
110 Freeway Trash Net Unit Installation	$	1,043,000
Vegetative Swale	$	9,000
Trench Drain	$	18,000
Rip Rap	$	8,000
Parking Lot	$	86,000
Storm Water BMPs	$	99,000
Catch Basins	$	39,000
Concrete Pipe with Headwall	$	38,000
Retaining Wall	$	723,000
Ramps	$	103,000
Subtotal	**$**	**6,614,000**
County of Los Angeles		
Retaining Wall	$	626,000
Channel Contouring - Lomita and PCH	$	5,117,000
Channel Contouring - North of Lomita	$	289,000
Channel Contouring - South of PCH	$	30,000
Channel Contouring - Maintenance Roads	$	88,000
Turf Reinforcement Mat	$	45,000
Ramps	$	62,000
Subtotal	**$**	**6,257,000**
Other		
Mobilization	$	279,000
Permit Allowance	$	209,000
Escalation to Mid-Point Construction	$	267,000
Trash Net	$	2,175,000
Contingency	$	1,363,000
Subtotal	**$**	**4,293,000**
Total	**$**	**17,164,000**
Grand Total	**$**	**207,697,000**

1. Cost subject to change, long term maintenance costs are not included

6.2 Long-term Maintenance Requirements

Many of the BMPs selected for inclusion in the *Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multi-Use Project* will require ongoing operational oversight and periodic, routine maintenance. Long-term maintenance is necessary for the optimal performance of each BMP to achieve the greatest capacity for pollutant reductions and improved ecosystem functioning. The City and LACDPW are in the process of establishing a Memorandum of Understanding to outline the roles and responsibilities that will guide the routine maintenance activities which include:

- Inspections
- Reporting and information management
- Equipment maintenance and repair
- Trash removal from the trash net systems
- Sediment and trash removal from the CDS units
- Potential caustic solution removal and disposal from phosphorus removal system
- Lake aquatic vegetation and biomass management and removal
- Terrestrial vegetation management with trash and minor debris removal
- Park facilities and structures maintenance
- Vector control

Other corrective and infrequent maintenance activities (e.g., unplanned and/or every 3 years or more) include:

- Wetland and channel aquatic vegetation and biomass management and removal
- Dredging of sedimentation basins and channel area (as necessary)
- Intermittent facility maintenance
- Sediment removal from Wilmington Drain and other Machado Lake storm water BMPs

Maintenance activities in Wilmington Drain and KMHRP are subjected to stipulations in five permits:

- California Department of Fish and Game (CDFG) – Streambed Alteration Agreement (SAA)
- California Department of Fish and Game – California Endangered Species Act Section 2081 Incidental Take Permit (ITP)
- Regional Water Quality Control Board – Section 401 Water Quality Certification
- Unites States Army Corps of Engineers (USACE) 404 Permit
- United States Fish and Wildlife Service (USFWS)– Federal Endangered Species Act Incidental Take Permit, Section 7 Biological Opinion

These permits will be issued prior to the start of construction.

The City and LACDPW have existing standard operating procedures (SOPs) for maintenance requirements associated with some of the recommended BMPs. Additional SOPs may need to be developed by both agencies in conjunction with various vendors associated with some of the storm water BMPs. The two agencies prepared Table 6-2 to provide a roadmap of future operations and maintenance strategies that, with appropriate resources, can be implemented over time. Table 6-2 provides a summary of the BMPs discussed in Section 3, the agency responsible for operation and maintenance, and a general description of the recommendation associated with maintenance to ensure optimum performance of each BMP.

Table 6-2
Operations and Maintenance Recommendations for Management Strategies

Management Strategy	Operations and Maintenance Responsibility	Operations and Maintenance Recommendations	Proposed Reporting and Information Management
Lake Dredging	LA City	Re-evaluate every 10 years	Yes –tons of sediment removed from system
Add Supplemental Water – microfiltration/reverse osmosis	LA City	Annual valve inspection and water use tracking: SOPs established between TIWRP and City	Yes – monthly water use
Oxygenation System	LA City	Annual pump station maintenance, SOP established between Speece Cone manufacturer and City	Yes – changes in DO concentrations within lake
Off-line Treatment Wetland	LA City	Annual pump station maintenance, inspection of valves and inlet and discharge facilities. Biomass harvesting ~ 3-yr cycle; SOPs established by City	None.
Phosphorus Removal System	LA City	Annual maintenance of treatment vessels and media filters; potential for caustic solution disposal; SOPs established between manufacturer and City	Yes – changes in phosphorus concentrations
Aquatic Plant Management and Littoral Zone Enhancements, including Ludwigia removal	LA City	Seasonal maintenance as needed; SOPs established by City	Yes – tons of plant biomass removed
Shoreline Erosion Control (Lake Edge) Treatments	LA City	Maintenance program for all park design elements and facilities; SOPs established by City	None.
Golf Course Maintenance Yard Site BMPs	LA City	Maintenance program for all design elements and facilities; SOPs established by City	None.
KMHRP Design Improvements (WQ benefits), including Southern Tarplant enhancement	LA City	Maintenance program for all park design elements and facilities; SOPs established by City	None.
In-Lake Sediment Basin – North (captures inflows from Drain P6545, Drain D24010, and Wilmington Drain)	LA City	Sediment, trash removal and disposal as needed; SOPs established by City	Yes –tons of sediment removed from system

Table 6-2
Operations and Maintenance Recommendations for Management Strategies

Management Strategy	Operations and Maintenance Responsibility	Operations and Maintenance Recommendations	Proposed Reporting and Information Management
Re-grade entire Wilmington Drain channel bottom (2011)	LACDPW	Re-evaluate every 10 years	Yes - tons of sediment removed from system
Clean box culverts at Lomita Blvd.	LACDPW	Re-evaluate every 10 years	Yes - tons of sediment removed from system
Clearing and annual maintenance of channel vegetation	LACDPW	Annual maintenance program required to maximize hydraulic capacity of Wilmington Drain; SOPs established by LACDPW	Yes – annual biomass removed
CDS at D24010 Drain	LA City	Sediment, trash removal and disposal as needed; SOPs established between manufacturer and City	Yes –tons of trash or sediment removed from system
CDS at Project 77	LA City	Sediment, trash removal and disposal as needed; SOPs established between manufacturer and City	Yes –tons of trash or sediment removed from system
CDS at Figueroa Drain	LA City	Sediment, trash removal and disposal as needed; SOPs established between manufacturer and City	Yes –tons of trash or sediment removed from system
Bioengineered swale at Project 77 Drain (dry weather treatment)	LA City	Maintenance as needed: SOPs established by City	None.
Bioengineered swale at Project 510 Line C Drain (dry weather treatment)	LA City	Maintenance as needed; SOPs established by City	None.
Trash Nets (Wilmington Drain at Fwy 110 and Wilmington Drain Project 510 Drain	LA City	Seasonal maintenance as needed; SOPs established by City	Yes –tons of trash removed from system.
Wilmington Drain Pocket Park	LA City	Maintenance program for all park design elements and facilities; SOPs established by City	None.
Dam Improvements	LA City	Maintenance as needed; SOPs established by City	None.
Invasive Plant Removal - Riparian Woodland	LA City	Annual maintenance program for all park design elements and facilities; SOPs established by City	Yes - annual biomass removed

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