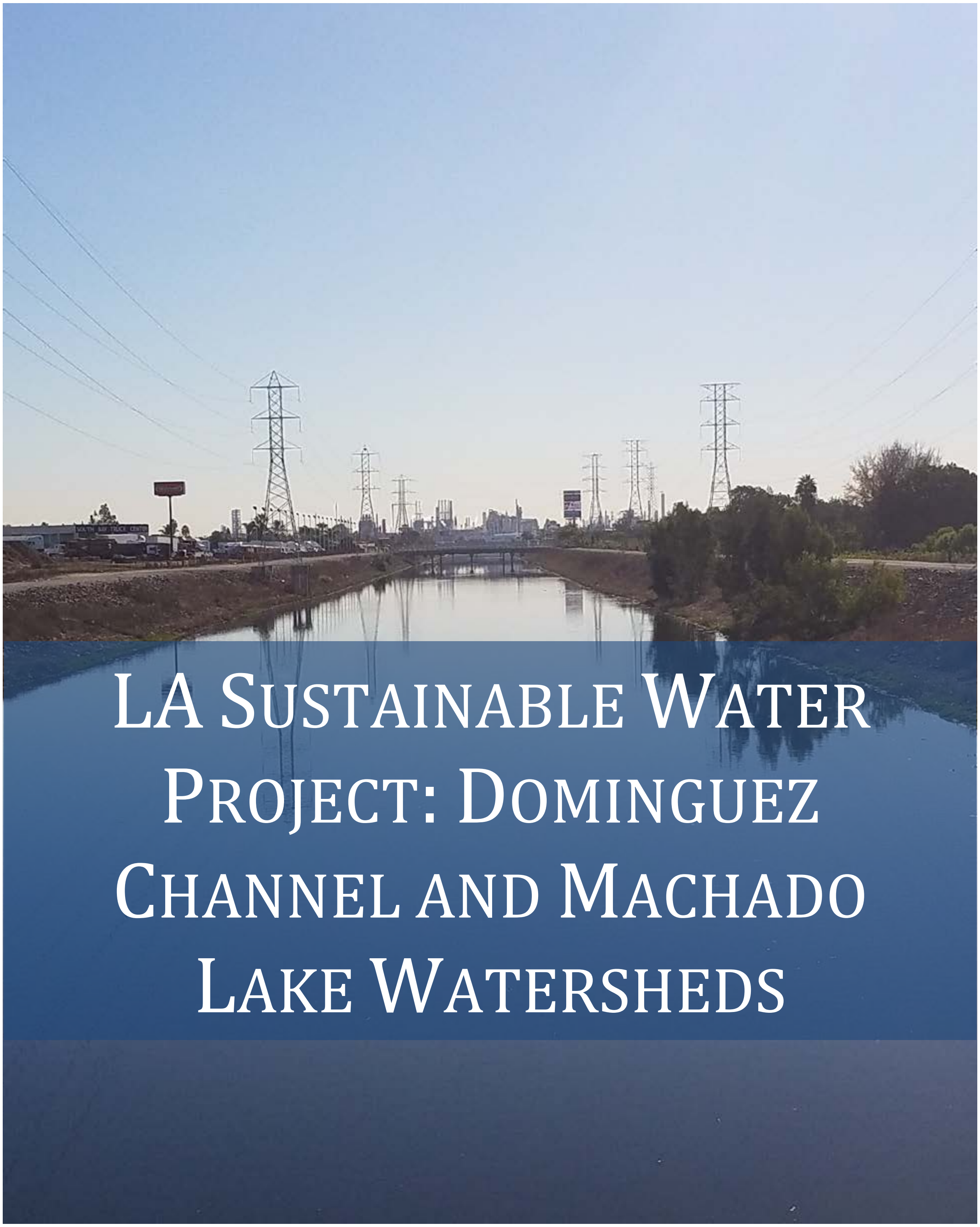

LA Sustainable Water Project: Dominguez Channel and Machado Lake Watersheds

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This report is a product of the UCLA Institute of the Environment and Sustainability, UCLA Sustainable LA Grand Challenge, and Colorado School of Mines.

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ACKNOWLEDGEMENTS

This research was supported by the City of Los Angeles Bureau of Sanitation (LASAN). Many thanks to LASAN for providing ideas and direction, facilitating meetings and data requests, as well as sharing the many previous and current research efforts that provided us with invaluable information on which to build. Further, LASAN provided edits which helped to deepen and improve this report. Any findings, opinions, or conclusions are those of the authors and do not necessarily reflect those of LASAN.

We would further like to acknowledge the many organizations which facilitated this research through providing data, conversations, and insights into the integrated water management world in the Los Angeles region: LADWP, LACDPW, LARWQCB, LACFCD, WRD, WBMWD, MWD, SCCWRP, the Mayor's Office of Sustainability, and many others.

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Contents

Executive Summary

The potential to meet water quality standards while also integrating complementary one water management practices that can increase potential local water supplies for the City of Los Angeles (the City) in the Dominguez Channel watershed (DC watershed) is explored in this report. The DC watershed covers approximately 133 mi² (85,120 ac) in the Los Angeles area and encompasses the 25 mi² (16,000 ac) Machado Lake (ML) watershed as well as the 37 mi² Los Angeles/Long Beach Harbors watershed. Only 9.59 mi² (6,138 ac) in the DC watershed and 5.05 mi² (3,232 ac) in the ML watershed are located in the City. The DC and ML watersheds are highly urbanized; Machado Lake, a 45 acre freshwater lake with a 63 acre seasonal freshwater marsh downstream, is located within the ML watershed. To assess the integrated water landscape in this watershed, current practices and future opportunities at the Terminal Island Water Reclamation Plant (TI-WRP) and in the underlying adjudicated groundwater basins, West Coast Basin and Central Basin, were also explored.

Dominguez Channel - Both dry and wet weather runoff contribute pollutant loads to many water bodies in Los Angeles County; implementing suites of BMPs is one mechanism to capture and infiltrate or treat and release this runoff before it reaches the adjacent water bodies. Briefly, in this study, a modified version of the US EPA's System for Urban Stormwater Treatment and Analysis (SUSTAIN) model was used to model the water quality impacts of implementing various suites of BMPs (vegetated swales, bioretention, dry ponds, infiltration trenches, and porous pavement). Six modeled scenarios, each with a unique suite of BMPs, were designed to capture the 85th percentile storm: a potential pathway to meeting the requirements in the Los Angeles County MS4 permit. Scenarios 1, 2, and 3 simulate bioretention, dry ponds & vegetated swales, and dry pond & infiltration trenches, respectively. Scenarios 1b, 2b, and 3b add porous pavement to scenarios 1, 2, and 3. For example, scenario 1 simulates bioretention and scenario 1b simulates bioretention and porous pavement. Additionally, three scenarios were designed to decrease the remaining number of wet weather exceedances by increasing the percentile storm capture, increasing the decay rate of the pollutants within the BMPs, and assessing the potential impact of a new Water Effects Ratio (WER) for copper on meeting water quality standards.

To summarize, eliminating copper and zinc exceedances in the DC watershed will be very challenging and source control and source tracking will be a critical component. While there is sufficient available public land to accommodate the BMPs required to capture the 85th percentile storm volume (2,353 AF) in all six modeled scenarios, the capture of this storm volume was not sufficient to eliminate wet weather exceedances for copper or zinc in any scenario except the one assessing the impacts of a WER of 3.2. If a study to characterize the water chemistry in Dominguez Channel was conducted and site-specific characteristics and calculations generated a WER of 3.2 or greater, then it would be possible to eliminate wet weather exceedances in the DC watershed for copper based on our modeling results. Even if a WER were not as high as 3.2, a WER could have the effect of reducing the total amount of BMPs needed to meet a revised criteria. It is important to note, however, that WERs do not provide any of the potential ancillary benefits of implementing BMP programs.

In addition to implementing watershed-scale BMP programs, source control and source tracking efforts to eliminate pollutant loads coming in from the watershed are critical to eliminating exceedances in the DC watershed. For example, wet weather exceedances for copper were not eliminated even in modeling scenarios in which the event mean concentrations (EMCs) for industrial land uses in the DC watershed were set to the Waste Load Allocations (WLAs) in the Total Maximum Daily Load (TMDL). Thus, identifying and remediating sources of metals throughout the DC watershed is absolutely critical to resolving chronic water quality issues in DC. Some monitoring of industrial facilities is required under state-wide general or individual permitting, and requirements exist for industrial facilities to implement stormwater pollution prevention programs which are expected to reduce runoff pollutant concentrations and loads. However, even if these programs are fully implemented, more source reduction efforts may be required to meet water quality standards for copper in the DC watershed.

Increasing the quality and quantity of water quality data collected in the DC watershed and available for analysis must occur to appropriately plan pathways to compliance. The DC watershed is heavily industrialized, and there are severe data gaps with regard to the actual pollutant loadings in stormwater from these land uses. Due to the inland influence of the tidal influx, the water quality monitoring station is located mid-watershed, so current monitoring efforts do not capture the lower portion of the watershed, which contains more industrial facilities than the upper portion of the watershed. Increasing monitoring efforts to include more sampling in DC and ML as well as more of the industrial facilities in the watershed that are potential sources of pollutants, will facilitate attaining water quality standards in the DC watershed. The City's monitoring efforts, planned through the DC Coordinated Integrated Monitoring Program (CIMP), and the installation of the ML monitoring system will also provide additional data that can inform future efforts.

Monitoring and/or data collection efforts should also include specific land use types to better characterize loads in the watershed. We conducted a preliminary analysis comparing industrial runoff data available through the Stormwater Multiple Application and Report Tracking System (SMARTS) database to the currently available industrial land use EMCs. The analysis demonstrated that the current EMCs may not accurately reflect the variability in runoff water quality from numerous industrial facilities in the DC watershed. Thus, conducting studies to better characterize industrial facilities and the water quality of the runoff leaving those facilities is necessary to accurately reflect the water quality in DC.

It is important to note that the presented modeling efforts did not include the impacts of other programs occurring throughout the region such as management control measures or the implementation of BMPs on private land through, for example, the City of LA's LID ordinance, which will also improve water quality. Watershed-scale BMP implementation programs such as those investigated in this study and in the Enhanced Watershed Management Programs (EWMPs) provide significant water quality benefits as well as opportunities to characterize the performance of BMPs over time and thus adapt strategies to more effectively improve water quality. The combination of lower TMDL targets and higher loading of pollutants in the DC watershed makes the elimination of zinc and copper exceedances even less likely without targeted source elimination efforts from industrial, transportation, and other sources; an effective LID program for new and redevelopment; and potentially, if appropriate based on conditions, site-specific metals criteria based on WERs.

Machado Lake - Similarly, modeling efforts in the Machado Lake watershed (the ML watershed) demonstrated that source tracking and source control (although for nutrients rather than metals) are critical components for complying with water quality standards in Machado Lake. In the presented work, the ML watershed was modeled using SUSTAIN and in-lake water quality was simulated using the Simplified Lake Analysis Model (SLAM), which was developed by the City during the process of developing the Machado Lake Water Quality Management Plan to attain compliance with water quality standards. Modeled scenarios included the implementation of suites of BMPs (including porous pavement, dry ponds, infiltration trenches, and wet ponds) to capture the 85th percentile storm volume (721 AF) and to explore pathways to eliminating exceedances in ML. Our approach using SUSTAIN and SLAM in concert provides the opportunity to better represent flows and loadings from the ML watershed into ML and simulate BMPs (and their effects on flows and loadings) throughout the watershed.

Our analysis indicates that a sufficient number of BMPs could be placed in the ML watershed to capture the 85th percentile storm, but eliminating water quality exceedances for total nitrogen and total phosphorus is challenging. Eliminating total nitrogen exceedances is more easily done; capturing the 85th percentile storm volume with wet ponds eliminates total nitrogen exceedances as does setting all external flows to the required WLAs. Modeling results indicate that eliminating total phosphorus exceedances will not occur in the watershed unless concentrations in runoff entering the lake are decreased to 0.025 mg/L (25% of the current WLA). However, it is important to note that limiting factors such as the severe lack of data in the ML watershed, notably flows going into Machado Lake, inhibits the analysis. This gap must be remedied and input into future modeling efforts to reassess the water quality impacts. SUSTAIN could not be calibrated for the ML watershed based on the paucity of data and instead, calibrated parameters used in Dominguez Channel were used. Earlier modeling efforts by the City have also found compliance with total phosphorus to be extremely difficult unless all permit holders in the watershed also meet the WLAs; compliance with total nitrogen was found to be easier.

The City is also currently implementing a range of projects that aim to address water quality concerns in Machado Lake including two projects funded by Proposition O: the Machado Lake Ecosystem Rehabilitation and Wilmington Drain Multiuse projects. These efforts should greatly improve water quality in ML, but intensive monitoring needs to occur after project completion to ascertain whether the expected water quality gains are being achieved. The City is implementing a monitoring strategy for ML that will provide continuous data for some flow into ML and the capacity to collect composite samples. This system is expected to be operational for the 2017-2018 storm season and will provide information to help address these gaps. The addition of newer lake water quality data (post lake dredging and capping) and wet weather flow and water quality data from sub-watersheds draining into the lake into the aforementioned modeling approaches may lead to more optimistic predictions of ML water quality and compliance status. The City should also conduct studies to identify opportunities to ensure that the ML ecosystem is improving, determine if the beneficial uses are attained, and ensure that all point and nonpoint sources have been addressed appropriately.

Water Supplies - In addition to implementing the mitigation efforts described above to address water quality concerns in Machado Lake, the City plans to add 140 AFY of high quality recycled water from the Terminal Island Water Reclamation Plant (TIWRP) to maintain constant lake levels despite evaporation and to maintain nitrogen concentrations at levels that are within the required water quality standards. TIWRP is designed to treat an average daily flow of 30 MGD and currently treats approximately 15 MGD; currently existing and potential future local demands for TIWRP advanced treated recycled water exceed potential flows at the current flow rates. Future demands of up to 24.5 MGD, which include the flow to Machado Lake, have been identified. In earlier research, the City has identified potential opportunities to increase influent flows to TIWRP through either diverting approximately 16 MGD of Title 22 water from the Edward C. Little Water Reclamation Facility or diverting similar volumes of secondary effluent from the Joint Water Pollution Control Plant.

The above potential recycled water demand includes increased injection of advanced treated recycled water from TIWRP for seawater intrusion barriers. Managing the 85^{th} percentile storm in these two watersheds can provide the potential to increase stormwater infiltrated per year by approximately 3,000 AF. Available dewatered space in West Coast (120,000 AF) and Central Basins (330,000 AF) provides potential opportunities to store and extract both recycled water and newly managed stormwater to increase local water supplies. The City has 1,503 AF of pumping rights in West Coast Basin and an allowed pumping allocation of 17,236 AF in Central Basin. The first opportunity for the City to more fully utilize these groundwater basins is to increase pumping capacity to allow full extraction of pumping rights in both basins. The City is currently undergoing efforts to expand their pumping capacity in Central Basin to allow the extraction of their total adjudicated rights volume; the City currently has no pumping capacity in West Coast Basin and no defined plans to add pumping capacity there.

Additional opportunities for the City to increase their pumping in these basins includes purchasing and leasing additional pumping rights, perhaps through offering recycled water to industrial users in exchange for a lease on their pumping rights. The brackish plume in West Coast Basin, a result of historical seawater intrusion, currently takes up 600,000 AF of space and offers another opportunity to increase the extraction and remediation of groundwater to increase local water supplies, as well as create additional space for storing, for example, recharged stormwater.

Recent amendments to the adjudications in these basins also greatly expanded the potential for rights holders to increase the conjunctive use of the basin. Partnerships are critical throughout the region to be able to take advantage of these opportunities. For example, if the City works with the other participants in the DC EWMP, the potential combined volume of all individual rights including the additional storage rights adds up to 26,000 AFY. Water augmentation projects offer additional opportunities beyond the existing pumping and storage rights for rights holders in the basin to store and extract water in these basins in each year. The Broadway Neighborhood Stormwater Greenway Project is an excellent example of a collaboration between the City of LA Bureau of Sanitation and Department of Water and Power, the Water Replenishment District, and others, which covers a 32 acre tributary area and is expected to capture 30 to 40 AFY. This is an example of a project that is not only helping to improve water quality, but also being monitored to quantify the potential water supply benefits of infiltrating the water.

This research demonstrates the complex interrelationships between all aspects of urban water management. Projects that are geared towards managing stormwater to improve water quality can also increase local water supply potential. Groundwater basins provide an opportunity to store water in times of excess, whether that water comes from increasing volumes of advanced treated recycled water or captured stormwater. The regulatory and political environment is complex and provides many opportunities and challenges to implementing integrated water management programs that can truly address the multiple needs of urban water landscapes. As more projects are designed with multiple goals in mind, partnerships will become established, methods of quantifying stormwater through the lens of water supply will become better defined, and regulations and policies can be adapted to reflect the equally important goals of cleaning up our surface water and increasing our local water supply resiliency in a semiarid region.

Background

For over fifteen years, the City of Los Angeles (City) has worked closely with local communities and stakeholders to develop an integrated approach to managing water. The City understood that siloed approaches to wastewater, water supply, stormwater, and flood control management was inefficient and that integration of its water management programs would result in improved water quality, increased local water supplies, and better flood control. The City developed an integrated water approach with a series of plans including the Integrated Resources Plan, the Water Quality Compliance Master Plan and associated watershed compliance plans [Total Maximum Daily Load (TMDL) Implementation Plans, Enhanced Watershed Management Programs, Coordinated Integrated Monitoring Programs, and a Water Supply Plan]. The City is currently developing a One Water LA Plan, which aims to identify projects and programs to help integrate a one water approach throughout the City.

For integrated water management to be effective, quantitative assessments identifying the feasibility of and opportunities for citywide implementation, including the benefits and costs of implementation are necessary. Quantitative assessments will provide the City of Los Angeles Sanitation (LASAN) with additional information to facilitate developing integrated water infrastructure priorities and management frameworks and garnering broader support for implementation and funding initiatives. The first report in this series was released in November 2015 with a focus on implementing integrated water management in the Ballona Creek Watershed.[1] This second report examines the opportunities and challenges to implementing integrated water management that are present in the DC and ML Watersheds and a third report on the Los Angeles River watershed is forthcoming.

I. Introduction

A. The City of Los Angeles

Many policies and plans have been created within the City that address urban water management, integrated resources planning, stormwater capture, and groundwater management. The following plans and programs have been described in the previous study on the Ballona Creek Watershed: *Los Angeles Urban Water Management Plan* (UWMP), *Recycled Water Master Planning* (RWMP) *Documents*, *LA Stormwater Capture Master Plan* (SCMP)*, Los Angeles Water Integrated Resources Plan* (IRP) 2006, The *Water Quality Control Master Plan*

[1] Gold M, Hogue T, Pincetl S, Mika K, Radavich K, 2015, "Los Angeles Sustainable Water Project: Ballona Creek Watershed", UCLA Grand Challenges | Sustainable LA; UCLA Institute of the Environment and Sustainability, Los Angeles, CA 2015 *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/ (UCLA CSM Ballona Creek Report 2015)

- *Urban Runoff* (WQCMPUR), *Standard Urban Stormwater Mitigation Plan* (SUSMP), *and Low Impact Development* (LID) *Requirements.*

Currently, the City is also developing the OneWater LA Plan to expand on the 2006 IRP and accelerate the development of an integrated framework to manage the City's water for sustainability. Phase I, which aimed to strengthen collaboration within the City as well as with other stakeholders, develop a vision statement, and identify objectives for One Water LA, was completed in June 2015. Phase II, currently ongoing, includes conducting additional technical studies to identify opportunities to increase integrated water management, generating additional planning documents for stormwater and wastewater facilities, and providing guidance for future City Master plans.[2] Phase II of the OneWater 2040 effort began in the second half of 2015 and will be completed in 2017.

B. Dominguez Channel and Machado Lake Watersheds

a. Study Area, Hydrology, Geography

The Dominguez Channel Watershed (DC Watershed), the Machado Lake Watershed (ML Watershed), and the Los Angeles / Long Beach Harbors Watershed cover approximately 133 square miles (85,000 acres); the Dominguez Channel Watershed Management Area (DC WMA) covers 58 of these square miles (37,120 ac). The DC WMA area is based on the agencies participating in the EWMP. DC WMA group members include the Cities of Carson, El Segundo, Hawthorne, Inglewood, Lawndale, Lomita, and Los Angeles, Los Angeles County, and the Los Angeles County Flood Control District (LACFCD). The remaining 75 square miles (46,720 ac) of the watershed is covered by other MS4 permittees. Only 9.59 mi^2 (6,138 ac) in the DC watershed and 5.05 mi^2 (3,232 ac) in the ML watershed are located in the City.

The DC Watershed includes the 71 square mile DC Watershed, 25 square mile ML Watershed, and 37 square mile Los Angeles/Long Beach Harbors watershed. The DC Watershed is comprised of the lined portion of the channel (approximately 6.7 miles or 10.7 km in length) ending at Vermont Avenue near the 110 freeway, the DC Estuary (8.2 miles 13.19 km of unlined portion) ending at the LA Harbor, and the Torrance Carson Channel (Torrance Lateral, approximately 3.4 miles or 5.47 km long) that is tributary to the DC Estuary.[3] Approximately 5.2 miles (8.36 km) of the channel are within the DC Watershed management area group which includes 3 and 2.2 miles (4.8 and 3.5 km) of the lined and unlined portions, respectively.[4] The DC Watershed drains into the Los Angeles Harbor on the northeast side of the Consolidated Slip; Fish Harbor, Inner Harbor, Outer Cabrillo Beach, and Inner Cabrillo Beach are other pertinent water bodies immediately downstream of the DC Watershed.[5] Two Superfund sites,

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[2] http://www.lacitysan.org/onewater/

[3] Dominguez Channel EWMP Draft June 2015, P. 1-5; SWRCB Resolution Number 2008 – 0089. Approving an Amendment to the Water Quality Control Plan for the Los Angeles region (basin plan) to Incorporate a Total Maximum Daily Load for Eutrophic, Algae, Ammonia, and Odors (Nutrients) in Machado Lake. P. 3

[4] Dominguez Channel EWMP P. 1-4

[5] Dominguez Channel EWMP Draft June 2015, P. 1-6

the Montrose Superfund site and the Del Amo Superfund site are located within the Torrance Lateral watershed.[6]

Machado Lake (ML) is a 45-acre freshwater lake located within the ML Watershed located south of the Pacific Coast Highway and adjacent to Vermont Avenue. 22 square miles (14,080 ac) of the total ML Watershed flows directly into the lake through stormwater drains and direct sheet flow from the surrounding park area. The Wilmington Drain, managed by the Los Angeles County Department of Public Works (LACDPW), drains 80% of the total watershed area flowing into the lake. The Wilmington Channel is entirely lined except for a 3,000 foot long soft bottom vegetated reach located at the bottom section of the channel from the Pacific Coast Highway to just north of the Lomita Boulevard. The Wilmington Drain routes stormwater through a roughly 600 foot long riparian woodland before entering the lake. Downstream of the lake is an approximately 63-acre seasonal freshwater marsh that receives water from the lake as well as from the remaining 3 square miles (1,920 ac) of the ML Watershed and empties into the harbor.[7]

The DC and ML Watersheds are two of the most heavily urbanized in Southern California, which impacts the hydrologic regime. The DC Watershed contains a variety of urban land uses: the largest uses are single-family residential (SFR, 30%), commercial (20%), industrial (21%), multi-family residential (MFR, 11.5%), and all other land uses (18%). The ML Watershed contains a variety of urban land uses: high-density SFR (20%), industrial (14%), vacant (11%), retail / commercial (22%), MFR (16%), transportation (3%), educational (6%), and all other land uses (8%).[8] Historical average annual precipitation in the DC and ML watersheds is 11 inches; the average annual runoff ratio is 0.73.[9]

[6] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 51

[7] Dominguez Channel EWMP P. 1-5

[8] SCAG data

[9] LADPW Stormwater Monitoring data

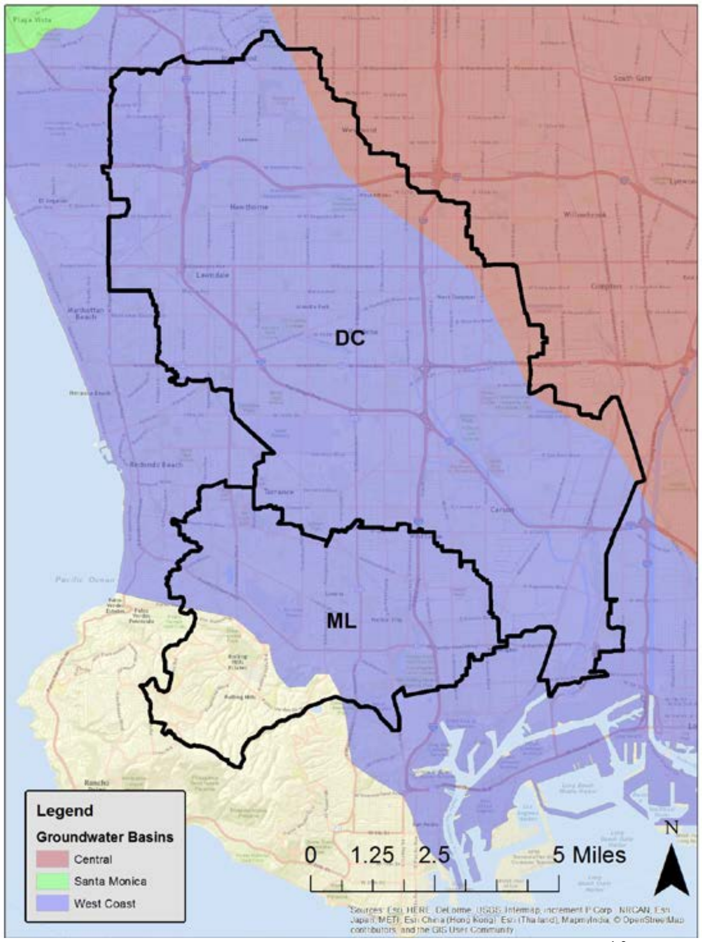

Figure 1: Dominguez Channel Watershed.[10].

b. Recycled Water and Groundwater

Current and future opportunities to expand the reuse of recycled water and increase the conjunctive use of groundwater basins within the DC Watershed were also assessed. The City's water reclamation plant within the DC Watershed is the Terminal Island Water Reclamation Plant Treatment Plant (TIWRP). TIWRP, which has an average dry weather capacity of 30 MGD, treats an average flow of 14.5 MGD.[11] Until recently, approximately 5 MGD of flow was treated at the TIWRP Advanced Water Purification Facility (AWPF); the remainder of the tertiary effluent was discharged to the LA Outer Harbor. AWPF capacity was expanded

[10] Beck, D., *Evaluating Best Management Practice Scenarios In Ballona Creek Watershed Using EPA's Sustain Model* (2014), Colorado School of Mines Master's Thesis Report, p.22 (Drew Beck Thesis)

[11] Prepared by Larry Walker Associates, Inc.; Todd Groundwater; Nellor Environmental Associates, Inc.; and Trussel Technologies, Inc. Prepared for City of LA DPW Bureau of Sanitation. Amended Engineering Report for the Terminal Island Water Reclamation Plant Advanced Water Purification Facility Expansion: Dominguez Gap Barrier Project (August 2015) p. 1-1. *Available at:* http://san.lacity.org/pdf/TIWRP_AWPF_Dominguez_Gap_Barrier_ER.pdf [TIWRP AWPF DGB Engineering Report (August 2015)]

to treat the entire flow at TIWRP and produce 12 MGD of advanced treated recycled water in early 2017.[12] As a result of this expansion, only brine and residuals from water reclamation at the plant will continue to be discharged into the harbor through the existing outfall.

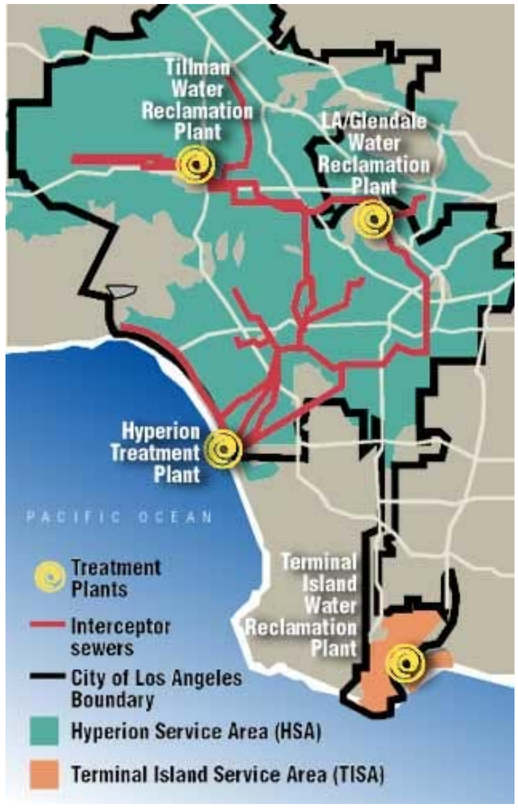

Figure 2. Image of Terminal Island Service Area and 4 LA POTWs[13]

To fully evaluate the potential to increase local water supply within the DC Watershed, the potential to increase recharge into and extraction from the underlying adjudicated groundwater basins, West Coast Basin (WCB) and Central Basin (CB) was also analyzed. The WCB underlies the majority of the DC Watershed, with CB underlying a small portion along the north-eastern edge of the watershed.

[12] https://www.lacitysan.org/san/faces/wcnav_externalId/s-lsh-sp-awpf-ep?_adf.ctrl-state=ljtyw8si3_4&_afrLoop=16304453241277602#!; http://www.tellmeladwp.com/go/doc/1475/2915446/

[13] LA Sewers website. http://lasewers.org/treatment_plants/about/index.htm

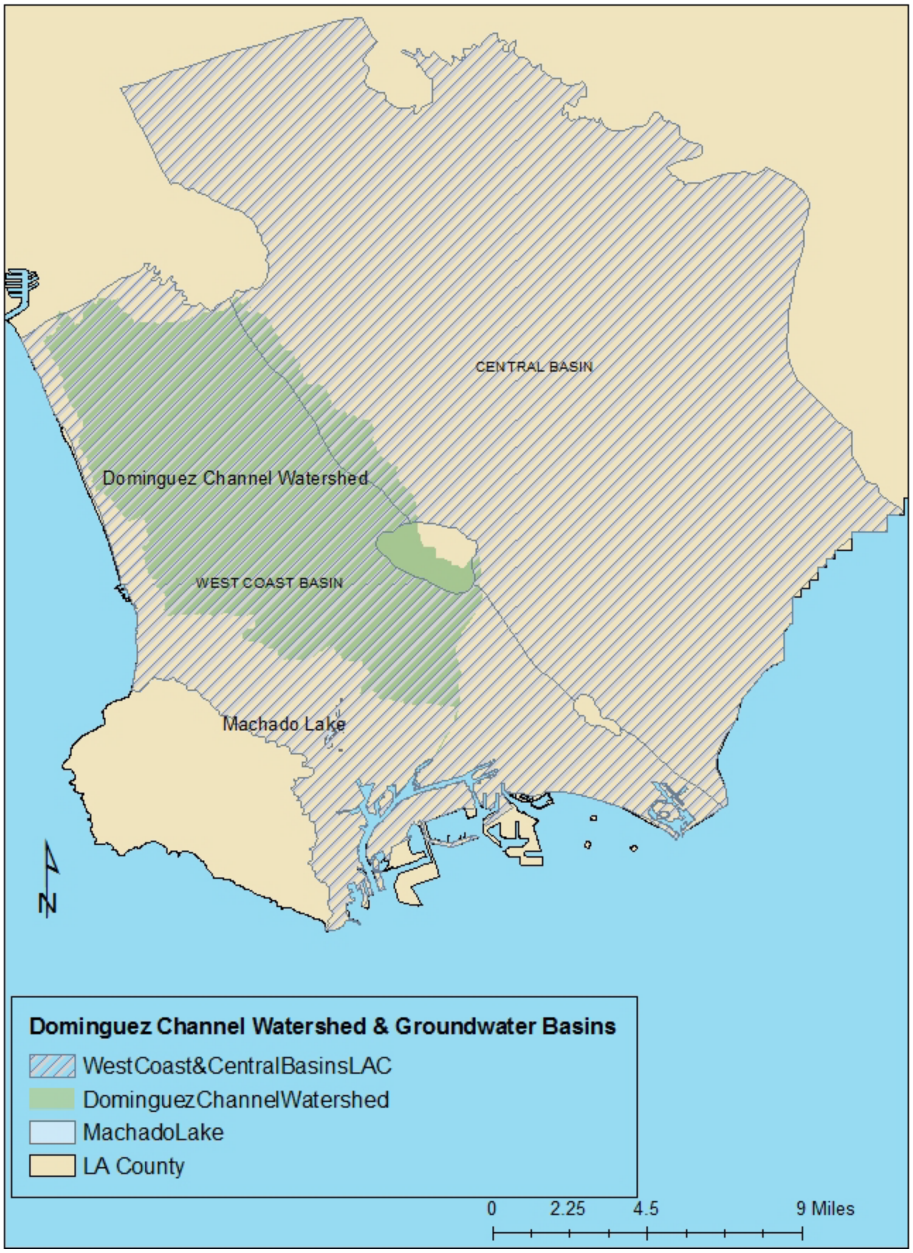

Figure 3: Groundwater basins underlying Dominguez Channel watershed.[14]

II. Dry Weather Urban Runoff and Stormwater Runoff

A. Introduction

In the Los Angeles area, both dry weather runoff and wet weather storm runoff contribute greatly to water quality impairments in regional water bodies. There are multiple benefits to capturing and reusing as much of this runoff as possible, especially during periodic times of

[14] Los Angeles County Department of Public Works

drought and water scarcity such as California's recent drought. In addition to improving receiving water quality, capturing this runoff represents a source of local fresh water that will replace water that would otherwise need to be imported. Stormwater capture and/or infiltration can also provide flood control benefits, and may additionally provide habitat and recreational open space benefits as well. Recent studies from UCLA have shown that while the timing and intensity of precipitation may change, the total amount of precipitation in Los Angeles is projected to be roughly the same through the end of the 21st century.[15] Capturing runoff offers a source of local water that may be more reliable than imported water supplies, which can be affected by declining snowpack, natural and manmade disasters, increased upstream environmental needs, legal or regulatory decisions, or rapid increases in the price of imported water.

In this section, we assessed opportunities to improve water quality and maximize stormwater capture in the DC Watershed through detailed modeling of various scenarios to investigate whether metals exceedances could be eliminated. We also discuss the current regulatory and policy-based requirements and frameworks. The ML TMDLs (nutrients) and modeling results are discussed in Section III of this report.

B. Regulations, Current Practices

a. Dominguez Channel Policy Documents

In the DC Watershed, the Los Angeles County Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permit requires compliance with Total Maximum Daily Loads (TMDLs) in impaired water bodies in the watershed. Waterbodies (and associated sediments) in the DC Watershed are currently under TMDLs for bacteria, trash, nutrients, pesticides and PCBs, and toxic pollutants.[16] Waterbodies in the DC Watershed contain a wide variety of beneficial uses, ranging from recreational water contact to rare, threatened, or endangered species habitat to municipal, domestic, and industrial supply.[17] Both wet and dry weather TMDL limits are concentration and loading based. The Waste Load Allocations (WLAs) are based on EPA's California Toxics Rule (based on the National Toxics Rule). Although TMDLs in this watershed address both water and sediment quality issues, we will focus on the water quality parameters in the DC and ML watersheds as the sediment quality concerns are outside of the scope of this research project. Below, we discuss the DC TMDL and other water quality compliance documents briefly. ML TMDLs will be discussed in the following section (III).

The DC and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL (DC Toxics TMDL) was developed and adopted by the Los Angeles Regional Water Quality Control Board (LARWQCB). The DC Toxics TMDL went into effect on March 23, 2012 and

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[15] http://newsroom.ucla.edu/releases/ucla-researchers-project-southern-california-rainfall-levels-through-end-of-century; Berg, N., Hall, A., Sun, F., Capps, S., Walton, D., Langenbrunner, B., & Neelin, D. (2015). Twenty-First-Century Precipitation Changes over the Los Angeles Region*. *Journal of Climate*, *28*(2), 401-421.

[16] DC EWMP draft June 2015 p. 1-8

[17] DC EWMP draft June 2015 p. 1-6

has a final compliance date of March 23, 2032.[18] DC includes the DC Estuary and the Torrance Lateral Channel. Elevated levels of copper, lead, and zinc have been measured during wet weather but not dry weather in both the Estuary and Torrance Lateral.[19] Thus, there are no dry weather TMDLs in DC. There are wet weather TMDLs for copper, lead, zinc, and toxicity in the DC water column; the Torrance Lateral has wet weather TMDLs only for copper and zinc as lead was below water quality criteria in both wet and dry weather.[20] For toxicity, a numeric toxicity target of 1 chronic toxicity unit (TUc, defined as 100% 'no observable effects limit') is set as the final waste load and load allocation.[21]

For metals, after applying conversion factors to account for hardness and the ratio of dissolved to total metals, wet-weather loading capacities for total recoverable metals in DC are as follows: 9.7 µg/L (copper), 42.7 µg/L (lead), and 69.7 µg/L (zinc), each multiplied by the daily storm volume as measured at mass emissions station S28.[22] The allowed loads in the DC Watershed are lower than those defined for the Ballona Creek Watershed Metals TMDL (13.70 µg/L, 76.75 µg/L, and 104.77 µg/L for copper, lead, and zinc, respectively).[23] In DC, wet-weather capacities are applied whenever the maximum daily flow is greater than or equal to the 90th percentile of annual flow rates, 62.7 cfs.[24] Torrance Lateral is under the same allocations as DC (9.7 µg/L for copper, 42.7 µg/L for lead, and 69.7 µg/L for zinc). However, Torrance Lateral standards are currently concentration-based rather than load-based as no flow data is available; this may be revisited as more data becomes available.[25]

The Dominguez Channel Watershed Management Area Enhanced Watershed Management Program (DC EWMP) and Coordinated Integrated Monitoring Program (CIMP) are policy documents generated to comply with the Los Angeles County MS4 permit. A final draft of the DC EWMP, detailing the management actions to achieve compliance with water quality standards in the DC Watershed Management Area (DC WMA), was submitted to the LARWQCB for review in June 2015. A final amended version of the DC EWMP was submitted in February 2016 and approved by the LARWQCB in April 2016. Jurisdictions that are

[18] Dominguez Channel EWMP draft June 2015, P. 2-14; SWRCB TMDLs info webpage. http://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/tmdl_list.shtml

[19] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 3,27,29

[20] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 29

[21] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 76

[22] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 77

[23] Attachment A to Resolution No. R13-010. Proposed Amendment to the Water Quality Control Plan- Los Angeles Region to Incorporate the Ballona Creek Metals TMDL. Proposed for Adoption LARWQCB Dec 5, 2013.

[24] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 77

[25] LARWCQB & EPA Region 9. Dominguez Channel and Greater Los Angeles and Long Beach Harbor Waters Toxic Pollutants TMDL Final Staff Report. May 5, 2011. P. 81

involved in the final version of the DC EWMP include Carson, El Segundo, Hawthorne, Inglewood, Lawndale, Lomita, the City of Los Angeles, unincorporated areas of Los Angeles County, and the LACFCD. The City is the jurisdiction with the largest share of the DC WMA, approximately 29.7 mi^2 (19,000 ac) or 38% of the watershed.[26] The waterbodies associated with the DC EWMP are DC, ML, and the Los Angeles Harbor.[27]

The DC EWMP incorporates final TMDL deadlines for DC and ML for many constituents, including metals such as cadmium, copper, zinc, and lead; toxics such as DDT and PCBs; trash; and bacteria. Milestones in the EWMP are based on the amount of water that needs capturing; interim goals for the metals / toxics TMDL include capturing 50% of the volume based on the reasonable assurance analysis (RAA) baseline by 2026, 75% by 2029, and meeting WQS by 2032.[28] EWMP projects will also reduce the concentrations of bacteria, for which DC, Wilmington Drain, and the Torrance Lateral channel are on the 303 (d) list. Volume and load reduction strategies in the EWMP include source control, Minimum Control Measures (MCMs) and non-structural BMPs, regional BMPs on public and private parcels, and distributed BMPs on private parcels, public parcels, or public right-of-way.[29]

For example, in the DC EWMP, a 5% reduction in pollutant load is assumed for the aggressive and consistent implementation of MCMs; this reduction was not included in the modeling efforts.[30] An additional 5% reduction was assumed through implementation of additional institutional BMPs such as enhanced street sweeping (vacuum sweepers), full capture devices in high-trash capture areas, or additional catch basin cleanouts.[31] However, limited studies exist on the actual impacts on pollutant loads of institutional BMPs such as vacuum sweeping. Further data collection and monitoring efforts are required to determine whether the projected load reductions will result from the implementation of these types of programs. Additional load reduction is expected to come from redevelopment that will incorporate the LID ordinances being enforced in the DC WMA.

The DC EWMP will be implemented through a combination of identified regional BMPs, additional BMPs needed to manage required volumes, green streets, and LID redevelopment and will also include an approach to identify and mitigate non-stormwater discharges.[32] Twelve potential regional project parcels were identified and evaluated to characterize opportunities at these sites; identified projects have a total combined storage volume of 332.8 acre-feet (AF) and drainage area of 9,165 acres.[33] Opportunities to implement distributed projects in the form of green streets were also assessed to reach the required volume reduction in the

[26] EWMP for the Dominguez Channel Watershed Management Area Group (DC EWMP 2016), Feb 2016, P. 1-1

[27] Dominguez Channel EWMP workplan page 2.

[28] DC EWMP 2016, p. 2-18

[29] Dominguez Channel EWMP draft June 2015, P. 3-29

[30] DC EWMP 2016, P. 3-11, 4-3

[31] DC EWMP 2016, P. 3-11, 4-2

[32] DC EWMP 2016, p. 5-4, 4-36

[33] DC EWMP 2016, P. 4-16, 4-17

DC WMA. An earlier draft of the DC EWMP identifies a need to implement 411 lane miles of green streets throughout the DC WMA, with 184 of those lane miles being implemented by the City.[34] The final DC EWMP instead identifies the volume of water that needs to be managed through green streets, approximately 290 AF overall and 96 AF for the City.[35]

The DC EWMP estimated the capital cost to implement identified regional BMPs to be approximately $290 million, with associated annual O&M costs at build-out of $2.9 million.[36] Total implementation costs of green streets required to manage approximately 290 AF of stormwater are estimated to be around $610 million dollars with an annual O&M cost of $6.1 million.[37] The capital cost of implementing additional BMPs (not yet identified) is approximately $350 million with an annual O&M of $5.2 million.[38] The estimated total capital cost to implement the EWMP is approximately $1.2 billion, with the City's share being about $412 million.[39] Every two years the EWMP will be modified for adaptive management based on a variety of inputs including modeling, a RAA, input from the public and the LARWQCB, progress toward compliance goals, and new data as it becomes available.[40] Earlier drafts of the EWMP estimated the local water supply potential of implementing the EWMP is approximately 20,000 AFY on average.[41]

The DC CIMP is a monitoring plan aimed at providing additional water quality and flow data in the receiving waters and from the stormdrain outfalls to inform the EWMP RAA as required by the LA County MS4 permit. On December 11, 2015, the DC WMG submitted a revised CIMP incorporating the City of Carson and the City of Lawndale into the WMG's monitoring program. Both of these cities joined the DC WMG after Regional Board conditionally approved DC WMG's CIMP September 11, 2015. As a result, modifications and additional monitoring were added to the CIMP to include the City of Carson and the City of Lawndale. The DC WMG submitted an updated revised CIMP on April 8, 2016 following comments and recommendations from the LARWQCB's staff. DC WMG received a final approval letter on June 1, 2016.[42]

The DC CIMP was implemented in a phased manner during the last storm year (2015-2016), with the remaining monitoring sites to be activated in the 2016-2017 storm year (Figure

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[34] Dominguez Channel EWMP draft June 2015, P. 4-37, (at an estimated cost over $1 billion, annual O&M 10.4 million p. 74)

[35] DC EWMP 2016, P. 5-5

[36] DC EWMP 2016, P. 7-7

[37] DC EWMP 2016 P. 7-4

[38] DC EWMP 2016 P. 7-7

[39] DC EWMP 2016 P. 7-8

[40] DC EWMP 2016. P. 6-1

[41] Dominguez Channel EWMP draft June 2015, P. 5-10

[42] LASAN, personal communication

4, excerpted from DC CIMP).[43] The DC CIMP monitoring locations include both receiving water and TMDL monitoring locations (both at previously installed stations and newly built stations) as well as outfall monitoring locations. Receiving water monitoring will have three main objectives: determine if water quality limitations are being attained, assess trends in pollutant concentration over time, and determine if water can be used for designated beneficial uses based on water chemistry.

A total of 11 sites have been identified for receiving water monitoring including 10 TMDL monitoring sites (4 for DC Toxics TMDL, 4 for ML TMDLs, and 3 for the LA Harbor Bacteria TMDL).[44] An additional six stormwater outfall monitoring sites at the jurisdictional boundary of the DC WMA will monitor the stormwater discharges from the MS4 outfall or channel. Factors included in the site selection process for these locations were that the majority of runoff was coming from DC WMA parties and the subwatershed contained a mix of land uses which generally represented HUC-12 (Hydrologic Unit Code[45]) characteristics.[46] Three additional TMDL outfall monitoring sites that are consistent with locations used in the ML Water Quality Management Plan (LWQMP) have been selected to monitor ML nutrients and toxics.[47]

A monitoring plan implementation schedule has been created for sampling sites from receiving water monitoring and TMDL monitoring programs. The annual frequency of sampling is summarized based on the number of wet weather / dry weather events to be monitored and varies across sample locations.[48] For example, lead and copper will be sampled at MES S28 during three wet weather events and two dry weather events and at Torrance Lateral during two wet weather events and one dry-weather event.[49] Flow (or depth) and field parameters including DO, pH, temperature, and specific conductivity will be measured during 3 wet weather events and 2 dry weather events at Mass Emission Station (MES) S28 and Wilmington Drain at Pacific Coast Highway and every other week at the upper and lower ML sample locations.[50] Please see the DC CIMP for more detailed information on the frequency of sampling and constituents monitored at specific locations. Monitoring efforts associated with the DC Watershed CIMP will begin in late 2016 at some locations and in 2017 aat others.

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[43] http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/municipal/watershed_management/dominguez_channel/Confirm_Approval_Dominguez_channel.pdf

[44] DCWMA CIMP 2016 P. 15

[45] Watersheds in the U.S. are divided and subdivided into six successively smaller hydrologic units. Every watershed is identified with a unique hydrologic unit code (HUC) with 2 to 12 digits based on the level that which it belongs. Subwatersheds identified as HUC-12 belong to the sixth and spatially smallest level. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_021581.pdf

[46] DCWMA CIMP 2016 P. 31

[47] DCWMA CIMP 2016 P. 9, 32; these three monitoring sites in ML WQMP are part of the stormwater outfall monitoring in DC CIMP. These sites are DOM-OF-004, P-77 and P-510. LASAN personal comm

[48] DCWMA CIMP 2016 P. 18

[49] DCWMA CIMP 2016 p. 21, Table 2-4 Constituents and parameters measured.

[50] DCWMA CIMP 2016 p. 21, Table 2-4 Constituents and parameters measured.

Further, the DC WMA group is required to implement a tracking system that will confirm whether the intended volume of stormwater is being captured, reused, or treated post-BMP construction, which should provide additional information on the performance of implemented BMPs over time. Tracking will be done by maintaining an informational database that will provide records for each new development or re-development project. DCWMA group members will maintain their own individual tracking system due to the complexity of land development across jurisdictions.[51] Additional data to be reported in the database includes project planning, building plans, and technical reports; approval of BMP construction; and post-construction inspections.[52]

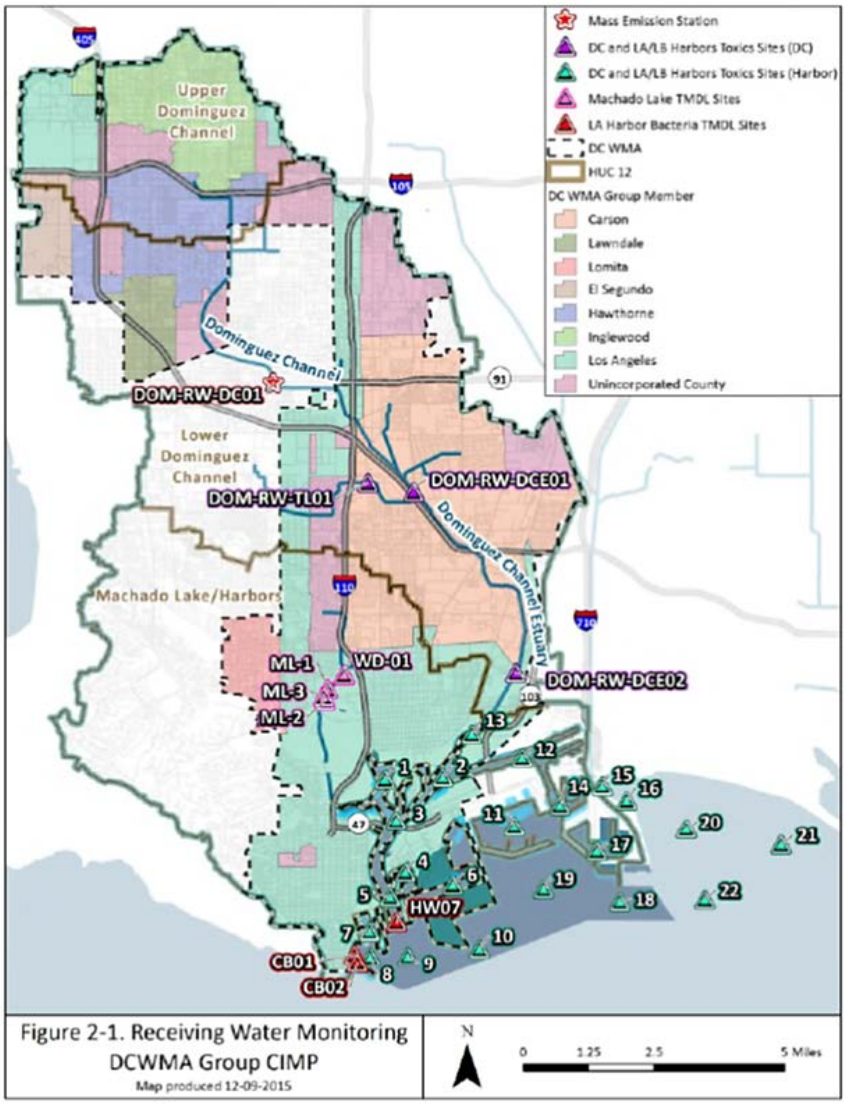

Figure 4: Overview of Receiving Water Monitoring Sites. DC CIMP 2016, p. 14.

[51] DCWMA CIMP 2016 P. 9

[52] DCWMA CIMP 2016 P. 44

C. Proposition O projects

There are five Proposition O projects that have been completed or are undergoing construction currently in the DC Watershed, including two in the ML Watershed that will be discussed in the following section (III). These are: the Inner Cabrillo Beach Bacterial Water Quality Improvement Project, the Wilmington Drain Multiuse Project, the ML Ecosystem Rehabilitation Project, the Rosecrans Recreation Center Stormwater Enhancements Project, and the Peck Park Canyon Enhancement Project.[53]

The Inner Cabrillo Beach Bacterial Water Quality Improvement Project consisted of replacing the sand, re-contouring the beach, constructing bird excluder devices with monofilament line, eliminating old stormdrain and sewer lines that were no longer in use, and promoting drainage through the sand to improve water quality of the recreational beach.[54] This project was completed in July.[55]

The Rosecrans Recreational Center Stormwater Enhancements Project consisted of installing smart irrigation systems, bioswales and other stormwater BMPs, a synthetic soccer field and decomposed granite pathway, and new landscaping at the site.[56] This project was completed in October 2013 for a total cost of $6,754,033, funded through Proposition O and Proposition K.[57] This project treats a tributary watershed of 12.73 acres, and incorporates water capture and use. However, since much of the water captured is from outside of the DC WMG area, this project was considered as having no impact on the water quality planning objectives in the DC EWMP.[58]

The Peck Park Canyon Enhancement project, consisting of the installation of vegetated bioswales, infiltration strips, stormwater catch basins, bank stabilization efforts and a step pool channel, was completed in May 2011 for a cost of $7,896,193.[59] Funding for this project included Proposition O ($6,190,000), Proposition 50 ($1,586,193), and a Recreation and Trails Grant ($120,000).[60]

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[53] http://www.lapropo.org/sitefiles/dominguez.htm

[54] August 2015 Prop O Monthly Report. Page 27

[55] August 2015 Prop O Monthly Report. Page 14

[56] August 2015 Prop O Monthly Report. Page 30

[57] August 2015 Prop O Monthly Report. Page 14

[58] Dominguez Channel EWMP draft June 2015, page 4-16

[59] August 2015 Prop O Monthly Report. Page 29

[60] August 2015 Prop O Monthly Report. Page 11, 14

D. Dominguez Channel Modeling Background

a. Modeling Selection and Comparison

Implementing BMP programs, including LID practices, was explored in this research as a method to improve stormwater quality and capture stormwater runoff for potential reuse and groundwater recharge in the DC Watershed. The US EPA's System for Urban Stormwater Treatment and Analysis model (SUSTAIN) version 1.2 in ArcGIS 9.3 was chosen to simulate stormwater runoff quantity and quality, primarily based on a model comparison undertaken for the Ballona Creek Watershed. SUSTAIN has the ability to successfully simulate pollutant loads and stormwater flow, implement BMPs, and optimize cost and pollutant reduction for multiple BMPs in user-defined scenarios.[61]

b. Model Setup, Calibration, Validation

The 71.1 mi^2 (45,504 acre), DC Watershed was divided into two subwatersheds, the 33 mi^2 (21,120 acre) Upper Dominguez Channel (UDC) and the 38.1 mi^2 (24,384 acre) Lower Dominguez Channel (LDC). The UDC was delineated with respect to the LA County MES S28 located at the Dominguez Channel and Artesia Boulevard in the City of Torrance. In addition to MES S28, six tributary stations (TES), identified as TS19 – TS24, were previously established throughout the DC Watershed. The six tributary subwatersheds upstream of these TES were also delineated for modeling purposes (Figure 5).[62] Subwatersheds were downloaded from the LAC Geographic Information System (GIS) data portal[63] and reshaped based on MES and TES locations. To ensure that the resulting subwatersheds were hydrologically distinct, the storm-drain network was used to further refine the subwatershed shape so all rainwater falling on a subwatershed exits only through the downstream gauge.[64]

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[61] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/

[62] "2009 - 2010 Monitoring Report." Los Angeles County Stormwater Quality Monitoring Reports. N.p., 04 Aug. 2000. Web. 17 Aug. 2016.

[63] Los Angeles County Subwatershed Delineation Data. Subwatersheds were delineated by the Hydraulic Water Conservation Division. Available at http://egis3.lacounty.gov/dataportal/2011/01/11/los-angeles-county-subwatersheds/ Accessed on 1/1/16

[64] LosAngeles County Storm Drain System Data. Available at http://egis3.lacounty.gov/dataportal/2013/08/08/los-angeles-county-storm-drain-system/ Accessed on 1/1/2016

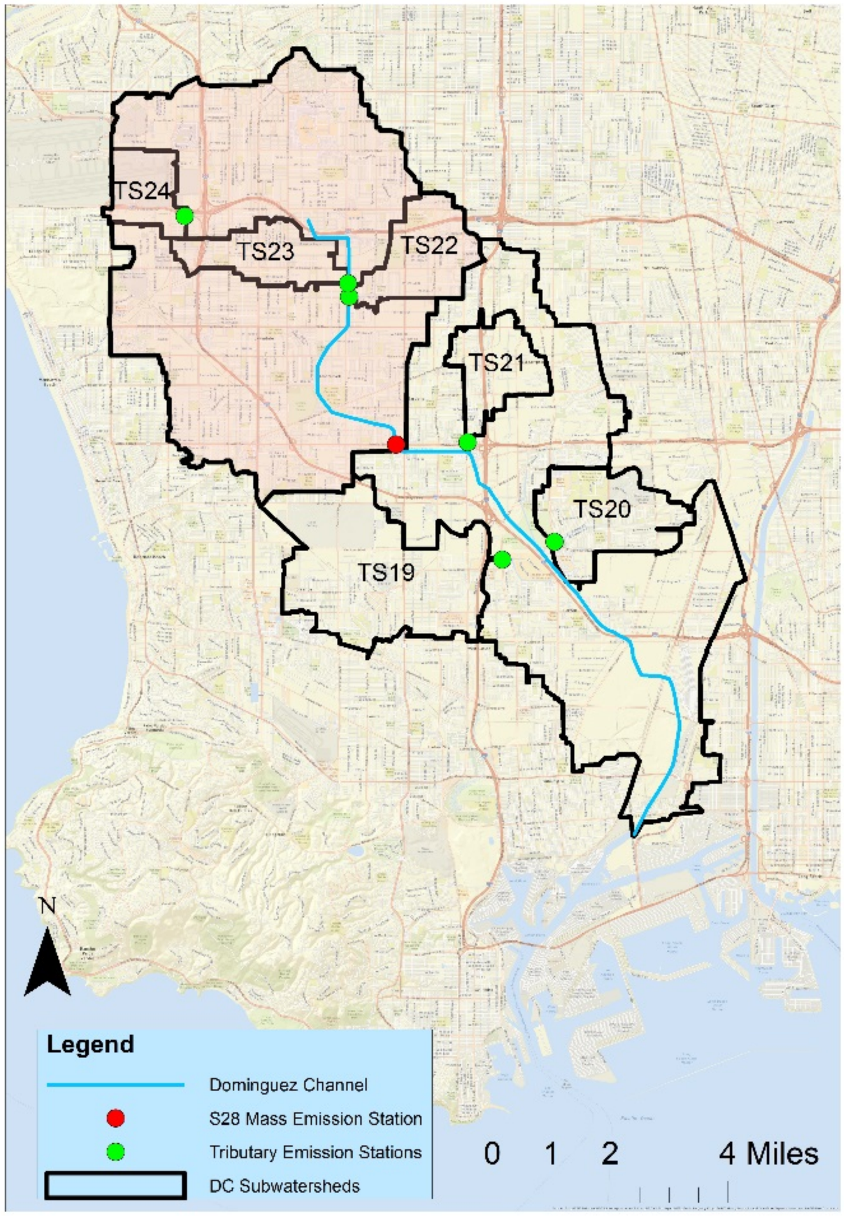

Figure 5: Dominguez Channel subwatersheds. The UDC is represented by the shaded area.

Observed discharge and water quality data to calibrate and validate stormwater runoff and pollutant loading simulations from the model were available from the seven monitoring locations described above. Monitoring at MES S28 began in the 2002 water year. The six TES were installed in accordance with the requirements in the 2001 Municipal Stormwater Permit to obtain more detailed information about the water quality of subwatersheds within the DC Watershed. Monitoring at TES began in water year 2009 and terminated in water year 2011.[65]

[65] "2009 - 2010 Monitoring Report." Los Angeles County Stormwater Quality Monitoring Reports. N.p., 04 Aug. 2000. Web. 17 Aug. 2016.

In addition to water quantity and quality data, land use/land cover type is needed for modeling stormwater runoff. A 2-acre resolution land cover raster was acquired from the Southern California Association of Governments (SCAG) and used to determine the area and percent imperviousness for each of the land use types. The breakdown of different land uses throughout the DC Watershed can be seen in Figure 6.

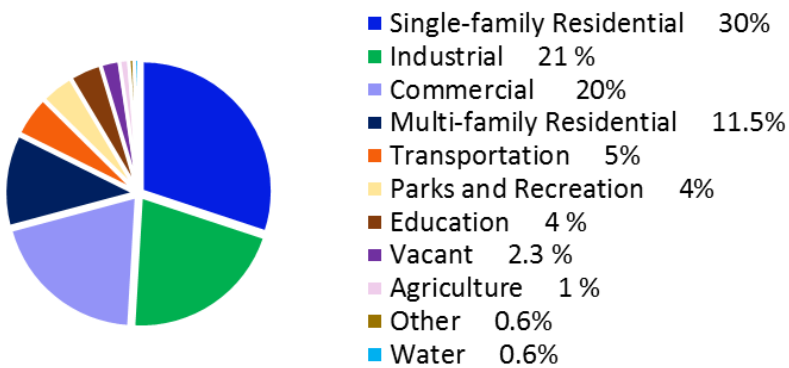

Figure 6: Land Use percentages for Dominguez Channel watershed based on SCAG.

Single-family residential and industrial land uses make up approximately 50% of the watershed area. SUSTAIN utilizes the area and percent imperviousness as well as event mean concentrations (EMCs) to estimate runoff volumes and pollutant loadings. EMC data to be input into SUSTAIN was compiled from both the LADPW Stormwater Quality Monitoring Program[66] and the Southern California Coastal Water Research Project (SCCWRP).[67] Figure 7 shows the SCAG land use distribution in DC.

[66] LA County DPW Annual Stormwater Monitoring reports, (1998-2014), available at http://dpw.lacounty.gov/wmd/NPDES/report_directory.cfm

[67] Watershed and Land Use Stormwater Pollutant Loading Data for the Greater Los Angeles Area, California, USA, 2007. Data provided courtesy of Southern California Coastal Water Research Project (SCCWRP - Downloaded from http://www.sccwrp.org/Data/SearchAndMapData/DataCatalog/2007StormWaterLoading.aspx, [2/1/2016].

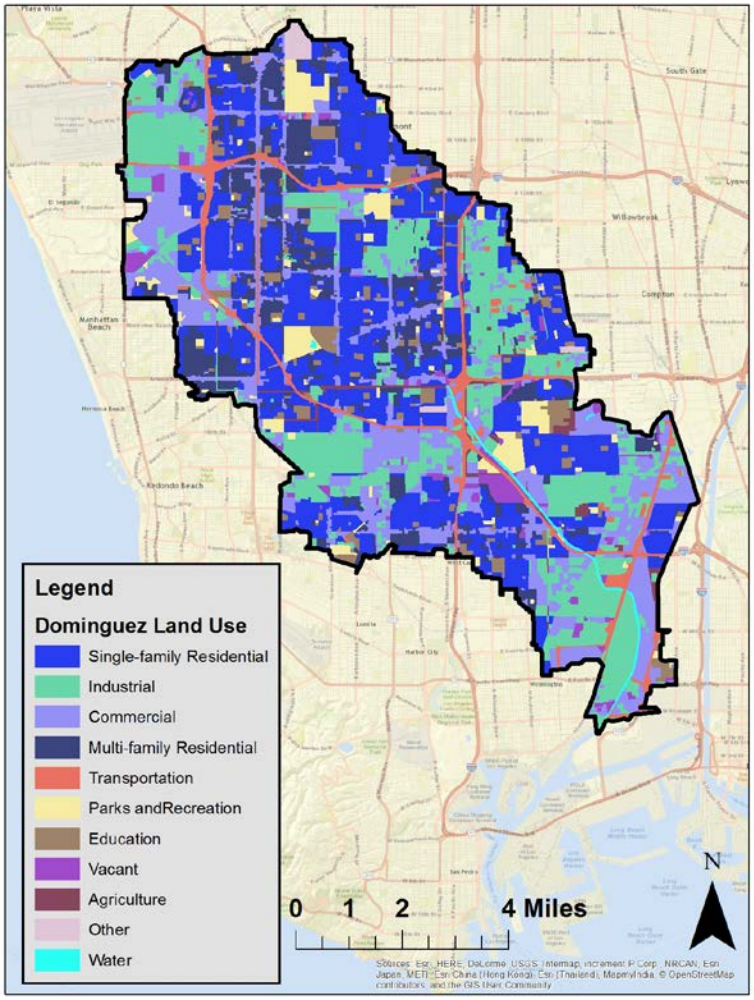

Figure 7: Dominguez Channel land use distribution created from SCAG. Legend items are listed in order of highest % of watershed area to least.

Water quantity was calibrated and validated using water years 2001-2008 and 2009-2011, respectively. These data periods were chosen due to the available data from TS19-TS24 which includes water years 2009-2011. Tributary watersheds were used to validate modeling efforts. TS19-TS21 were used to validate portions of the LDC since there is no available data at the output of the LDC (MES S28 only captures runoff from UDC) and TS22-TS24 were used to ensure that the variability of watershed properties and runoff were accurately represented throughout the UDC. Hourly precipitation and daily climatology data (temperature, reference evapotranspiration and wind speed) acquired from Los Angeles County rain gauges[68] and the California Irrigation Management Information System (CIMIS), respectively, are input in SUSTAIN.[69] The inverse distance-weighting method was used to determine a single value to

[68] Los Angeles County department of Public Works. Water Resources Department. http://www.ladpw.org/wrd/precip/ Accessed on 1/1/2016.

[69] California Department of Water Resources. California Irrigation Management Information System site. http://www.cimis.water.ca.gov/ Accessed on 1/1/2016.

represent the entire watershed from several rain gauge locations distributed throughout the DC Watershed.

The calibration for SUSTAIN included manually adjusting specific watershed parameters such as percent imperviousness, hydraulic conductivity, overland flow width, and *Manning's n* for impervious area. These parameters were the main focus due to their higher sensitivity as determined in the initial model sensitivity analysis.[70] Other parameters that were adjusted for the DC Watershed included percent slope, *Manning's n* for pervious area, depression storage for pervious area and % zero impervious area. Parameters were varied until modeled individual storm volumes matched observed volumes using statistical values (Table 1). When these statistics, specifically the Nash Sutcliffe Efficiency (NSE), reached acceptable values, model parameters were considered calibrated. A "very good" hydrologic model calibration has an NSE that falls between 0.75 and 1.00;[71] a minimum NSE value of 0.8 was determined to be an optimal value in the presented work. These calibrated parameters were then used to run model simulations for the validation period and the same statistics were calculated. The calibration and validation of the DC Watershed at MES S28 is shown in Figure 8.

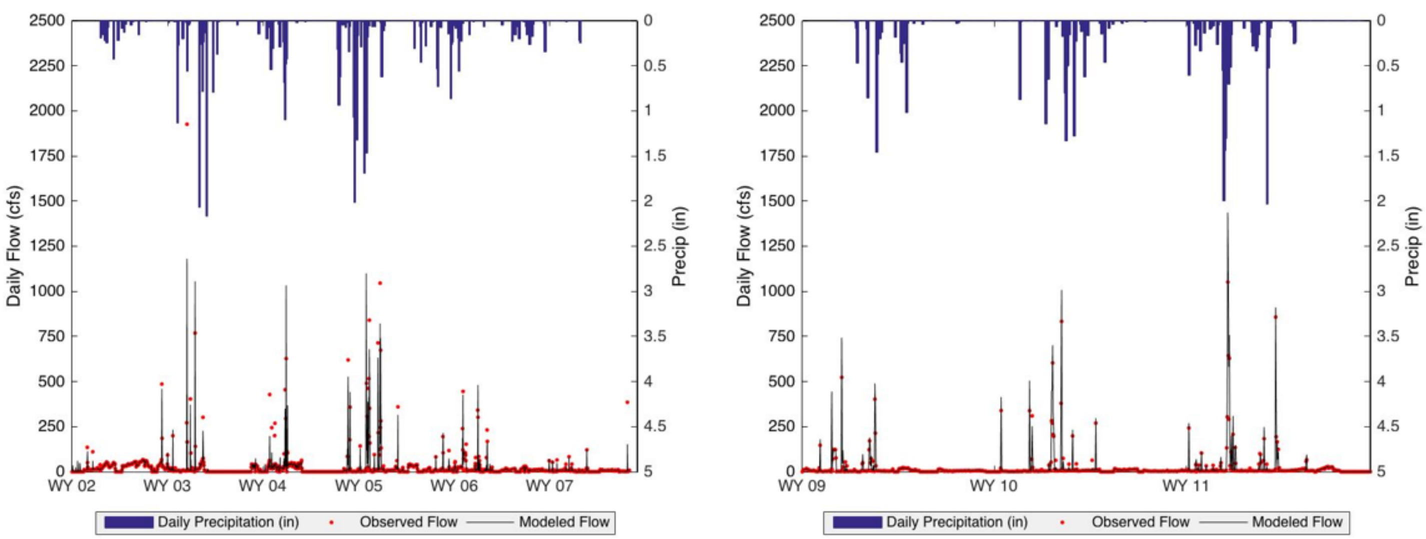

Figure 8: Water quantity calibration (left) and validation (right) for UDC at MES S28. Daily precipitation is represented on the top x-axis.

[70] Beck, Drew J., Evaluating Best Management Practice Scenarios in Ballona Creek Watershed Using EPA's SUSTAIN Model (2014), Colorado School of Mines, Master's Thesis, section 3.4, pp. 44-47

[71] Moriasi, D.N. et al., 2007: Model evaluation guidelines for systematic quantification of accuracy in watershed simulations. Transactions of the ASABE 50 (3), 885–900

	Calibration WY 02-07	Validation WY 09-11						
	UDC S28	**UDC S28**	**TS19**	**TS20**	**TS21**	**TS22**	**TS23**	**TS24**
Abs Err	5.09	5.14	2.02	1.83	0.51	0.49	0.42	0.53
%Bias	-1.67	21.9	-4.74	4.19	7.89	5.13	3.95	0.72
NSE	0.83	0.85	0.86	0.37	0.87	0.92	0.92	0.95
R^2	0.83	0.96	0.86	0.40	0.88	0.92	0.93	0.96
Avg daily flow MOD (cfs)	21.65	21.96	7.35	4.35	1.93	2.41	1.88	2.83
Avg daily flow OBS (cfs)	22.02	18.01	7.72	4.17	1.79	2.29	1.81	2.81

Table 1: Statistical values for both the calibration and validation of the model. Validation includes the six tributary subwatersheds TS19-TS24. While all statistical values were considered, the NSE is most important in terms of flow regime prediction.

Table 1 shows the NSE and other statistics for all subbasin calibration and validation. All subwatersheds fall within an optimal NSE range except TS20. An additional attempt to calibrate TS20 by conducting a sensitivity analysis on the watershed parameters as well as data screening the observed data did not improve the NSE. Possible reasons TS20 could not be calibrated include error in subwatershed delineation or inaccuracy in monitored water quantity data. As the remaining statistical values for TS20 were similar to those of the other subwatersheds and the NSE values were otherwise high, the watershed parameters were accepted as is. Watershed parameters were taken from TS19-TS21, averaged, and inserted into SUSTAIN to represent the remaining area of the LDC to model the full DC Watershed.

After the model was validated for stormwater runoff, pollutant loading was calibrated by using EMCs provided by the Los Angeles County Stormwater Management Program (SWMP) and SCCWRP sampling data. Due to the variability between the daily modeled and observed pollutant loads the mean, max, and total loads were evaluated to determine the optimal EMC percentiles. The EMC percentile values for each pollutant were adjusted and considered calibrated when the modeled mean, max, and total loads matched the observed. An example of this calibration is shown in Table 2 and shows that all modeled values are equal to or slightly larger than the observed. The same EMC percentile was used for each land use type of a certain pollutant. The final EMC percentiles developed for the watershed for copper, lead and zinc are 78.5%, 62% and 60%, respectively; 50% is the mean seen throughout the City. Thus, EMCs in DC are 10-18% higher than the average EMCs seen throughout the City. The calibrated washoff EMCs utilized in SUSTAIN for each pollutant and land use are shown in Table 3. The modeling approach is further shown for zinc in Figure 9, which shows the modeled to observed zinc loads for all wet weather days in DC at MES S28 for water years 2001-2011. Plots for copper and lead were very similar and are not shown here.

kg/day	Cu	Pb	Zn
EMC Percentile	78.5	62.0	60.0
MOD Total	636	266	3091
OBS Total	678	216	3055
MOD Mean	31	13	154
OBS Mean	31	10	152
MOD Max	99	41	483
OBS Max	74	27	353

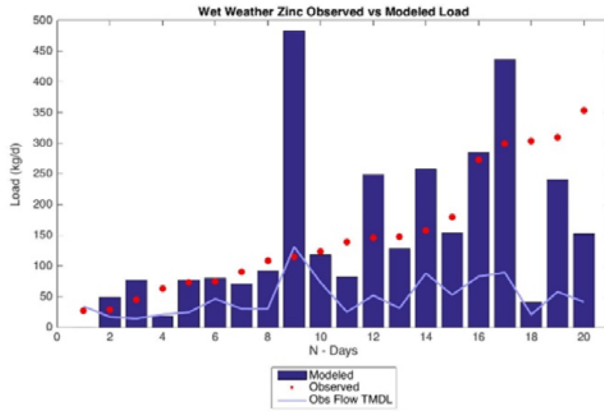

Table 2, Figure 9: Pollutant calibration at MES S28. Figure on the right shows observed vs modeled loads on wet weather days for zinc. The statistical values for zinc in the table were generated form the same data that created the plot.

Washoff EMCs	Agriculture	Commercial	Education	Industrial	Multi-Family Residential	Single - Family Residential	Other	Parks&Recreation	Transportation	Vacant
Cu (mg/L)	0.068	0.047	0.030	0.051	0.073	0.032	0.036	0.036	0.079	0.076
Pb (mg/L)	0.007	0.016	0.010	0.026	0.012	0.024	0.013	0.013	0.015	0.069
Zn (mg/L)	0.319	0.237	0.128	0.459	0.133	0.105	0.123	0.123	0.278	0.026

Table 3: Calibrated pollutant washoff EMCs utilized in SUSTAIN. These are the 78.5, 62 and 60 percentile values for copper, lead, and zinc, respectively, acquired from the La County Stormwater Quality Monitoring Program and SCCWRP EMC database.

c. BMP Technologies in SUSTAIN

The BMPs implemented in SUSTAIN for the DC Watershed study include bio-retention, dry ponds, infiltration trenches, porous pavement, and vegetated swales. These five BMP types were originally chosen for the Sustainable LA Water Project Ballona Creek Watershed study and were also used in the forthcoming Los Angeles River watershed study. These BMPs were assessed based on their ability to improve water quality, decrease peak storm flows, and infiltrate water for groundwater recharge among other benefits. Additionally, these BMPs were chosen as they perform well in a semiarid climate and had the most available data in the BMP database. The final types and dimensions of the five BMPs were chosen to be a representative population of the most common BMP systems by reviewing multiple sources of BMP construction projects: Standard Urban Stormwater Mitigation Plans (SUSMP),[72] the International BMP Database (IBMPD),[73] Proposition O,[74] and other City project reports. A more in-depth

[72] Standard Urban Stormwater Mitigation Plans, *Information and Documentation found at* http://www.swrcb.ca.gov/losangeles/water_issues/programs/stormwater/susmp/susmp_details.shtml

[73] International BMP Database, *available at* http://www.bmpdatabase.org/

[74] LA City Bureau of Sanitation, Proposition O, http://lacitysan.org/wpd/Siteorg/LAPropo/index.htm

description on the selection of BMPs, their physical dimensions, and their respective advantages and disadvantages can be found in the Ballona Creek Watershed Final Report.[75] Each BMP has a unique treatment volume as well as a slight difference in pollutant and flow attenuation processes (Table 4).

	Vegetated swale	Bio-retention	Dry Pond	Infiltration Trench	Porous pavement
Length (ft)	250	46	45	90	62
Width (ft)	10	23	15	45	30
Depth (ft)	0.5	1.5	5	5	1
Cu decay rate (hr^{-1})	1.7	0.55	0.6	0.6	0.01
Pb decay rate (hr^{-1})	20	0.2	0.65	0.65	0.01
Zn decay rate (hr^{-1})	60	0.85	1.08	1.08	0.01

Table 4: Dimensions and metal pollutant removal efficiencies for selected BMPs.

d. Cost Background

The unit cost scheme developed in the Ballona Creek study[76], which customized costs to Southern California, was utilized for the BMP cost database in SUSTAIN (Table 5). Note that all costs are for initial construction only, as is typically included in a SUSTAIN simulation. Median values were used for cost analysis in both the optimization, in which SUSTAIN utilizes the NSGAII algorithm,[77] and in the decision matrix summarizing the benefits of the 6 BMP scenarios (1-3b) and 3 additional scenarios (4-6).

	Vegetated Swale	Bioretention	Dry Pond	Infiltration Trench	Porous Pavement
# of Constructed Projects	4	5	5	14	8
25% Quartile	5.37	12.30	4.40	3.33	10.57
Median	10.07	14.60	5.88	6.03	15.69
75% Quartile	18.53	16.24	15.71	16.63	16.17
Unit	$\$/ft^3$	$\$/ft^3$	$\$/ft^3$	$\$/ft^3$	$\$/ft^3$

Table 5: BMP construction costs ($) per unit treatment volume of water. The number of constructed projects represent the number of BMPs were analyzed for construction costs in Los Angeles.

e. BMP Scenarios

SUSTAIN utilizes an aggregate BMP approach to efficiently model at the watershed scale. A specified number of each type of BMP are grouped together as a single aggregate BMP. As

[75] UCLA CSM Ballona Creek Watershed Report (2015) https://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/

[76] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/

[77] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/

described in the Ballona Creek report, one aggregate BMP represents multiple BMPs of each type that have the same dimensions and pollutant removal decay rates.[78] A specified portion of runoff from the upstream subwatershed is routed to each BMP type in the aggregate BMP and then directed to the outlet.

Several BMP scenarios were explored to optimize cost and pollutant reduction in this study. Modeling runs include six optimization simulations, six BMP scenarios, and three additional scenarios to facilitate WQS compliance. First, the optimization simulation utilizes all five BMPs to capture a range of volumes based on the 85th percentile storm in the DC Watershed with each BMP type set to capture an equal share of the stormwater flow. This range is determined by a minimum and maximum number of BMPs to be implemented. The minimum bound is sufficient to capture 75% of the 85th percentile storm volume while the maximum bound captures 150% of the 85th percentile storm volume. The following five optimization simulations remove one BMP at a time to analyze how each BMP impacts pollutant reduction and cost. The 85th percentile storm volumes for each subwatershed, as well as the number of BMPs to capture that volume, are presented in Table 6. A map showing the distribution of 85th percentile storm depth can be seen in Figure 10.

Sub-Watershed	85th storm volume (AF)	Area mi^2	VS	BR	DP	IT	PP
TS24	56.9	1.6	397	313	147	25	267
TS23	75.3	2.2	526	414	195	32	353
TS22	89.5	2.6	624	492	231	39	419
TS21	71.8	2.1	501	395	186	31	337
TS20	103.2	3.4	720	567	267	44	484
TS19	242.7	7.2	1693	1334	627	105	1138
UDC*	953.4	26.9	8198	6457	3036	506	5509
LDC*	752.3	25.3	8162	6429	3023	504	5485
All	2345.2	71.2	16360	12886	6059	1010	10995

Table 6: Number of BMP units needed to capture 85th percentile storm volume in each subwatershed. *Number of BMPs required for the whole UDC and LDC subwatershed including their tributaries TS22-TS24 and TS19-TS21, respectively.

[78] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/

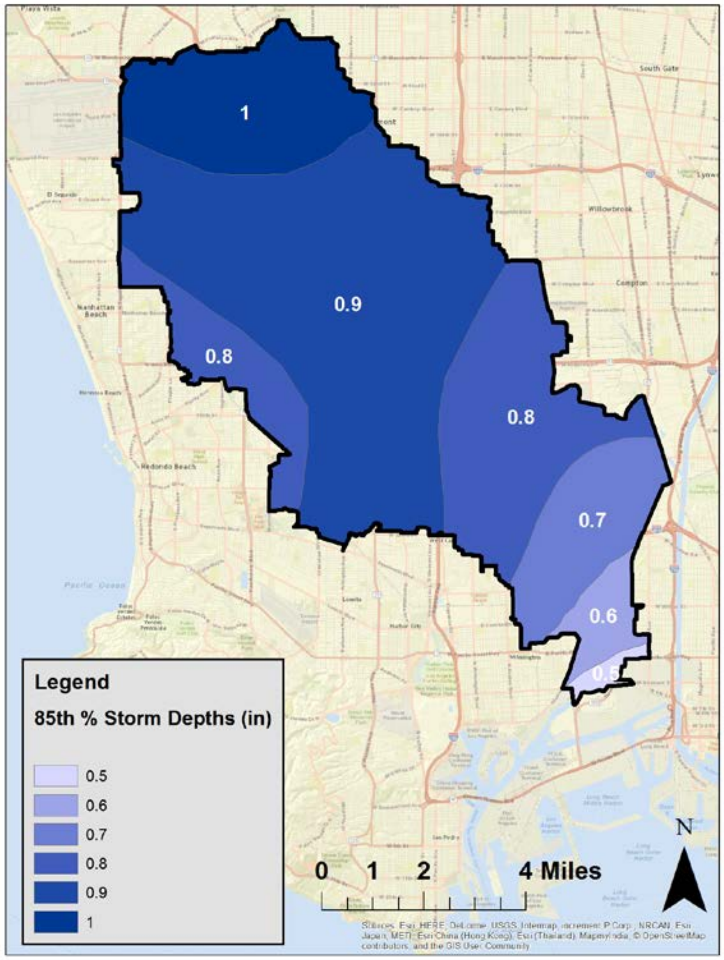

Figure 10: Dominguez Channel 85th percentile storm depths in inches per 24 hour time period. The area of each storm depth was used to determine the 85th percentile storm volume.

Aggregated BMP placement was based on the amount of total land plausible for BMP construction. The eleven SCAG land uses were grouped into "urban private," which consists of agriculture, commercial, industrial, multi-family residential, and single-family residential lands; "urban public," which contains education, recreation, and transportation lands; and "water." BMPs were only placed on "urban public" land uses in these modeling efforts as constructing BMPs on these parcels would face the least amount of resistance in terms of "buy-in" from stakeholders, and would not have to be acquired/purchased. Further, the land use types in "urban public," Education, Recreation, and Transportation, are well-distributed throughout the DC watershed's urban area, and thus facilitate constructing BMPs at many locations throughout the watershed.

Land in the "urban private" group was not included in the modeling as public lands are more readily available for BMP placement by the City and other public agencies. For example, placing BMPs on private land would require purchasing land or rights of way from private landowners or initiating large programs to encourage or require private landowners to install and maintain BMPs on site. BMP placement was also not allowed to occur on "water" uses as there are many regulatory hurdles that must be overcome to place a BMP in a waterbody. It is important to note that, although not modeled here, BMP implementation on private land will play a role in managing stormwater in the region through, for example, the City of LA LID ordinance. The potential impacts of this ordinance were assessed in a post-modeling ordinance (Section II.E.e).

Each 'urban public' land use type was further analyzed to identify the type and amount of available space on which BMPs could be placed on education, recreation, or transportation parcels. BMPs are assumed to be placed only on pervious land area. The pervious area of the education and recreation land uses determines the area that is available for BMP placement and thus the maximum number of BMPs that can be constructed throughout the DC Watershed. Using the SCAG data, it was determined that education and recreation land uses in the DC Watershed are on average 25% and 81% pervious, respectively. Based on these pervious percentages, the maximum area available for BMPs on, for example, educational land uses throughout the whole DC Watershed is 0.69 mi^2 or 442 ac (Table 6). It is important to note that all of this land may not need to be utilized to capture the required 85^{th} percentile storm.

The area available for transportation and parking lots was determined differently than for education and recreation as major highways were the only roads able to be identified due to the resolution of the SCAG land use raster. To better represent the entire transportation land use area throughout the DC Watershed, a road map that included all primary, secondary, and minor roads was analyzed using GIS. Using acquired datasets, this analysis identified 1,365 miles (2,196 km) of linear roadway throughout the DC Watershed. BMPs are assumed to be placed in the space between the roads and sidewalks; a width of two feet was chosen to represent the space on either side of the road. Thus, using the length of roads and width of space available on either side of the road, a total area of 1.03 mi^2 (659 acres) was determined to be available for BMP construction in these areas.

Porous pavement was assumed to replace parking lots of all land uses categorized as schools, government offices, and other public facilities. All individual locations and their area footprint were identified using the SCAG raster in GIS. The total area that these land use categories occupy was used to determine the total area of parking lots associated with these facilities. The City of Los Angeles Department of Building and Safety parking regulation requires one parking space for every 500 ft^2 of the associated facility.[79] Using the standard area of a parking spot, 18' x 8' 4", the area available for porous pavement was determined to be 1.05 mi^2 or 672 ac (Table 7). It is important to note that site-specific investigation would be necessary at each site before installing BMPs to determine the appropriateness of, for example, an infiltration-based BMP to infiltrate stormwater on-site. The major function driving the treatment process of porous pavement is infiltration, which is simulated in SUSTAIN using the Green-Ampt method. Green-Ampt is a function of soil moisture, saturated hydraulic conductivity, average wetting front suction head, and Darcy's law.[80]

[79] Parking Design Information Bulletin/Public-Zoning Code. City of Los Angeles Department of Building and Safety. Reference #: L.A.M.C. 12.21A5. Document #: P/ZC 2002-001. http://ladbs.org/docs/default-source/new-forms-publications/information-bulletins-guidelines/zoning-code/parking-lot-design-ib-p-zc2002-001.pdf Accessed on 2/15/16

[80] SUSTAIN Manual

Dry ponds and infiltration trenches are regional BMPs with a large footprint and thus were assumed to be implemented only on recreational land as they tend to have larger available spaces for the construction of these larger-scale BMPs (Table 7). Smaller distributed BMPs such as bioretention and vegetated swales are assumed to be more plausible on transportation and education land uses where the space available for construction is smaller and thus were only implemented on these land use types. Figure 11 shows the spatial distribution of urban public, urban private, and waterbodies throughout the DC Watershed. Approximately 5.12 mi^2 (3276 ac) of urban public land is available for BMP implementation throughout the 71 mi^2 (45,440 ac) DC Watershed.

	Land Use	Total Area (mi^2)	Percent Pervious (%)	Area available for BMPs (mi^2)	Total Area for BMPs (mi^2)	BMPs
Urban Public	Parking Lots	3.49	9	1.05	5.12	PP
	Transportation	18.41	9	1.03		BR + VS
	Education	2.17	15	0.69		BR + VS
	Recreation	2.27	81	2.35		BR + DP + IT

Table 7: Urban public land use breakdown for the DC Watershed as well as the plausible BMPs.

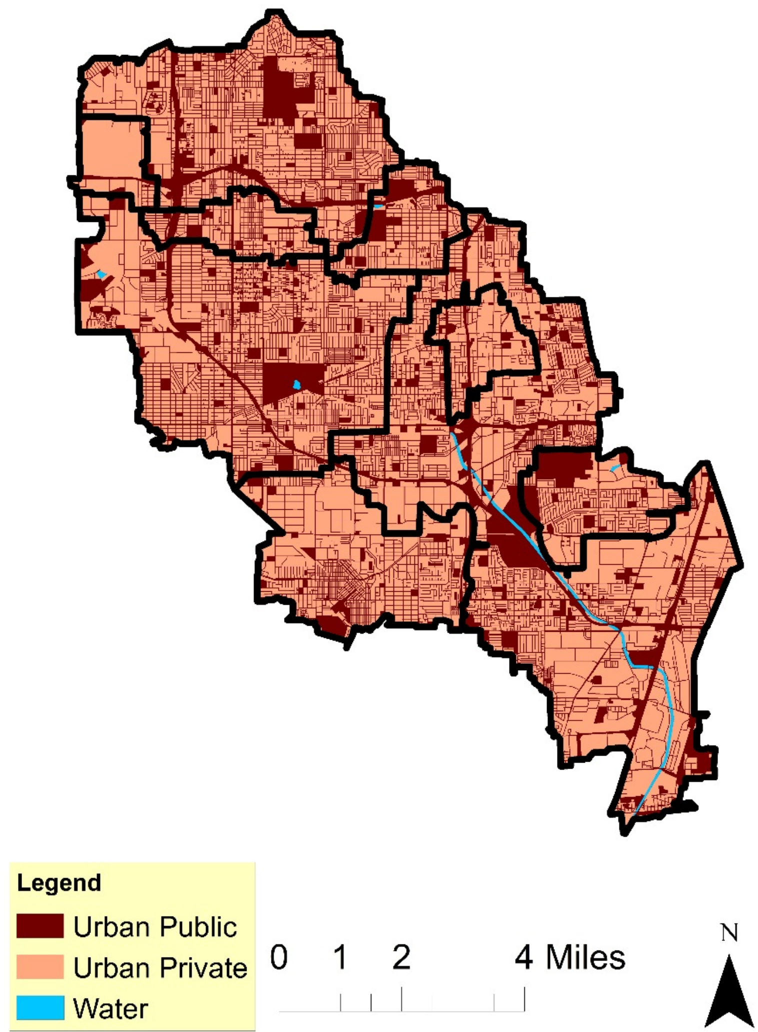

Figure 11: Land use distribution in the DC Watershed broken up by public, private and waterbodies. Subwatersheds discussed previously are also delineated.

BMP scenarios were designed to meet the MS4 permit requirements in that the number of BMPs simulated would capture the 85th percentile storm volume (2,353 AF). The six BMP scenarios designated as 1, 1b, 2, 2b, 3, and 3b were developed and modeled to present different options to the City to minimize exceedances in the DC Watershed. Scenarios 1, 2 and 3 each have a different suite of BMPs (Table 8). Scenario 1 utilizes bioretention, Scenario 2 utilizes vegetated swales and dry ponds, and Scenario 3 utilizes vegetated swales and infiltration trenches. Scenarios 1b, 2b, and 3b add porous pavement to the first three scenarios. This range of scenarios allow a reasonable representation of the various benefits and costs depending on the BMPs utilized.

Three additional scenarios were run in the DC watershed to identify the potential impacts on the water quality exceedances that remained after the 85th percentile storm BMP scenarios (through infiltration-based and treat-and-release BMPs) were modeled. The three assessed scenarios included simulating the impacts of: increasing the volume captured beyond the 85th percentile storm to the 95th percentile storm (Scenario 4), implementing BMPs with higher efficiency removal rates (Scenario 5), and implementing a water effect ratio (WER) in DC for copper (Scenario 6). Results from these scenarios are discussed in the following sections. Scenarios 4 – 6 all utilize vegetated swales and dry ponds (as in Scenario 2, which had the best results as discussed in the modeling results section).

Scenario	Vegetated Swale	Bioretention	Dry Pond	Infiltration Trench	Porous Pavement	% Storm Captured
1		x				85th
1b		x			x	85th
2	x		x			85th
2b	x		x		x	85th
3			x	x		85th
3b			x	x	x	85th
4	X		X			~95th
5	X		X		X	85th
6	X		X			85th

Table 8: BMP scenarios simulated in SUSTAIN with the BMPs utilized and percentile storm volume capture.

E. Dominguez Channel Modeling Results

a. Water Quality Modeling

The SUSTAIN optimization NSGA-II algorithm determines optimal solutions based on cost and pollutant reduction criteria. The model finds solutions based on these two criteria and selects the number of BMP units that will optimize (lower) cost as well as pollutant load reduction targets. Plotting cost vs pollutant load reduction produces a cost-effectiveness or Pareto curve (Figure 12A). The best solutions, which minimize cost and maximize reduction, are located in the "elbow" of the curve (lower left hand corner). Total storm volume capture is also represented in the optimization plot by the color scale. As discussed previously, the number of BMPs utilized in SUSTAIN captures a range of storm volumes based on the 85th percentile storm. This is simply to show the relationship between volumes of storm capture to the percent pollutant load reduction. The vertical black line in the plot roughly estimates where simulations are capturing the 85th percentile storm. Simulations to the left of the line capture less than the 85th percentile storm volume while simulations to the right capture greater than the 85th percentile storm volume. The range of pollutant load reduction is a fairly small window from 80% to 83%.

Different BMP types have varying impacts on the cost and pollutant reduction (Figure 12B). The optimization spread seen in Figure 12A is the same as the optimization in 12B labeled "All BMPs." Simulations in the bottom left corner represent options that are the most cost effective with the highest percent pollutant load reduction. Utilizing all BMPs to capture the 85th percentile storm is more expensive than selecting only a specific suite as seen in the remaining optimization scenarios. Optimizations "No BR," "No DP," and "No PP" are the highest performing optimization scenarios with the lowest cost. Optimizations "No VS" and "No IT" have a lower percent pollutant reduction along with a higher cost. Using this analysis can provide guidance on identifying the best combination of BMPs to use depending on, for example, desired outcomes and location-specific characteristics.

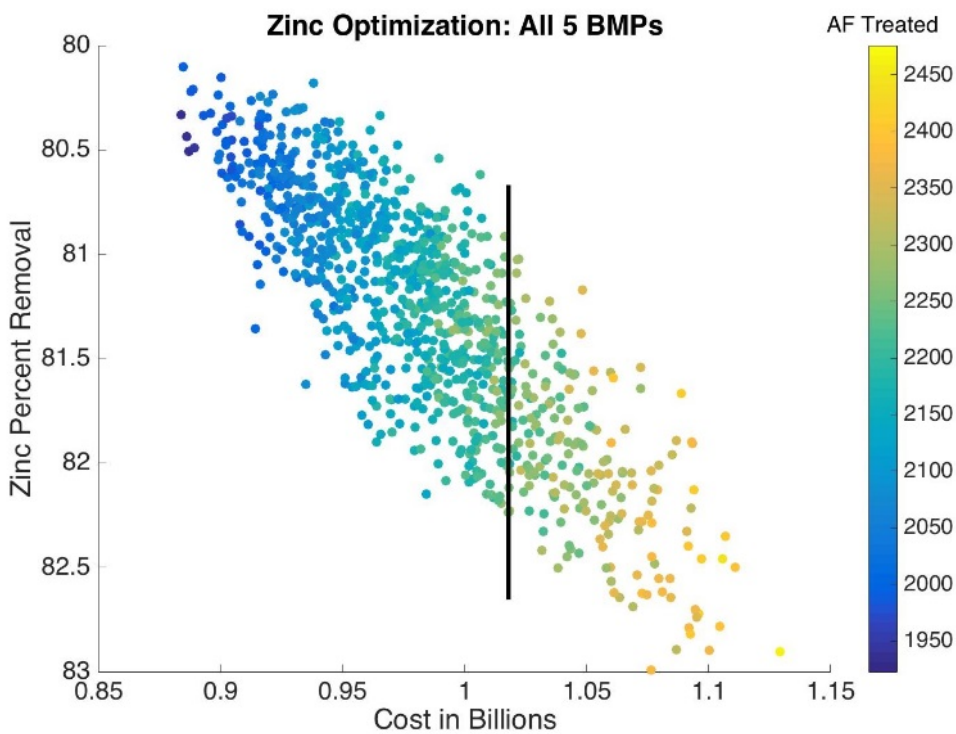

Figure 12A, caption on following page

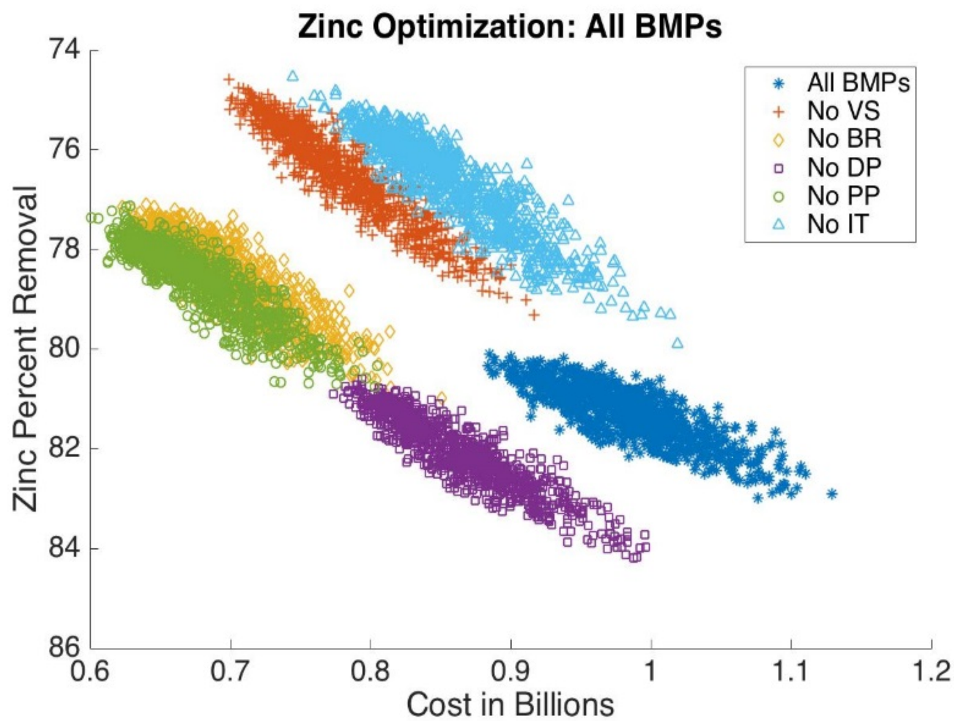

Figure 12 A (top) and B (bottom): Optimization of cost and zinc pollutant load reduction for the whole Dominguez Channel. The black vertical line in 12A roughly estimates where solutions begin to capture the full 85th percentile storm volume.

Modeling results facilitated the development of a decision matrix to compare several criteria of BMP Scenarios 1, 1b, 2, 2b, 3, and 3b (Table 9). Exceedances were assessed based on TMDL requirements for both concentrations and loads. Patterns in exceedances were fairly similar using load-based or concentration-based criteria; concentration-based exceedances were generally slightly lower or the same [e.g., wet weather exceedances in Scenario 2 for copper were 11 (load-based) vs 9 (concentration-based) and 5 for zinc (for both concentration and load-based), Table 9]. Criteria such as cost, potential infiltration, and peak flow reduction are also included in the matrix. Scenario 2 (VS + DP), for example, generally offers the maximum cost efficiency and minimum BMP footprint area but also provides the lowest potential infiltration volume as this scenario mainly includes are treat-and-release BMPs (Table 9). Scenario 1b (BR + PP) minimizes the total number of wet weather exceedances per year but is not as effective in cost efficiency or area required for BMP placement as Scenario 2 (VS + DP, Table 9). We also assessed the benefit of the City of LA LID ordinance as a post-modeling analysis [discussed below in Section E(e)].

	Dominguez Scenarios	Baseline	1	1b	2	2b	3	3b
	BMPs	No BMPs	BR	PP + BR	VS + DP	PP + VS + DP	VS + IT	PP + VS + IT
	Wet Weather Days/yr (2002-2011)	32	8	6	11	9	8	7
	Volume Capture	0	2353	2353	2353	2353	2353	2353
	Storm Capture %	0	85th %	85th %	85th %	85th %	85th %	85th %
Ancillary Criteria	Cost (Billions)	-	1.51	1.51	0.70	0.89	0.70	0.90
	BMP area (mi^2)	-	2.48	2.68	2.14	2.72	2.09	2.67
	Infiltration (% of Precip)	-	30.6%	22.8%	2.4%	14.9%	18.6%	22.1%
	Infiltration (AFY)	-	13,762	10,254	1,084	6,701	8,365	9,948
	Peak Flow Reduction	-	69.6%	55.7%	4.4%	34.0%	45.4%	55.3%
Water Quality Criteria	Concentration Based WW Exceedances/yr (Cu)	16	6	5	9	8	7	6
	Concentration Based WW Exceedances/yr (Pb)	0	0	0	0	0	0	0
	Concentration Based WW Exceedances/yr (Zn)	16	5	4	5	7	6	6
	Load Based WW Exceedances/yr (Cu)	18	7	5	11	9	8	7
	Load Based WW Exceedances/yr (Pb)	0	0	0	0	0	0	0
	Load Based WW Exceedances/yr (Zn)	17	6	5	5	7	7	6
	Cu % Load Based TMDL Compliance (WW)	4.20%	8.6%	7.5%	5.9%	4.9%	5.4%	6.2%
	Pb % Load Based TMDL Compliance (WW)	100%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Zn % Load Based TMDL Compliance (WW)	8.40%	22.9%	11.3%	53.5%	20.7%	13.5%	12.3%
	Cu Average Annual Load % Reduction	-	80.4%	74.9%	74.7%	77.1%	80.0%	82.2%
	Pb Average Annual Load % Reduction	-	75.5%	73.5%	77.1%	78.3%	82.3%	83.1%
	Zn Average Annual Load % Reduction	-	84.5%	76.0%	80.3%	80.3%	82.2%	83.1%

Table 9: Decision matrix for evaluating tradeoffs between BMP scenarios. The color scale was created in Microsoft Excel by using the Conditional Formatting tool and displays a range from dark green to white for each criteria row. Darker colors indicate a better result for that row.

Although copper and lead were also modeled, zinc is the focus of the remaining discussion to analyze differences between modeled scenarios for a variety of reasons, including the following. First, the amount of copper in the stormwater system is expected to decrease significantly due to new regulations eliminating copper from brake pads. As a result, zinc is expected to become the limiting metal to meet WQS. Next, there were no wet weather exceedances for lead in all scenarios and so lead was not analyzed further.

Scenario 1b (BR +PP) has the lowest number of zinc exceedances per year (5) and fewer wet weather days (6) than the other scenarios (Table 9) after BMP implementation as these are infiltration-based BMPs which remove flow from the channel. Scenario 2 (VS + DP) had the same number of exceedances but more wet weather days per year (11) as these BMPs return flow to the channel. The annual average load (AAL) percent reduction of zinc is similar across all scenarios, only differing by approximately 1-3%; the peak flows and infiltration potential, however, differ greatly. Scenario 2, with the treat-and release BMPs (VS + DP), has the greatest AAFV and lowest peak flow reduction. Treat and release BMPs result in fewer exceedances because they return treated, cleaner water to the channel to dilute remaining pollutants. Infiltration-based BMPs significantly reduce TMDL exceedances compared to no BMPs but are not as good for reducing exceedances as treat and release BMPs. Infiltration BMPs remove water from the channel, thus lowering the TMDL target at the point of compliance. Treat and release BMPs are more effective at reducing water quality exceedances. However, infiltration BMPs remove more pollutant load than treat and release BMPs, and also offer other potential integrated water management benefits such as groundwater recharge and peak flow reduction.[81] For example, Scenario 1 (BR) provided potential infiltration of approximately 14,000 AFY of stormwater (30% of precipitation) and 70% reduction in peak flow versus Scenario 2 (VS + DP) with potential infiltration of 1,000 AFY and 4% reduction in peak flow (Table 9).

Thus, physical characteristics of the modeled BMPs provide different sets of benefits; modeling results can provide additional information on the optimum suite of BMPs to address the higher priority concerns or benefits in the specific watershed area. For example, the DC Watershed might not be an optimal location for groundwater recharge due to soil properties and salt water intrusion in the harbor areas. While infiltration trenches, which infiltrate 70% of the flow routed through them, might be optimal for BC or LAR to recharge the groundwater where soil properties allow for infiltration, they would not produce the same result for DC, and may result in movement of groundwater contaminant plumes. Instead, "treat and release" BMPs such as vegetated swales and dry ponds might be chosen to maintain flow volume in the channel for alternative benefits.

b. Modeling to Further Improve Water Quality

Scenarios 1-3b showed that wet weather exceedances still occur even after modeling BMP scenarios that managed (through infiltration-based and/or treat-and-release BMPs) the 85th percentile storm. Hence, as described above, Scenarios 4 through 6 were designed to assess the impacts on water quality of implementing additional structural and non-structural approaches in the DC Watershed. These scenarios included managing a higher storm volume, increasing BMP decay rates, and implementing a copper WER. Scenario 2 (VS + DP) was chosen as the baseline scenario because it produced the best results in terms of wet weather exceedances (lowest number, Zn, Table 9).

In Scenario 4, the number of BMPs simulated was increased to evaluate the capture of a volume around the 95th percentile storm. Even though the increased number of BMPs results in the capture of a larger volume of water, there is little effect on copper exceedances (decrease from 11 to 10) and the number of zinc exceedances actually increases (from 5 to 6, Table 10). This is due in part to the fact that, as described above, infiltration-based BMPs are not as good for reducing exceedances of receiving water concentration based standards as treat and release BMPs. The implementation of additional BMPs in this scenario resulted in a reduction in flow that lowered the TMDL target more than pollutant loads were reduced, and thus wet weather zinc exceedances increased. Therefore, both the quantity and types of BMP impacted the number of exceedances. It is important to note that, although exceedances were reduced by the greatest amount through modeling treat-and-release BMPs, the potential ancillary benefits such as stormwater infiltration and peak flow reductions were reduced compared to scenarios with infiltration-based BMPs.

In Scenario 5, the impact of increasing the decay rates of the two BMPs (VS + DP) utilized in this scenario was evaluated. Treatment efficiency was tested by increasing the 1st order

[81] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/, pg 6.

decay rates for each BMP in the SUSTAIN simulations (i.e. improved pollutant removal). Each BMP type takes into account inflow time series, concentration times series for each pollutant, and the 1^{st} order decay factor/rate (1/hr) for each pollutant to predict the outflow and concentration time series for each pollutant.[82] The decay factor simulates an exponential decay over time. The goal was to determine the theoretical decay rates needed for zero days of wet weather exceedances. The percent pollutant reduction reached a maximum, however, even when simulating decay rates that were 100 times greater than the original rates. Copper decay rates for vegetated swales and dry ponds were both increased to 10 (1/hr) while zinc decay rates were increased to 80 and 10 (1/hr), respectively. These are the lowest decay rates at which pollutant reduction reached its maximum. This is most likely due to factors relating to both the BMP design as well as external factors such as the volume of water routed to the BMPs. The best possible results for scenario 5 (increased decay rates) was a reduction in copper exceedances from 11 to 9 and in zinc exceedances from 5 to 4 (Table 10).

	Scenario	Baseline	2	4	5	6a	6b
	Description	No BMPs	VS + DP	More BMPs	Higher Decay Rates	Cu WER (2.0)	Cu WER (3.2)
	Pre BMPS Wet Weather Days/yr (02-11)	32	11	9	11	11	11
	Volume Capture	0	2353	3159	2353	2353	2353
	Storm Capture %	0	85th %	~95th%	85th %	85th %	85th %
Ancillary Criteria	Cost (Billions)	-	0.698	0.897	0.698	0.698	0.698
	BMP area (mi2)	-	2.14	2.34	2.14	2.14	2.14
	Infiltration (% of Precip)	-	2.41%	3.01%	2.41%	2.41%	2.41%
	Infiltration (AFY)	-	1.08E+03	1.69E+03	1.08E+03	1.08E+03	1.08E+03
	Peak Flow Reduction	-	4.41%	11.15%	4.41%	4.41%	4.41%
Water Quality Criteria	WW Exceedances/yr (Cu)	18	11	10	9	3	0
	WW Exceedances/yr (Pb)	0	0	0	0	0	0
	WW Exceedances/yr (Zn)	18	5	6	4	5	5
	Cu TMDL Compliance (WW)	4.2%	5.9%	6.2%	22.8%	75.0%	100.0%
	Pb TMDL Compliance (WW)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
	Zn TMDL Compliance (WW)	8.4%	53.5%	52.6%	63.4%	53.5%	53.5%
	Cu Average Annual Load % Reduction	-	74.7%	80.7%	78.0%	74.7%	74.7%
	Pb Average Annual Load % Reduction	-	77.1%	78.7%	79.9%	77.1%	77.1%
	Zn Average Annual Load % Reduction	-	80.3%	81.2%	83.9%	80.3%	80.3%

Table 10: Comparison of additional scenarios 4-6 which evaluate changes made to scenario 2.

It is important to note, however, that the actual removal efficiency of the BMPs could not be modeled due to constraints within SUSTAIN. As a result, the decay rate was used as a proxy. A decay rate is not linearly related to the percent reduction in pollutant loads or removal efficiency of a BMP, and thus, the highest possible decay rate will not ensure 100% removal of pollutants. Ideally, the 90^{th} percentile removal efficiencies for BMPs from the ASCE database could have been used in the modeling efforts to assess whether utilizing more efficient BMPs would have resulted in greater reductions in water quality standard exceedances. However, BMP removal efficiency is not a variable that can be adjusted in SUSTAIN as it does not

[82] LAI, DENNIS, T. DAI, J. ZHEN, J. RIVERSON, K. ALVI, AND L. SHOEMAKER. SUSTAIN - AN EPA BMP PROCESS AND PLACEMENT TOOL FOR URBAN WATERSHEDS. In Proceedings, WEF 2007 TMDL Specialty Conference, Bellevue, WA, June 24 - 27, 2007. Water Environment Federation, Alexandria, VA, (2007).

exist as a modeling control. Future research to identify the impact of BMP efficiency on modeled outcomes would provide better information on which BMPs provide the most benefit as well as how efficient they must remain post-installation to provide the expected benefits.

Further research could lead to performance-based BMP approaches that would ensure that BMP technologies and removal efficiencies would continue to improve, thus leading to better water quality. The decay rate analysis here provides some useful information as the decay rate is one factor that determines the overall pollutant removal efficiency of a BMP. Other factors include, but are not limited to, materials, design, dimensions and hydrologic characteristics. In addition, as stormwater from only 90% of the land is being routed to BMPs in our simulations, the pollutant washoff from the remaining 10% of the watershed is still entering the channel and may also have impacted water quality in this analysis.

WERs account for site-specific water conditions at different locations and allow for variations in pollutant aquatic toxicity based on the water's chemical characteristics. While WERs for copper have not been developed for the DC Watershed, copper WERs have been assessed for reaches and tributaries in the LAR watershed for both wet and dry weather. In the LAR, copper WERs ranging from 1.32 to 9.69 during dry weather and 3.97 during wet weather have been approved by the LARWQCB.[83] Our modeling efforts in the Ballona Creek Watershed found that a WER of 2 would result in 100% TMDL compliance for copper in dry weather and in most modeled scenarios for wet weather.[84]

Two potential WERs were analyzed in the DC Watershed for discussion purposes. These WER scenarios were not meant to imply that a copper WER is justified for the DC watershed, but rather to investigate how WERs, if appropriate based on DC water characteristics, would impact compliance in the future. Scenario 6a analyzed the impacts of the implementation of a copper WER of 2, resulting in a numeric target for copper of 9.7 * 2 or 19.4 ug/L, to facilitate direct comparison with the Ballona Creek Watershed WER analysis. Modeling results in Scenario 6b identified the WER, 3.2 (resulting in a new copper target of 9.7 * 3.2 or 31.0 ug/l) at which wet weather copper exceedances would be zero in the DC Watershed.

Figure 13 illustrates the comparison in terms of wet weather loads and TMDLs between scenario 2 (VS+DP) and 6 (WER). On average, the daily load is about 70% higher than the TMDL for the baseline when no BMPs are simulated in SUSTAIN. A WER greater than one effectively increases the allowable concentrations in the water. As a result, applying a WER of 2 reduces exceedances from 11 in the baseline modeling Scenario 2 (VS + DP) to 3. It is important to note that no reduction in copper concentrations has occurred in these WER scenarios; the reduction in the number of exceedances is a result of higher allowable concentrations in the water. As noted above, applying a WER of 3.2 results in zero copper wet weather exceedances in scenario 2 (VS + DP).

A WER study would need to be completed for DC to ascertain the site-specific water chemistry and the resultant impacts on copper toxicity. While the WERs needed for Ballona Creek

[83] Los Angeles River Copper WER Final Report, April 2014, p. ES-4

[84] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/ pg 60

(2) and DC (3.2) to reach 100% TMDL compliance are similar in magnitude, the WER needed for the DC Watershed is higher as the TMDL target is lower. In addition, as discussed in the Ballona Creek study, SB 346 (the law that requires the phase out of copper in brake pads by 2025) will have an impact on copper loads and concentrations in receiving waters; this law alone is unlikely to result in the elimination of copper exceedances within the DC watershed.[85]

WERs of 2 and 3.2 were applied to all 6 BMP scenarios (Table 11). These results give a better understanding on how WERs impact water quality exceedances. A WER of 3.2 resulted in the elimination of water quality exceedances in three scenarios (2, 2b, and 3). The three BMP scenarios (1, 1b and 6) in which exceedances were not eliminated with a WER of 3.2 are also the three scenarios that infiltrate the highest volume of water. This again shows that while infiltration-based BMPs offer potential water supply benefits through infiltrating stormwater, they are at a disadvantage for reducing exceedances as they remove flow from the channel and thus lower the load-based TMDL at the point of compliance.

Scenarios 4-6 were designed to offer insight into how to increase the likelihood of eliminating water quality exceedances. Wet weather copper exceedances per year were slightly reduced in Scenario 4 when capturing a higher volume of water (10 exceedances) and in Scenario 5 with an increased decay rate (9 exceedances) as compared to the baseline scenario (11 exceedances, Table 10). In Scenario 4, increasing the number of BMPs to capture more volume beyond the previously modeled BMP scenarios (that already capture the 85th percentile storm volume from 90% of the watershed) is more expensive and offers relatively small gains in water quality. Scenario 5, which increases the BMP pollutant decay rates, is more effective than Scenario 4, but still only reduces exceedances from 11 to 9 and from 5 to 4 for copper and zinc, respectively.

As described above in scenario 6a and 6b, however, exceedances are eliminated in some scenarios as the allowed concentrations are effectively increased through the application of a WER. Even if a WER were not as high as 3.2, a WER could have the effect of reducing the total amount of BMPs needed to meet a revised criteria. It is important to note that a WER would not have any of the ancillary benefits associated with implementing BMP programs, nor do they result in improvement of actual water quality. Rather, if site-specific conditions are found to make metal less toxic or bioavailable, then WERs increase the allowable concentrations of metals.

[85] UCLA CSM Ballona Creek Report 2015, *Available at*: http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/ pg 19

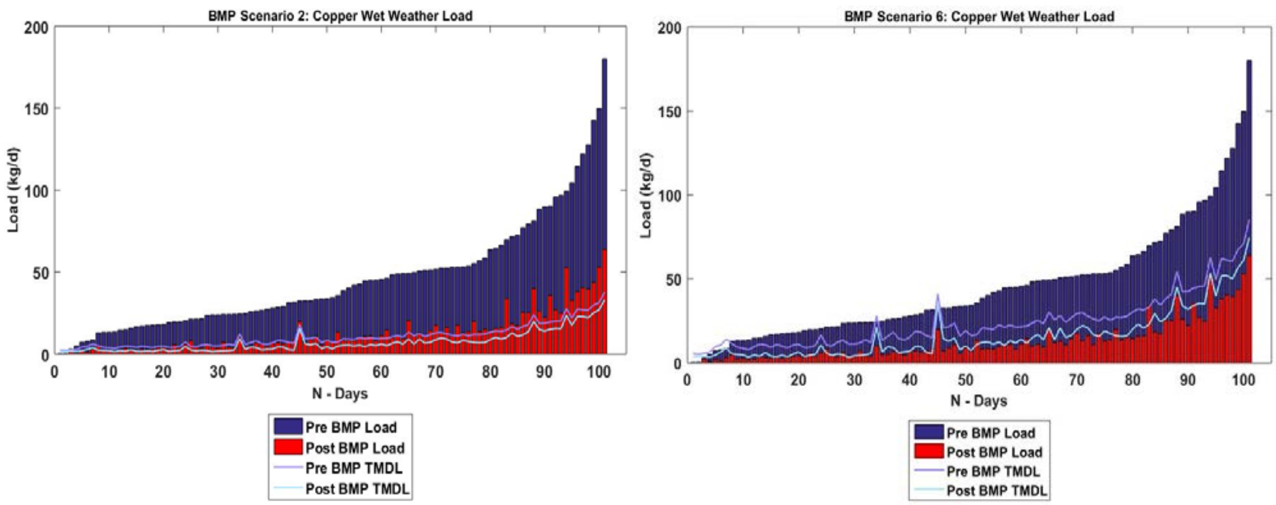

Figure 13: Copper loads at MES S28 pre-BMP and post- BMP implementation as well as the associated TMDLs for scenario 2, vegetated swales and dry ponds, and scenario 6 which mirrors scenario 2 except with a WER of 2. The impact of the WER on the TMDL is noticeable in Scenario 6 as there are far fewer instances where the post-BMP loads exceeds that post-BMP TMDL line.

		Baseline	BR	PP+BR	VS+DP	PP+VS+DP	VS+IT	PP+VS+IT
	Wet Weather Days/yr (02-11)	32	8	6	11	9	8	7
No WER	WW exceedances/yr (Cu)	18	7	5	11	9	8	7
WER (2.0)	WW exceedances/yr (Cu)	18	6	5	2	3	5	6
WER (3.6)	WW exceedances/yr (Cu)	18	2	3	0	0	0	1

Table 11: Shows the change in wet weather exceedances and copper load-based TMDL exceedances for each BMP scenario when a WER of 2 and 3.2 is applied.

c. DC TMDL Analysis

A comparison between the DC Watershed and the BC watershed was also conducted to further analyze the TMDLs in the DC Watershed (Table 12). A modeling summary is provided for both watersheds. This includes the average annual flow volume (AAFV) gauge as well as the average annual load (AAL) of copper and zinc at MES S28 and the outlet for the DC and BC watersheds, respectively. Lead was not included in this analysis since no lead exceedances were observed for the DC Watershed in all pre and post-modeling scenarios. While TMDLs are applied to daily flow, this analysis provides insight into the difference in water quality standards between the two watersheds (Table 12). Instead of applying the TMDL to the daily flow, this analysis applies the TMDL to the average annual load for both copper and zinc. The goal of this discussion is to be used as strictly a comparative analysis.

The TMDLs were applied to the AAFV listed below to calculate an estimate of the average annual TMDL (AA-TMDL). This is an estimate of the total allowable loads of pollutants per year based on the AAFV, AAL, and TMDL numeric targets.[86] Comparing this number to the modeled baseline AAL of 1323 pounds of copper, it is determined that a pollutant load reduction of 60% is required to reach the estimated AA-TMDL of 529 pounds. The pollutant load percent reduction required for the DC Watershed to reach the AA-TMDL is higher than that of the BC watershed (Table 12). For example, while the BC watershed requires a 24.1% pollutant load reduction to reach the estimated average allowable pollutant load of 2,358 pounds per year, the DC Watershed requires a pollutant load reduction of 68.6%. This demonstrates that the numeric targets are lower in the DC Watershed. The main factor attributing to the lower TMDL targets is the determined lower hardness of the DC water, which is taken into account when calculating the TMDL for a specific watershed.

	Upper Dominguez	Ballona Creek
AAFV (AF)	20143	63490
Cu AAL (lbs)	1323	4088
Zn AAL (lbs)	6431	23824
Cu TMDL Numeric Target (ug/L)	9.7	13.7
Zn TMDL Numeric Target (ug/L)	69.7	104.77
AA-TMDL Cu (lbs)	529	2358
AA-TMDL An (lbs)	3813	18077
% Reduction Required for Cu	60.0%	42.3%
% Reduction Required for Zn	68.6%	24.1%

Table 12: Comparison of water quantity, quality, and TMDLs between DC and Ballona Creek.

Figure 14 shows a side-by-side visual comparison of the copper loads and TMDLs in the DC and BC watershed. The dark blue bars represent the baseline daily copper load in pounds without the implementation of any BMPs throughout the watershed. The light blue bars are the resulting daily load after implementation of BMPs in SUSTAIN. The red and black lines are the daily TMDLs based on the total daily flow, pre and post BMP implementation, respectively. For example, in order for zero exceedances to occur in the DC Watershed on daily flow without BMPs the dark blue bars would need to be equal to or less than the red TMDL line. The same is applied for the post-BMP implementation with the light blue bars and black line. The TMDLs in the DC Watershed are lower than the loads for each day while the BC watershed loads and TMDLs are closer in loads per wet weather day (Figure 14).

[86] For example, the DC AAFV of 20,143 AF is multiplied by the copper TMDL of 9.7 ug/L, using the appropriate conversions to get units in pounds, to get an AA-TMDL of 529 pounds.

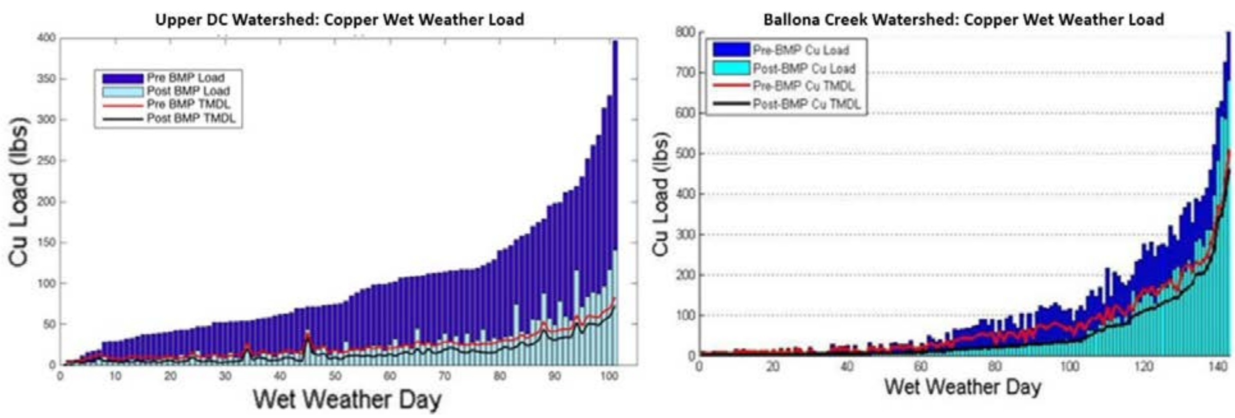

Figure 14: Comparison of pre and post BMP loads and TMDLs between Dominguez Channel (left) and Ballona Creek (right). DC Watershed TMDLs are lower than those in the BC watershed.

d. Industrial Land Use Modeling Analysis

i. WQ Impacts of Industrial Land Uses

As described previously, we determined the maximum number of BMPs to be implemented within a subwatershed based on the area of 'urban public' land only as it would be easier for the City to implement BMPs on public land. As a result, our modeling efforts did not include industrial land uses. Based on these assumptions, higher percentages of 'urban private' land (including industrial land uses) lead to less area available for BMP construction (Table 13). In addition, UDC and LDC do not include the areas of the tributary subwatersheds within the UDC and LDC (Figure 5) as these subwatersheds have been separated out for this analysis. It is important to note that although not included in this modeling analysis, BMPs can be placed onto private land uses, such as industrial parcels, in actual practice and future research should identify those opportunities as well.

	% Industrial	% Land available for BMPs	% Cu Reduction	% Zn Reduction
TS24	66.8%	1.3%	38.2%	39.3%
TS23	20.1%	6.3%	81.6%	84.5%
TS22	16.5%	8.8%	83.9%	86.3%
TS21	44.5%	2.2%	77.9%	81.5%
TS20	12.3%	12.6%	87.2%	88.4%
TS19	31.6%	4.1%	67.8%	72.3%
UDC*	9.3%	6.8%	79.2%	82.4%
LDC*	27.0%	3.7%	76.4%	80.2%
All	20.9%	6.2%	77.2%	80.8%

Table 13: Analysis on % industrial, % land available for BMPs, and resulting pollutant reductions for each subwatershed in DC Watershed. SUSTAIN evaluates pollutant loading at the output of each subwatershed

Thus, the four DC subwatersheds with the lowest percent of industrial land cover ("urban private") have the highest percent of land available for construction of BMPs on "urban public" land uses as well as the greatest pollutant reduction (Table 13). Conversely, the three subwatersheds (TS24, TS21, and TS23) with the highest percent industrial land cover have the lowest percent of land available for BMPs. Overall, these three subwatersheds each have less than 0.03 mi^2 (19.2 acres) of educational and recreational public land uses that were considered available for BMPs in our modeling efforts; this restricted the potential to place BMPs.

Pollutant reduction within TS24 is substantially lower because of the high percentage of industrial land use. This is due to two factors: the number of BMPs that can be implemented based on quantity of "urban public" land available and the pollutant loads coming off the subwatershed. Lower quantities of available land on which to implement these BMPs means that there is not sufficient space available to place the number of BMPs that would be required to capture the full 85^{th} percentile storm. For example, the 85^{th} percentile storm volume in TS24 is 57 AF but the maximum number of BMPs that can be placed in TS24 can only capture 3 to 18 AF in the modeled scenarios. BMPs in TS21 and TS23 are also unable to capture the full 85^{th} percentile storm, capturing 50 of 70 AF and 64 of 75 AF, respectively.

The second factor affecting pollutant reduction is the concentration and loads of pollutants washoff (EMCs) coming from the industrial land use parcels. The EMC from industrial land use is the highest value for zinc and lead of all land uses, and above average for copper. Thus, watersheds with a higher percent of industrial land use area are expected to have higher loads of pollutants than those with less industrial land use. The larger pollutant loads in combination with insufficient space to place enough BMPs to capture the 85^{th} percentile storm volume, results in lower pollutant reduction in these more heavily industrialized subwatersheds. Extra BMPs were not added to these subwatersheds to better compare results across subwatersheds. However, when these subwatersheds were included in the overall DC Watershed scenario analyses, extra BMPs were manually added in to adjacent subwatersheds to ensure the capture of the 85^{th} percentile storm volume for the whole DC Watershed. For example, as TS20 had the ability to capture greater than the 85^{th} percentile storm volume, extra BMPs were included in modeling simulations for the TS20 subwatershed to make up for the lack of storm capturing capacity in BMPs in TS24.

ii. WQ Impacts of Varying Industrial Land Use EMCs

The previously described modeling approaches demonstrated that eliminating copper and zinc exceedances was very difficult in the DC watershed. We decided to modify the modeling approach by reducing the EMCs from industrial facilities. The logic behind the approach was that well designed and implemented Stormwater Pollution Prevention Plans (SWPPPs), which are currently required by industrial individual and general NPDES permits and TMDL requirements, should result in source reduction success where EMCs would be at or below the WLAs in the TMDL. Therefore, two additional analyses were run to further explore the potential impacts of changing pollutant loads from industrial land uses on eliminating exceedances. In one, industrial land use EMCs were set to the WLAs that are currently required under the TMDL, and in the other, industrial land use EMCs were set to zero.

This analysis explores how the baseline water quality changes throughout the watershed if all industrial point sources meet the concentration-based WLAs. EMCs from all industrial classified land use areas were set to the WLAs in the DC TMDL: 9.7, 42.7, and 69.7 ug/L for copper, lead, and zinc, respectively.[87] Table 14 shows the difference in industrial EMCs from the calibrated modeled baseline values used in all previous modeled simulations, and the WLAs determined for all point sources. To reach the concentration-based WLAs, industrial wash-off EMCs would have to be reduced by approximately 80% for copper and zinc. However, it should be noted that the calibrated baseline EMC for lead is actually lower than the WLA, therefore the lead EMC was set to remain at the baseline, 0.0260 mg/L, in SUSTAIN. All other land use EMCs remained the same as originally calibrated for the DC Watershed. Thus, the magnitude of the industrial land use wash-off EMCs for copper and zinc is the only difference being compared between these two simulations.

		Cu	Pb	Zn
WLAs	mg/L	0.0097	0.0427	0.0697
Modeled Baseline	mg/L	0.0510	0.0260	0.4590

Table 14: Difference between WLA EMCs and calibrated and simulated EMCs in SUSTAIN for the DC watershed.

Simulations were run from water year 2002 to 2011. The average annual load (AAL) between two sets of EMCs were compared at the outlet of the full DC Watershed. The first column, AAL Baseline, in Table 15 shows the baseline AAL of each pollutant, meaning without the simulation of any BMPs. The second column shows the resulting AAL when all industrial land use wash-off EMCs meet the WLA. These values also do not include the implementation of BMPs on public lands. Copper and zinc AALs were reduced by 20% and 39%, respectively (Table 15) with the lower EMCs; there was no change for lead as the EMC remained constant as described above.

	AAL Baseline (lbs)	AAL Ind. meeting WLAs (lbs)	% Reduction
Cu	2859	2285	20%
Pb	1197	1197	0%
Zn	13893	8536	39%

Table 15: Change in average annual loads when industrial EMCs are set to WLAs (Table 14).

The impact of BMPs on these scenarios was then assessed by comparing these industrial EMCs across scenario 2 (VS + DP, Table 16). Analyses were taken one step further to compare scenario 2 (VS + DP) with and without industrial sites meeting the WLAs (Table 16). The same number of BMPs is utilized for both simulations. Copper exceedances decrease from 11 to 9 while zinc exceedances decrease from 5 to 1 under Scenario 2 (VS + DP) with the industrial land use EMCs set to the WLAs (Table 16).

[87] Amendment to the Water Quality Control Plan (Attachment A) p.12

	Scenario	Baseline	2	IND meet WLAs	IND EMCs set to 0 mg/L
	Description	No BMPs	VS + DP	VS + DP	VS + DP
	Pre- BMPs Wet Weather Days/yr (02-11)	32	11	11	11
	Volume Capture	0	2353	2353	2353
	Storm Capture %	0	85th %	85th %	85th %
Ancillary Criteria	Cost (Billions)	-	0.698	0.698	0.698
	BMP area (mi2)	-	2.14	2.14	2.14
	Infiltration (% of Precip)	-	2.41%	2.41%	2.41%
	Infiltration (AFY)	-	1084	1084	1084
	Peak Flow Reduction	-	4.41%	4.41%	4.41%
Water Quality Criteria	WW Exceedances/yr (Cu)	18	11	9	8
	WW Exceedances/yr (Pb)	0	0	0	0
	WW Exceedances/yr (Zn)	18	5	1	<1
	Cu % Exceedance (WW)	56.2%	94.1%	88.7%	86.6%
	Pb % Exceedance (WW)	0.0%	0.0%	0.0%	0.0%
	Zn % Exceedance (WW)	56.2%	46.5%	10.4%	6.2%
	Cu AAL % Reduction	-	74.7%	79.9%	81.1%
	Pb AAL % Reduction	-	77.1%	77.1%	77.1%
	Zn AAL % Reduction	-	80.3%	87.9%	89.3%

Table 16. Scenario "IND meets WLAs" shows the updated water quality criteria for a scenario that is identical the Scenario 2 except that all industrial land use EMCs were set to the WLAs.

When all industrial land use wash-off EMCs (in addition to the implementation of the VS + DP BMPs included in Scenario 2) are set to the WLAs, the daily load for the DC Watershed decreases. For example, the maximum load is decreased from 850 kg to 550 kg (Figure 15). Figure 15 shows a side by side comparison of the two scenarios (TMDL lines are identical and can be used for scale).

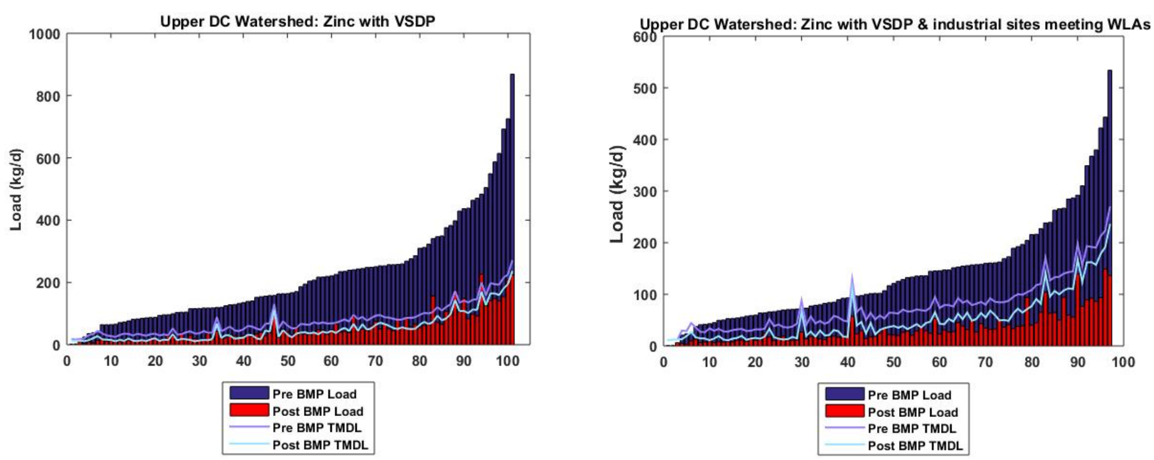

Figure 15: Comparison of all zinc wet weather loadings from the original Scenario 2 (VS + DP) and Scenario 2 when all industrial sites throughout the DC watershed meet WLAs. Note the y-axis changes scale between the two plots.

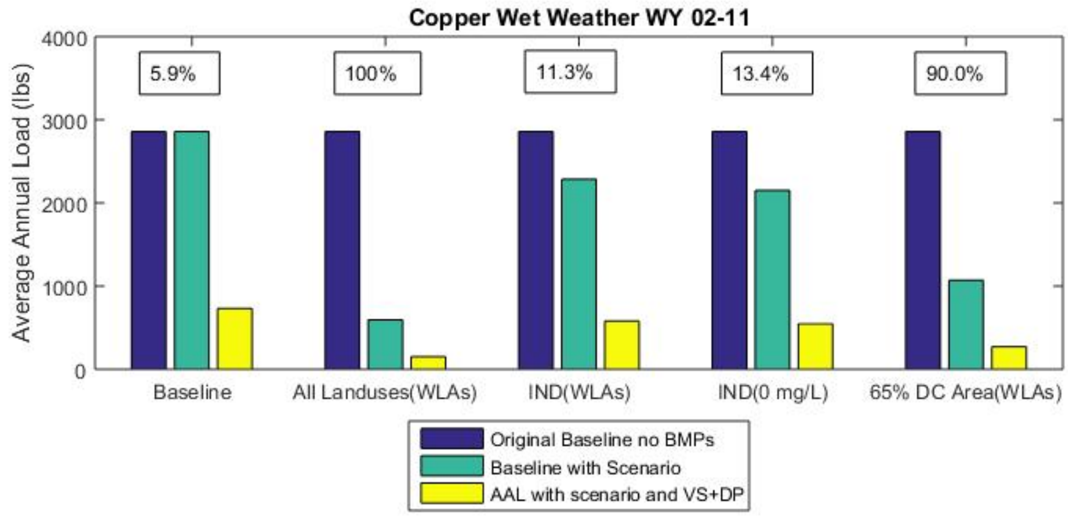

Figure 16: Copper average annual loads under various scenarios run in SUSTAIN. For example, “IND(WLAs)” means all industrial landuse EMCs were set to the WLAs.

As described above, 6 scenarios were run to identify the impacts of different EMCs on the average annual load of copper and zinc, ranging from a baseline scenario to scenarios in which various land uses were set to WLAs or to zero (Figures 16 and 17). The baseline modeled AAL of copper, with all EMCs set to original calibrated values and no BMPs, results in an AAL of around 2,800 lbs (Figure 16). When all industrial EMCs are set to WLAs the AAL of copper decreases again to around 2,500 lbs. Finally, when all industrial EMCs are set to WLAs and BMPs are implemented into the model the AAL of copper is around 600 lbs (Figure 16). The average annual loads for both metals generally decreased with the implementation of BMPs and as the EMCs from surrounding land uses were decreased (Table 17).

Wet weather exceedances for copper loads were not eliminated even in modeling scenarios where the EMCs for industrial land uses in the DC watershed were set to the WLAs in the TMDL. Zinc loads are close to 90% compliant with the average annual loads allowed under the TMDL after setting industrial land use (21% of land use, Figure 18) EMCs to the WLAs, showing that ensuring industrial properties are appropriately managing their stormwater to meet water quality requirements is an important piece of eliminating water quality exceedances in the watershed. Copper loads, however, do not reach 90% compliance until land uses that comprise 65% of the DC watershed (including industrial, commercial, educational, transportation, vacant, and parks and recreation) are set to the WLAs (Figure 19). When all EMCs from the DC watershed were set to the WLAs, the AALs for copper and zinc were 151 and 180 lbs, respectively (Table 17), which resulted in 100% TMDL AAL compliance.

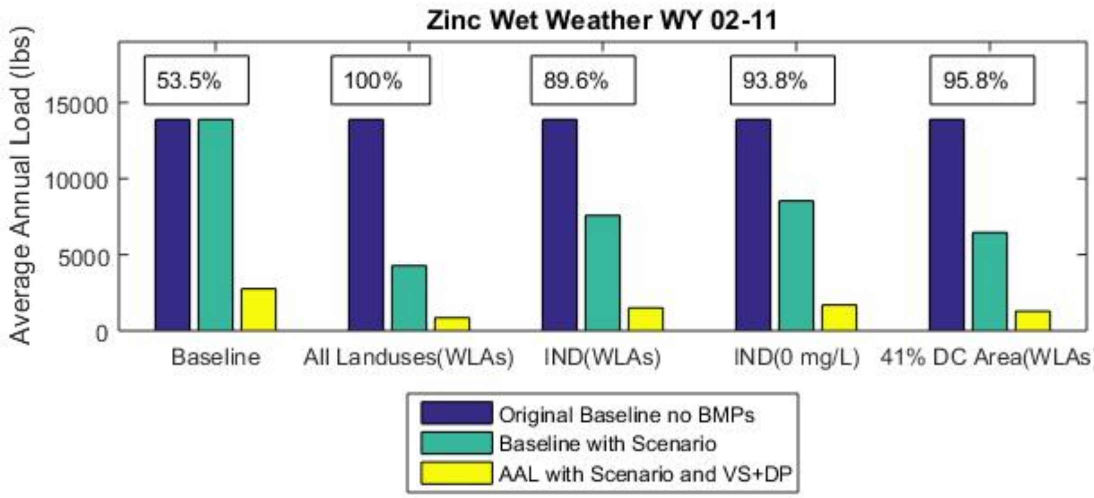

Figure 17: Zinc average annual loads under various scenarios run in SUSTAIN. For example, "IND(WLAs)" means all industrial landuse EMCs were set to the WLAs.

Scenario	Pollutant	AAL Original Baseline (lbs)	AAL Baseline Post Scenario (lbs)	AAL with VS + DP***	TMDL Compliance at MS28
All EMCs set to baseline calibrated values	Cu	2859	2859	730	5.9%
	Zn	13893	13893	2764	53.5%
Ind. EMCs set to WLAs	Cu	2859	2285	580	11.3%
	Zn	13893	8536	1694	89.6%
Ind. EMCs set to 0 mg/L	Cu	2859	2152	546	13.4%
	Zn	13893	7578	1503	93.8%
All EMCs set to WLAs	Cu	2859	595	151	100.0%
	Zn	13893	4282	850	100.0%
Required area set to WLAs to reach ~90% compliance (1 exceedance per year)	Cu*	2859	1070	272	90.0%
	Zn**	13893	6467	1284	95.8%
	* 65% of the DC watershed (46 mi2) must meet WLAs with VS + DP to reach ~90% compliance				
	** 41% of DC watershed (29 mi2) must meet WLAs with VS + DP to reach ~90% compliance				
	*** Simulating enough VS + DP to capture the 85th percentile storm volume				

Table 17: The impact of varying the copper and zinc EMCs for various land uses on the Average Annual Loads

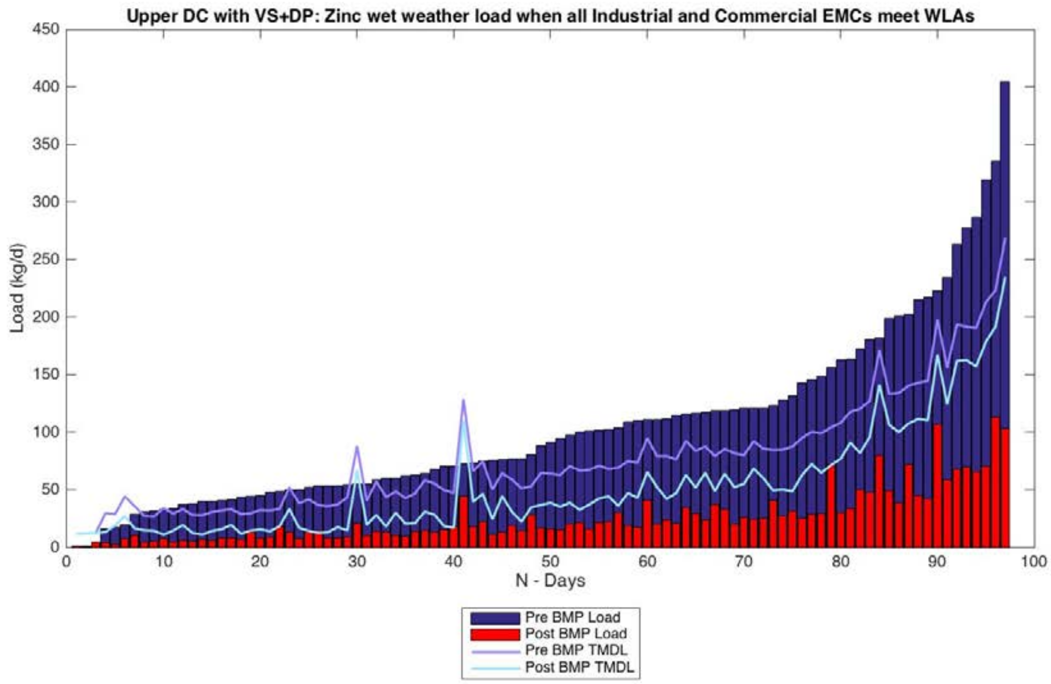

Figure 18: Zinc wet weather loads. In order for zinc in Scenario 2 (VS + DP) to reach > 90% TMDL compliance 41% (industrial and commercial landuses) of the watershed required EMCs to be set to the WLAs.

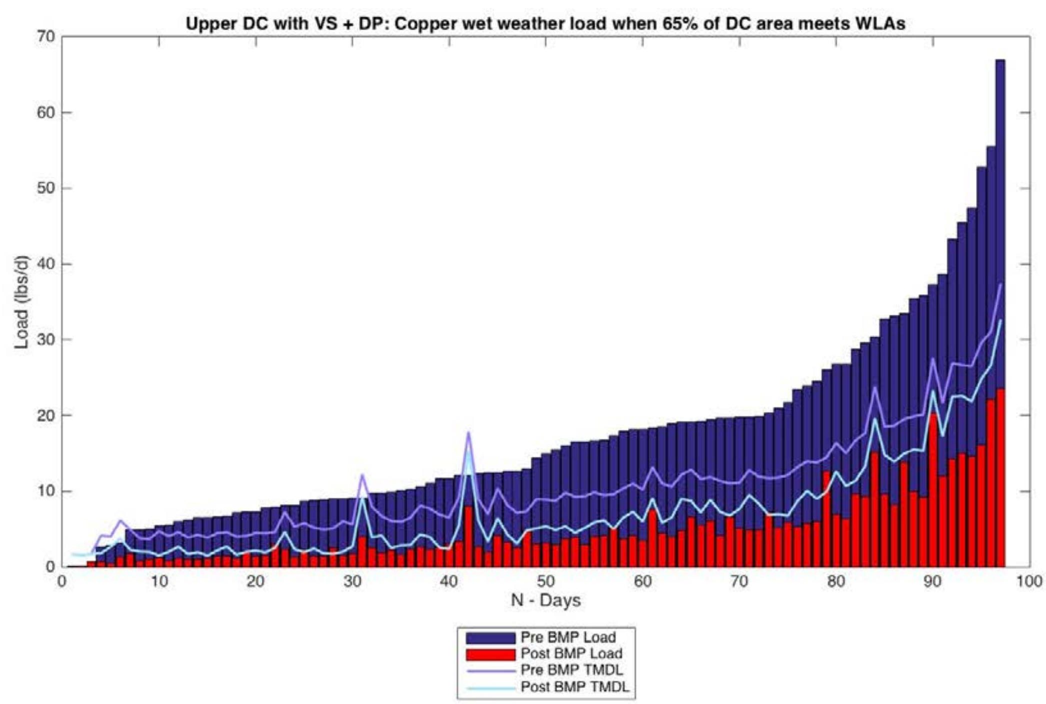

Figure 19: Copper wet weather loads. In order for copper in Scenario 2 (VS + DP) to reach > 90% TMDL compliance 65% of the watershed required EMCs to be set to the WLAs.

e. Private Land Redevelopment

Modeling conducted for this project assumes there are currently no implemented BMPs throughout the DC Watershed. The number of BMPs required for each scenario must account for the full 85th percentile storm volume as discussed previously. However, the implementation of the City of Los Angeles LID Ordinance, which became effective in May 2012, impacts the 85th percentile storm volume needed to be captured in the DC watershed by City-implemented BMPs. This LID ordinance states that if private properties redevelop 500 ft^2 of impervious land or more, they are required to capture the ¾ inch rain event for that site. Redevelopment rates for private land uses utilized in previous City efforts are also used in this analysis (Table 18).[88] These redevelopment rates can be used to project the amount of stormwater being captured by private properties in 2032 (compliance deadline in DC metals TMDL).

If the City plans to take into account the redevelopment rates, then the required 85th percentile storm volume and, thus, the number of BMPs required to capture the projected volume, decreases. Total redeveloped area and required volume of stormwater are projected into the year 2032 (Table 18). It should be noted that these calculations assume that all redeveloped areas include impervious land greater than 500 ft^2 and thus represents an optimistic scenario. The post–redeveloped 85th percentile storm volume, 2,044 AF (as compared to the pre-redeveloped 2,353 AF), was used to project the new cost and savings due to the lower number of BMPs to be implemented.

DC Land use	% Redeveloped (2032)	Redeveloped Area (mi^2)	Volume Captured (AF)
Residential	15%	4.51	181
Commercial	13%	1.80	72
Indsutrial	29%	4.28	171
Educational	14%	0.37	15
85th Percentile Storm	Pre - redevelopment	Post - redevelopment	% Reduction
Volume Captured (AF)	2353	1915	18.62%
Scenario	Cost (billions)	New Cost (billions)	Savings (billions)
1a	1.5	1.30	0.20
1b	1.5	1.30	0.20
2a	0.7	0.61	0.09
2b	0.9	0.78	0.12
3a	0.7	0.61	0.09
3b	0.9	0.75	0.11

Table 18: Projection of private use redevelopment rates and the resulting changes in required storm capture and cost.

Further analysis was undertaken to evaluate the effect of the LID ordinance on the average annual pollutant loading and channel flow outside of SUSTAIN. The area, percent impervious

[88] LADWP SCMP, LASAN EWMPs

and calibrated EMCs for each land use, as well as the total depth of rain and volume of baseflow for WY 2002-2011, were used in a basic Excel spreadsheet to determine an estimate of pollutant load and flow reduction. Table 19 compares the zinc average annual load and total flow determined by SUSTAIN to the calculated values. The redevelopment rate was applied to the impervious area of each private land use type to determine the area of land that will be redeveloped and thus required to capture on-site stormwater runoff by 2032. This area was subtracted from the original impervious area, leaving the new area of private land from which the stormwater must still be captured in 2032. Next the total depth of precipitation from a ten-year span was used to determine the volume of water (AF) coming off of each land use. The EMCs used to calibrate the SUSTAIN model were then applied to find the total pounds of pollutant coming from each land use. These were added together and divided by the number of years to get an AAL for each pollutant coming from the whole watershed.

WY 02-11	Modeled	Excel Calculation
Zn AAL	14021	15218.00
Total Flow ft3	1.56 E 10	1.20 E 10

Table 19: Comparing modeled AAL and flow from SUSTAIN to calculation done in Excel.

Table 20 shows the baseline pollutant AAL and total flow, the estimated AAL, and the total flow due to the projected private land stormwater capture. The pre-redevelopment loads and flows in this table do not include the implementation of BMPs. The flows and loads reduction resulting from the expected redevelopment gives an estimate of how much the baseline flow and pollutant loads will decrease due to the LID ordinance requirements. Again, lead was not included in this analysis due to the fact that it already meets water quality standards. Based on BMP implementation due to the LID ordinance, our results estimate that pollutants and flow could be reduced by around 15 to 18% by 2032. This result is also within the range of pollutant reductions, 3.8% to 15.8%, which are estimated to occur in the DC EWMP due to the future implementation of technical BMP standards after development and construction.[89]

	DC	DC Redeveloped	% Reduction
Zn Average Annual Load	15218.3	12393.3	18.56%
Cu Average Annual Load	3200.1	2708.3	15.37%
Total Flow (Ft^3) (2015-2032)	1.01 E09	8.51 E08	15.74%

Table 20: Projecting future baseline pollutant loads and flow considering only implementation of BMPs due to the LID ordinance.

[89] DC EWMP pg 4-6

F. Policy Discussion

a. Water Quality Monitoring Data Gaps

Obtaining water quality data that is both broad enough to capture the impacts of all potential land uses in a watershed and frequent enough to provide not only seasonal information, but also a well-populated dataset for analysis, is critical to understanding the best approaches to attaining water quality standards for impaired water bodies and to assessing waterbody health. Robust datasets are also essential to calibrate and validate water quality models and identify the best scenarios to determine the most appropriate type and location of BMPs to implement to achieve water quality standards. The importance of high quality data does not end after project implementation; high quality data is also essential to track water quality after implementation of these programs has begun to determine if the BMPs perform as designed under real-world conditions. While several monitoring programs have been implemented at various times and locations in the DC and ML watersheds, severe data gaps persist. The implementation of the DC CIMP will provide progress towards addressing these gaps.

Monitoring efforts are generally conducted and managed by both City and County agencies. MES have been installed and implemented in the DC Watershed and are monitored by LACFCD to characterize water quality. These monitoring programs aim to characterize and prioritize watersheds in LA County for water quality management. Monitoring occurs during both the dry and wet season; wet season monitoring involves composite sampling that is automatically programmed to begin when in-channel flow has exceeded a set level.[90]

One major MES and six tributary stations (TES) are currently installed throughout the DC Watershed. Only the major MES is currently operational as the six TES sites ceased sampling in the 2011 water year. The major MES, S28, is located at the DC and Artesia Boulevard in the City of Torrance and captures flow from 33 square miles (21,120 ac) of the upper DC Watershed (which only represents 46% of the watershed). Monitoring at MES S28 began in the 2001-2002 water year. The six tributary monitoring stations were installed in accordance with the requirements in the 2001 Municipal Stormwater Permit to obtain more detailed information about the water quality of subwatersheds within the DC Watershed. Water quality monitoring at these TES (TS19 to TS21) began in the 2008-2009 water year and continued annually through the 2011 water year. The subwatersheds of TS22-TS24 are located within the S28 upper DC Watershed. Gauges TS19-TS21 are located in the lower half of the DC Watershed, downstream from S28 (Figure 20).[91]

[90] https://dpw.lacounty.gov/wmd/NPDES/2009-10tc.cfm

[91] http://dpw.lacounty.gov/wmd/NPDES/2009-10_Report/ReportText/Section2_SiteDescriptions.pdf

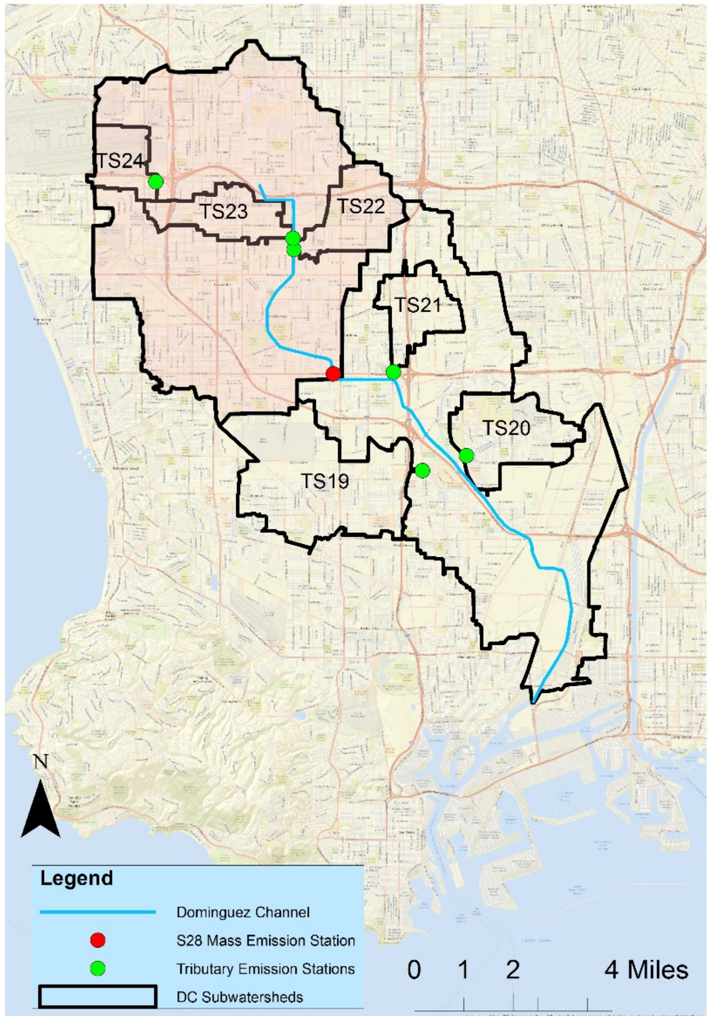

Figure 20: Dominguez Channel subwatersheds TS19-TS24. The upper DC is represented by the shaded area.

For the DC Watershed, the observed flow and water quality data collected as part of the LACDPW Stormwater Quality Monitoring program was sufficient to calibrate and validate the model in SUSTAIN for the portion of the DC Watershed upstream of MES S28.[92] MES S28 is the compliance point for various TMDL requirements in the watershed, and its location was originally chosen to avoid tidal influence which extends very far into the DC Watershed due to the relatively flat topography of the area. However, the location of MES S28 complicates the use of this data to accurately represent the DC Watershed land use characteristics as a whole because only 46% of the watershed is captured at this gauge. Further, the land uses in the upper half of the watershed that are captured by MES S28 and the land uses in the lower half

[92] LA DPW. 2015. "Stormwater Quality Monitoring Reports." *Los Angeles Department of Public Works*. http://dpw.lacounty.gov/wmd/NPDES/report_directory.cfm.

of the watershed are different, and thus the water quality data from MES S28 is not reflective of the water quality of the watershed as a whole.

The lower half of the DC watershed has a higher percentage of commercial, industrial, and transportation designated land uses (Figure 21). Based on SCAG data, the area upstream of S28 is only 9% industrial as compared to the area downstream, which is 23% industrial.[93] Capturing the water quality impacts of industrial land uses is especially important in the DC Watershed as industrial land use comprises a larger portion of the watershed than in either the BC or the LA River watersheds. The DC Watershed is 21% industrial in comparison to 4% in the BC watershed. The entire LA River watershed is 6% industrial; this increases to 10% industrial without the forested area at the head of the watershed.

The TES monitoring data offered additional insights into the potential impact on water quality of more highly industrialized land uses. In the upper DC Watershed, the majority of this industrial land is located in the NW corner of the watershed within the TS24 subwatershed. Although no tributary stations capture the flow from the most heavily industrialized lower quarter of the Dominguez watershed, TS19-TS21 do fall within the lower DC Watershed area and have observed flow and water quality from water year 2009 to 2011 (Figure 20). Specifically, the subwatershed that flows to TS24 is 67% industrial while TS21 is 45% industrial. Water quality data from subwatersheds TS24 and TS21 were examined to determine whether any difference in water quality existed in discharges from these industrialized subwatersheds compared to the EMC data used for the DC Watershed as a whole.

Briefly, although the EMC data used in the SUSTAIN model was sufficient to calibrate the area upstream of S28, the general industrial EMC used did not accurately represent observed pollutant loads generated from the two more heavily industrialized subwatersheds for which we had TES data, TS24 and TS21 (Table 21). It should be noted that the calibration of pollutant EMCs at MES S28 resulted in the modeled total, mean, and max loads being equal to or higher than the observed loads across the many land uses represented in the entire DC Watershed. However, the opposite is true for these more industrialized subwatersheds.

The comparison between the modeled and observed loads at gauges TS24 and TS21 show that the model is under-predicting the total, mean, and max loads using the same industrial EMCs. Even though the difference appears to be small, all total mean and max modeled values are lower than the observed for each pollutant (Table 21). This is true for both TS24 and TS21, which illustrates that these currently available industrial EMCs may not accurately reflect water quality impacts from heavily industrialized areas. In other words, to accurately predict observed loads, heavily industrialized subwatersheds would require higher EMCs than are reflected in the best available industrial EMCs commonly used in this region.

93 Southern California Association of Governments Land Use Data. Available at http://gis-data.scag.ca.gov/Pages/GIS-Library.aspx Accessed on 12/1/15

mg/L	Cu	Pb	Zn
EMC %	78.5	62	60
Mod Total	57	37	505
Obs Total	67	53	530
Mod Mean	3.4	1.6	21.1
Obs Mean	4.0	2.2	22.1
Mod Max	8.9	5.9	81.3
Obs Max	11.7	9.4	92.5

Table 21: Comparison of observed to modeled pollutant load (kg) stats for tributary station TS21. Mod and Obs Total is the sum of all wet weather loads while the mean and max values are statistics on the individual wet weather loads. Observed stats are higher than modeled stats for TS21, demonstrating that the actual concentrations are greater than modeled.

These analyses point to the possibility that the water quality in the DC Watershed is experiencing higher loads than are currently reflected in the modeling efforts based on available data. As shown through the above analysis of the subwatersheds draining to TS21 and TS24, the best-available industrial EMCs that are currently being used to calibrate stormwater models may be too low to accurately reflect the loads coming off of areas of more highly industrialized land uses. Further, the baseline water quality data that is collected at MES S28 to inform these models is not capturing the majority of the industrialized land uses and thus is likely to have better water quality than is actually present in the DC Watershed.

The outflow concentration and loadings of pollutants are likely to be underrepresenting the true degradation of water quality in the DC Watershed as runoff from much of the industrial land use is not adequately monitored. Although the loads from mass emission stations TS24 and TS21 offer a snapshot of how the heavy industrial land uses affect the water quality of the channel, this data is not of sufficient quantity or geographic scope to be used to accurately predict EMC values for the whole DC Watershed. Also, some of the biggest and oldest industrial sites, located in the lower part of the LDC watershed, were still not captured by the subwatershed monitoring efforts.

These results demonstrate the importance of accurately characterizing pollutant loadings from various land uses, and highlight severe gaps in data which need to be addressed to better understand the contributions of existing industrial land uses to pollutant loads in DC and in other urban areas. The current state of industrial stormwater permitting regulations and existing data will be discussed in the following section in more detail.

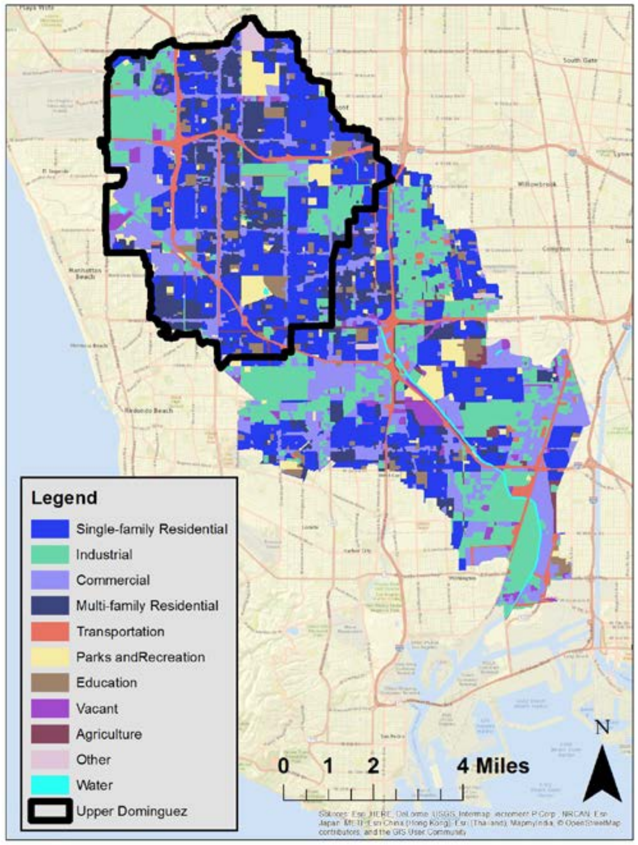

Figure 21: Dominguez Channel Land Use with the Upper Watershed delineated in bold.[94]

b. Data Recommendations and Proposed Solutions

Proposed new sampling locations in the CIMP will capture water from areas that are more heavily industrialized, including locations with some of the industrial dischargers with the highest pollutant concentrations from the Stormwater Multiple Application and Report Tracking System (SMARTS) data assessed in this study. The new sampling locations throughout the DC Watershed, ML Watershed, and Harbor areas will improve knowledge about the characteristics of water quality degradation occurring from the heavily industrialized portions of these watersheds.

More specifically, the City of LA is also in the process of implementing a monitoring strategy for Machado Lake; monitoring in ML was resumed in December 2016. The monitoring strategy at Machado Lake includes a real-time monitoring system that will provide continuous

[94] SCAG

data for flow into Machado Lake, as well as automated samplers for collecting composite samples (at P510, P77, and Wilmington Drain). The system is currently being installed, and will be operational for the 2017-2018 storm season.[95]

Monitoring efforts stemming from the MS4 and CIMP are expected to occur during three wet weather events per year for the foreseeable future.[96] This data, in combination with the continuous flow data that will be collected at storm drains entering Machado Lake, will provide valuable information to inform hydrologic models. Additional data to characterize the pollutant loading coming off specific land uses should also be collected to better understand their impacts on water quality in the watershed.

c. Industrial Stormwater

i. IGP Permit Background

Controlling pollutants stemming from industrial sites, which can range from TSS to nutrients, metals, and toxics, is critical as this runoff can be a significant contributor to water quality degradation where these land uses are present. Industrial uses comprise 21% of the area in the DC Watershed and 9% of the area in the ML Watershed. Many of the industrial sites are large and located in the bottom quarter of the DC Watershed. In CA, industrial properties are regulated through the NPDES program under either an individual permit or a multi-sector general permit for facilities in similar geographic areas generating similar discharges, [Industrial General Permit (IGP)].[97]

The current IGP was adopted on April 1, 2014 and went into effect on July 1, 2015 (2015 IGP), replacing an earlier industrial stormwater permit that had been in effect since 1997 (1997 IGP).[98] The 2015 IGP requires industrial facilities to submit documentation if they are planning to discharge stormwater to waters of the US [(WoUS) (known as a Notice of Intent, NOI)], if they have industrial activities on their site but these activities aren't exposed to stormwater (No Exposure Certification, NEC), or if they will not discharge stormwater to any WoUS (Notice of Non-Applicability, NONA).[99]

In general, facilities under the IGP are required to sample after two qualifying storm events (QSEs), which are precipitation events that produce discharge from at least one discharge area and were preceded by 48 hours with no discharge, in each half of the reporting year (July through December and January through June).[100] TSS, Oil and Grease, and pH must be included in the sampling, plus any additional parameters identified by dischargers or

[95] LASAN personal communication

[96] LASAN personal communication

[97] CWA §402

[98] http://www.waterboards.ca.gov/water_issues/programs/stormwater/industrial.shtml

[99] SWQCB Order 2014-0057-DWQ, P. 3

[100] SWQCB Order 2014-0057-DWQ, p. 39

required based on their Stormwater Industrial Classification (SIC) code, any parameters included in relevant TMDLs as described below, and any other requirements required by RWQCBs.[101] This sampling data must be submitted online to SMARTS within 30 days of the facility receiving all results.[102]

Under several conditions, sampling frequency can be reduced to 1 QSE per each half of the year. Some examples of these conditions include facilities which have had 4 consecutive QSEs that did not exceed numeric action levels (NALs) and facilities that are participating in compliance groups.[103] NALs are guidelines set to help dischargers monitor the effectiveness of their stormwater management and whether they are at risk of exceeding water quality regulations. If pollutant results exceed NALs, the facility must take action to improve the prevention of stormwater pollution. The 2015 IGP requirements for group member facilities are stronger than under the 1997 IGP requirements. Under the old permit, only one facility in the group was required to conduct stormwater sampling under certain conditions but now all facilities in the group must conduct stormwater sampling.

The 2015 IGP includes more assessment requirements such as reporting, action plans, and training requirements which will ideally enable the public to gather a stronger understanding of the pollutant controls at individual facilities as well as the performance of this program across the state.[104] SWRCB sponsored or approved training programs must be undertaken by Qualified Industrial Stormwater Practitioner (QISPs) and Compliance Group Leaders, which are responsible for assisting dischargers in completing Exceedance Response Actions (ERA) requirements if NALs are exceeded and leading a group of similar dischargers in a Compliance Group, respectively.[105] Importantly, all required documents must be submitted electronically under the 2015 IGP to facilitate public and SWRCB access.[106]

The 2015 IGP requires the implementation of the best technologies to "reduce or prevent pollutants in stormwater discharges and authorized non-stormwater discharges" and includes requirements in keeping with applicable WQS.[107] In addition to requiring sampling of the parameters as described above, the 2015 IGP requires the development of TMDL-specific permit requirements for those watersheds which include WLAs for dischargers which fall under the purview of the 2015 IGP.[108] These additional sampling requirements should result in an increased quantity and quality of data for pollutants including metals.

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[101] SWQCB Order 2014-0057-DWQ, p. 39 & 40, Table 1.

[102] SWQCB Order 2014-0057-DWQ, p. 41

[103] SWRCB Order 2014-0057-DWQ, p. 39, 47

[104] SWQCB Order 2014-0057-DWQ, p. 11

[105] SWQCB Order 2014-0057-DWQ, P. 9 and 57

[106] SWQCB Order 2014-0057-DWQ, P. 3

[107] CWA, cited on p.1 & 5of Order 2014-0057-DWQ (2015 IGP)

[108] 2015 IGP p.6

Draft TMDL-specific permit requirements for the industrial dischargers in the LA Harbor and DC (Toxic Pollutants TMDL) and ML (Nutrients as well as Pesticides and PCBs TMDLs) were issued for public comment by the LARWQCB in the spring of 2016 and have not been finalized at the time of this writing.[109] Responsible dischargers in the ML Nutrients TMDL include IGP 2015 Permittees with SIC codes that are associated with related pollutants (102X, 144X, 207X, 281X, 284X, 287X, 34XX, 3479, 45XX, and 4953).[110] For the ML Pesticides and PCBs Draft TMDL-IGP responsible dischargers are IGP 2015 permittees 'that discharge stormwater associated with industrial activities and/or non-stormwater to the impaired waterbody either directly or via a municipal separate storm sewer system (MS4) or an upstream [reach] or tributary.[111]

Briefly, if the constituents which the TMDL addresses are not already addressed in the facility's SWPPP, then the Responsible Dischargers must conduct an assessment of all processes which may generate these constituents and update all plans according to the results.[112] Responsible dischargers must comply with the NALs in the IGP 2015 as well as with TMDL Action Levels (TALs). Where facilities identify industrial areas as sources of the regulated constituents, they must add these to their Facility Monitoring Implementation Plan and sample these constituents during Qualifying Storm Events (QSE) and in authorized non-stormwater discharges (NSWDs) twice each reporting year.[113]

Similar monitoring requirements exist in both the ML and DC draft TMDL-IGPs. However, in the DC, responsible dischargers of lead, copper, or zinc are assigned Level 1 status (which would otherwise occur at facilities in years after NALs were exceeded) and must conduct a Level 1 ERA to assess sources unless they are already in Level 1 or 2 status; have conducted a reassessment under the supervision of a QISP who finds that none of the industrial discharges contain lead, copper, or zinc; a sufficient number of sampling events has not exceeded TALs; or they have installed advanced BMPs that retain all NSWDs and stormwater volume from the 85th percentile, 24 hr event.[114] If facilities find they are a potential source of

[109] Draft TMDL-specific permit requirements for the state water resources control board's industrial general stormwater permit (Machado Lake subwatershed) March 16, 2016 (ML draft TMDL-IGP) and Draft TMDL-specific permit requirements for the state water resources control board's industrial general stormwater permit (Dominguez Channel / Los Angeles Harbor watershed) March 25, 2016 p. 1 (DC draft TMDL-IGP). More info available at: http://www.waterboards.ca.gov/losangeles/water_issues/programs/stormwater/sw_index.shtml

[110] Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Machado Lake nutrients TMDL p. 1

[111] Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Machado Lake Pesticides and PCBs TMDL p. 1 and for DC/LAR Toxic Pollutants p.1

[112] Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Machado Lake TMDLs p. 1

[113] Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Machado Lake TMDLs p. 2&3

[114] Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Dominguez Channel Toxic Pollutants TMDL p. 2

cadmium, chromium, mercury, PAHs, DDT, and / or PCBs, then they will need to monitor for and comply with TALs for Suspended Sediment Concentration.[115] The additional data on the concentration of pollutants in runoff from industrial facilities should be immensely helpful in assessing progress towards and attaining water quality standards. Ideally, monitoring at these facilities would occur during three wet weather events per year (as in the CIMP), and at sampling locations that capture discharges that match the vast majority of the industrial areas of the parcel that are exposed to rainfall or runoff.

ii. Data Management- SMARTS

SMARTS is an online database developed by the SWRCB. Water boards have the authority for stormwater regulation in California. To regulate stormwater pollution, numerous dischargers within the water board jurisdictions are required to have an NPDES permit. Dischargers electronically file these permits in the SMARTS database which can be accessed by the public. CalTrans, construction, industrial and municipal stormwater reports are available. Individual facilities provide information about site location, description and discharge location. Sampling data includes collection date/time, parameter, and results.

The best available data in the SMARTS database for the ten-year period between 2005 and 2015 for industrial facilities in the DC Watershed was recently explored in a UCLA senior practicum team project. Briefly, 2008 - 2009 was the only year in which all submitted pollutant data had been entered into the SMARTS database; submitted data from other years existed in a combination of online and other formats (such as hard copies).[116] 430 industrial facilities registered under the IGP and 32 facilities registered under individual permits were present in the DC Watershed; facilities were more concentrated along the eastern edge of the watershed (Figure 22).[117]

Of the 430 industrial sites which had submitted NOIs in the DC Watershed, only approximately 170 had submitted pollutant monitoring data despite the fact that rainfall events that should have been sampled occurred in 2008-2009.[118] In the two years examined in more detail in the UCLA Senior project (2008-2009 and 2011-2012), less than 50% of the sites registered under the IGP submitting monitoring data.[119] There were several exemptions to the sampling requirements in the 1997 IGP permit that may have contributed to the paucity of data, such as requiring sampling within the first hour of a rain event after 3 dry business days, only requiring sampling during business hours, and only requiring one facility in a group monitoring plan to sample during an event. Improved sampling should occur under

[115] Proposed Addition to Attachment E (of IGP 2015), List of TMDLs Applicable to Industrial Stormwater Dischargers March 2016 for Dominguez Channel Toxic Pollutants TMDL p. 3

[116] Franz Anunciacion, Kristelle Batucal, Zoe Filippenko, Amy Mitchell, Jacqueline Ostermann, Yiwei Shen, Xiaoyun (Cloudy) Xu, advised by Noah Garrison. Geographic Study of Industrial Stormwater Pollution Sources in the Dominguez Channel Watershed final report for LARWQCB. 2015 P. 14. (UCLA IoES Senior Practicum 2015)

[117] UCLA IoES Senior Practicum 2015 p.18

[118] UCLA IoES Senior practicum 2015 p. 15

[119] UCLA IoES Senior practicum 2015 p. 27

the 2015 IGP, which has tightened some of these conditions, including requiring sampling at all facilities involved in a group permit (although less frequently than at non-grouped industrial facilities) and more broadly defining a QSE.

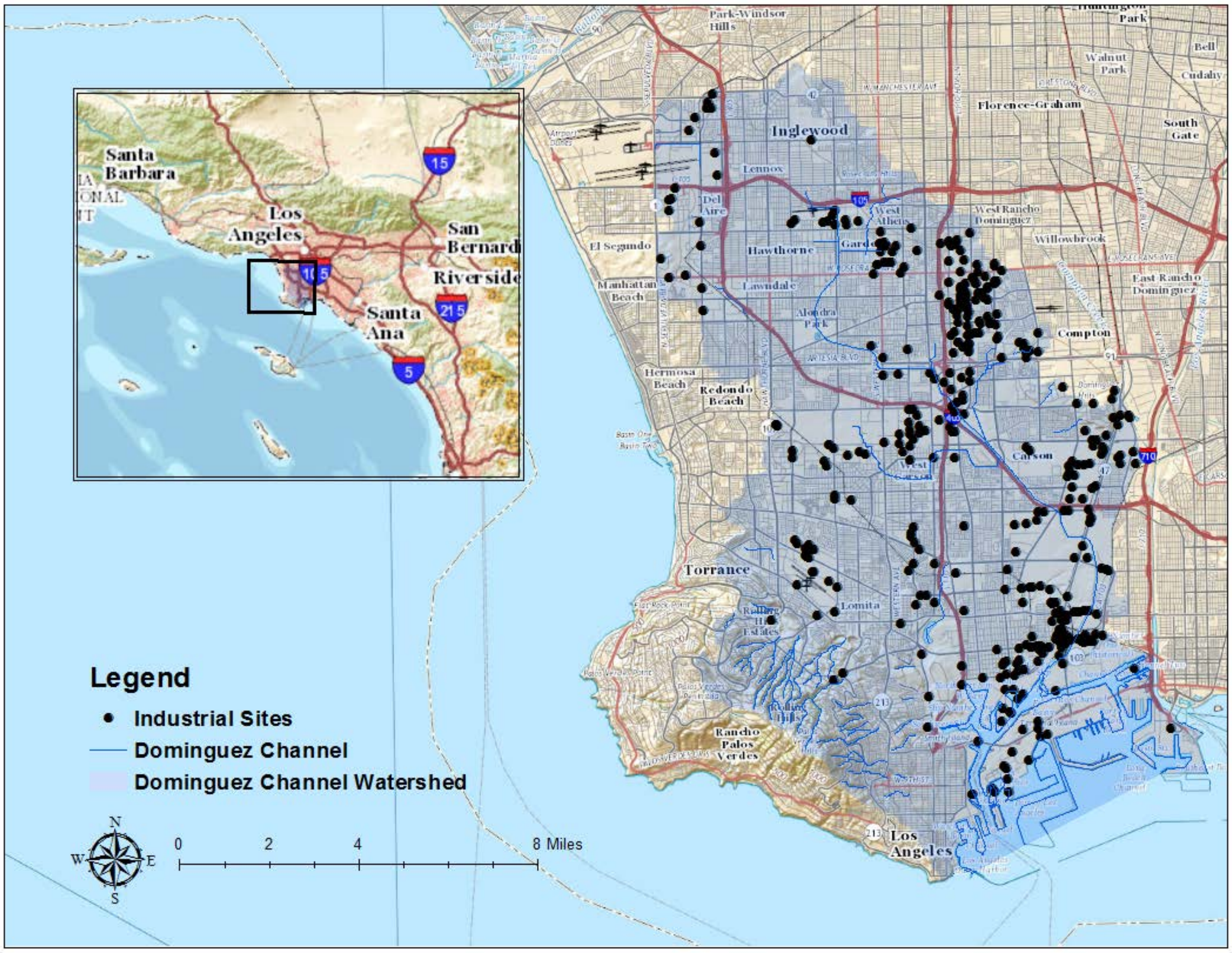

Figure 22: Industrial sites registered under the Industrial General permit or an individual NPDES permit in the Dominguez Channel watershed, excerpted from IoES 2015 IGP Capstone Report

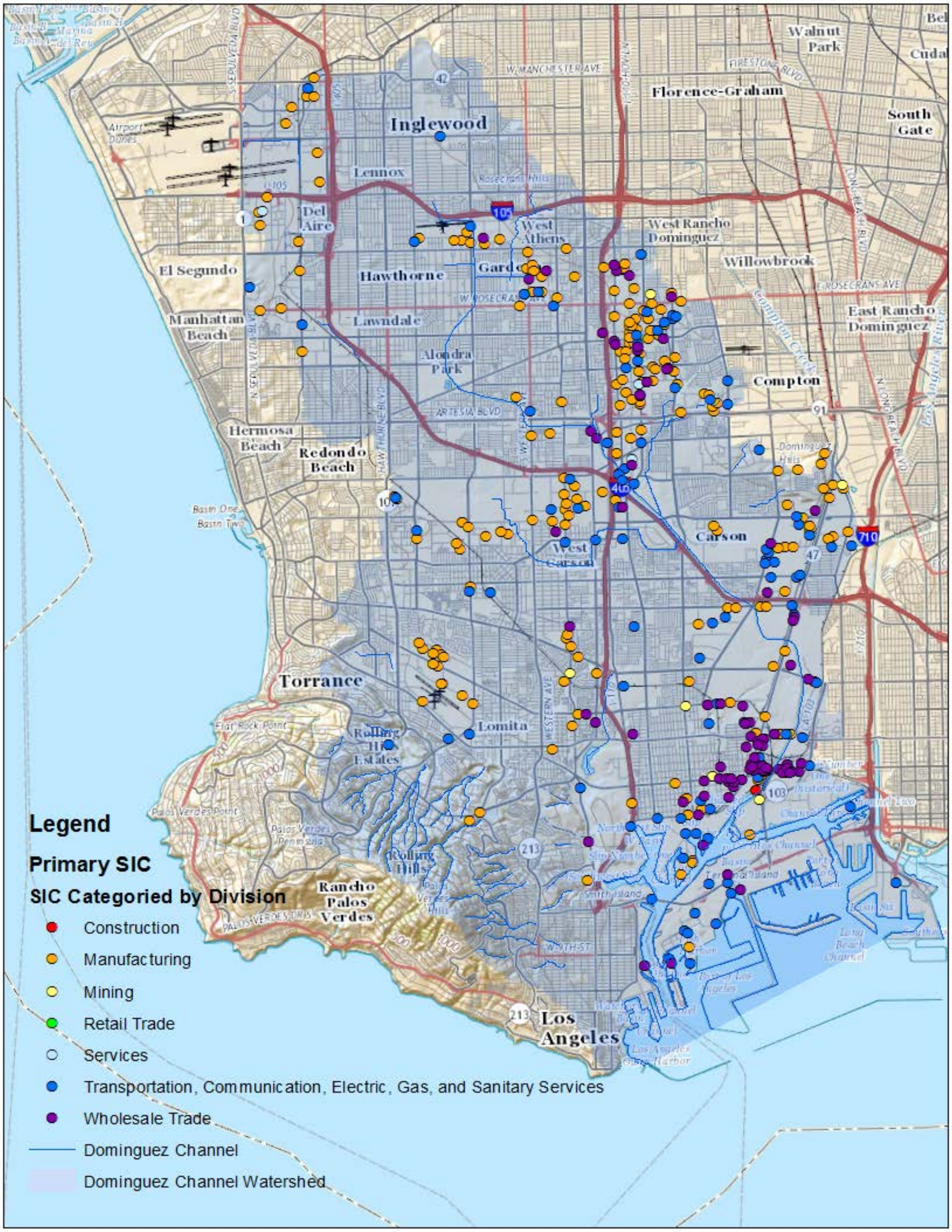

Figure 23: Industrial sites classified by groups of SIC codes in the Dominguez Channel Watershed, excerpted from IoES 2015 IGP Capstone Report.

Further, the UCLA student group did three site visits to the areas with high concentrations of industrial facilities to assess the presence of industrial facilities operating without permits in this area. Although the results are very preliminary and would need further investigation to verify the nature and permit status of the observed facilities, the UCLA team identified as many as 86 facilities which appeared to be industrial in nature based on their names and appearance, yet did not show up on the NOI list for either the general or individual industrial permits.[120] While some of these facilities may be NONA (Notice of Non-Applicability), non-discharging, or otherwise exempt from industrial stormwater permit requirements, at a minimum this preliminary survey raises the question of whether the permit and/or monitoring program are capturing complete data or information on all existing industrial sources in the DC watershed.

Poor industrial land use monitoring and the resultant paucity of data make assuring compliance exceedingly difficult. A complete and thorough accounting of all industrial sites in the watersheds (both registered and unregistered), their current compliance status, and potential pollutant contributions must be conducted. An additional UCLA practicum study in 2015/2016 looked at the implementation of the industrial stormwater permitting program and found that ensuring that municipalities maintain and make public their industrial facility inventory is a necessary first step to increasing the implementation of this program. If an annually updated list of industrial facilities and their enrollment status in the IGP program was available online, it would enable identification of industrial facilities which were not currently enrolled and thus facilitate potential enforcement actions.[121]

However, with the recent State Supreme Court decision on LA County stormwater MS4 permit unfunded mandates, there is uncertainty on the local government requirements for industrial facility inspections, data collection, and source control. Future legal rulings may shed light on the extent of the unfunded mandate decision, and whether or not state funding is required for specific requirements under the current MS4 permit.[122] If the state is required to reimburse LA County and the cities for industrial inspection efforts, then the future of municipal industrial inspection programs is unclear.

A complete assessment of the industrial facilities in the DC Watershed and high quality monitoring data of the runoff generated by these sites is especially important as the DC EWMP modeling efforts assumed that IGP properties (and other permitted facilities or permittees with WLAs in the watershed area) are in compliance with permit requirements and that thus, these permitted dischargers "did not contribute to the flow, volume, or constituent loading, as they are covered under other stormwater permits.[123]" Therefore, it is critical that the effectiveness of IGP monitoring be assessed and then enforced to protect water quality.

[120] UCLA IoES Senior practicum 2015 p. 34

[121] Chiang, S. Lindsay, M. Ruxin, G., Salem, J. Industrial Stormwater Regulatory Compliance in LA County. UCLA Senior Practicum Final Report 2015-2016.

[122] Dept of Finance vs Commission on State Mandates and the County of LA, S214855, Ct App 2/1 B237153, LA County Super. Ct. No. BS13070. Filed 8/29/16 http://sos.metnews.com/sos.cgi?0816//S214855

[123] DC EWMP 2016 p. 3-2.

Further, as described above, MES S28 in the DC Watershed is too far upstream to capture the majority of these industrial contributions to the channel. As tidal influx is still a concern with putting a MES further down-channel, this industrial monitoring data may offer the best potential opportunity to glean real information about likely water quality in the receiving waters along densely industrial land uses in the DC Watershed.

Assuming all industrial sites follow future required monitoring for water quality, these recent permit improvements should provide useful industrial stormwater data for impairing pollutants in runoff discharged from industrial facilities in the DC Watershed.

iii. Data - EMCs

As discussed in the previous section, ensuring that currently used EMCs are accurately reflecting the land uses with which they are associated is also critical to understand how well current models are portraying water quality realities. To assess this question in the DC Watershed, we retrieved sampling data for copper, zinc, and lead from the SMARTS database for facilities in the watershed to compare to the industrial EMCs being used in the modeling efforts. Facilities were selected from the summary that was compiled by the UCLA IoES students in the DC Watershed[124] of industrial facilities which had submitted reports to the online SMARTS database in 2008-2009.

To compare the EMCs used in the modeling to the broadest possible range of existing industrial data, 10 facilities with the highest copper, lead, and zinc concentrations in the dataset, 5 facilities with the lowest reported concentrations, and 5 facilities with median concentration values were selected for analysis. Facilities were placed in a high-range, mid-range, or low-range list based on how the maximum recorded sample from that facility fell relative to other facilities. Each metal (copper, lead, and zinc) were taken into account when placed into one of the three lists. Thus, the same facility could appear on both the high-range list for copper and the mid-range list for zinc. Compiling the list of the ten facilities with the ten highest concentrations for each pollutant resulted in a list of 24 high range industrial dischargers (Figure 24) and 14 facilities for both mid- and low- range dischargers.

Sampling data was collected for these facilities for each year it was available online through the SMARTS database between 2008 and 2015. These data were compiled to compare existing sampling data from industrial dischargers to the EMC values used for modeling purposes in SUSTAIN. An analysis on the water quality from two subwatersheds with heavy industrial land use and industrial dischargers can be seen in section F.A. In general, each industrial facility did not upload their data in each year. While some facilities have uploaded data for several years, eight of the 24 facilities only had the data from the 2008-2009 water year uploaded to the system.

[124] UCLA IoES Senior practicum 2015

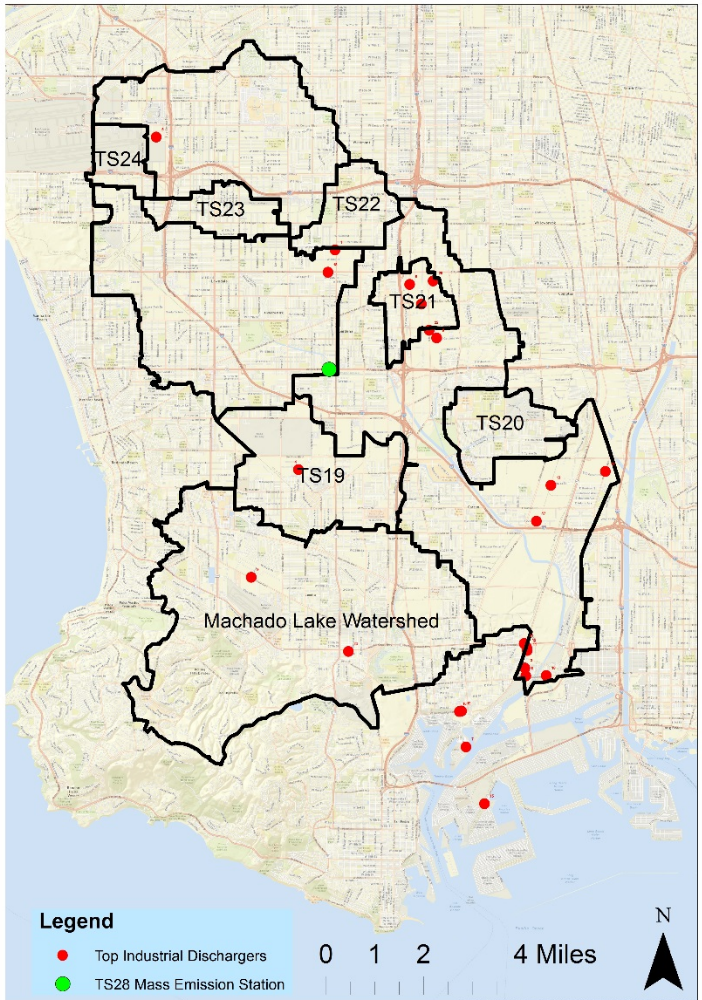

Figure 24: Location of 24 facilities discharging the highest concentration of metals in the analyzed years from SMARTS database in DC and ML watersheds.

A further analysis of the twenty-four facilities shows that the facilities discharging the highest concentration of metals in the analyzed years fall under three SIC divisions; manufacturing (11 sites), wholesale trade (10 sites) and transportation, communication, electric, gas and sanitary services (3 sites). Each division is broken down into a SIC major group which is further separated into primary SIC categories. The SIC major groups were used to gain a better understanding of the source of pollutants in the DC and ML Watersheds. The wholesale trade division is evenly distributed between the motor vehicle parts and supplies as well as the scrap and waste metal SIC major group. Transportation etc. falls under the electric gas and sanitary as well as the water transportation major groups. Manufacturing industrial dischargers with the highest concentrations are represented by five different SIC major groups, but the majority of the sites are identified as either fabricated metal products or primary metal industries. The remaining three groups are rubber and plastic products, transportation equipment, and chemicals and allied products.

The spatial distribution of these twenty-four facilities (Figure 24) further emphasizes that the majority of heavy industrial use is located in the lower half of the DC Watershed below the S28 mass emissions station. The majority of the high-range dischargers are located in the lower half of the DC with a high concentration in the TS21 subwatershed as well as in the Los Angeles/Long Beach harbor areas. Half of the twenty-four facilities were in the high-range group for more than one metal, three facilities were listed for two metals, and nine were listed for all three metals. All nine of these sites are also located in either the highly industrialized TS21 subwatershed or in the harbor areas.

The heavy presence of industrial land use in the lower watershed is significant as the EMC values for copper, lead, and zinc were calibrated by comparing the modeled to observed loads at the S28 gauge, which only incorporates the upper portion of the DC Watershed. This upper DC Watershed area only contains three of the top 24 dischargers. This again points to the likelihood that the calibrated EMC values for the UDC are underestimating the pollutant runoff for the LDC.

The sampling data obtained from the SMARTS database[125] offers insight to how well the EMC data from the LACDPW Stormwater Quality Monitoring Program[126] and SCCWRP represents actual pollutant concentrations in runoff collected from industrial dischargers throughout the DC and ML Watersheds. Table 22 provides a summary of both the EMC data used to calibrate SUSTAIN and the sampling data from SMARTS described above. This includes data from each year uploaded to the database and each sampling location as some facilities have more than one sampling location. For example, Alcoa Global Fasteners, Inc. has available data for seven separate water years as well as two outfall sampling locations.

	ug/L	Min	Max	Median	Mean	25th%	75th%	N - samples
EMCs	Cu	7	990	22.1	51.0	14.6	42.3	53
	Pb	3.9	178	13	27.9	8.0	39.5	31
	Zn	50	5970	367	575.2	249.8	582.5	53
SMARTS Low Range	Cu	0.0084	200	0.125	21.0	0.034	26.0	58
	Pb	0.0085	24	0.0295	7.9	0.012	10.8	45
	Zn	0.027	3100	1.5	199.9	0.5	217.5	62
SMARTS Mid Range	Cu	0.0381	890	0.783	38.8	0.4	2.6	84
	Pb	0.66	55.3	16.9	18.6	10.0	23.0	52
	Zn	68	6100	497	848.0	280.0	1060.0	84
SMARTS High Range	Cu	5.7	1280	42	117.8	23.0	110.0	106
	Pb	1	2600	20	128.9	10.0	63.0	132
	Zn	50	63000	600	1673.6	315.0	1465.0	294

Table 22: Comparison of EMC values from LA County Stormwater Quality Monitoring Program and SCCWRP used to calibrate SUSTAIN to sampling data from SMARTS

[125] http://www.waterboards.ca.gov/water_issues/programs/stormwater/industrial.shtml

[126] LA DPW. 2014. "Stormwater Quality Monitoring Reports." *Los Angeles Department of Public Works*. http://dpw.lacounty.gov/wmd/NPDES/report_directory.cfm.

Based on this data snapshot, current industrial EMCs obtained from the LA County Stormwater Quality Monitoring Program and SCCWRP may not accurately represent observed sampling data from all of the industrial facilities in the DC Watershed. The SMARTS data has a wider range of values for pollutant washoff concentrations from actual industrial sites in the DC area than is reflected in the EMC data. Statistical values from the high-range SMARTS dischargers are higher than those from the EMC data used in this study. For example, the mean and max samples collected for zinc from the SMARTS database are much higher than those of EMCs collected by the LA County Stormwater Quality Monitoring Program and SCCWRP (Table 22). The SMARTS data is widely variable, however, and mid- and low-range SMARTS data are generally at or below EMCs.

The sampling mechanism is different between these two data sources; EMCs were generated over a decade ago through collecting 10 to 15 discrete grab samples to create a pollutograph while industrial monitoring samples tend to be individual grab samples.[127] EMCs were generated from data from multiple storms for each metal (53 for copper, 31 for lead, and 53 for zinc, Table 22) while SMARTS data stems from individual storms that meet conditions for sampling as required in the facility's permit. Thus, EMCs provide a good overview of pollutant loadings across a wide range of land uses, but may need to be supplemented with additional watershed or site-specific data to fully reflect local loadings and thus assess water quality impacts.

EMCs should accurately reflect observed pollutant loads to ensure that implementation of modeled BMP scenarios will result in water quality compliance. Through the use of SUSTAIN and existing EMC data,[128] percentiles of 78.5, 62, and 60 for copper, lead, and zinc, respectively, were chosen for use in the model by comparing modeled load outputs to observed loads. Based on these percentiles, the industrial EMCs used in SUSTAIN for copper, lead, and zinc were 51.44, 26.26, and 459.3 µg/L, respectively. However, applying these same percentiles to the data retrieved from the SMARTS database yields concentrations of 136, 46, and 882 µg/L for copper, lead, and zinc, respectively. Concentrations were higher for all three metals using the SMARTS database than the EMCs, which indicates that the EMCs are currently lower than is reflective of some existing industrial runoff data.

Although this analysis of SMARTS data was based on a relatively small subset of facilities in DC, the wide variability between the actual measured industrial stormwater data in the SMARTS database and the currently used industrial EMCs demonstrates the importance of obtaining additional accurate data (and/or investigating existing SMARTS data over a longer period of time) to define more robust EMCs for heavily industrialized land uses. The current

[127] - http://www.sccwrp.org/ResearchAreas/Stormwater/TimeVariableStormwaterPollutantRunoffFromWatershed.aspx; http://www.waterboards.ca.gov/water_issues/programs/stormwater/docs/industrial_permitdocs/igp_factsheet.pdf

[128] Watershed and Land Use Stormwater Pollutant Loading Data for the Greater Los Angeles Area, California, USA, 2007. Data provided courtesy of Southern California Coastal Water Research Project (SCCWRP - Downloaded from http://www.sccwrp.org/Data/SearchAndMapData/DataCatalog/2007StormWaterLoading.aspx, [2/1/2016].

EMCs are a compilation of a wide variety of data and thus do not have the more specific information required to understand water quality impacts from locations with specific land use or industrial types. For example, EMCs used in the current study were collected by SCCWRP and the LA County Stormwater Quality Monitoring Program from locations distributed throughout the Los Angeles region and then combined to represent all watersheds as a whole (Figure 25). Industrial sites in various parts of the DC Watershed may be substantially different in the pollutant loads coming off each parcel. Industrial facilities vary greatly in runoff quality, yet there is one EMC value to represent all types of industrial land use, regardless of the type of industry that is present.

The additional information obtained from this small survey of data from the SMARTS database demonstrates that IGP 2015 monitoring data may offer a potential pathway towards obtaining better water quality data and more accurate pollutant runoff concentration values from industrial sites representing a specific area. An additional study that analyzes a larger set of available SMARTS data should be conducted to assess how existing SMARTS data can improve EMC information and identify opportunities to improve this database further. Potential improvements include that future sampling locations should take into account the multiple outfall locations on an industrial site (to ensure the vast majority of the industrial portion of the parcel that is exposed to rainfall and runoff is captured by the sampling location) and proximity to the DC channel itself. Also, identifying outfall locations with higher concentrations through monitoring should be a sampling priority to identify potential hotspots that can be addressed. Finally, industrial facility monitoring programs should be designed to determine how industrial runoff impacts receiving water quality.

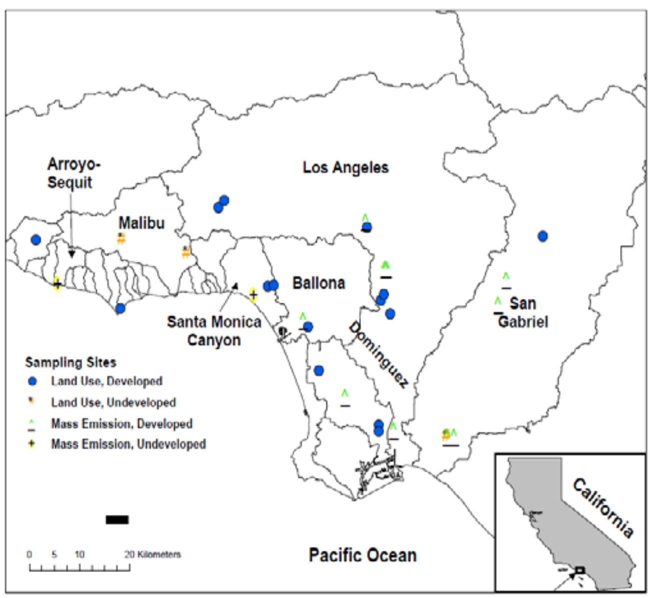

Figure 25: SCCWRP sampling sites, including high- and low- density residential, commercial, industrial, agricultural, recreation, transportation, vacant area, and watersheds.[129]

[129] ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/AnnualReports/2008AnnualReport/AR08_015_027.pdf

Increasing the quality and quantity of available data of pollutant loading coming off of industrial facilities is critical to accurately characterize potential compliance pathways to meeting water quality standards. More and more frequently, modeling of large scale watersheds is used to help determine the best plan to reach compliance and attain water quality standards. Therefore, if the available observed water quality data does not accurately represent the water quality characteristics of a certain location, such as the heavily industrialized portions of DC, then the modeling efforts are not as accurate and compliance is less likely to be achieved based on implementing scenarios that stem from inaccurate or too highly generalized data.

To fully understand how the distribution of land uses in a watershed affect the water quality in urban bodies of water, more detailed EMC studies on specific land use types, particularly those which are potentially large contributors to the current impairments in the watershed, need to be conducted. In particular, a heavy industry EMC study on the industries in the watershed should be conducted in DC to characterize the impacts of the heavy industry, located near one the largest port complexes in the country, on the water quality in nearby waterbodies. The EMC characterization efforts which are widely used today were completed over a decade ago and included a wide range of industrial land uses from throughout LA County. Further, additional water quality sampling that also captures flow from the heavily industrialized locations of the DC would greatly enhance the ability of these models to accurately reflect current water quality and thus accurately predict the impacts of potential BMP implementation plans that could result in compliance with water quality standards.

d. Improving Water Quality in the DC watershed

As our modeling and subsequent work on industrial runoff sources demonstrate, eliminating exceedances within the DC watershed is exceedingly difficult. Capturing and/or treating and releasing the 85th percentile storm flows for the entire watershed is a potential compliance pathway in the MS4 permit. If the 85th percentile storm is being managed and all requirements of an approved EWMP are being implemented then a permittee is deemed to be in compliance with receiving water quality standards. The presented modeling efforts, however, demonstrate that this approach alone may not be adequate to ensure that pollutant concentrations do not exceed numeric receiving water quality standards.

It is important to note that the presented modeling efforts did not include the impacts of other programs occurring throughout the region such as MCMs or the implementation of BMPs on private land through, for example, the City of LA's LID ordinance. Watershed-scale BMP implementation programs such as those investigated in this study and in the EWMPs provide significant water quality benefits as well as opportunities to characterize the performance of BMPs over time and thus adapt strategies to more effectively improve water quality. There is a relatively large percentage of industrial land uses in the DC watershed that contribute higher pollutant loadings. In addition, DC TMDL targets for metals are lower than those in the LA River and Ballona Creek because of lower hardness in channel waters during wet weather.

The combination of lower TMDL targets and higher loading of pollutants makes the elimination of zinc and copper exceedances even less likely without targeted source elimination efforts from industrial, transportation, and other sources; an effective LID program for new and redevelopment; and potentially, if appropriate based on conditions, site-specific metals criteria. These types of programs, along with watershed-scale BMP programs and other efforts to improve water quality in the region, will go a long way to improving water quality in the DC watershed; data collection to learn from these efforts must also be a critical component of these efforts.

III. Machado Lake

A. Introduction

Machado Lake (ML) is located in the 231-acre Ken Malloy Harbor Regional Park, a Los Angeles City Park that serves the relatively park-poor communities in the urban Harbor City area and therefore represents an important opportunity to provide recreational benefits to this region.[130] ML and its surroundings also offer diverse environmental benefits to this region, especially for migrating and resident bird species and freshwater aquatic life. The KMHRP has been designated a Significant Ecological Area (SEA) by Los Angeles County Regional Planning as it contains the lake, a seasonal freshwater marsh, and a riparian woodland.[131] ML and Wilmington Drain together comprise one of the largest remaining coastal wetland ecosystems in Los Angeles County.[132]

ML is listed as impaired for trash, pesticides and PCBs, and eutrophic conditions, algae, ammonia, and odors on California's §. 303d list of impaired waters. Major improvements have occurred at the site (e.g. installing trash capture devices at storm drain outlets) or are currently occurring (construction of Proposition O-funded water quality improvement projects at Wilmington Drain and in ML) to address these impairments.

One of the outstanding questions that only time and additional data collection can answer is: will the regional-scale Proposition O projects to improve water quality at ML and Wilmington Drain result in eliminating exceedances? In this section, we provide background on water quality issues, assess potential water quality impacts through modeling efforts, and identify data gaps that must be filled to accurately assess the current and future in-lake water quality.

[130] Machado LWQMP 2014 p. 2-1

[131] Machado LWQMP 2014 p. 2-3

[132] Machado LWQMP 2014 p. 2-1

B. Machado Lake Policy Documents

a. TMDL Summary

MACHADO LAKE TRASH TMDL: ML is impaired for trash; the LARWQCB adopted the trash TMDL on June 7, 2007 and it went into effect on March 6, 2008.[133] The numeric target for trash is zero, based on the narrative water quality objective in the Basin Plan for both floating materials and for solid, suspended, or settleable materials.[134] Trash is mainly transported into ML through the storm drains, wind action, or direct dumping or littering.[135] Baseline WLAs for relevant land uses are based on LACDPW data collected from 2002 to 2004; responsible parties may also derive the trash generation rate based on data collected from implementation of their own Trash Monitoring and Reporting Plan.[136] The Ken Malloy Regional Harbor Park is the main, adjacent nonpoint source area. Critical conditions for this TMDL include during major storms, wind advisories, and high traffic periods (defined as weekends and holidays from May 15 to October 15).[137] Compliance with this TMDL can be achieved through implementing the minimum frequency of assessment and collection (defined as daily) or through installing full capture systems.[138] The final compliance date is March 6, 2016.[139]

MACHADO LAKE PESTICIDES AND POLYCHLORINATED BIPHENYLS (PCBs) TMDL: ML was on the 303 (d) list of impaired water bodies for chlordane, DDT, dieldrin, Chem A, and PCBs in fish tissue. Of the Chem A pollutants, only chlordane and dieldrin were addressed in this Pesticides and PCBs TMDL as the other Chem A pollutants had not been detected for 25 years. This TMDL went into effect on March 20, 2012.[140] Numeric targets for pesticides and PCBs in the water column are the same as the CTR criteria for human health: total PCBs (0.00017 µg / L); 4,4' DDT & DDE (0.00059 µg / L); 4,4' DDD (0.00084 µg / L); chlordane (0.00059 µg / L); and dieldrin (0.00014 µg / L).[141] The main sources of pesticides and PCBs are stormwater and urban runoff discharges and the legacy internal lake sediments.[142] While wet weather events are the critical condition in terms of loading, this TMDL

[133] http://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/tmdl_list.shtml

[134] Machado Lake Trash TMDL, July 11, 2007, P. 12

[135] Machado Lake Trash TMDL, July 11, 2007, P. 13

[136] Machado Lake Trash TMDL, July 11, 2007, P. 16

[137] Machado Lake Trash TMDL, July 11, 2007, P. 21-24

[138] Machado Lake Trash TMDL, July 11, 2007, P. 23

[139] Dominguez Channel EWMP draft June 2015, P. 2-15

[140] Attachment A to Resolution No. R10-008, p. 2

[141] Attachment A to Resolution No. R10-008, p. 3

[142] Attachment A to Resolution No. R10-008, p. 4

also takes into consideration the long term aquatic life and human health effects of pesticides and PCBs.[143] The final compliance date is September 30, 2019.[144]

MACHADO LAKE EUTROPHIC, ALGAE, AMMONIA, and ODORS TMDL (NUTRIENTS TMDL): Existing and potential beneficial uses of ML include those related to recreation, aquatic life, and water supply. These uses are currently impaired by ammonia, algae, odors, and eutrophic conditions. The algal impairments, odors, and eutrophic conditions are all exacerbated/caused by excessive nutrient levels in the water. The total phosphorus target is a monthly average in the water column of 0.1 mg / L; the total nitrogen target is 1.0 mg / L.[145] Additional targets exist for ammonia (5.95 mg / L as an hourly average, 2.15 mg / L as a 30 day average), chlorophyll-*a* (20 µg / L), and dissolved oxygen (no less than 5 mg / L at 0.3 meter above the sediments).[146] The critical condition for this TMDL is during the summer months. The ML Nutrients TMDL was adopted by the LARWQCB on May 1, 2008 and went into effect on March 11, 2009.[147] Elements of this TMDL will be explored further in the following section and in Section 3(E). The final compliance date is September 11, 2018.[148]

b. ML Nutrients background

Briefly, the presence of nutrients (especially nitrogen and phosphorus) has been linked to one of the main symptoms of eutrophication, algal blooms. In recent years, algal blooms have also occurred in other Los Angeles lakes, such as the cyanobacteria bloom in Echo Park Lake in December 2014. Eutrophication and algal blooms can lead to many negative impacts on lake ecosystems such as increased turbidity, altered food chains including fish kills, harmful algal blooms, reduced dissolved oxygen concentrations, and increased nutrient recycling.[149] These negative environmental impacts affect the ability of ML to support its existing and potential beneficial uses as described in the Basin Plan [existing uses are water contact recreation (REC 1), non-contact water recreation (REC 2), warm freshwater habitat (WARM), wildlife habitat (WILD), rare, threatened, or endangered species (RARE), wetland habitat (WET), and the potential use as municipal and domestic water supply (MUN)].[150]

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[143] Attachment A to Resolution No. R10-008, p. 6

[144] Dominguez Channel EWMP draft June 2015, P. 2-15

[145] Attachment A to resolution No. R08-006, p.2

[146] Attachment A to resolution No. R08-006, p.3

[147] http://www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/tmdl_list.shtml

[148] Attachment A to resolution No. R08-006, p. 16 (WLA & LA load allocations to be achieved within 9.5 years of effective date of TMDL)

[149] SWRCB Resolution Number 2008 – 0089. Approving an Amendment to the Water Quality Control Plan for the Los Angeles region (basin plan) to Incorporate a Total Maximum Daily Load for Eutrophic, Algae, Ammonia, and Odors (Nutrients) in Machado Lake. P. 3

[150] SWRCB Resolution Number 2008 – 0089. Approving an Amendment to the Water Quality Control Plan for the Los Angeles region (basin plan) to Incorporate a Total Maximum Daily Load for Eutrophic, Algae, Ammonia, and Odors (Nutrients) in Machado Lake. P. 4

There is evidence that ML has been fairly high in nutrients since at least the 1940's. Based on the relatively large size and type of dominant algal diatoms found in sediment core samples (oldest part of core dated to 66 years ago), ML waters have been mesotrophic to eutrophic (high phosphorus and chlorophyll content) and fairly nutrient-rich over this entire time period (1943 to 2009).[151] A shift in species composition between 1953 and 2006 shows that waters were high in nutrients over this 53 year period.[152] The ratio of watershed to lake surface area at ML, 389:1 acres, is far higher than typical (generally less than 100:1 acres). Watershed to lake surface areas above 40:1 acres tend to indicate eutrophic conditions.[153]

Multiple sources contribute nutrients to ML, including six main City and County-owned storm drains that drain into ML from the approximately 16,000 acre watershed that include areas outside of the City and County's jurisdictions. The LA County-owned Wilmington Drain conveys stormwater runoff from approximately 19 square miles (12,097 acres), or 88%, of the subwatershed that drains to ML. The drain also functions as a sedimentation basin. Wilmington Drain is a 150-foot wide soft bottom channel which provides habitat for both endangered and other native species, as well as invasive species and a site that collects urban litter.[154] Other storm drains that convey stormwater directly to ML are two County-owned storm drains [Project 77 drain (1,604 acres), Project 510 Line C (81 acres)], and three LA City-owned storm drains [D24010 (158 acres), P6545 (71 acres), and P36466 (37 acres)]. In addition to these storm drain inputs, sheet flow from 108 acres of adjacent land provides nutrient loading to ML. An additional 1,337 acres of ML Watershed are tributary to areas below the lake and are not included in the above summary.[155]

Both numeric (e.g, DO > 5.0 mg/L in single sample, Nitrogen ≤ 10 mg/L) and narrative (e.g., biostimulatory substances must not be present at concentrations that will lead to adverse impacts on beneficial uses) water quality objectives are set in the 1994 Basin Plan to attain the listed beneficial uses for ML.[156] Regulators determined that meeting the 10 mg/L standard for TN, as it is based on criteria acceptable for drinking water rather than for eutrophic lakes, would not be protective of the narrative biostimulatory objective. As a result, this TMDL sets acceptable nitrogen concentrations at a lower value, 1.0 mg/L, for reasons described below.[157]

Numeric ML targets were derived through a literature review, assumptions based on the chemistry of ML, and a modeling effort using the Nutrients Numeric Endpoints BATHTUB spreadsheet tool. Briefly, acceptable levels of chlorophyll-a (20 µg / L monthly average) were determined using the Carlson Trophic State Index, EPA guidance to develop nutrient TMDLs,

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[151] Machado LWQMP 2014 p. 2-6

[152] Machado LWQMP 2014 p. 2-7

[153] Horne & Goldman 1994, cited in Machado LWQMP 2010 on p. 2-4

[154] Machado LWQMP 2014 p. 2-1,3

[155] Machado LWQMP 2014 p. 2-9

[156] Machado Lake Nutrients TMDL p. 26

[157] Machado Lake Nutrients TMDL p. 26,32

and in-situ data, and then the relationship between total nutrients and chlorophyll-a was analyzed using the BATHTUB model.[158] This tool takes the target level of chlorophyll-a and generates acceptable nitrogen and phosphorus loads that will allow this target to be met. Further, the phosphorus limit was set to 0.1 mg/L based on EPA guidance in the 2000 EPA Nutrient Criteria Technical Guidance Manual – Lakes and Reservoirs. Based on target phosphorus concentrations, nitrogen was set to 1.0 mg/L using a ratio of 10 to 1 to maintain a balance of nutrients for biomass growth and prevent limitation as described in a 1987 study by Thomann & Mueller.[159]

c. Current Water Quality Improvement Efforts

The development of the Machado LWQMP was required as part of the Memorandum of Agreement that was signed with the LARWQCB to incorporate both LASAN and the City of Los Angeles Department of Parks and Recreation. The Machado LWQMP includes an Implementation Plan and Compliance Analysis, a Monitoring and Reporting Plan, and a Quality Assurance Project Plan to understand the issues and define the solutions that would bring ML water up to required standards.[160] The LWQMP required biweekly sampling events (26 sample events annually) at two mid-lake sample locations starting in 2006 to better characterize the pollutant patterns in ML. A lake water quality model was developed in the Machado LWQMP to analyze external loading data (from water quality monitoring in wet and dry weather) and internal loading data (from bench-scale studies of nutrient fluxes using ML sediments and water).[161] The construction of the non-point and point source BMPs detailed in the Machado LWQMP Implementation Plan will further the objectives of water quality improvement, flood control, ecosystem restoration, and recreation enhancement.[162]

The Machado LWQMP outlines the implementation plans for a combination of BMPs intended to address both in-lake and external nutrient contributions to attain compliance with ML water quality standards. One of the most important components of the proposed rehabilitation strategies was dredging to remove lake bed and lake edge sediments, which are a source (contaminated sediments) that contributes internal nutrient loading.[163] Removing sediment will also increase or create recreational opportunities and improve aquatic habitat in the lake.[164]

Additional projects to enhance lake water quality, particularly during the critical time periods of March through November, include the replacement of water lost to evaporation with TIWRP AWPF water and the installation of an oxygenation system to increase the lake DO

[158] Machado Lake Nutrients TMDL p. 26

[159] Cited in Machado Lake Nutrients TMDL, p. 35

[160] CDM with Parsons, for LA City BoS and Dept of Recreation and Parks. (August 18, 2010) Machado Lake Nutrients TMDL Lake Water Quality Management Plan p. 1-7

[161] Machado Lake LWQMP 2014 p. 2-13

[162] Machado Lake LWQMP 2014 p. 3-1

[163] Machado Lake LWQMP 2014 p. 3-7

[164] Machado Lake LWQMP 2014 p. 3-7

concentrations.[165] An off-line treatment wetland to filter nutrients from the water before returning the treated flows to ML, a phosphorus removal system that functions through adsorbing phosphorus to an adsorption media, aquatic plant management to control nuisance species and establish species that improve water quality, shoreline stabilization to enhance habitats and limit external loading of sediments and nutrients through erosion, and floating islands to provide both terrestrial and aquatic habitat are also slated for implementation at ML.[166]

Many of the above improvements are being accomplished through the ML Ecosystem Rehabilitation Project and the Wilmington Drain Multiuse Project, which are both funded by Proposition O. The overarching goals of these projects include improving water quality, meeting TMDLs, and enhancing habitat and recreational opportunities. While some of the distributed BMPs installed for these projects will reduce the amount of flow reaching downstream receiving waters, the main goal of these projects is to function as treat and release BMPs.[167] Ground was broken for these projects on March 22, 2014.[168] Wilmington Drain improvements included installing trash netting systems, smart irrigation, vegetated BMPs, and re-contouring the channel; construction was recently completed. The currently approved Wilmington Drain Multiuse project budget is $25,093,711.[169]

The currently approved ML Ecosystem Rehabilitation Project budget is $110,457,563.[170] This project includes in-lake rehabilitation techniques such as sediment dredging and replacement and installing a layer of AquaBlok to prevent historic contaminants from filtering through to new, clean sediments and the lake. Treatment BMPs, pedestrian trail system improvements, and riparian system enhancements are also included in this project.[171] Wilmington Drain BMPs and lake dredging and capping were recently completed and the expected completion date for the entire project is 2018.

Strategies described in the Machado LWQMP to mitigate nonpoint source pollution from the adjacent woodlands, park, and golf courses included designing habitat and park improvements to decrease nutrient loading, improving existing wetlands for more efficient runoff pollutant removal efficiency, and installing BMPs to mitigate runoff from the City Golf Course Maintenance Yard. Runoff from the Maintenance Yard will be captured and treated on-site through catch basins, a dry well that meets SUSMP design criteria, and an earthen swale (for runoff and dry well overflow during larger storm events) before flowing into the lake.[172]

[165] Machado Lake LWQMP 2014 p. 3-7

[166] Machado Lake LWQMP 2014 p. 3-8

[167] Dominguez Channel EWMP draft June 2015, P. 4-15

[168] Dominguez Channel EWMP draft June 2015, P. 4-15

[169] October 2016 Prop O Monthly Report. Page 12

[170] October 2016 Prop O Monthly Report. Page 12

[171] August 2015 Prop O Monthly Report. Page 28

[172] Machado Lake LWQMP 2014 p. 3-9, 10

To address point sources, the Wilmington Drain channel bottom has been regraded to remove accumulated sediment (approximately 30,000 cubic yards) and provide storage space for significant volumes of future sediment. Box culverts have been cleaned up and the channel regraded as needed to diminish the amount of sediment being transported. Vegetation will be selectively cleared from the channel bottoms and banks annually as appropriate to improve the hydraulic storage capacity of Wilmington Drain.[173] Other BMPs which will address stormwater discharges to ML include the installation or construction of hydrodynamic separation devices, bioengineered swales, and trash nets at various outfalls to the lake. In-lake sediment traps, or depressions, will be created at storm drain outfalls to contain the sediment deposition and provide a localized area which can be dredged for ongoing maintenance, rather than allowing sediment to more evenly spread across the entire lake bottom.[174] Public education and outreach will also be an important part of this overall effort.

The City has conducted multiple studies to identify pathways to attaining compliance in Machado Lake, including the Machado LWQMP and the Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis (TAF).[175] Briefly, the TAF modeling efforts found that compliance with the final TMDL numeric target would be impossible without all other jurisdictions in the ML watershed meeting their WLAs for total phosphorus (TP) and many of the jurisdictions for total nitrogen (TN, Table 23). These modeling efforts are described in greater detail in Appendix A. However, both these earlier modeling efforts by the City and the work presented here are severely constrained by a lack of flow data going into ML. Increasing the amount of monitoring that is conducted, not only for water quality parameters but also for flows into ML, is critical going forward to assess the efficacy of the completed Proposition O projects and any additional implemented BMPs at achieving the expected water quality as these modeling efforts were based on limited initial data. A real-time monitoring system is being installed at ML as part of the Prop O project that will include flow meters at P77, P510, and Wilmington Drain to collect continuous flow data.[176] The DC CIMP also includes monitoring that will provide additional data to help fill this gap.

[173] Machado Lake LWQMP 2014 p. 3-10, 11

[174] Machado Lake LWQMP 2014 p. 3-11

[175] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-6

[176] LASAN personal communication

Constituent	Final TMDL Numeric Target	Predicted WQ with-LWQMP BMPs	Predicted WQ with LWQMP BMPs and all WLAs met
Total Phosphorus (mg/L)	0.1	0.16	0.08
Total Nitrogen (mg/L)	1.0	1.22	0.57
Chlorophyll-a (µg/L)	20	19	8

Table 23. TMDL numeric targets for Machado LWQMP modeled parameters, total phosphorus, total nitrogen, and chlorophyll-*a*. Final numeric targets and predicted values under critical summer conditions in 2024.[177]

C. Model Setup, Calibration, Validation

a. Modeling Selection and Comparison

The ML analysis includes both in-lake modeling (to assess nutrient pollution within ML) and upstream watershed modeling (to assess water quality of runoff entering ML and resulting impact on ML water quality). Modeling efforts covering the Machado Lake watershed as a whole are referred to as "ML Watershed" and those in the lake only are referred to as "ML." As ML water quality is impacted by both internal and external loading, two models were utilized for this study: SUSTAIN and the Simplified Lake Analysis Model (SLAM), a model developed by CDM Smith for ML to evaluate in-lake pollutant fate and transport. As described previously, earlier modeling efforts were conducted for LASAN (LWQMP and TAF) to determine whether ML would be in compliance with TMDLs taking into account external loads and flow, internal loads, and BMP implementation within and near the lake.[178] In the presented work, the ML Watershed is modeled using SUSTAIN to simulate external loads and flows as in the DC Watershed. SLAM was then utilized to simulate internal ML nutrient loading as a response to external loads predicted by SUSTAIN. Using these two models in concert provides the opportunity to better represent flows and loadings from the ML watershed into ML. Utilizing SUSTAIN also allows for the simulation of BMPs throughout the watershed and to assess the effect of those BMPs on the external flows and loadings.

b. SUSTAIN Setup, Calibration, Validation

Several stormwater drains that route water from the upstream 25 mi^2 (16,000 acre) ML watershed into ML; five subwatersheds were delineated to set up the model in SUSTAIN. Four of these subwatersheds represent the area drained by four major storm drains that flow directly into ML. The four city-owned drains are Project 510, Project 510 Line C, Project 77, and the Wilmington Drain (Figure 26). The Wilmington Drain subwatershed accounts for 80% of the ML Watershed. The fifth subwatershed represents the area directly connected to the lake that contributes sheet flow into ML. This area includes the Ken Malloy Harbor Regional Park and the Los Angeles Harbor College. The City collected stormwater flow and water quality at all drains except for the Project 510 drain, which flows into the Wilmington Channel downstream of where the Wilmington Drain monitoring occurred. A 4 m^2 land cover raster was acquired from SCAG and used to determine land use characteristics (Figure 27).

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[177] Machado LWQMP 2014 p. 5-5, 5-7, 5-8

[178] TAF no.16; http://www.lastormwater.org/wp-content/files_mf/lwqmpmachadolake2014.pdf

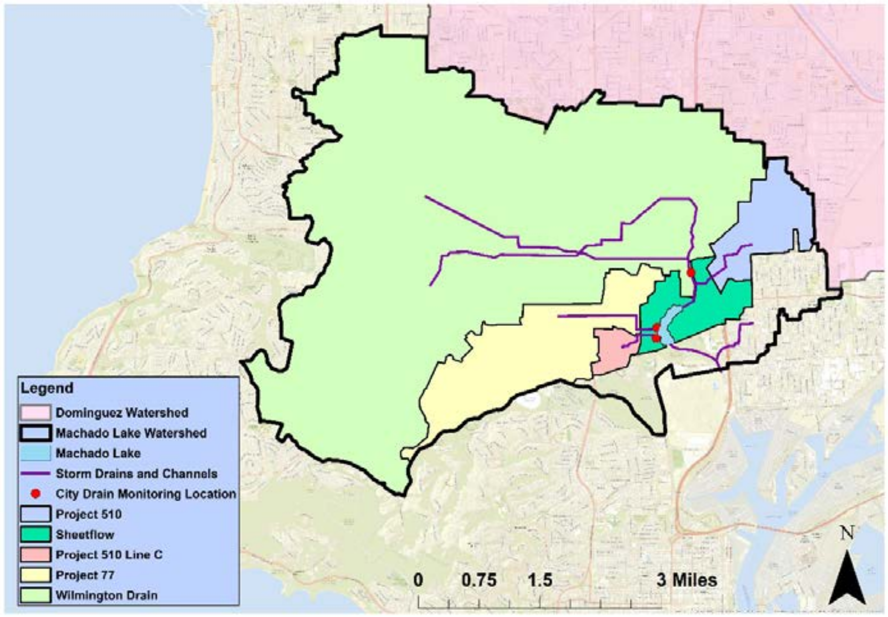

Figure 26: Machado Lake subwatersheds and associated storm drains flowing into the lake.

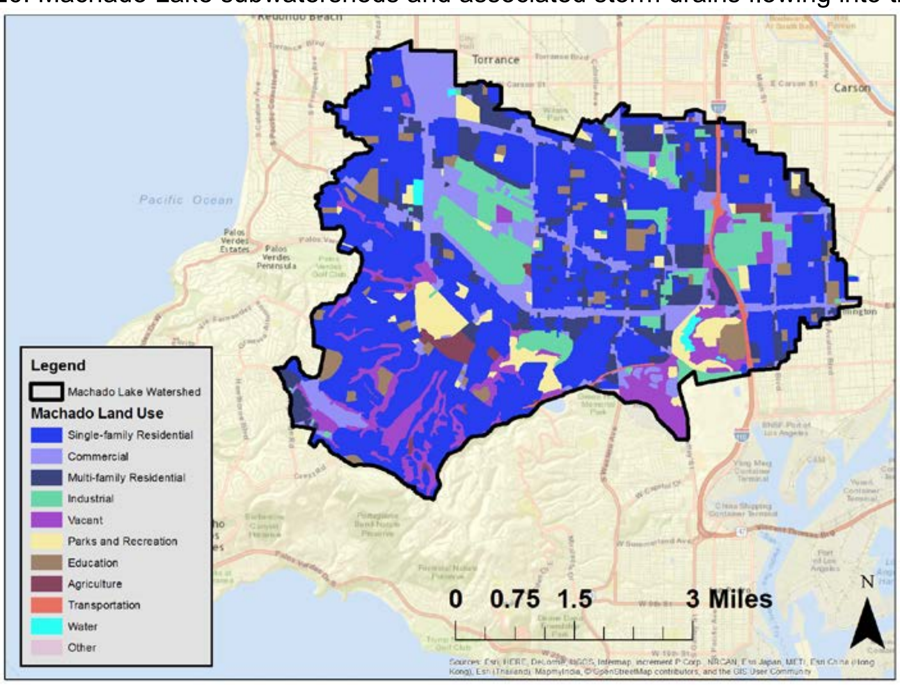

Figure 27: Machado Lake watershed land use distribution created from SCAG. Land uses are listed in the legend with 'single-family residential' listed first with the highest watershed area percentage and 'other' listed last with the smallest watershed area percentage.

As discussed earlier, extremely limited wet weather flow (only one storm from the Wilmington Drain) and water quality data were available. SUSTAIN parameters from the calibrated DC Watershed (percent impervious, percent slope, N-impervious, N- pervious, S – impervious, S – pervious, and hydraulic conductivity) were averaged and used in the ML Watershed model because calibrating and validating the SUSTAIN model was difficult with such limited data. Area-defined parameters such as the width and area of each subwatershed as determined by the ArcGIS shapefiles (delineations) were calculated for the ML watershed. The ML and DC Watersheds were assumed to have similar watershed properties as they are adjacent to one another; observed and modeled flows were compared to validate this assumption. Table 24 is a summary table of all observed flow and water quality data available from the three drains.

		Total Nitrogen			Total Phosphorous		
		510 Line C	77	Wilmington	510 Line C	77	Wilmington
Flow Data	Total days of Flow Data	21	46	11	21	46	11
	Wet weather Days	1	4	3	1	4	3
	Average Dry Weather Flow (CFS)	0.02	0.08	2.6	0.02	0.08	2.6
	Average Wet Weather Flow (CFS)	26.67	9.58	97.36	26.67	9.58	97.36
WQ Data	Total days of Concentration Data	32	47	36	30	47	36
	Average Dry Weather WQ (mg/L)	2.59	3.11	2.79	0.43	0.56	0.65
	Average Wet Weather WQ (mg/L)	2.16	4.36	2.34	0.81	1.15	0.65
	Average Daily Dry Weather Load (lbs)	0.26	3.95	6.47	0.05	0.55	1.2
	Average Daily Wet Weather Load (lbs)	307	748	2676	114	383	1220

Table 24: Summary of all available flow and water quality data available for the three storm drains flowing in the lake.

Modeled flow from SUSTAIN was compared to the available observed flow in the Wilmington Drain, Project 77, and Project 510 Line C. From October 2007 to July 2009, Wilmington Drain had 11 days of recorded flow with only 3 of those being wet weather days. Project 77 and Project 510 Line C had 46 and 21 sampled days, respectively, of flow from that time period but only 4 and 1 wet weather days, respectively (the same dates for all storm drains); the remaining flow measurements occurred on dry weather days. Of the three wet weather day samples, only one was collected during a storm and the other two were classified in the database as "1-2 days post rain event" samples. Therefore, the first wet weather day was kept as the more accurate sample to compare since it reflected an actual rain event even though it resulted in the model over-predicting the other two post-rain days. This wet weather storm matched modeled results in Wilmington Drain fairly well even though the model is biased low (Figure 28). Modeled flows for Project 77 and Project 510 Line C on this wet weather day also matched observed flows within the same magnitude as the Wilmington Drain. While three wet weather days were not sufficient to calibrate or validate the model, this analysis showed that the model is within the same range (~18% bias) as available observed data. Thus, DC Watershed parameters were the best available route to obtain the most accurate modeled flow.

It is important to note here that while this is the best possible approach to model ML given the severe lack of flow data, it is critical to gather more data going forward to accurately assess and predict ML water quality as these projects come online and additional BMPs are implemented. The earlier City-led modeling efforts such as the TIWRP TAF and the Machado LWQMP were based on similarly sparse data. Thus, the City's future modeling efforts to determine the efficacy of the implemented BMPs and completed projects on meeting expected water quality goals must be built upon a robust monitoring effort that includes both extensive stormdrain and lake water quality data and extensive flow and BMP performance data. The DC CIMP includes monitoring and data collection that will begin to address some of these gaps. Current and expected ML water quality must be modeled again when sufficient additional data has been collected to more fully characterize all potential ML inputs. Additional inputs such as potential impacts of bird waste on lake nutrient concentrations should also be included in future modeling efforts to quantify all potential internal loading sources in ML.

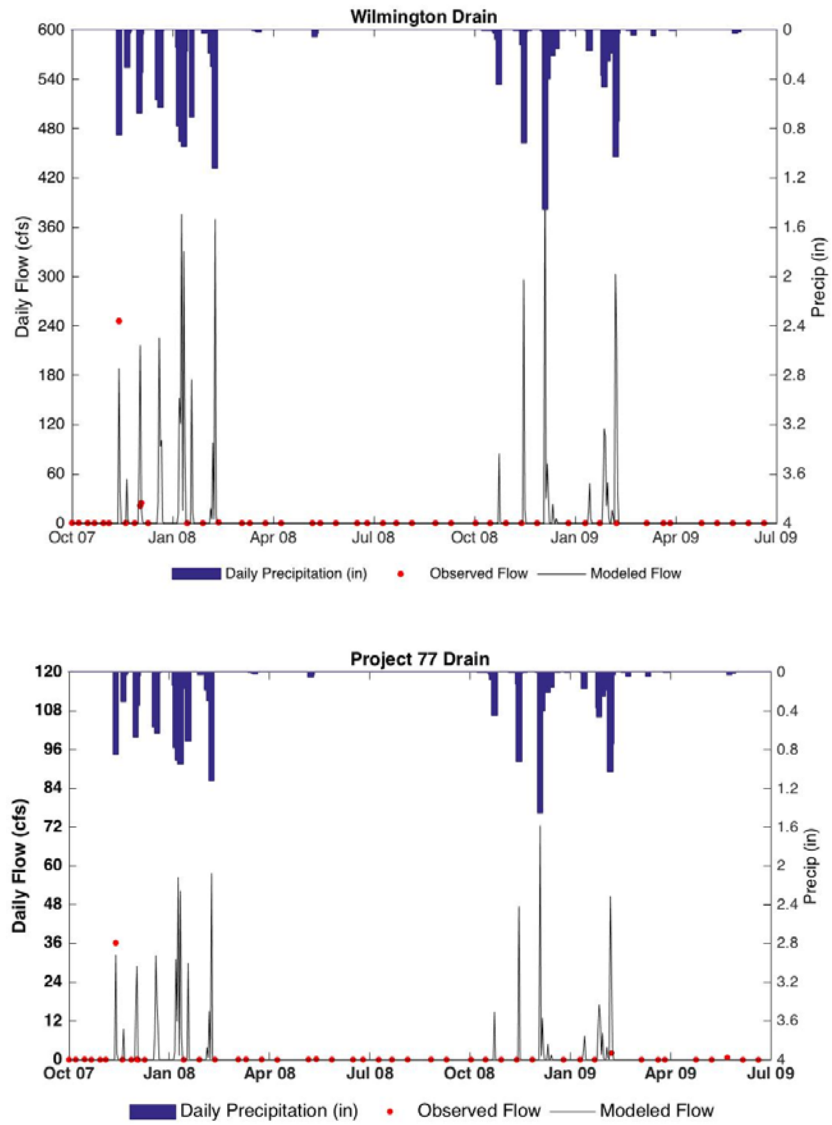

Figure 28: Water quantity calibration for Machado Lake at the Wilmington Drain (top) and Project 77 drain (bottom). Daily precipitation is represented on the top x-axis.

As an additional check on the accuracy of our modeling efforts, additional flow and water quality data was acquired from the LA County Watershed Protection Division (LACWPD) at several sites throughout the ML watershed that were located upstream of the storm drain outputs flowing into ML. This data was obtained through a study called The Machado Lake Multipollutant Monitoring and Reporting Program (MRP), in which wet and dry weather events were monitored at sites throughout the ML watershed for three years. While seven monitoring stations were included in the MRP study, only two were used for flow analysis modeling discussed in this report. Nutrient sampling events were taken quarterly with a total of 11 dry weather and 8 wet weather storms were monitored for each of the three years. This data was used as a validation of SUSTAIN's ability to reproduce flow.

Two subwatersheds were delineated that captured the two main sampling locations, gauges 3O_VAND and 3O_VERSEP (Figure 29), which could help with validating SUSTAIN. 3O_VERSEP could not be used to assess the accuracy of modeled flows as a diversion of stormdrains upstream of 3O_VERSEP precluded the use of that gauge without additional information on the diverted subset of stormdrains. Thus, only 3O_VAND, which captures a 1.01 mi^2 (648 acre) subwatershed, could be used to further analyze whether the watershed parameters resulted in modeled simulations that were acceptably similar to the observed flow (Figure 30). Comparisons between modeled and observed flow at 3O_VAND provided additional verification that the selected parameters drawn from the DC Watershed result in model simulations that are within the same range as the wet weather sample day calibration (with a percent bias of simulated flow at gauge 3O_VAND around 20%).[179]

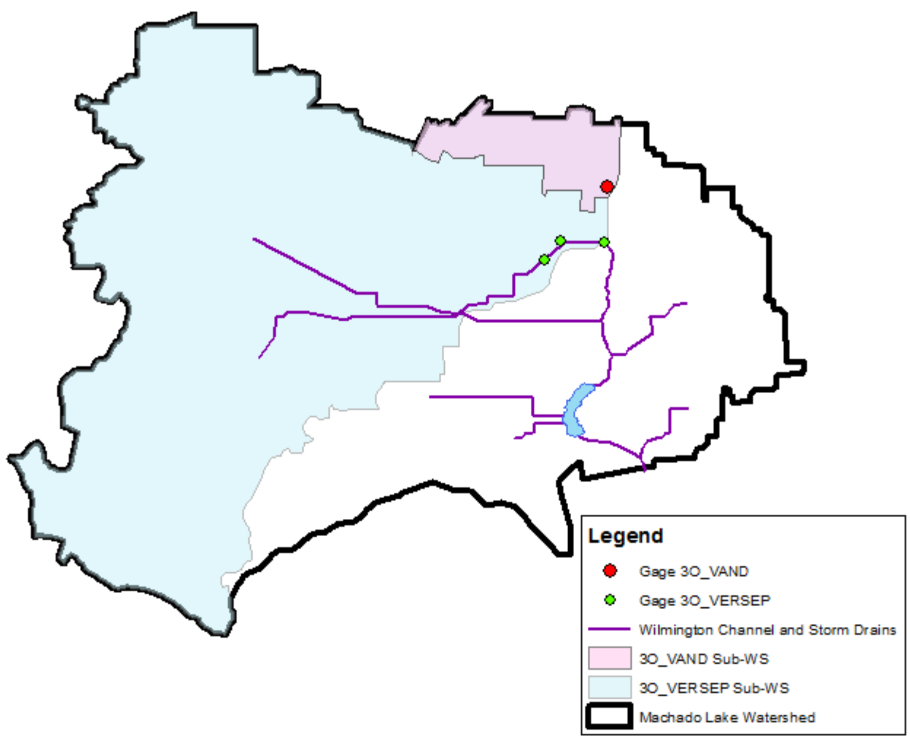

Figure 29: Delineation of subwatersheds upstream of LA County owned gauges. The diversion of the storm drains upstream of the 3O_VERSEP and 3O_VAND gauges can be seen where storm drains cross.

[179] County of Los Angeles Department of Public works, Year 2 Nutrient Monitoring for the County of Los Angeles Unincorporated Area of the Machado Lake Watershed. November 2014.

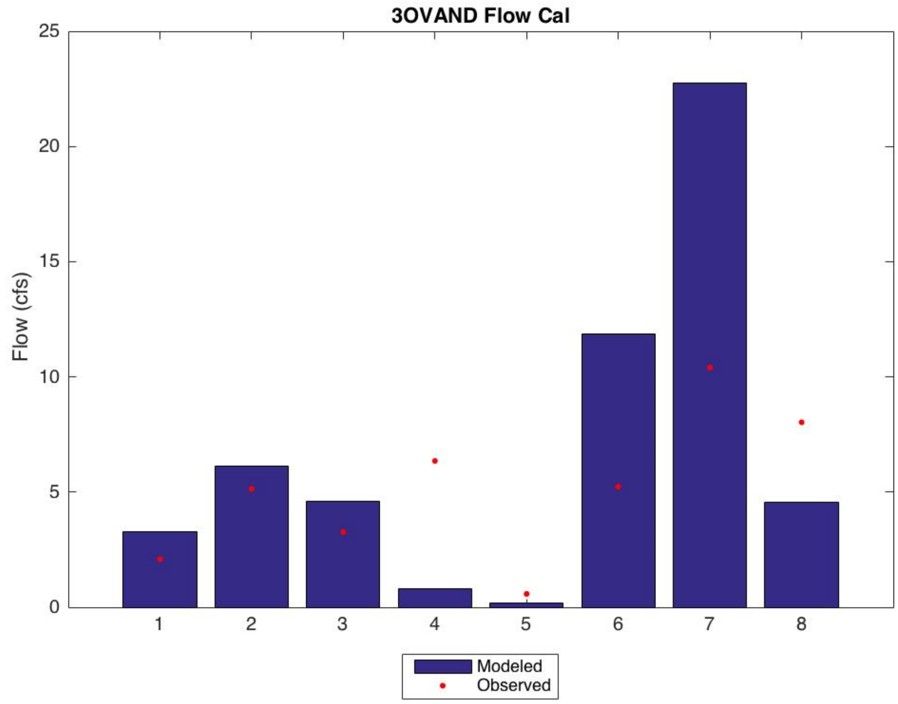

Figure 30: Water quantity calibration for Machado Lake at county owned gauge 3O_VAND.

c. SLAM Setup, Calibration, Validation

As introduced above, SLAM is an Excel-based model created by CDM Smith to simulate projected concentrations of nutrients and toxics in ML. It should be noted that the SLAM model is the same model as the Lake Water Quality Model used in the LWQMP.[180] Projections available through SLAM include baseline concentrations as well as concentrations after the installation of in-lake BMPs. Parameters within SLAM, including model segmentation, lake hydraulics, watershed parameters, lake nutrient parameters, phytoplankton parameters, and sediment layer parameters can be adjusted in SLAM to best simulate real time lake conditions.[181] Parameters in SLAM can either be calculated by the model or prescribed by the user.[182] Lake nutrient parameters, phytoplankton parameters, and sediment layer parameters were left to the default values originally calibrated by CDM Smith for the LWQMP to set up the model for ML for the analysis presented in this study. Thus the model should accurately represent the in-lake dynamics in terms of nutrients and toxics within ML.[183]

[180] Machado LWQMP 2014, p. 2-16.

[181] SLAM model

[182] SLAM model

[183] Machado LWQMP 2014 p. 2-15.

Watershed parameters and lake hydraulics were the only model inputs adjusted from the default values set by CDM Smith for the LWQMP. The watershed parameters were manually adjusted and prescribed by inputting external flow and loads for nutrients while the lake hydraulics were manually adjusted and prescribed by updating the lake volume and surface area. Using calibrated and validated flow values simulated from SUSTAIN as inputs to SLAM provides the opportunity to assess the impacts of implementing various BMP scenarios and incorporate modeled flows to assess the impact of external loading on nutrient loads within ML. While the modeling effort presented here provides valuable information and a potential pathway to better link watershed-scale BMP program impacts with ML water quality, it is important to note again here that the paucity of data available must be remedied and models rerun when better data is available to accurately reflect actual water quality.

The lake volume and surface area were adjusted in the model setup to reflect the lake dredging that occurred as part of the ML Ecosystem Rehabilitation Project. The final lake hydraulics used in SLAM are further discussed below. To calculate external loads and flows, the model was originally set up with the average monthly dry and wet weather EMCs, a set constant dry weather flow of 0.1 cfs, and observed daily precipitation to determine wet weather flow.[184] Incorporating SUSTAIN allowed for the input of daily flow (cfs) and nutrient loads (lbs/day) into SLAM and thus for a more detailed representation of external loading. This approach also allowed for a more accurate representation of how the implementation of BMPs in SUSTAIN and throughout the watershed effects the resulting in-lake nutrient concentrations. The previous studies conducted for LASAN (LWQMP and TAF) did not simulate BMPs within the watershed; external EMCs in those studies were manually adjusted to match WLAs. Thus, the final baseline setup for the presented SLAM analyses included an updated lake volume, prescribed external flows and loads based on SUSTAIN outputs, and all other parameters at calibrated defaults used by CDM Smith.

While the DC watershed land use EMCs were adjusted in SUSTAIN to match observed water quality within the DC channel, ML watershed land use EMCs utilized in SUSTAIN were calibrated based on in-lake concentration simulations from SLAM so that modeled watershed pollutant loads would best represent in-lake concentrations. This approach facilitated model calibration using observed water quality data within the lake, which had far more data points than from the storm drains flowing into the lake. Although we would have preferred to have a more robust stormdrain dataset and utilize EMCs without modification in the modeling effort, since the SLAM model was calibrated by CDM Smith to accurately represent ML and external flows were calibrated in SUSTAIN with minimal available data at multiple locations, it was also necessary to adjust the EMCs to match observed data and accurately represent real life nutrient in-lake concentrations. Adjusting EMCs in SUSTAIN to match in-lake concentrations is similar to adjusting EMCs within the DC watershed to match observed water quality data within storm drains. This approach also ensured that accurate in-lake concentrations (based on water quality data) were being represented to better understand the impacts of BMP implementation in the ML watershed on in-lake water quality. Simulating BMP impacts with the model under-predicting in-lake concentrations (as was the case prior to adjusting the EMCs to

[184] SLAM model

match in-lake water quality conditions) may not have provided as accurate a picture of potential impacts on in-lake water quality.

EMCs were adjusted in SUSTAIN until modeled in-lake concentrations from SLAM matched the observed water quality data. The observed in-lake TN and TP water quality data included 150 samples taken from water year 2007 to 2013.[185] No lake monitoring data was available subsequent to 2013 due to construction efforts; in-lake monitoring began again in late 2016. The observed in-lake water quality and EMC sensitivity analysis is plotted in Figures 31 and 32; the 95th percentile and 75th percentile EMCs best reflected observed in-lake water quality data for TN and TP, respectively (Table 25). At these EMCs, the external nutrient concentrations flowing into the lake were 6.24 mg/L for TN and 1.35 mg/L for TP which are extremely high. It is important to note that these values were higher than the actual observed external concentrations flowing into the lake (2.95 mg/L for TN and 0.86 mg/L for TP). However, as the focus of this analysis was to model in-lake concentrations, these higher EMC values were needed in order for in lake modeled concentrations to match observed concentrations. Using external modeled TN concentrations of 6.24 mg/L resulted in an average in-lake TN concentration of 1.80 mg/L, which closely matched the observed average of 1.75 mg/L; the modeled in-lake TP concentration is 1.35 mg/L and the observed average was 1.5 mg/L.

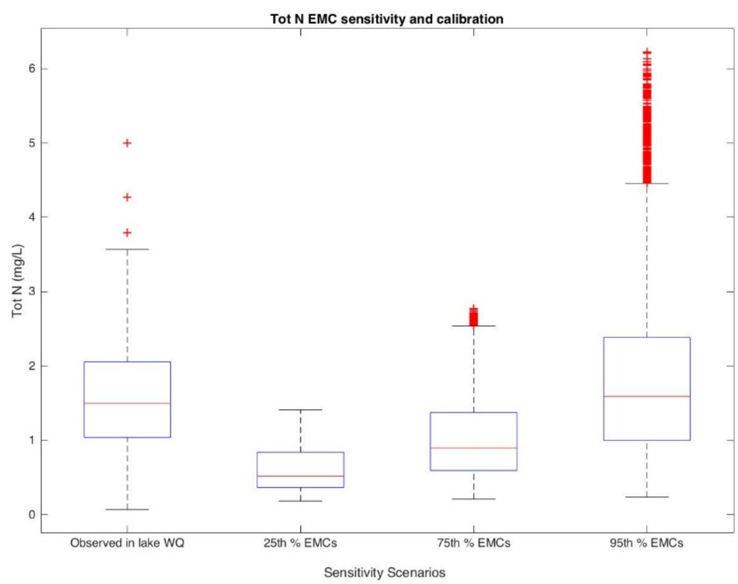

Figure 31: Water quality calibration in ML for total nitrogen. Observed in-lake water quality data is shown in the far left boxplot. The following three boxplots show modeled in-lake concentrations based on EMC percentiles set in SUSTAIN.

[185] City of Los Angeles Machado Lake Drain Monitoring

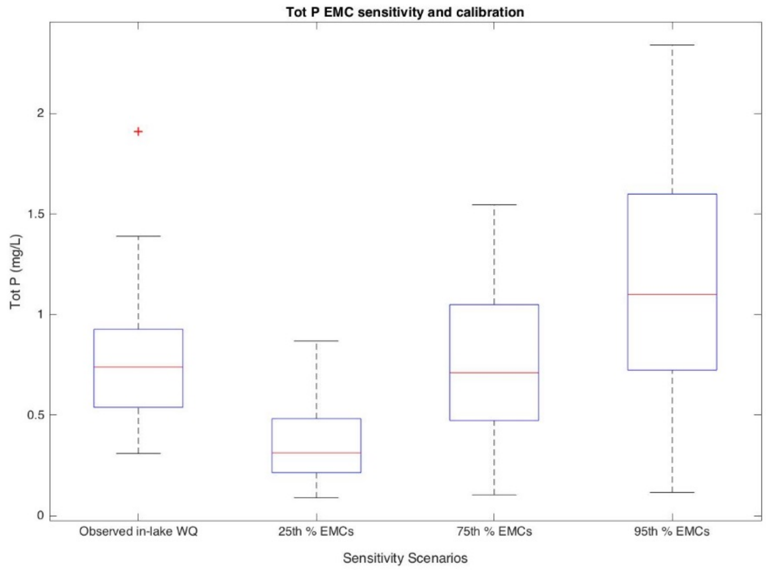

Figure 32: Water quality calibration in ML for total phosphorous. Observed in-lake water quality data is shown in the far left boxplot. The following three boxplots show modeled in-lake concentrations based on EMC percentiles set in SUSTAIN.

mg/L		MFR	SFR	COM	IND	AGR	REC	OTH	TRN	VAC
Tot N	Mean	**2.6**	1.9	2.8	4.2	4.2	7.1	7.1	2.3	0.8
Tot P	Mean	0.7	0.7	1.0	3.4	1.4	N/A	N/A	0.7	0.3
Tot N	95th%	6.0	4.6	7.9	10.1	11.0	10.0	10.0	3.5	2.3
Tot P	75th%	0.6	0.7	1.4	6.8	1.4	N/A	N/A	0.6	0.3

Table 25: Mean and calibrated pollutant washoff EMCs utilized in SUSTAIN. Calibrated EMCs are the 95 and 75 percentile values for TN and TP, respectively, acquired from the LA County Stormwater Quality Monitoring Program and SCCWRP EMC database.

The observed pollutant loads and the external loads simulated by SUSTAIN and inputted into SLAM were also compared (Table 26, Figures 31 and 32). Flows and pollutant concentrations from each drain were separated into dry weather days and wet weather days. All dry weather loads were averaged for each drain and then summed to get a total dry weather baseflow loading of TN and TP; modeled and observed dry weather loading of TN and TP were very similar. The two wet weather events were analyzed individually; wet weather loads for TP were similar for the two wet weather events. Wet weather loads for TN are higher in the model than observed.

			TN (lbs)	TP (lbs)
Dry Weather	Daily loading	Modeled	8.29	1.44
	Average of all data	Observed	10.68	1.81
Wet Weather Events	11/30/2007	Modeled	6069	1752
		Observed	3731	1717
	12/20/2007	Modeled	533	136
		Observed	329	86

Table 26: Comparison of modeled loads of nutrients entering Machado Lake from the storm drains to the available observed loading.

d. BMP Technologies in SUSTAIN

The same BMPs utilized in the DC Watershed modeling efforts were analyzed for the ML Watershed in the SUSTAIN model for consistency and to facilitate comparisons across all study watersheds. However, as the BMPs selected for the BC, LAR, and DC Watersheds were selected for their ability to remove metals rather than nutrients (the modeled pollutant for ML), results are mixed on their ability to effectively remove nutrients and decrease nutrient concentrations in the effluent leaving the BMPs (Table 27).[186] In addition, earlier research efforts such as the TAF found that reaching TP compliance in the ML Watershed would be more difficult than reaching TN compliance.[187] Therefore, the BMP suites chosen for use in the ML Watershed study were varied slightly from those analyzed in the DC Watershed study to reflect their performance at removing nutrients based on the BMP database. The BMPs selected for the ML Watershed were those that were the most effective at TP removal. For example, biofilter – grass swale (vegetated swale) and bioretention BMPs actually increase the effluent TP concentration based on available data and so were not included in the ML Watershed modeling. Wet ponds were added based on their efficiency in removing both TP and TN from stormwater. Thus, the BMPs implemented in SUSTAIN for the presented ML Watershed modeling efforts include dry ponds, infiltration trenches, porous pavement, and wet ponds.

[186] International BMP Database, *available at* http://www.bmpdatabase.org/

[187] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

BMP Type	Total Nitrogen (mg/L)				Total Phosphorous (mg/L)			
	N - Samples		Median		N - Samples		Median	
	In	Out	Influent	Effluent	In	Out	Influent	Effluent
Biofilter - Grass Swale	241	207	0.77	0.87	393	341	0.11	0.17
Bioretention	245	194	1.16	0.92	515	435	0.12	0.24
Dry Pond/Infiltration Basin	90	89	1.32	1.6	307	322	0.25	0.20
Porous Pavement	NA	NA	NA	NA	325	192	0.18	0.10
Wet Pond/Wetland Basin	629	660	1.43	1.2	1250	1236	0.17	0.09

Table 27: Observed influent and effluent concentrations for TN and TP as reported in the BMP database. BMPs that have higher effluent concentrations of nutrients than influent concentrations are shaded as these BMPs are not as effective at nutrient pollution removal.

BMP decay coefficients, K (hr^{-1}), were calibrated and validated for nutrient pollution removals for these four BMPs using the same method as was applied in earlier research for heavy metals and TSS.[188] Briefly, influent concentrations from the BMP database were input into SUSTAIN and decay coefficients were adjusted until modeled effluents matched observed effluents from the BMP database.[189] Final BMP dimensions and nutrient decay coefficients are displayed in Table 28. A decay coefficient of 0.01 was chosen for dry ponds and infiltration trenches when simulating TN decay so that the simulation of the two BMPs would have a minimal effect on TN concentration. This decay rate was chosen as it resulted in modeled results that matched the influent and effluent concentrations found in the BMP database.

	Porous Pavement	Dry Pond	Infiltration Trench	Wet Pond
Length (ft)	62	45	90	45
Width (ft)	30	15	45	15
Depth (ft)	1	5	5	5
Tot N decay rate (hr^{-1})	0.1	0.01	0.01	0.5
Tot P decay rate (hr^{-1})	0.5	0.6	0.6	0.5

Table 28: Dimensions and nutrient pollutant removal efficiencies for selected BMPs.

e. BMP Technologies in SLAM

Not all of the BMPs included in the Proposition O projects were available to be simulated in SLAM; the six available BMP options were the introduction of supplemental cleaner waters, lake dredging, a re-circulating wetlands area, a phosphorus removal system, an oxygenation system, and alum treatment. While most of the BMPs were simulated by simply adjusting model parameters from the parameters as originally calibrated by CDM Smith, the wetlands and alum treatment were included in a BMP module.[190]

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[188] Drew Beck CSM Thesis

[189] For a full description of this process, please see Drew Beck CSM Thesis page 52

[190] Machado LWQMP 2014, p. C-23, 35.

First, the addition of supplemental water was modeled as ML experiences increased levels of nutrients during the summer months due in part to higher levels of evaporation. With increased evaporation, the lake volume decreases and nutrients become more concentrated, thus resulting in higher concentrations. Earlier modeling efforts for the City determined that introducing 0.3 cfs of supplemental recycled water from TIWRP with lower levels of nutrients during the dry season (from June through October) would address this issue. TN and TP concentration levels are 0.3 and 0.02 mg/L, respectively, in this supplemental water.[191]

Supplemental water was simulated in SLAM by adding these flows and loads to the external flows and loads outputted from SUSTAIN ML watershed modeling efforts. The combined loads and flows were then input into SLAM. As described above, external flows and loads stemmed from watershed stormwater runoff while supplemental flows and loads were those manually inputted into the lake by the City through, for example, adding advanced treated recycled water from TIWRP. Adding this supplemental water will keep the lake at a semi-constant volume of around 200 AF, which will be beneficial for nutrient levels during the summer months.

The second BMP simulated in SLAM was lake dredging, which resulted in an increase in average depth from 3 feet to approximately 6 feet and a corresponding increase in volume.[192] Simulating this in SUSTAIN includes entering the monthly average lake volume as well as the surface area and depth of the lake. An estimate was chosen on a monthly basis based on an assumption that lake volume would be the lowest in the summer months due to evaporative losses. Prescribed lake volumes range from 202.7 AF to 170 AF based on wet and dry months; these monthly averages were used for all modeled years.

The BMP module in the SLAM model included the addition of an offline wetlands treatment as well as the alum treatment. While other BMPs implemented in the SLAM model required only changing parameters such as lake depth, the wetland and alum treatment each have their own module that is described below. Proposition O plans included installing an offline treatment wetlands to reduce TP levels in the lake; wetlands have natural tendencies to reduce nutrient levels. Further, a phosphorus removal system is planned for the entrance to the treatment wetlands to treat the water prior to entering the wetlands.[193]

The offline wetlands treatment in SLAM was modeled using the pump and treat option in the BMP modules; the BMP module did this simulation by routing water from the lake into the wetlands where it is treated and then returned to the lake. Both the uptake rates and the output nutrient concentrations were prescribed in the model.[194] TP concentrations were found to not be sensitive to the pump and treat BMP while TN concentrations were found to be extremely sensitive to this BMP. The lack of TP sensitivity can be seen in that TP in-lake maximum and

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[191] LASAN, personal communication. Nitrogen Compounds Profile at AWPF, and the Average Nitrogen Compound Concentrations tables provided by TIWRP in August 2016.

[192] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-6

[193] Machado LWQMP 2014, p. C-38.

[194] SLAM model

average concentrations went from 0.76 mg/L and 0.31 mg/L to 0.76 mg/L and 0.29 mg/L, respectively, when pump and treat was simulated. Modeling results, however, demonstrated that the TN concentrations are extremely sensitive to wet weather storms that occur in the same months that pump and treat occurs. For example, when the wetlands were simulated during a storm during a dry weather month, the modeled maximum TN concentration went from 5.4 mg/L to 27.2 mg/L and the average simulated TN concentration went from 1.0 mg/L to 1.9 mg/L as compared to the original Scenario ML-2 (DP + IT + PP) results. As the modeled maximum TN concentration (27.2 mg/L) overshoots the observed maximum by 20 mg/L, it was decided not to simulate the pump and treat BMP in SLAM modeling scenarios.

The Machado LWQMP also involved the one-time treatment of the entire lake with alum, which reacts with the phosphorus in the water to form an insoluble compound in water and quickly reduces in-lake levels of phosphorus.[195] Alum treatment was simulated in SLAM using a BMP module. Time frames for the treatment and the percent removal associated with different phosphorus concentrations in the water column are required for input. Alum treatment was simulated in SLAM in April of the first modeled water year with a 90% TP removal efficiency as described in the LWQMP.[196]

LWQMP plans also included the installation of an oxygenation system due to the potential high flux of nutrients from the sediment into the water under conditions with low levels of dissolved oxygen in the water. The oxygenation system is intended to increase the dissolved oxygen and help reduce that flux to help prevent large amounts of nutrients from dissolving out of the sediment. The oxygenation system should also reduce the risk of eutrophication caused hypoxia in the lake. To simulate this process, the oxic and anoxic rate constants for the sediment layer were modified to represent a system where nutrients are fixed in the sediment. Values were varied based on data used previously in SLAM by CDM Smith, with a wide enough range to analyze the sensitivity of these rates.[197]

The final list of all BMPs simulated in SLAM includes: supplemental water, lake dredging, alum treatment, and an oxygenation system. These four BMPs are simulated in all modeling scenarios described in the following section. For previously described reasons, the offline treatment wetlands (pump and treat) and the phosphorous removal system were not simulated.

f. BMP Scenarios: SUSTAIN

External flows and loads outputted from SUSTAIN were manually input into SLAM to determine the resulting impacts on ML concentration levels. SLAM analyses included all BMPs and parameters discussed in the previous section. Thus, all scenarios described in this section utilized both external BMPs throughout the watershed and the in-lake BMPs that could be simulated in SLAM.

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[195] Machado LWQMP 2014 Appendix C pg C-35.

[196] Machado LWQMP 2014, p. C-35, C-38.

[197] Machado LWQMP 2014, p. 3-8.

BMP scenarios utilized in SUSTAIN for the ML Watershed were set up in the same manner as in the DC Watershed; subwatersheds were also delineated (Figure 26). An optimization run as well as six BMP scenarios were modeled. Urban public land uses were identified and analyzed to determine the maximum number of BMPs that could be constructed throughout the ML Watershed on those designated areas (Table 29, Figure 33). Recreational land uses were determined to be the most appropriate land use for wet and dry ponds. The 85th percentile storm volume was calculated for each subwatershed throughout the ML Watershed (Table 30, Figure 34) to determine the number of each BMP type required to capture that volume.

	Land Use	Total Area (mi^2)	Area available for BMPs (mi^2)	Total Area for BMPs (mi^2)	BMPs
Urban Public	Parking Lots	0.84	0.25	2.25	PP
	Transportation	5.56	0.35		BR + VS
	Education	1.3	0.33		BR + VS
	Recreation	1.63	1.32		BR + DP + IT + WP

Table 29: Urban public land use breakdown for the ML Watershed as well as BMPs well-suited for the type of land use.

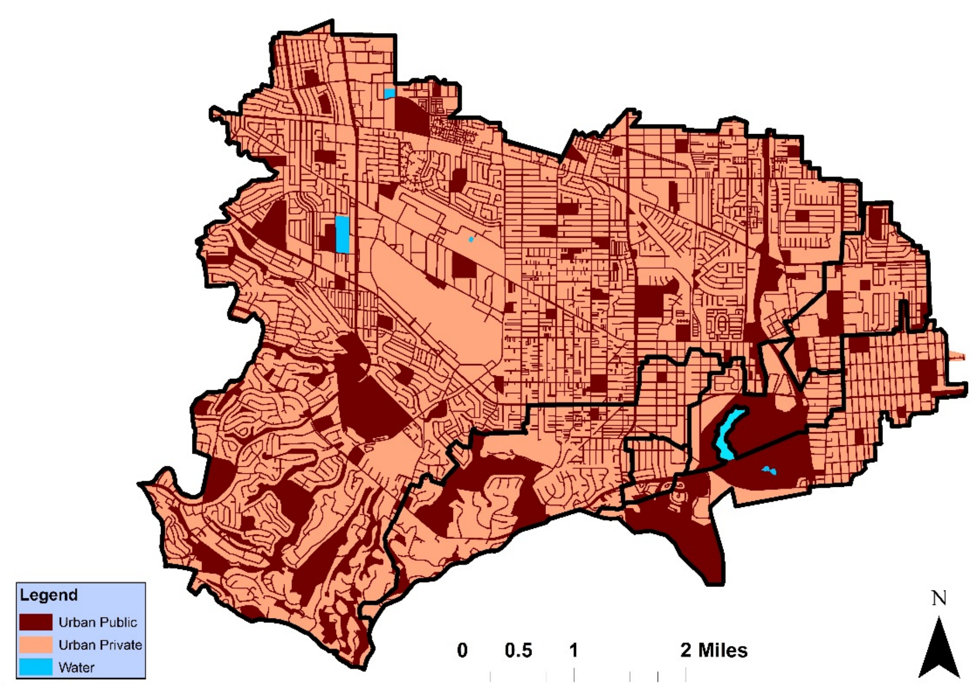


Figure 33: Land use distribution in the ML Watershed broken up by public, private and water-bodies. Subwatersheds discussed previously are also delineated.

Sub-Watershed	Wilmington	Project 77	Project 510 Line C	Project 510	Sheetflow	Total
Area (mi^2)	17.88	2.51	0.25	1.08	0.82	22.54
85th Storm Volume (AF)	560	94	9	33	25	721

Table 30: Area and 85th percentile storm volume for each subwatershed.

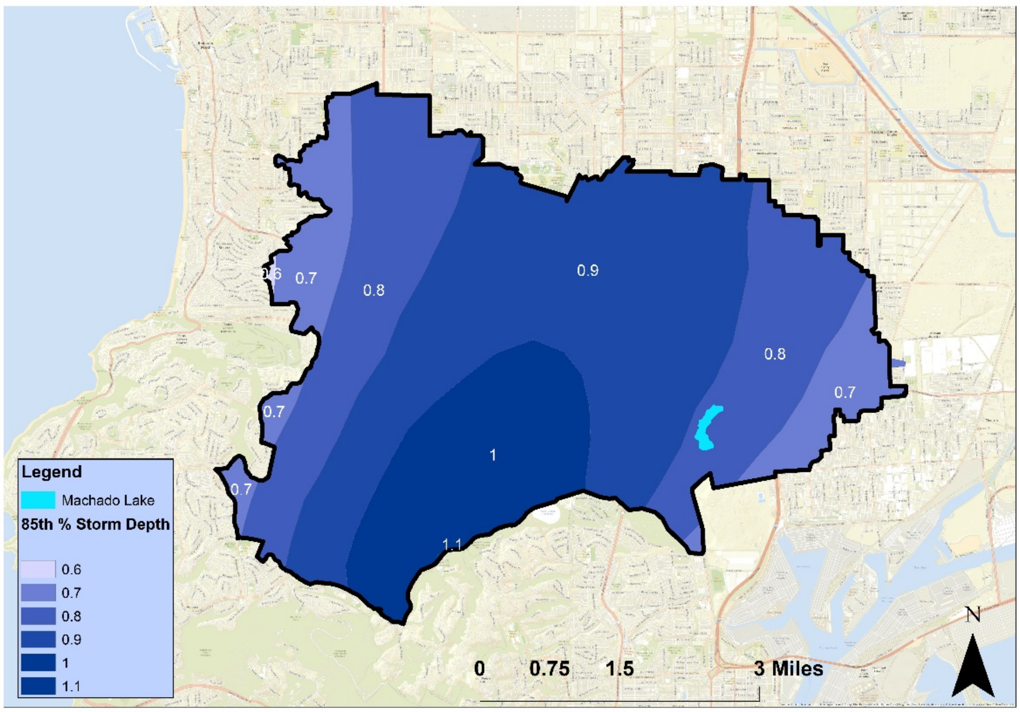


Figure 34: ML 85th percentile storm depths in inches per 24 hour time period. The area of each storm depth was used to determine the 85th percentile storm volume.

Optimization was set up in a different manner for the ML watershed than for the DC Watershed; SUSTAIN was set up to model five optimization "windows" that were plotted together to create a full Pareto solution. Optimization scenarios simulate thousands of scenarios at once to determine the optimal suite and number of each type of BMP. Each of the thousands of simulations has a resulting cost and pollutant reduction that are plotted together to create the Pareto curve. The resulting curve analyzes the relationship between cost and nutrient load reduction over a range of BMP scenarios that can capture total storm volumes from 10 AF to 950 AF. For example, while one optimization "window" implements a range of BMP units to capture 80% to 110% of the 85th percentile storm (604 AF to 830 AF) the next "window" models the range of BMP units to capture 60% to 80% of the 85th percentile storm (453 AF to 604 AF). The following three "windows" model 40% to 60%, 20% to 40%, and 0% to 20% of the 85th percentile storm.

The six scenarios (ML-1 to ML-6) were designed to comply with the MS4 permit requirements (Table 31); sufficient BMPs were simulated to capture the 85th percentile storm volume of 721 AF. Three 'BMP' scenarios (ML-1, ML-2, and ML-3), each utilized a specific suite of the four modeled BMP types. Scenario ML-1 includes dry ponds and infiltration trenches; Scenario ML-2 adds porous pavement on top of the ML-1 BMPs. Wet ponds were analyzed alone in Scenario ML-3 as they had not been assessed in previous watershed analyses. Three additional "Target Scenarios," ML-4 to ML-6, were also analyzed (Table 31) to assess water quality impacts. Scenarios ML-4 and ML-5 were designed to analyze in-lake concentrations when the external wet weather nutrient concentrations from the storm drain flow were set to the WLAs for TN and TP, 1.0 mg/L and 0.1 mg/L, respectively. Scenario ML-6 assessed the nutrient concentrations needed in external flows for the lake to eliminate exceedances for the selected modeled years (Table 31).

For scenarios ML-4 to ML-6, it was further assumed that some level of upstream BMP implementation would have occurred in the watershed in order for the external flows entering the lake to be at the TN and TP WLAs. Therefore, wet weather external flows were set to the ML-1 flow levels (after DP and IT implementation was modeled in SUSTAIN) rather than using the baseline external stormdrain flows (before any BMPs were implemented). The main difference between ML-4 and ML-5 was how the dry weather baseflow is simulated; wet weather concentrations are set to WLAs in both ML-4 and ML-5. Dry weather baseflow, nutrient concentrations, and loads are kept at the calibrated values in ML-4, but set to the WLAs in Scenario ML-5. Dry weather baseflow volume remains constant at 1.0 cfs in both.

<table>
<tr><th>Compliance Scenarios</th><th>Dry Pond</th><th>Infiltration Trench</th><th>Porous Pavement</th><th>Wet Pond</th></tr>
<tr><td>ML -1</td><td>x</td><td>x</td><td></td><td></td></tr>
<tr><td>ML- 2</td><td>x</td><td>x</td><td>x</td><td></td></tr>
<tr><td>ML- 3</td><td></td><td></td><td></td><td>x</td></tr>
<tr><th>Target Scenarios</th><th colspan="4">Description</th></tr>
<tr><td>ML - 4</td><td colspan="4">All external wet weather concentrations set to 1.0 and 0.1 mg/L for TN and TP respectively. External ww flow based on ML-1.</td></tr>
<tr><td>ML - 5</td><td colspan="4">All external wet weather and baseflow concentrations set to 1.0 and 0.1 mg/L for TN and TP respectively. External ww flow based on ML-1.</td></tr>
<tr><td>ML - 6</td><td colspan="4">Assesses the external nutrient concentration needed for lake to reach 100% compliance. Includes both wet weather and baseflow concentrations.</td></tr>
</table>

Table 31: BMP scenarios simulated in SUSTAIN with the BMPs utilized and percentile storm volume capture.

D. Modeling Results

As described above, the paucity of data, in particular of flow data entering ML, means that the modeling results described in this section provide some useful insights into the impacts of BMP implementation throughout the watershed on in-lake water quality but cannot be relied upon for accuracy until better data is available. The data collection efforts planned through a monitoring strategy at ML, in particular the real-time monitoring system and automated samplers for Wilmington Drain, P510, and P77 being installed as well as the resumption of in-lake water quality monitoring will provide additional data to inform future modeling efforts. The modeling approach here using both SUSTAIN and SLAM allows the assessment of BMP implementation on in-lake water quality and should be considered for future studies.

The SUSTAIN optimization NSGA-II algorithm evaluated optimal solutions using cost and pollutant reduction as criteria. The model selected the number of BMP units by finding solutions that optimize these targets. Plotting cost versus pollutant load reduction produced a Pareto curve (Figure 35). All five optimization "windows" were plotted on the same scale to show the full Pareto curve based on a range of total BMP storm volume capture from 10 to 950 AF. The 85^{th} percentile storm volume for the ML Watershed is 721 AF (roughly represented by the vertical black line on the plot). Simulations to the left of the line capture less than the 85^{th} percentile storm volume while simulations to the right capture greater than the 85^{th} percentile storm volume.

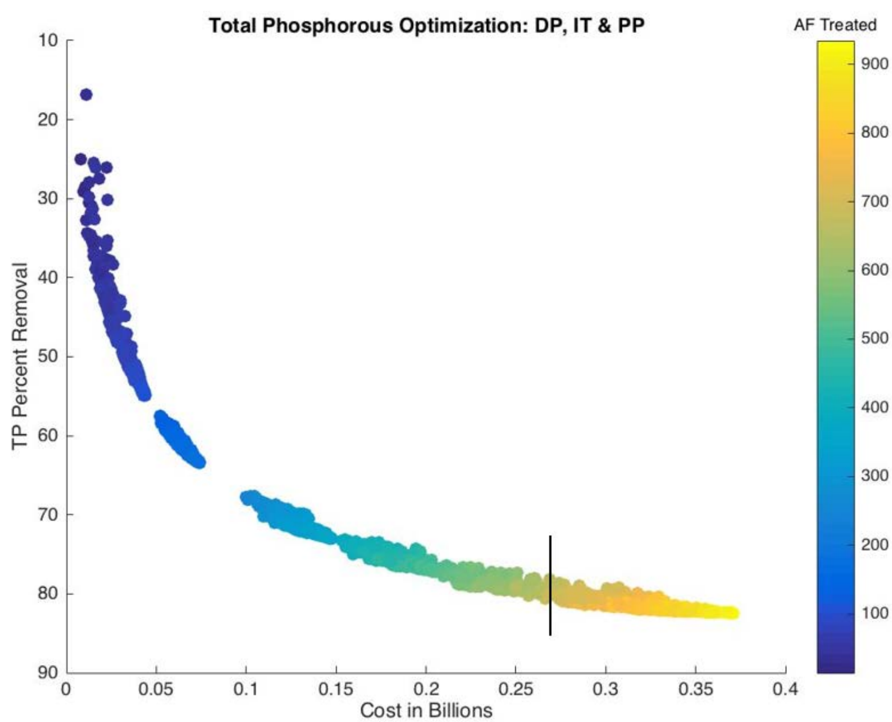


Figure 35: Optimization of cost and TP pollutant load reduction for the whole ML Watershed. The black vertical line roughly estimates where solutions begin to capture the full 85^{th} percentile storm volume. Total storm volume capture is also represented in the optimization plot by the color scale.

To assess the impact of the BMPs implemented by the City within the lake, SLAM was initially simulated without the implementation of BMPs in SUSTAIN. Thus the external flows and loads from the watershed flowing into Machado Lake represent the calibrated baseline. BMPs simulated in SLAM include lake dredging, alum treatment and supplemental water, and the oxygenation system. SLAM outputs with in-lake BMPs varied only slightly from the original calibrated outputs without any BMPs simulated. For example, while the average concentration for TN and TP without any BMPs are 1.80 mg/L and 0.77 mg/L, respectively, the average concentration for TN and TP with the in-lake BMPs are 1.55 mg/L and 0.71 mg/L, respectively. This is a small decrease in the lake nutrient concentrations which suggests that eliminating exceedances in the lake cannot solely rely on the in-lake BMPs being implemented in the lake. BMPs also must be implemented throughout the DC watershed to address pollutant loads coming into ML through external sources.

To better compare the results across all modeled scenarios (ML-1 through ML-6), criteria sections were broken up in two to reflect outputs from each model, SUSTAIN and SLAM, in a decision matrix (Table 32). The percent reduction in average annual load (AAL) for each pollutant represented the reduction in the total AAL entering ML based on wet weather stormwater runoff as simulated by SUSTAIN (External SUSTAIN Criteria, Table 32). The average annual concentration (AAC) of external flows changed in each scenario based on the implemented BMPs for scenarios ML-1 to ML-3 and was set to the nutrient WLA AAC in scenarios ML-4 to ML-6 (In-Lake SLAM Results, Table 32).

	Scenario	Baseline	ML-1	ML-2	ML-3	ML-4	ML-5	ML-6
	BMPs		DP + IT	DP + IT + PP	WP	*	*	*
	N - Modeled Months	84	84	84	84	84	84	84
	Cost (Billions)	-	0.19	0.26	0.19	-	-	-
	BMP area (mi^2)	-	0.23	0.43	0.22	-	-	-
External SUSTAIN Criteria	**TN** External AAL % Reduction	-	55.3%	62.7%	89.3%	-	-	-
	TP External AAL % Reduction	-	76.6%	80.0%	90.0%	-	-	-
	TN WW External AAC (mg/L)	6.24	6.12	5.58	1.47	1	1	1
	TP WW External AAC (mg/L)	1.35	0.69	0.65	0.29	0.1	0.1	0.025
In-Lake SLAM Results	Months in Compliance (**TN**)	5	47	56	84	84	84	84
	Months in Compliance (**TP**)	0	2	2	29	46	67	84
	TN Compliance	6.0%	56.0%	66.7%	100.0%	100.0%	100.0%	100.0%
	TP Compliance	0.0%	2.4%	2.4%	34.5%	54.8%	79.8%	100.0%
	TN monthly average concentration mg/L	1.8	0.98	0.87	0.48	0.31	0.22	0.22
	TN Wet weather monthly average	1.5	0.89	0.78	0.34	0.16	0.12	0.12
	TN Dry weather monthly average	2.15	1.11	0.99	0.64	0.46	0.32	0.32
	TP monthly average concentration mg/L	0.77	0.31	0.29	0.17	0.11	0.05	0.02
	TP Wet weather monthly average	0.57	0.22	0.22	0.11	0.05	0.03	0.01
	TP Dry weather monthly average	0.99	0.4	0.38	0.25	0.16	0.08	0.01
	* Scenarios were not run in SUSTAIN, thus no set suite of BMPs. However daily flow was taken from scenario ML-1 in order to determine daily external load based on set external AAC.							

Table 32: Decision matrix for evaluating tradeoffs between BMP scenarios. Table includes the number of months in compliance out of the total 84 modeled months and TN and TP monthly average in-lake concentrations, for dry weather and wet weather months.

In-lake water quality generally improved for both TN and TP for all modeled scenarios (Figure 36). The number of months in which TN concentrations were lower than 1.0 mg / L went up significantly from the baseline (5/84 months) in both ML-1 (47/84 months) and ML-2 (56/84 months). As discussed in the BMP selection section, wet ponds are more efficient in removing TN; this is confirmed as ML-3 (WP) resulted in no exceedances for TN in all 84 months modeled (Table 32). Wet weather exceedances were no longer present when wet weather external storm drain TN concentration at 1.47 mg/L (greater than the TN WLA). While some days still exhibit in-lake TN concentrations above 1.0 mg/L, the average monthly concentration is always below 1.0 mg/L. Wet weather exceedances at ML are also zero for TN in all modeled months in Scenarios ML-4 through ML-6, with external runoff concentrations set to the TN WLAs (Figure 37). Thus, if all upstream jurisdictions were meeting their water quality requirements (e.g. all runoff was at or below TN WLAs), then TN exceedances at ML would also be zero. To summarize, exceedances are eliminated for TN in scenarios ML3 through ML6.

Observed in-lake concentrations for TP were well over the TMDL limit (0.1 mg/L) with a mean in-lake concentration of 0.75 mg/L. Even though modeled BMPs were found to remove TP more efficiently than TN, the percent reduction of TP loading required to eliminate exceedances much larger in magnitude than the reduction in loading required to do the same for TN (e.g., the same suite of BMPs in ML-1 resulted in an AAL reduction of 55% for TN and 77% for TP). For example, even though the loads of TP are reduced by 75% and 80% in scenario ML-1 (DP + IT) and ML-2 (DP + IT + PP), respectively, ML was still only lower than the required TP concentrations for two months out of 84 (Table 32).

Daily time series plots were created based on the SLAM outputs to facilitate further analysis among the following modeled scenarios: baseline, ML-2 (DP + IT), ML-3 (DP + IT + PP), and ML-5 (WP) (Figures 37, 38). As can be seen in the modeled baseline water quality for water years 2007 to 2013, TN levels need to be reduced by a lesser degree to meet its TMDL (Figure 37a) than TP levels do to meet its TMDL (Figure 38a). Even in the baseline scenario, TN concentrations sometimes meet the TMDL; TP concentrations never do. In general, in-lake concentrations of both TN and TP decrease with BMP implementation throughout the watershed (Figures 37 and 38). While scenario ML-2 (DP + IT + PP) results in 56 months (out of 84) meeting TN requirements (Figure 37b), only two months meet required TP concentrations (2.3% compliance, Figure 38b). As wet ponds remove TN more efficiently than dry ponds, infiltration trenches, and porous pavement, the results from ML-3 are better, especially during wet weather months (Figure 37c, Table 33). Meeting water quality standards for TP is challenging in dry weather months. Even though all wet weather and baseflow concentrations are set to the WLA of 0.1 mg/L for TP in scenario ML-5, TP is lower than the TP requirements in only 67 months (out of 84) (Figure 39d, Table 34).

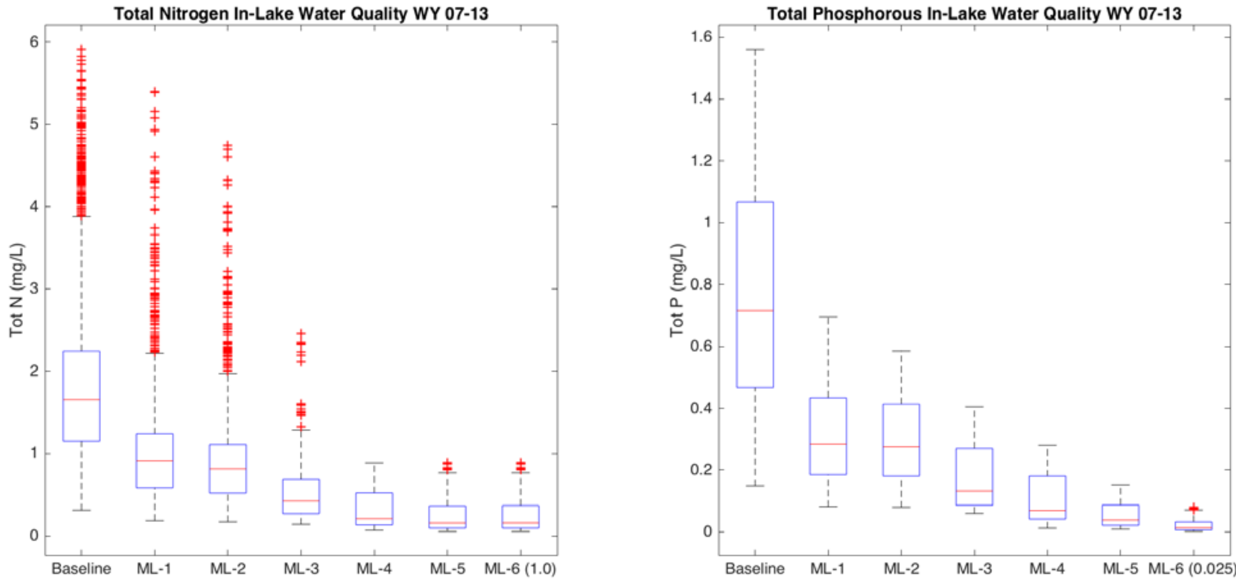
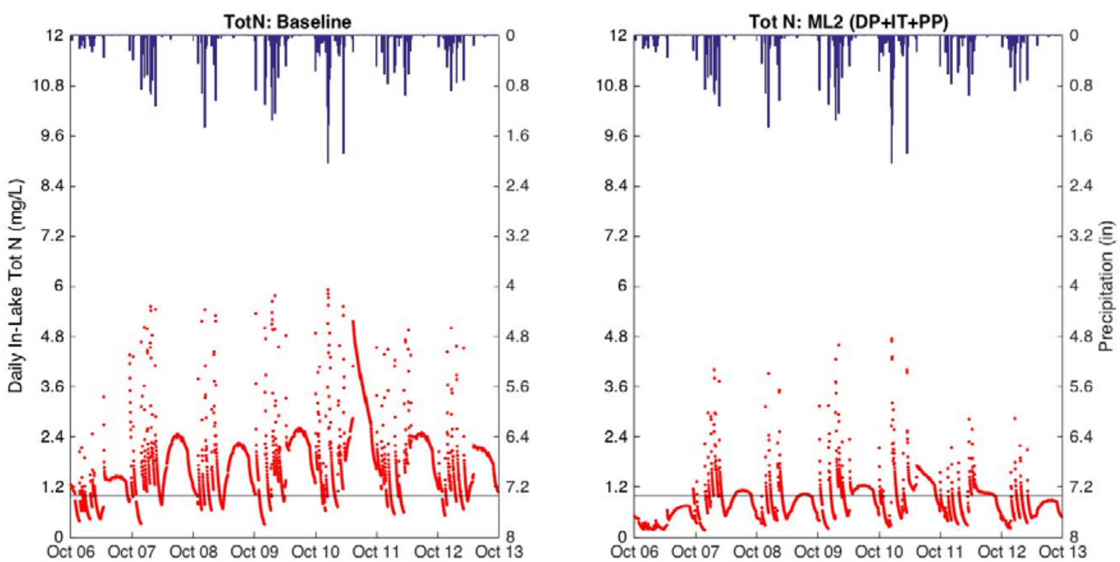


Figure 36: Boxplots showing the change in spread of in-lake concentration from the calibrated baseline (far left) with no BMPs to each of the simulated scenarios. ML-6 shows the concentration of external flows required to eliminate exceedances.



Caption on following page.

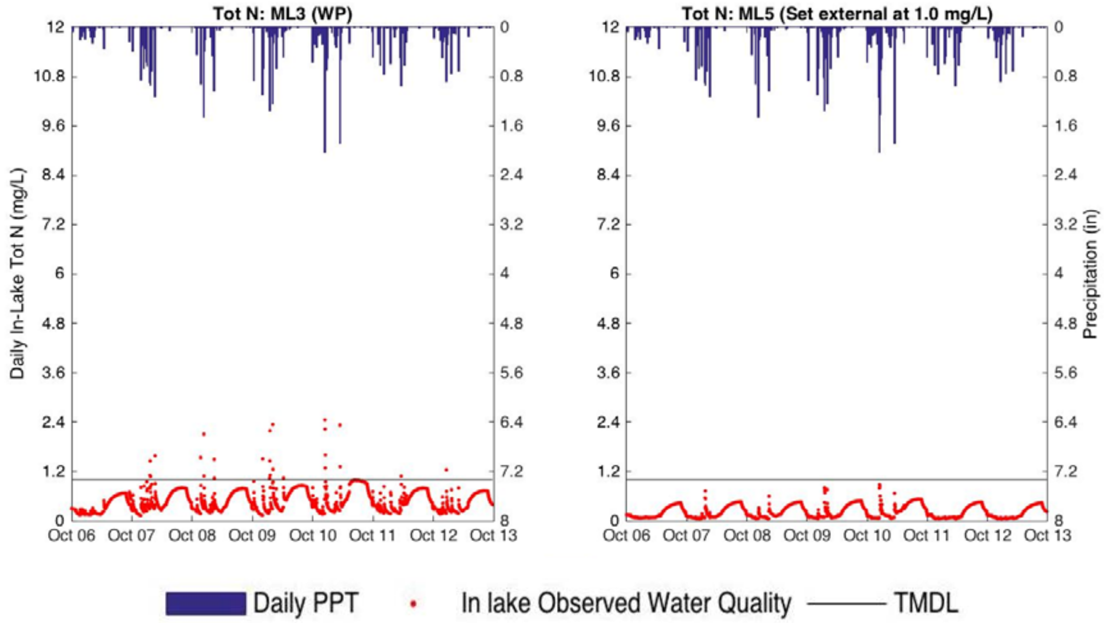


Figure 37. The red dots are daily in-lake TN concentrations based on combined modeling of SUSTAIN and SLAM. The black horizontal line is the TN TMDL and the blue bars on the top x-axis show daily precipitation. Upper left (a) is baseline, Upper right (b) is ML-2, Lower left (c) is ML-3, Lower right is (d) ML-5

Scenario BMPs	Baseline	ML-2 DP + IT + PP	ML-3 WP	ML-5 *
N - Modeled Months	84	84	84	84
TN External AAL % Reduction	-	62.7%	89.3%	-
TN WW External AAC (mg/L)	6.24	5.58	1.47	1
Months in Compliance (**TN**)	5	56	84	84
TN Compliance	6.0%	66.7%	100.0%	100.0%
TN monthly average concentration mg/L	1.8	0.87	0.48	0.22
TN Wet weather monthly average	1.5	0.78	0.34	0.12
TN Dry weather monthly average	2.15	0.99	0.64	0.32

* Scenarios were not run in SUSTAIN, thus no set suite of BMPs. However daily flow was taken from scenario ML-1 in order to determine daily external load based on set external AAC.

Table 33: Decision matrix for TN scenario results.

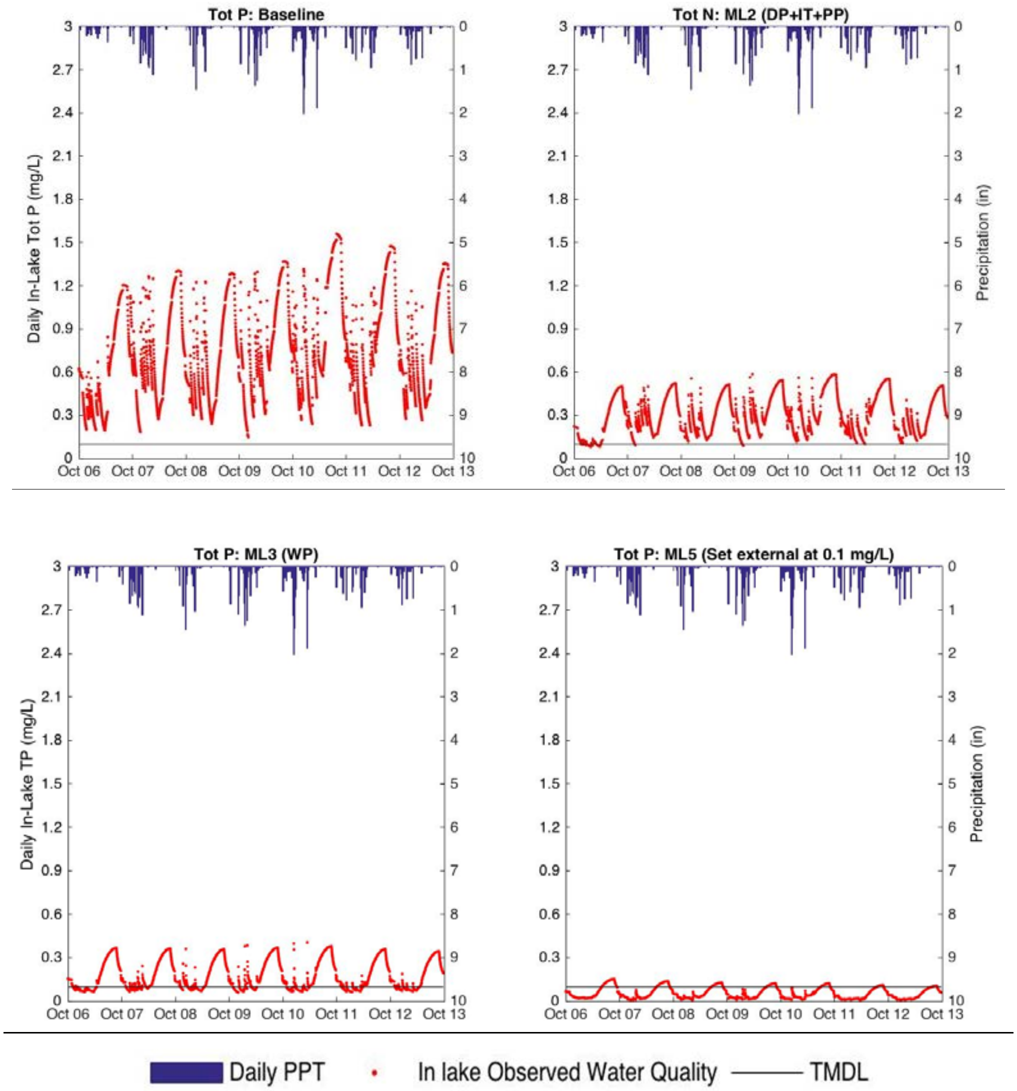


Figure 38. The red dots represent daily in-lake TP concentrations based on a combined modeling of SUSTAIN and SLAM. The black horizontal line represents the TP TMDL and the blue bars on the top x-axis show daily precipitation. Upper left (a) is baseline, Upper right (b) is ML-2, Lower left (c) is ML-3, Lower right is (d) ML-5

Scenario BMPs	Baseline	ML-2 DP + IT + PP	ML-3 WP	ML-5 *
N - Modeled Months	84	84	84	84
TP External AAL % Reduction	-	80.0%	90.0%	-
TP WW External AAC (mg/L)	1.35	0.65	0.29	0.1
Months in Compliance (**TP**)	0	2	29	67
TP Compliance	0.0%	2.4%	34.5%	79.8%
TP monthly average concentration mg/L	0.77	0.29	0.17	0.05
TP Wet weather monthly average	0.57	0.22	0.11	0.03
TP Dry weather monthly average	0.99	0.38	0.25	0.08

* Scenarios were not run in SUSTAIN, thus no set suite of BMPs. However daily flow was taken from scenario ML-1 in order to determine daily external load based on set external AAC.

Table 34: Decision matrix for TP scenario results.

As described above, Scenario ML-5 (with all external wet weather and baseflow concentrations set to the TMDL WLA of 0.1 mg/L) still only resulted in 67 out of 84 months meeting the TMDL requirements for TP. However, it is important to note that TP requirements were met in all wet weather months but not in the dry weather months (Figure 39), which indicates that setting the external loads to the WLA did result in ML concentrations at or below 0.1 mg/L in months with stormwater inputs to ML. However, this TP concentration was not sufficient to provide enough dilution to meet water quality standards in the dry months when there was little to no modeled input of stormwater to ML. Also, as set up in our model, the lake volume is still lower in summer (~180 AFY in dry months up to ~200 AF in wet months) resulting in less dilution of pollutants and a higher nutrient concentration in dry weather months.

Under these conditions, results from scenario ML-6 demonstrated that to eliminate TP exceedances in ML, all external wet weather and baseflow concentrations must be set at 0.025 mg/L (Figure 36). Setting the external EMCs to 0.025 mg/L is the first instance that the wet weather external flow is clean enough to keep the dry weather months lower than the TMDL. This is lower than results from the LWQMP, which found that the TMDL would be met for TP if external loadings are set to 0.1 mg/L.[198] The difference in modeling results may be due to differences in external flow and loading inputs between the approach of this report (based on results modeled in SUSTAIN) and the approach used in the LWQMP. The daily flow outputted from SUSTAIN was multiplied by the 0.1 mg/L to input the calculated daily loading of TP from SUSTAIN. Our approach using SUSTAIN and SLAM in concert provides the opportunity to better represent flows and loadings from the ML watershed into ML and simulate BMPs (and their effects on flows and loadings) throughout the watershed. The City plans to replace ML evaporative losses with advanced treated water from TIWRP in the summer months, which has a TP concentration of approximately 0.02 mg/L and can fulfill the dilution needs simulated by cleaner stormwater in our ML-6 scenario.

[198] Machado LWQMP 2014, p. 5-6, 5-7, 5-8.

Thus, modeling results demonstrate that in-lake nutrient pollution as determined by SLAM is mostly driven by the external loads entering the lake. In addition, the watershed to lake surface area ratio is 389:1 which is relatively high and makes eutrophic conditions more likely to occur. Therefore, BMP implementation throughout the watershed is needed to decrease the external loading coming into ML from the watershed enough to eliminate TN and TP exceedances in ML. It is, however, important to highlight again here that the data (in particular with regard to the flow entering ML) that informed this modeling effort and earlier City modeling efforts such as the Machado LWQMP and TAF is very limited. This need - stormdrain water quality and flow data, and post dredge and capping water quality data - must be addressed as the City and other jurisdictions move ahead with programs to improve water quality in ML and its watershed.

Newer data plugged into the aforementioned modeling approaches may lead to more optimistic predictions of ML water quality and compliance status. In addition, the recommended monitoring is needed to assess the efficacy of programs that have been implemented already in these waterbodies for achieving the expected water quality gains. The City's plans to implement a monitoring strategy at Machado Lake that includes a real-time monitoring system for flow into ML and automated samplers at P510, P77, and Wilmington Drain as well as monitoring efforts included in the DC CIMP will also provide data to inform future efforts.

E. Attaining ML Nutrient TMDL Targets

As described above, many water quality improvement projects are currently under construction to improve ML water quality, some of which include monitoring requirements. However, even with the implementation of BMP suites that can capture the 85^{th} percentile storm, compliance with the nutrients TMDLs, in particular TP, will be difficult. Modeling results in this study provide useful insights into the water quality impacts of these planned projects, but existing data gaps must be addressed and re-fed into models to gain a more accurate understanding of the actual impacts on water quality of these programs. Further, many factors can affect the real-time performance of these BMPs, including actual pollutant removal efficiency of the BMPs, the effectiveness of behavioral change efforts (e.g. not feeding birds), and changes in the environment. Climate change, with a potential associated increase in warmer weather, has the potential to exacerbate the conditions that increase the concentrations of nutrients in the water (e.g. increased evaporation rates that will lead to higher concentration of nutrients in the water or increased rates of algal growth in the lake that could lead to more frequent eutrophic conditions).

Much needs to be done to demonstrate that all potential point and non-point sources of nutrients have been addressed; implementing rigorous monitoring programs is a critical component of identifying whether these plans and programs are having the intended beneficial impacts on water quality. In this section we explore the mechanisms by which nutrients enter ML and identify a variety of steps to assess and attain ML water quality standards.

There are two main mechanisms by which nutrients enter the waters of ML. The first avenue is external loading, which mainly occurs through permitted urban runoff discharges from the subwatershed, and a small amount of nutrient loading from the park areas surrounding the lake. Average observed concentrations for nutrient runoff were found to be 2.89 mg/L (TN) and 0.71 mg/L (TP). The second avenue is internal loading, which occurs mainly through the release of phosphorous and nitrogen from lake sediments as changes in water chemistry occur (such as anoxic conditions), as well as from in-lake vegetation and wildlife.[199]

Further, nutrient loading stems from both point sources (MS4 permitted stormwater, Caltrans, general construction, and general industrial discharges) and non-point sources (sediment loading from storm drains, internal nutrient loading, atmospheric deposition, birds, vegetation, wind re-suspension, bioturbation, and surface runoff from surrounding park).[200] Large properties adjacent to ML include the Harbor Park Golf Course, a Kaiser Permanente facility, and a Conoco-Phillips Oil Refinery. Both point and non-point pollution sources that are negatively impacting water quality must be fully controlled and remediated as part of achieving compliance with water quality standards in ML.

It may be possible to demonstrate that all non-point sources have been addressed to the maximum extent practicable through a combination of modeling and monitoring efforts. ML has high sedimentation rates, ranging between 0.6" and 2.1" per year in different parts of the lake, based on the dating of sediment core samples.[201] Extensive sampling would be required to ensure that these incoming sediment loads are either clean enough to no longer be a source of internal pollutant loading or are removed from the lake rapidly enough that impacts on water quality from the input of contaminated sediment deposition are minimal. Similarly, modeling and monitoring would be required to show that either the dredged lake depth is sufficiently deep to prevent the wind re-suspension of sediment particles or that the lake bottom sediments are clean enough that sediment resuspension will not contribute to water quality exceedances.

Atmospheric deposition is an additional non-point source that occurs in two ways: 1) deposition on the overall watershed that is then washed in to the lake; and 2) direct deposition onto the lake's surface. The first source of atmospheric deposition would be addressed if the WLAs have been met as those pollutants would be included in the watershed runoff that was cleaned up to meet the WLAs. The second source, direct deposition, is much smaller, estimated to be roughly 220 kg TN / year.[202] Monthly volumes in ML before dredging ranged between 92 and 125 AF. Assuming that this annual deposition occurs evenly throughout the year, monthly deposition is approximately 18 kg per month. Therefore, monthly concentrations of nitrogen resulting from direct deposition would range between 0.12 and 0.16 mg/L, which is 12 to 16% of the TMDL limit of 1 mg/L.

However, the dredging activities conducted by the City at ML will mitigate the impact of atmospheric deposition on in-lake water quality. Since ML was dredged to a uniform depth of 6 feet and evaporative loss replacement with TIWRP AWPF water will soon occur, ML will

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[199] CDM with Parsons, for LA City BoS and Dept of Recreation and Parks. (August 18, 2010) Machado Lake Nutrients TMDL Lake Water Quality Management Plan p. 1-8 (LWQMP)

[200] Machado LWQMP 2010 p. 1-11

[201] Machado LWQMP 2010 p. 1-3

[202] Machado Lake Nutrients TMDL. p. 46

be maintained at its full volume of 224 AF.[203] At this volume, the contribution to TN levels from aerial direct deposition will be reduced to approximately 0.07 mg/L (7% of TMDL limit), a marked improvement from pre-project levels. An additional slight decrease might result as the lake surface area post-project, 32 ac, is slightly smaller than that used in the TMDL analysis, 13.7 hectares (33.8 ac) and thus will provide slightly less surface area for TN deposition.[204]

Three additional non-point sources were discussed but not specifically quantified in the TMDL: the impacts of wildlife in the form of bioturbation of lake sediments, the presence of bird populations living in or near ML, and nonpoint source runoff from adjacent lands.[205] Fish, in particular bottom-feeding fish such as carp (the most frequently caught fish species in ML in more recent sampling events), can disturb lake sediments and release nutrients or toxics into the water through this disturbance.[206] Therefore, to demonstrate that this non-point source has been addressed, the City would need to monitor the sediment quality throughout the lake to show that even in the event of disturbance by bottom dwelling fish or benthic invertebrate bioturbators, the sediment is clean and thus will not contribute pollutants to the lake water. Further water quality and sediment monitoring also should be conducted to quantify the actual impacts of bioturbation on lake water quality.

Demonstrating that sufficient pollution stemming from birds has been addressed is complex, as one of the potential (and desired) benefits of improving the water quality and habitat at ML and in its surrounding environs is an increase in use by local native or migratory bird populations. This is a positive result and should not be an obstacle to meeting water quality standards. Thus, one potential method to manage the pollutant contribution from the relevant bird population is to put in place all possible measures to decrease nuisance bird populations such as seagulls, domestic waterfowl, and pigeons. The most critical piece to control nuisance bird populations is managing human behavior to minimize food sources for these bird populations. These behaviors include active feeding (e.g. taking leftover bread down to the lake to feed the birds) and unintentional attractive nuisances (e.g., food-rich trash in open trash cans or on the ground).

Ensuring all trash cans are lidded will also help decrease these populations by removing a constant food source, as will posting signage and enforcing prohibitions to discourage the feeding of these birds as well as geese and ducks that are present in ML. Additional options to scare birds away include noise makers, balloons, streamers, and bird barriers (fencing or wires in the sky) to prevent birds from landing in certain areas, birth control measures to limit non-native bird population growth, and many others. However, care would need to be taken with these approaches to ensure that non-nuisance migratory or local birds are not also driven away

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[203] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-6

[204] Lake volume post-project: CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-6; lake volume pre project: staff report form the Machado Lake Nutrient TMDL, p. 45 of the staff report. Annual mean total N dry deposition in DC Watershed is 44g /ha/day based on "Nitrogen deposition on coastal watersheds in the LA region, SCCWRP research project ann report (2003) p73-81. Lake surface area 13.7 ha.

[205] Machado Lake Nutrients TMDL. p. 44, 45

[206] Machado Lake Nutrients TMDL. p. 44

from the habitat. The best results will likely stem from a variety of techniques that are varied over time as birds tend to adapt to these tactics and these techniques can lose efficacy over time. Monitoring of the quantity and types of birds present in the area would be required to ensure that bird populations, and their nutrient contribution, are being controlled to the maximum extent practicable. Further, pet waste must be immediately picked up and properly disposed of in a lidded container.

The final non-point source which would need to be controlled is the runoff from adjacent land uses (e.g. the Ken Malloy Harbor Regional Park and the Harbor Golf Course) which can contain nutrients from bird feces and fertilizers among other, smaller, potential sources. Nutrient loads present on these landscapes as a result of bird populations could be addressed by measures described above; nutrient loads from fertilizing could be addressed by ensuring the minimum required amount of fertilizer is applied at the times least likely to be washed into the lake, and other management practices. All landscape maintenance at the golf course and adjacent park must be timed and managed in a manner that minimizes or prevents excessive nutrients or pesticides from being washed off into the lake either during storms or as a result of over-watering. The use of fertilizers on adjacent land areas should be banned from October to April and kept to a minimum the rest of the year. In areas where runoff goes from the golf course to ML, there should be berms and swales on the course along the water's edge to eliminate sheet flow into the lake.

Controlling irrigation to prevent nuisance runoff into ML is another need. The BMPs planned in the Machado LWQMP (described in an earlier section), such as the SUSMP swale and cistern that will be installed at the golf course maintenance yard, will also mitigate this non-point source. Fully preventing stormwater and nuisance runoff during storm events or demonstrating through monitoring that no pollutants are being washed off adjacent land uses into ML may also be sufficient to demonstrate these non-point sources have been controlled.

As is also emphasized in the Machado LWQMP and TAF efforts, compliance in ML is only possible if all upstream permittees satisfy their WLA requirements. As defined by our modeling boundaries, the City is responsible for roughly 20% of the watershed within its jurisdiction, and the remainder of the sources fall under the jurisdiction of the many other permittees who are responsible for implementing their own path to attain water quality standards.[207] Eliminating TP exceedances was found to be especially challenging; our analysis found the elimination of TP exceedances only occurred when all flows entering ML were set to 0.025 mg/L (25% of the current TP WLA of 0.1 mg/L). Additional data, including that collected through the City's planned monitoring efforts, is necessary to confirm or modify the results in this modeling as the data available severely limited our ability to calibrate and validate the model using only ML-specific parameters (as described above, DC parameters were used in some cases).

Thus, sufficient data to identify whether nutrient levels in ML stem from sources within or outside of the City's jurisdiction is critical to attaining compliance in ML. To demonstrate that storm drain water quality is being met, outfall monitoring samples would need to consistently

[207] Machado LWQMP 2010 p. 5-7, CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-6

meet water quality requirements, which would likely be the result of all permittees in the watershed (with MS4 stormwater, Caltrans stormwater, general industrial stormwater, or general construction stormwater permits) meeting their own permit discharge requirements, including WLAs. In addition to the MS4 permittees, discharges from participants in other stormwater permitting programs, such as the general industrial program described above, will also impact in-lake water quality at ML and must be included in assessments of water quality compliance potential. At a minimum, the City and other upstream cities and permittees should meet quarterly or biannually to ensure that sufficient programs are in place to meet WLAs throughout the watershed. Ideally, the entire watershed would be managed under one EWMP that includes all permittees in the watershed (not only cities but also industrial permittees, etc).

EWMPs, WMPs, or any other form of implementation plan to meet water quality standards must include BMPs, compliance schedules, and sufficient monitoring to demonstrate both that water quality standards are being met and BMPs are performing at expected efficiencies. Further information on the success of modeled BMPs at achieving the expected water quality in the receiving waters is especially critical as watershed-scale modeling of various BMP implementation options has become an integral part of designing plans to meet water quality standards. If, however, the BMPs do not perform as expected once they are in place, the water quality standards may not be met as predicted through the modeling efforts.

Source reduction, tracking, and control of nutrients is vital for meeting in-lake WQS. To assess progress towards water quality goals and identify accurately any existing sources of pollutants that are consistent contributors of pollutants to this watershed, the City and other permittees should conduct a comprehensive, multi-year study to characterize water quality in both ML waters and all ML inputs. Monitoring nitrogen and phosphorus levels in ML prior to the implementation of the water quality improvement projects at ML and Wilmington Drain show that nutrient levels, in particular phosphorus, consistently exceed TMDLs.

Monitoring will confirm whether or not in-lake nutrient levels have dropped greatly after removing the contaminated sediments as an in-lake source. As described above, the DC CIMP includes monitoring to collect additional data to assess these impacts. It may be that nutrient concentrations stem in large part from the historical contamination of the sediments in the lake. Monitoring data could help the City assess how much nutrient levels have dropped as a result of the contaminated sediment removal and capping efforts. If levels are still high or show similar seasonal patterns, monitoring efforts to identify the source of these pollutants should be conducted. Increasing and enforcing legal requirements to implement additional LID practices across all land uses in the watershed would also assist with this effort.

This intensive monitoring study should include grab samples to assess in lake and in storm drain water quality and flow measurements of the inputs to fully assess the impacts of the water quality improvement projects and upstream source reduction efforts. The monitoring data will enable more accurate modeling of BMP performance changes over time and predicted resultant improvements in runoff and lake water quality. In addition, this monitoring study will provide critical information on nutrient sources in the lake and throughout the watershed. For example, TP levels in the lake before implementing the water quality improvement projects were unusually high for urban runoff. Intensive studies of all inputs to the lake will provide additional information on potential sources that remain above ML TMDL limits. The City's planned monitoring efforts at ML described earlier will also help provide additional data.

This study should also include an assessment of what specific levels of nitrogen in ML waters cause or contribute to algal blooms and, thus, what concentrations would still protect existing and potential beneficial uses. As discussed in the Machado LWQMP, while nitrogen and phosphorus are key nutrients for eutrophication, the relationship between these nutrients and actual algal blooms (measured by chlorophyll-*a*) can vary among lakes. One opportunity for reconsideration of the current water quality standards is already in the TMDL. If the numeric targets for both chlorophyll-*a* and dissolved oxygen are met in the lake, but those for nitrogen and phosphorus are not (or the reverse), then the TMDL may be reconsidered to adjust the allocations and targets.[208] The intent of the TMDL is to eliminate lake impairment due to eutrophication and the targets may either be too rigorous or lenient to achieve that objective.

After the implementation of the planned BMPs and additional mechanisms described above to address all point and non-point sources, the completion of a thorough ecosystem study, and the gathering of additional monitoring data to understand the impacts on water quality, the City could explore a study to determine whether the remaining pollutants are caused only by natural sources. The natural source exclusion approach and the reference system/antidegradation approach have been applied mainly for bacteria levels as natural sources of bacteria may exceed bacteria objectives even in undeveloped areas. The reference system/antidegradation approach requires that "bacteriological water quality is at least as good as that of a natural (reference) system, and that no degradation of existing water quality is allowed, where it is better than the natural system.[209]" The next approach, natural source exclusion, "requires the control of all anthropogenic sources of bacteria and identification and quantification of natural sources of bacteria. The exceedances are allowed based on residual exceedances of natural sources.[210]"

If permittees can demonstrate that all sources discharging to the lake are in compliance with WLAs and LAs, then ML may be eligible for a natural source exclusion. It is important to note, however, that no such approach for nutrients is currently outlined or allowable in the LA Basin Plan as it is for bacteria. Specifically, all man-made or augmented sources must meet load allocations, and levels of dissolved oxygen (DO) and chlorophyll-a must meet targets. Further, it is critical to monitor ecosystem health over time to ensure conditions are improving. Biodiversity and ecosystem health would need to improve over time (for example, as verified through measuring system biodiversity and other biological indices two to four times per year during different seasons). However, given ML is an urban lake with stocked fish populations, establishing appropriate, site-specific, and attainable biodiversity and ecosystem health objectives is needed. If all of the above are true, and all point sources and non-point sources have been eliminated to the maximum extent practicable through the options

[208] Machado LWQMP 2010 p. 5-11

[209] Informational Document: Public Scoping Meeting for Proposed Statewide Water Contact Recreation Bacteria Objectives Amendments To Water Quality Control Plans For Inland Surface Waters, Enclosed Bays And Estuaries And The Ocean Waters Of California. State Water Resources Control Board. P.6 January 7, 2015

[210] Same as above, P.6 January 7, 2015

discussed above or other implementation methods with the same end result, it may be possible to demonstrate that all remaining ML pollutant load is due solely to natural sources.

IV. Wastewater and Recycled Water

A. Introduction

Watersheds and wastewater service areas are strongly linked together through flows of wastewater influent and effluent, treatment and supply of recycled water, and relationships to allow exchanges and sales of these different flows. These interrelationships offer huge opportunities to fully utilize recycled water within Los Angeles boundaries as the relationships span regions with differing supply and demand opportunities, but can also provide challenges in finding ways to work together and to overcome differences among chartered responsibilities, jurisdictions, agencies, and governances. The focus of this section will be on the opportunities and challenges that exist in the Harbor Service Area.

LADWP, in partnership with LASAN and BOE, created the RWMP in 2012 to guide and identify future recycled water efforts. The plan developed strategies for achieving and exceeding the recycled water target of 59,000 AFY by 2035, which was established in the 2010 UWMP. The two major strategies that came from the RWMP were the development of a groundwater basin replenishment program with indirect potable water reuse and the expansion of the existing non-potable reuse (NPR) systems. However, additional goals with timelines and targets that surpass some of those in the RWMP were established in the 2014 Mayor's Executive Directive 5 (ED5) and the 2015 Los Angeles Sustainable City pLAn (pLAn). For example, the pLAn requires expanding recycled water production by at least 6 MGD by 2017 at the TIWRP, developing a strategy to convert the City's lakes to recycled water, and expanding recycled water production, treatment, and distribution to include indirect potable reuse and direct potable reuse.[211] ED5 also required a plan to convert 85% of public golf courses to recycled water, which was included as a goal in the pLAn.

LADWP recycled water use is projected to reach 46,540 AFY by 2020 and increase to 102,140 AFY by 2040. This is planned by achieving 19,800 AFY of planned municipal/industrial use by 2020 and increasing this use to 45,400 AFY by 2040. LADWP further expects a constant use of 30,000 AFY of groundwater replenishment by FY 2024/25 through 2040 and a constant environmental reuse, e.g. to maintain water levels in lakes, rate of 26,740 AFY.[212]

[211] City of LA's pLAn, Environment section, p.20, 21

[212] Draft LADWP UWMP 2015 Exhibit 4O p.4-27

B. Terminal Island Water Reclamation Plant

TIWRP is designed to treat an average daily flow of 30 MGD and a peak flow of 50 MGD through tertiary treatment.[213] Currently, TIWRP treats an average flow of 14.5 MGD.[214] TIWRP currently has the capacity to produce five MGD of MFRO quality water through its AWPF, but has plans to expand capacity to treat the entire flow volume to comply with permit requirements by 2017.[215] The first phase of the AWPF was completed in 2002 and has produced and delivered MFRO treated recycled water to the Dominguez Gap Barrier (DGB) since February 2006. The current treatment train includes microfiltration, reverse osmosis, and chlorine disinfection with breakpoint chlorination; the plant treatment will include all of the above with the addition of advanced oxidation process subsequent to reverse osmosis.[216]

Until recently, approximately 5 MGD of flow was treated at the TIWRP Advanced Water Purification Facility (AWPF); the remainder of the tertiary effluent was discharged to the LA Outer Harbor. AWPF capacity was expanded to treat the entire flow at TIWRP and produce 12 MGD of advanced treated recycled water in early 2017.[217] As a result of this expansion, only brine and residuals from water reclamation at the plant will continue to be discharged into the harbor through the existing outfall. As outlined in LARWQCB Resolution 94-009, the final phase (3) is defined as achieving total reuse by 2020.[218]

The current demand for recycled water in the Harbor Area stands at 6,080 AFY (5.47 MGD). The majority of this water (6,000 AFY / 5.4 MGD) is used for groundwater injection at the DGB to prevent seawater intrusion and the remainder (80 AFY/0.07 MGD) is used for industrial purposes at the Harbor Generation Station.[219] Previously, under the WDR and water recycling requirements (WRR) set by the LARWQCB (R4-2003-0134-A03), the total volume of recycled water that can be recharged at the DGB is limited to 6 MGD and 50% of the total injected water.[220] This percentage has recently been increased to 100% of the total injected

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[213] RWMP, LASAN and DWP, March 2012, Terminal Island Water Reclamation Plant Barrier Supplement and Non-Potable Reuse Concepts Report. P. 2-1

[214] TIWRP AWPF DGB Engineering Report (August 2015) p.1-1

[215] Recycled Water Implementation Strategy Study (April 2014) Prepared by MWH for the City of Los Angeles Bureau of Sanitation and Department of Water and Power. P. 2-2.

[216] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P 1-3

[217] https://www.lacitysan.org/san/faces/wcnav_externalId/s-lsh-sp-awpf-ep?_adf.ctrl-state=ljtyw8si3_4&_afrLoop=16304453241277602#!; http://www.tellmeladwp.com/go/doc/1475/2915446/

[218] TIWRP AWPF DGB Engineering Report (August 2015) p. 1-2

[219] Recycled Water Implementation Strategy Study (April 2014) Prepared by MWH for the City of Los Angeles Bureau of Sanitation and Department of Water and Power. P. 2-4. (LADWP & LASAN RW Implementation Strategy Study 2014)

[220] Order No. R4-2003-0134-A03 (File No. 97-208) Amending Waste Discharge Requirements and Water Recycling Requirements for Harbor Water Recycling Project, Dominguez Gap Barrier Project P. 6

water, which will result in additional recycled water demand. TIWRP AWPF water is projected to replace imported water at DGB by WY 2018-19, resulting in approximately 7,500 AFY (~7MGD) of recycled water demand.[221]

Twelve projects in the Harbor Service Area are planned to be online by FY 2025/2026 that represent a demand of 12,820 AFY, including 140 AFY to replenish ML evaporative losses beginning in 2017.[222] The largest estimated demand, 6,100 AFY, stems from the West Basin Carson RW Pipeline or Alternative. Other planned projects include two expansions at the DGB (2,500 AFY), Harbor Industrial Onsite Improvements (2,360 AFY), Harbor Refineries Pipeline Project (1,000 AFY), ML Pipeline Project (340 AFY), Roosevelt Memorial Park Water Recycling Project (90 AFY), the San Pedro Waterfront Port of LA (140 AFY), and the Harbor Recycled Water Tank (50 AFY).[223]

Further, sufficient future potential demand in this area has been identified to fully utilize the potential supply of MFRO water that could be generated from TIWRP if sufficient advanced water treatment capacity was installed to treat the design flow of TIWRP, 30 MGD. Potential uses of this recycled water include industrial use at several additional facilities, irrigation at various locations within the Harbor, and makeup water to replace evaporative losses at ML (as described above). Together, these potential uses comprise a future demand in this area of 27,495 AFY (24.75 MGD).[224] To maximize long-term recycled water use in the Harbor Area, LADWP is investigating full expansions of Leo Van Der Lans Advanced Water Treatment Facility and Burbank WRP to utilize the 2,000 AFY and 6,000 AFY respectively of excess supply that is generated in the winter season.[225] These expansion efforts would also require the addition of new pipeline connections to the existing recycled water system.

TIWRP is faced with a very different set of circumstances than Hyperion Water Reclamation Plant (HWRP). Where HWRP has an ample supply of wastewater to treat but limited local demand on which to use it, TIWRP has more potential future local demand than can be met by the current flow volumes being treated at TIWRP. A 2014 report for the City identified various scenarios by which additional flow could be sent to TIWRP to meet the potential demand. Two scenarios rose to the top in that report based on weighted evaluation criteria including cost-effectiveness, recycled water use goals, environmental sustainability, public policy and institutional issues, flexibility and adaptability, and ease of implementation.[226] The first option described in that report consisted of producing 70 MGD of NDN MBR secondary effluent at HWRP for additional treatment at the Edward C. Little Water Recycling Facility (ELWRF). The second option outlined was transferring secondary effluent from Joint Water

[221] WRD WCBCB SNMP p. 26 February 12, 2015

[222] Draft LADWP UWMP 2015 Exhibit 4P p.4-27, p. 4-28

[223]Draft LADWP UWMP 2015 Exhibit 4Q p.4-29

[224] LADWP & LASAN RW Implementation Strategy Study 2014 P. 2-4

[225] Draft LADWP UWMP 2015 p.4-33

[226] LADWP & LASAN RW Implementation Strategy Study 2014 P. 5-2

Pollution Control Plant (JWPCP) to TIWRP. Under this scenario, 54 MGD of HWRP secondary effluent would be delivered to ELWRF for treatment and distribution to its customers. The additional 16 MGD of flow required to maximize recycled water reuse at TIWRP would come in the form of secondary effluent from JWPCP rather than Title 22 water from ELWRF.[227]

C. Regulatory Requirements

Currently, a combination of tertiary-treated effluent, AWPF permeate, and AWPF brine are discharged into the Los Angeles Harbor through outfall 001. TIWRP must meet the Waste Discharge Requirements (WDR) in Order No. R4-2015-0119 as amended by Order No. R4-2015-0119-A01 (also serves as NPDES NO. CA0053856) for effluent discharged through outfall 001. The current permit was adopted on June 11, 2015, amended on October 8, 2015, became effective on December 1, 2015, and will expire on July 31, 2020.[228] Under this order, TIWRP is generally prohibited from discharging treated municipal wastewater to the outer harbor by 2020 with the exception of brine waste. Occasional discharge of tertiary treated municipal wastewater is also permitted under certain conditions such as emergency situations, fluctuations in recycled water demand, and maintenance. After 2020, records of all such discharges must be reported monthly.[229]

It is important to note that the current NPDES permit at TIWRP allows the disposal of brine waste from advanced treatment processes and occasional discharge of tertiary treated municipal wastewater under certain conditions as an exception to the Water Quality Control Policy for the Enclosed Bays and Estuaries of California (EBE Policy). By allowing discharge of MFRO brine and residuals into the Harbor rather than requiring the construction of a longer outfall to discharge effluent beyond the enclosed Harbor, the permit requirements incentivize the maximum reuse of TIWRP wastewater. However, the EBE Policy does require all discharges of municipal wastewater into these waterbodies to end at the earliest possible date. The City should continue to explore additional opportunities to end all discharge into the Harbor in the event that the terms of the current WDR / NPDES permit change to disallow this exception. Some opportunities include diverting the brine and residuals to a coastal plant such as HWRP or JWPCP (as long as the additional brine would not result in exceedances of the existing permit requirements at those plants) or exploring additional advanced treatment trains that may have reduced brine stream flows.

In addition to the requirements of the EBE Policy and TIWRP WDR and NPDES permits which protect water quality near its outfall located in the Los Angeles Harbor portion of San Pedro Bay, recycled water reuse in CA is governed under WRR. TIWRP has two WRR permits, one for injection into DGB and one for other NPR uses of the advanced treated water.

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[227] LADWP & LASAN RW Implementation Strategy Study 2014 P. 3-24

[228] Waste Discharge Requirements for the city of Los Angeles Terminal Island Water Reclamation Plant Los Angeles County Discharge to Los Angeles Outer Harbor Via Outfall 001. RWQCB. Adopted: 06/11/15, amended 10/08/15. Cover page

[229] Waste Discharge Requirements for the city of Los Angeles Terminal Island Water Reclamation Plant Los Angeles County Discharge to Los Angeles Outer Harbor Via Outfall 001. RWQCB. Adopted: 06/11/15, amended 10/08/15. P. 5

Specifically, TIWRP AWPF water for DGB is regulated under RWQCB Order No. R4-2003-0134-A03 and other NPR uses are regulated under Order No. R4-2003-0025 as amended by Order No. R4-2011-0033.[230]

Current plans to improve and maintain ML water quality at a level that is in compliance with water quality objectives by replacing evaporative losses from ML with TIWRP AWPF water bring additional regulatory requirements for TIWRP. ML is subject to TMDLs in which TIWRP does not currently have a WLA. Therefore, TIWRP AWPF water discharged to ML will need to comply with both the regulatory requirements for intended NPR uses and injection into DGB and the strict water quality objectives for ML.

First, TIWRP will need to request amendments to its existing NPDES permit to add an additional outfall for the discharge of advanced treated recycled water to ML. Permit amendments could also include expanding the definition of TIWRP to include the AWPF and adding the regulatory requirements associated with meeting WQS in ML.[231] Other general permit considerations the RWQCB could assess during the amendment process include identifying the beneficial uses, any antidegradation impacts, effluent and / or receiving water limitations for the additional outfall, whether mixing zones are necessary or appropriate, additional monitoring efforts for toxicity, effluent, or receiving water, and / or any additional special studies to determine the potential impacts of this new discharge.[232]

Second, to issue a permit for a new discharge (like the additional outfall), regulatory requirements apply to ensure that any discharges into ML meet the in-lake water quality objectives. All point and nonpoint sources contributing to an impaired water body such as ML need to be incorporated into the associated TMDLs (ML Toxics, ML Nutrients, and Harbors Toxics in this case)[233] to ensure that the requirements imposed by the TMDL account for all potential pollutant sources and, thus, are sufficient to attain water quality standards. As TIWRP has not previously been contributing water of any kind to ML, TIWRP is not currently included as a WLA under any of the ML TMDLs.

A variety of potential scenarios exist with regard to the Harbor Toxics TMDL, including whether or not the waters flowing from ML will have the potential to affect loadings in the Inner Harbor and if this flow could then be included in the WLAs for the MS4 jurisdictions or

[230] TIWRP AWPF DGB Engineering Report (August 2015) p. 1-1

[231] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 5 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[232] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 7 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[233] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 10 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

would require a separate WLA.[234] Current LASAN plans will limit the replacement of water to the ML evaporative losses (~140 AFY), which will not result in overflow to the Harbor during dry weather conditions and thus won't impact Harbor water quality conditions. Limiting the flows to evaporative loss replacement also eliminates the potential need to conduct a biological assessment of the effects of increased overflows through the wetlands on the vegetation and / or to reopen the CEQA studies to assess these changes.[235] The ML Toxics TMDL WLAs include allocations for other non-stormwater discharges, so as long as AWPF water meets the suspended solids concentration effluent limit, discharge of AWPF water appears relatively straightforward under this TMDL as written.[236]

The Nutrients TMDL does not include any additional WLAs except for MS4 dischargers, and so there is the potential that an additional WLA will need to be added to this TMDL. Ensuring that TMDL requirements for total nitrogen, ammonia, and phosphorus are met in the TIWRP AWPF water may be sufficient to allow discharge without re-opening the TMDL to add an additional WLA for TIWRP. With the currently planned treatment trains, the AWPF water is projected to be within the acceptable range of concentrations for these constituents. There is a reopener period to discuss potential changes to the Nutrients TMDL that began in September 2016.[237]

To discharge into ML without a TMDL WLA, TIWRP AWPF water must meet the TMDL water quality objectives for all constituents present in the recycled water for which there is a listed receiving water impairment (Table 35). The planned treatment train for the TIWRP AWPF expansion, which includes Advanced Oxidation Processes (AOP), is expected to result in water that meets these requirements; TN levels are projected to be as low as 0.3 mg/L.[238] The concentrations for total phosphorus are well within these requirements; the expected concentration of Total Phosphorus as TP in TIWRP AWPF water is 0.02 mg / L.[239] Additional processes to remove nitrogen, including breakpoint chlorination, additional denitrification, ion exchange, or more frequent replacement of the RO membranes, were identified as necessary

[234] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 16 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[235] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 5-4, 5-5, 5-17

[236] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 16 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[237] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 17 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[238] LASAN, personal communication. Nitrogen Compounds Profile at AWPF, and the Average Nitrogen Compound Concentrations tables provided by TIWRP in August 2016.

[239] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 23 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

in an earlier study to assess the possibility of adding TIWRP AWPF water to ML [240] as projected levels of TN at TIWRP were projected to be 1 mg /L with the addition of new RO membranes (or greater as membranes aged).[241] However, as described above, current studies show that much better effluent quality for nutrients will be achieved (Table 36).

	Numeric Target (ML TMDL)	TIWRP WDR / WRR	LARWQCB Basin Plan – inland surface waters[242]
Total Phosphorus	0.1 mg/L monthly average		
Total Nitrogen (TKN + NO_3-N+NO_2-N)	1.0 mg/L monthly average	5.0 mg/L	
NO_3-N+NO_2-N	NA		
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		
Chorophyll-*a*	20 µg/L monthly average		
Chlorine, total residual			0.1 mg / L

Table 35. ML Water Quality Objectives and Numeric Targets[243]

	Total N (mg / L)	NH3-N	Phosphorus
Post Treatment Train Updates	0.3	<0.05	0.02

Table 36. Projected TIWRP AWPF water quality after new treatment trains including AOP

The presence of chlorine in the AWPF water poses an additional treatment requirement to meet in-lake water quality standards as chlorine levels in the AWPF water must be low enough at the discharge point to maintain compliance with LARWQCB Basin Plan aquatic life protection requirements for total residual chlorine in inland surface waters such as ML (0.1 mg / L).[244] It is not possible to de-chlorinate at TIWRP because some chlorine residual is required

[240] Attachment B "Estimated Average Total Nitrogen Concentration of Purified Recycled Water with Ultraviolet Light Disinfection and Advanced Oxidation (UV/AOP) p B-1 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.,

[241] Attachment C "Regulatory Assessment of TIWRP Recycled Water Opportunity for Machado Lake (Nov 2012) p 24 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015; Attachment B "Estimated Average Total Nitrogen Concentration of Purified Recycled Water with Ultraviolet Light Disinfection and Advanced Oxidation (UV/AOP) p B-1 in CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[242] LARWQCB BASIN PLAN, Regional Objectives for Inland Surface Waters, WATER QUALITY OBJECTIVES – MAY 2, 2013 p. 3-25

[243] Attachment A to resolution No. R08-006, p.3

[244] LARWQCB BASIN PLAN, Regional Objectives for Inland Surface Waters, WATER QUALITY OBJECTIVES – MAY 2, 2013 p. 3-25

in the distribution system to inject AWPF water into DGB.[245] There are a couple of options to bring potential levels of residual chlorine down to acceptable levels before the AWPF water enters ML, including the addition of a dechlorination facility at which a chemical such as sodium bisulfate could be added for dechlorination or mixing the AWPF water with a sidestream of lake water before adding the blended waters to the lake.[246] While installing a dechlorination facility will ensure that chlorine water quality standards will be met, there are additional costs of constructing, maintaining, storing chemicals, and securing a dechlorination facility near the outfall to ML, which is publically-frequented areas.

Thus, the City's preferred alternative at the time of this writing is to dechlorinate the AWPF water through mixing with a sidestream of ML water prior to discharge into ML. In addition to eliminating the need to store chemicals and maintain a facility at ML, the blending process would provide the additional benefit of reducing the bacterial and algal concentrations in the blended water with the residual chlorine concentration.[247] A recent study for the City identified two opportunities through which to conduct this blending under the current design, in which AWPF water discharges into the Project No. 510/77 bioswales. One is adding AWPF water to oxygenation system pumps for blending with ML recycled water that is pumped through the speece cone. The other is adding AWPF water to the Project No. 510/77 bioswales and/or a storm drain for mixing with stormwater/urban runoff prior to discharge into ML.[248]

V. Groundwater

A. Introduction

Groundwater throughout California is a critical resource that provides water supply resiliency for the state's variable climate. As discussed in our previous report on the Ballona Creek Watershed, available storage capacity in WCB and CB (WCBCB) creates an opportunity to increase the infiltration of tertiary treated recycled water, full advanced treated recycled water, or captured stormwater into WCB and CB, thereby increasing the potable water supply from those basins. In this section, we discuss in greater detail potential scenarios to maximize the conjunctive use of WCB and CB, some of which were initially identified in the Ballona Creek Watershed report.[249]

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[245] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 2-3

[246] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 2-3

[247] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 2-3

[248] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 2-3

[249] UCLA CSM Ballona Creek Report 2015, *Available at:* http://grandchallenges.ucla.edu/happenings/2015/11/13/100-local-water-for-la-county/

B. Fully Utilizing Existing Groundwater Pumping Rights

While the majority of the City's water rights, and hence, focus on groundwater production, are in the ULARA groundwater basins, the City has additional groundwater pumping rights in WCBCB that can contribute to local water supply. Amendments to the WCBCB adjudications in the past few years provide an opportunity for the City to store additional water in and extract more from WCBCB, in addition to their existing pumping rights. The City has 1,503 AF of adjudicated pumping rights in WCB and an allowed pumping allocation (APA) of 17,236 AFY in CB.[250]

The City does not currently have the capacity to extract the entirety of their pumping rights out of either WCB or CB but is undertaking projects that will increase their pumping capacity to enable the extraction of their full pumping rights. LADWP produces CB groundwater from the Manhattan and 99th Street well fields. In addition to their annual APA of 17,236 AFY, the City had 14,570[251] AF of allowable extraction going into FY 2015/2016, which is comprised of 6,020 AF of stored water (accrued through the new storage provisions), 3,300 AF of normal carryover, and 5,250 AF of drought carryover.[252] Over the most recent 5-year period, CB has provided as much as 15% of the City's local groundwater supply ranging from 5,099 AFY to 9,727 AFY through two wells.[253] At the Manhattan well field, 6 production wells were originally installed but only 2 active wells, with a capacity of 7.0 cfs, remain. Wells have been taken out of service due to TCE contamination and other mechanical deterioration issues; 4 replacement wells have been installed and test results have shown improved water quality. LADWP is implementing the Manhattan Wells Improvement Project (MWIP) to restore pumping capacity in CB.[254]

The MWIP aims to restore pumping capacity to allow the City to utilize its annual groundwater entitlement in CB. It is expected to reduce cost from imported water by $2 million/year.[255] The MWIP is comprised of the construction of two groundwater monitoring wells, up to 8 production wells, and related facility infrastructure (e.g. well collector and discharge lines).[256] The 99th Street well field has only 4 active wells remaining with a production capacity of 6.1 cfs.[257] While the 99th Street well field does not show industrial contamination

[250] LADWP UWMP 2015 p.6-2

[251] WRD, personal communication.

[252] Draft LADWP UWMP 2015 Exhibit 6B p.6-15

[253] Draft LADWP UWMP 2015 Exhibit 6B p.6-4

[254] Draft LADWP UWMP 2015 p.6-15, 6-16

[255] Draft LADWP UWMP 2015 p.6-15

[256] Draft LADWP UWMP 2015 p.6-16

[257] Draft LADWP UWMP 2015 p.6-11

above Maximum Contaminant Levels (MCLs), two naturally occurring constituents, manganese and iron, are present at levels which exceed secondary MCLs. These constituents affect taste, color, and odor and require treatment to comply with drinking water standards.[258]

To fully extract the City's pumping rights in CB, especially considering the potential to accrue storage rights, additional capacity for extraction will be needed. LADWP is evaluating possibilities to expand extraction capacity (early results indicate 5,000 to 15,000 AF of potential additional capacity) as well as construct two monitoring wells to evaluate hydrogeology, groundwater quality, and well performance.[259] None of the 1,503 AFY of pumping rights in WCB is currently being produced as LADWP discontinued operating the Lomita well fields in 1980 due to localized groundwater contamination issues and deterioration of water quality. While LADWP intends to study the feasibility and cost of restoring groundwater pumping in WCB, no projects are currently being carried out.[260]

In FY 2012-2013, a lower volume of water than the allowable extraction was pumped out of both WCB and CB, leaving approximately 95,000 AF of water in the ground that could have been used for water supply (Table 37). In addition to this unused balance, which may offer opportunities for rightsholders to trade water amongst themselves, most WCB and CB rightsholders can store up to 200% of their adjudicated pumping rights in the basins. WCB rightsholders may store up to 250% of their adjudicated pumping rights upon approval from the Watermaster. While there are some limitations on the exporting of water from CB, they do not apply to parties that are also supplying water elsewhere in the CB, nor do they apply to stored water that did not originate through carryover conversion.[261] Exchange pool water provides another opportunity for rightsholders to trade water in situations where the party who would like to pump more water out of CB would not otherwise be able to meet its estimated demands without undue hardship.[262]

[258] Draft LADWP UWMP 2015 p.6-15

[259] Draft LADWP UWMP 2015 p.6-16

[260] Draft LADWP UWMP 2015 p.6-15

[261] CB adjudication, p.17.

[262] CB adjudication, p.43

Basin	Party	Adjudicated Rights / APA	Allowable[263] Extraction	Amount Pumped	Unused Balance[264]
WCB	All parties	64,468.25	76,570.86	42,068.18	34,502
	City of LA	1,503	1,803.60	0	1,803
CB	All parties	217,367	259,508.82	196,261.73	61,067
	City of LA	15,000	23,250	6,310.08	16,939.92

Table 37. 2012-2013 pumping rights and pumping volumes in WCB and CB.

C. Available Dewatered Space

The recent amendments to the WCB and CB adjudications, in December 2014 and December 2013 respectively, provided additional opportunities to maximize the use of these groundwater basins beyond the volumes allowed by the extraction of existing pumping rights. The WCBCB amendments identified large volumes of available dewatered space that could be used to store and extract additional water in the basins; 120,000 AF and 330,000 AF of available dewatered space was identified in WCB and CB, respectively. Further, two general avenues by which parties can increase their recharge and extraction of groundwater utilizing this available space were identified in these amendments. The first avenue is through increasing the volume of water stored in the basin using storage rights and the second is through water augmentation projects to increase the sustainable yield of the basin over the long-term.

Multiple conditions must be in place to be able to increase the storage and extraction of water in adjudicated basins beyond the adjudicated rights. First, it is necessary to demonstrate that the recharged water is 'new' water that would not otherwise have made its way into the groundwater basin through natural processes (e.g., advanced treated wastewater that would otherwise have been discharged to the ocean would qualify where diverted stormwater which would have fallen on pervious surfaces such as parks above the groundwater basin may not). Second, that the recharged water is actually increasing the sustainable yield for that basin (e.g., that the water is reaching portions of the basin accessible for water supply), and, finally, that the relevant adjudications allow rightsholders to extract beyond their adjudicated rights if they are recharging additional water.

There may be additional opportunities to utilize larger storage rights potential through relationships which have been established between the City and other parties to these adjudications through the EWMPs. These relationships could potentially facilitate partnerships to increase the extraction and recharge of water into WCBCB through storage rights projects. For example, eight of the nine regional projects proposed in the DC EWMP are in WCB and several

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[263] Allowable extraction = adjudicated right + carryover + leases. Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. P. 11

[264] Balance left unused in WCB and CB FY 2012-2013 (includes adjudicated rights, carryover, and leased rights). Balance = Allowable extraction – amount pumped – in lieu. Watermaster Service in the West Coast Basin Los Angeles County. Department of Water Resources. July 1, 2012 to June 30, 2013. P. 11

members of the DC EWMP WMA, including LA County and the cities of Los Angeles, El Segundo, Hawthorne, Inglewood, and Lomita, have pumping rights in WCB. Together, these agencies have a total of approximately 10,600 AF of adjudicated rights in WCB (Table 38).[265] With the additional storage opportunities (up to 200%-250% of adjudicated rights) under the recent WCB amendments, these combined rights represent approximately 20,000 - 25,000 AF of extraction potential.

Agency	AFY	AFY (w/ up to 250% storage)
Carson	0	0
City of Los Angeles	1,503	3,757.5
County of Los Angeles[266]	466	1,165
El Segundo	953	2,382.5
Hawthorne	1,882	4,705
Inglewood	4,450	11,125
Lawndale	0	0
Lomita, City of Water System	1,352	3,380
Total	10,606	26,515

Table 38. Allowable Pumping Allocations in West Coast Basin among permittees in DC WMA EWMP.[267]

An additional opportunity for the City to both inject and extract additional volumes of groundwater in WCB and CB beyond utilizing storage rights lies in proposing and creating water augmentation projects in these basins. To increase opportunities to fully utilize the available dewatered space, amendments to both the WCB and CB adjudications also created a category of projects, water augmentation projects, intended to increase recharge into and extraction from these basins. Parties to the adjudications, including the City, can create water augmentation projects that would increase the long-term sustainable yield of the basin and allow participating parties to inject and then subsequently extract additional water on an annual basis.[268] The water added through water augmentation projects is intended to be extracted within the same year; both CB & WCB adjudications explicitly state 'because water made available for Water [Rights] Augmentation will be produced annually, fluctuations in groundwater levels will be temporary, minimal, and managed within the Basin Operating Reserve."[269] Importantly, the extraction of augmented water will not be charged a Replenishment Assessment Fee as the water injected by parties does not need to be replenished by WRD.[270] Please see

[265] Compiled from brief description in DC EWMP February 2016 and more detail from the adjudications.

[266] LA County APA: 363.70 AFY for LAC Recreation Facilities & 102 AFY for LAC Sanitation District 2. Exhibit A Adjudicated Rights for West Coast Basin amended adjudication.

[267] DC EWMP compiled APAs to discuss potential water supply benefits of injected stormwater. Rights and storage capacities from West Coast Basin adjudication.

[268] Central Basin Adjudication; Case of *California Water Service Company et al. v City of Compton et al.*, (1961, amended 2014) Los Angeles Superior Court No. 506806. (West Coast Basin adjudication)

[269] water rights augmentation in CB Adjudication, p. 67; water augmentation in WCB Adjudication, p. 20&21

[270] CB adjudication, p. 58

Appendix A for a more thorough discussion of Storage Rights and Water Augmentation Projects.

D. WRD Plans for WCBCB Replenishment

The Water Replenishment District (WRD) is the entity with the responsibility to ensure that WCBCB are managed for long-term sustainability both in terms of water quality and water supply. Along with monitoring groundwater quality and groundwater levels and fulfilling the requirements of being the WCBCB watermaster, WRD also provides replenishment water to keep groundwater at levels needed to ensure the protection of the groundwater basins. Currently, rightsholders do not extract their full allocation of pumping rights, so to increase pumping in WCBCB by rightsholders such as the City from the current rate to the full extraction of pumping rights or beyond as permitted under the amended adjudications, additional groundwater replenishment is also needed. From WY 2000 to 2009, rightsholders in WCB pumped an average of 37.5 MGD (42,000 AFY), approximately two-thirds of their 57.6 MGD (64,468 AFY) adjudicated rights.[271] During the same time frame, CB rightsholders also extracted groundwater at a volume below their adjudicated rights; groundwater was extracted at an average annual pumping rate of 174.1 MGD (195,500 AFY) as compared to the adjudicated limit of 194.1 MGD (217,367 AFY).[272]

WRD provides artificial replenishment to WCBCB to enhance natural recharge to a level that can support the current groundwater pumping rate. To facilitate pumping to the full adjudicated limits in WCBCB, WRD would be responsible for replenishing an additional 16.1 MGD (18,000 AFY) in WCB and 10.7 MGD (12,000 AFY) in CB.[273] ELWRF, TIWRP, and Leo J. Vander Lans Water Treatment Facility (LVLWTF) can currently provide up to 15.2 MGD (17,000 AFY), 7.1 MGD (8,000 AFY), and 5.4 MGD (6,000 AFY), respectively, of recycled water for artificial recharge.[274] While these water treatment facilities could provide an additional 4 MGD (4,500 AFY), WRD would also need to secure an additional 22.3 MGD (25,500 AFY) of replenishment water to extract the full WCBCB adjudication over the long-term.[275]

The Montebello Forebay Spreading Grounds (MFSG) is the most significant area of recharge in CB and includes the Rio Hondo Spreading Grounds and the San Gabriel River Spreading Grounds. The MFSG is located in the northeast section of CB and owned, operated, and maintained by the Los Angeles County Department of Public Works (LACDPW). The

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[271] Central and West Coast Basin Groundwater Basins Master Plan Draft Program Environmental Impact Report 2015 (CBWCB GBMP DPEIR) p. 3-2

[272] CBWCB GBMP DPEIR 2015 p. 3-2

[273] CBWCB GBMP DPEIR 2015 p. 3-4, footnote 1

[274] CBWCB GBMP DPEIR 2015 p. 3-4, footnote 1; WRD pers. comm.

[275] CBWCB GBMP DPEIR 2015 p. 3-4, footnote 1

MFSG is currently being recharged by a mix of tertiary-treated recycled water, untreated imported water, and stormwater.[276] The historical total recharge at the MFSG, calculated as a 10-year average from the baseline period WY 2000-01 to 2009-10 was found to be 118,028 AFY. The average recharge is greater than in WY 2014-2015, which had a recorded total recharge volume of 77,993 AF. This volume includes imported water, recycled water, and "local water."[277]

WRD is aggressively pursuing recharge of the groundwater basins they manage with 100% local water under their Water Independence Now (WIN) program. WRD's strategy to address the need for increased volumes of locally sourced water to recharge WCBCB to enable additional groundwater extraction includes the development and utilization of groundwater storage capacities and an increase in recycled water and stormwater recharge. In CB, the Los Angeles County Sanitation District's (LACSD) San Jose Creek Water Reclamation Plant (SJCWRP) is a potential source for increased recycled water supply. WRD's current implementation of GRIP is currently increasing recharge of SJCWRP effluent at the MFSG from 40,000 AFY to 61,000 AFY; future flows are assumed to mirror the existing production of 70 MGD (78,400 AFY) as both water conservation and population are expected to increase and thus, nearly all of SJCWRP's effluent is expected to be reused during summer months.[278]

Similarly, future flows at Los Coyotes WRP are expected to mirror the current flows of 26 MGD (29,120 AFY) and up to 12 MGD (13,441 AFY) is projected to be available for use.[279] An additional opportunity to produce high quality recycled water for injection into the LA Forebay is through the construction of a satellite AWTF. In WCB, potential water supplies from the JWPCP and TIWRP could provide up to 42.9 MGD (48,000 AFY) of recycled water for injection into the barrier projects or at proposed new injection wells.[280] This increased expansion could include 15,000 AFY of JWPCP effluent pumped to new inland injection wells. An additional 15,000 AFY, comprised of 2,000 AFY from JWPCP and 13,000 AFY from TIWRP, could go to increasing recharge at the DGBP.[281] The proposed injection wells could be located north of JWPCP and west of the 110 freeway, running north to south.[282] In CB, the San Gabriel River and Los Angeles River are potential sources of additional stormwater recharge. The San Gabriel River could produce an estimated average of 49.1 MGD (55,000 AFY) to replenish the MFSG.[283] This volume is based on the historical average of local runoff

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[276] Salt and Nutrient Management Plan for Central and West Coast Basin February 2015 p.24

[277] SNMP for Central and West Coast Basin 2015 Appendix H, Table H-1; Engineering Survey and Report 2016 Water Replenishment District of Southern California, Table A

[278] CBWCB GBMP 2016 p 3-20.

[279] CBWCB GBMP 2016 p. 3-21, 3-22

[280] CBWCB GBMP 2016 p. 5-2, Table 5.1 Alt WCB-B1

[281] CBWCB GBMP 2016 p. 5-2, Table 5.1 Alt WCB-B1

[282] CBWCB GBMP DPEIR 2015 p. 3-3, Figure 3-1

[283] CBWCB GBMP DPEIR 2015 p. 3-9

between 1999-2009 as reported in LACDPW hydrologic reports and DWR watermaster reports.[284]

Potential replenishment projects and management strategies to supply enough basin recharge to meet full pumping rights (Concept A) as well as to supply enough basin recharge to allow rights holders such as the City to take advantage of the most recent 2013 and 2014 amendments that permit stakeholders to recharge and extract a volume above the adjudicated limits (Concept B), are described in the draft PEIR for the WRD WCBCB GBMP.[285] Concept B projects and strategies identified by WRD in this master plan would facilitate the extraction in WCB of an additional 26.8 MGD (30,000 AFY) on top of its 57.6 MGD (64,468 AFY) adjudication and an additional 92.2 MGD (103,250 AFY) in CB on top of its 194.1 MGD (217,367 AFY) adjudication.[286] Proposed projects that involve the City will be described briefly in this section; please see Appendix A for a more detailed description of WRD's Concepts A and B.

The following management strategies and projects work toward the goal of Concept A in WCB to additively provide enough local replenishment water to enable complete extraction of the full adjudicated rights volume. WRD needs to recharge an additional 16.1 MGD (18,000 AFY) to facilitate the sustainable extraction of the complete adjudication of 57.6 MGD (64,468 AFY).[287] Water used for injection at the barrier projects has historically been a combination of recycled water and imported water. The RWCs, however, at West Coast Basin Barrier Project (WCBBP) and the Dominguez Gap Barrier Project (DGBP) have recently been increased from a 50 percent recycled water contribution (RWC) to a 100 percent RWC. Therefore, up to 15.2 MGD (17,000 AFY) from the ELWRF could be injected at WCBBP; DGBP is anticipated to inject 4.5 MGD (5,000 AFY) of recycled water.[288]

TIWRP is currently undergoing onsite expansion. After construction of the AWTF and pipeline, TIWRP will be able to produce an additional 4.5 MGD (5,000 AFY) of advanced treated recycled water for injection at the DGBP.[289] The ELWRF could also produce an additional 13.4 MGD (15,500 AFY) of recycled water for injection at WCBBP. However, this would require a 13.8 MGD (15,456 AFY) capacity increase either on existing facility property or on adjacent property. This plan would also necessitate the construction of two pipelines, one from HWRP to ELWRF to convey the necessary additional source water and another one to increase the capacity of conveyance from ELWRF to the WCBBP injection wells.[290]

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[284] WRD Groundwater Reliability Improvement Project Alternatives Analysis Final Report 2011 p. 20

[285] CBWCB GBMP DPEIR 2015 p. 3-7

[286] CBWCB GBMP DPEIR 2015 p. 3-7

[287] CBWCB GBMP DPEIR 2015 p. 3-7

[288] CBWCB GBMP DPEIR 2015 p. 3-12 and p. 3-13

[289] CBWCB GBMP DPEIR 2015 p. 3-13

[290] CBWCB GBMP DPEIR 2015 p. 3-13

One of the key management strategies described in the GBMP to facilitate the extraction of the full volume of adjudicated rights in WCB involves a shift in industrial groundwater use, particularly from oil refineries. This strategy could be an opportunity for the City and other rightsholders with recycled water supplies to increase their pumping in WCB. For example, the City could offer recycled water to industrial users in exchange for a lease on their groundwater pumping rights and thus increase their groundwater pumping for potable use. An estimated 5.9 MGD (6,600 AFY) of industrial pumping rights are currently being used in the Long Beach/San Pedro area which could be redistributed to municipal pumpers upon supply of recycled water to the industrial rightsholders.[291] If municipal purveyors maintain the current industrial use pumping rate, it would increase water supplies in WCB without requiring direct replenishment and there would be no net increase in extraction.

Beyond the industrial rights currently being utilized, there are 20.1 MGD (22,500 AFY) of unused rights that could also be transferred to municipal pumpers through this type of approach. If the total adjudication for these industrial users is utilized, pumping in WCB could be increased by approximately 25.9 MGD (29,000 AFY).[292] This plan would require treatment plant upgrades, and the construction of pipelines and pump stations to produce and convey recycled water to the industrial users.

Further, WRD developed the GRIP Supplemental Recharge Wells Project to accept AWT when MFSG cannot; this project is an addition to the GRIP project. The volumes in this project were not considered in WRD's GBMP Concept A goals. The project proposes 3 storage wells and 3 monitoring wells near the AWTF site. Storage wells in this context refer to wells that inject and store AWT for replenishment and later use by other groundwater users.[293] The purpose of these wells is to allow the AWTF to operate and inject AWT at a constant minimum when MFSG is unavailable during the wet season. Each storage well will have the capacity to inject 1.5 MGD (1,680 AFY), for a total of 4.5 MGD (5,040 AFY).[294] The current expectation is for these wells to be operated on average a minimum of 3 months per year, which results in an annual storage volume of approximately 137 million gallons per year per well (420 AFY).[295] The total storage volume of all three wells would be 411 million gallons per year (1,260 AFY).[296] However, these wells could also potentially be operated year round, which would increase the potential storage capacity. The storage wells are proposed to be mainly gravity-operated, thus requiring a negligible amount of operational energy. This operation would allow maximum groundwater recharge while simultaneously minimizing the unit cost of producing recycled water. The 3 monitoring wells would be used to monitor groundwater levels

[291] CBWCB GBMP DPEIR 2015 p. 3-13

[292] CBWCB GBMP DPEIR 2015 p. 3-14

[293] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. 2-5

[294] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. ES-1

[295] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. ES-5

[296] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. ES-5

and water quality, which is subject to permitting requirements of the LARWQCB and the SWRCB Division of Drinking Water (DDW).

The Alamitos Gap Barrier Project (AGBP) is currently transitioning to 100% RWC and is expected to inject 7.1 MGD (8,000 AFY) of recycled water (Project C0-B).[297] The recycled water will be supplied by LVLWTF through recently expanded production capacity. On average during WY 2000-2009, 5.4 MGD (6,000 AFY) was injected at AGBP; the anticipated rate of 7.1 MGD (8,000 AFY) would result in 1.8 MGD (2,000 AFY) volume of new replenishment.[298] Another plan to increase recharge in CB is through Project C5, Aquifer Recharge and Recovery Facilities (ARRF). These facilities would divert stormwater from the LA River to spreading basins near the river along the 710 Freeway. The stormwater would be initially treated through the soil into the shallow aquifer and then pumped from this aquifer and injected into a deeper aquifer of the LA Forebay. It is estimated that these facilities could replenish up to 4.5 MGD (5,000 AFY) of stormwater into CB.[299] This plan would require new spreading basins along the 710 Freeway, 7 extraction wells in these basins, and 8 injection wells.

The following management strategies and projects work toward the goals of Concept B in WCB, to provide an additional 26.8 MGD (30,000 AFY) for replenishment that would enable an increase of pumping rights by the same amount. Total permitted extraction in WCB under this scenario would be 84.3 MGD (94,468 AFY). A part of the strategy intends to take advantage of the existing seawater intrusion barrier injection well capacities and additional recycled water production opportunities. Recycled water injections at the DGBP and the WCBBP are each estimated to increase by 6.7 MGD (7,500 AFY) above Concept A amounts to 11.6 MGD (13,000 AFY) and 35.7 MGD (40,000 AFY) respectively.[300] DGBP is expected to receive the necessary additional source water from TIWRP and approximately 1.8 MGD (2,000 AFY) from a proposed new AWTF at JWPCP.[301] ELWRF (or a new offsite facility) could supply WCBBP. Construction of conveyance pipelines and pump stations would be required to send the recycled water from the plants to the barrier wells; construction of new injection wells inland of the existing intrusion barriers is an additional possibility to increase the injection of recycled water into WCB.[302]

Concept B projects and management strategies in CB could provide additional local water for replenishment to facilitate the extraction of an additional 92.2 MGD (103,250 AFY) to allow a total extraction of up to 286.3 MGD (320,617 AFY).[303] If the proposed projects replenish the maximum expected amount of water, as much as 96.4 MGD (108,000 AFY) could

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[297] CBWCB GBMP DPEIR 2015 p. 3-19

[298] CBWCB GBMP DPEIR 2015 p. 3-16 Table 3-5

[299] CBWCB GBMP DPEIR 2015 p. 3-20

[300] CBWCB GBMP DPEIR 2015 p. 3-18

[301] CBWCB GBMP DPEIR 2015 p. 3-18

[302] CBWCB GBMP DPEIR 2015 p. 3-18

[303] CBWCB GBMP DPEIR 2015 p. 3-20

be injected in CB.[304] Project C10 involves the construction of a new satellite water reclamation facility in eastern Los Angeles that could supply up to 40.6 MGD (45,500 AFY) of AWT for recharge at the LA Forebay.[305] This facility would further treat wastewater from the HWRP collection system. New pipelines, pump stations, up to 50 new injection wells, and 21 new extraction wells would need to be installed to connect the new treatment facility to the injection wells and the extraction wells to the LADWP potable water distribution system.

E. Silverado Aquifer Saline Plume Remediation

Another strategy identified in the draft PEIR for the WCBCB Groundwater Master Plan is to shift pumping patterns in WCB and eventually increase groundwater extraction to contain and remove the salt water plume in the Silverado Aquifer. This remediation project is an essential piece of WRD's WIN program.[306] The plume occupies a volume of approximately 600,000 AF and extends from El Segundo into Manhattan Beach and through Redondo Beach; the majority of the plume, however, is located in the city of Torrance.[307] Currently, two treatment facilities treat water that is pumped from the saline plume to potable standards: WRD's Goldsworthy Desalter and WBMWD's Brewer Desalter. Currently Goldsworthy Desalter and Brewer Desalter operate at a capacity of and produce 2.5 MGD (2,800 AFY) and 5 MGD (5,600 AFY) of potable water respectively.[308]

The Goldsworthy Desalter Expansion Project, which increased the treatment capacity from 2.5 MGD (2,800 AFY) to 5 MGD (5,600 AFY), the installation of two new supply wells, and the construction of pipelines to convey the pumped groundwater to the expanded desalter, has been completed. The desalter uses reverse osmosis (RO) as the primary process to treat the brackish groundwater. The capacity expansion mainly consisted of adding a second RO treatment train as well as the construction of two new groundwater wells to supply the new desalter. The two wells each have a production capacity of 2,200 gallons per minute (gpm), or 3.2 MGD (3,584 AFY) to supply the new desalter with sufficient water to meet the 4,400 gpm, or 6.3 MGD (7,056 AFY) production demand.[309] The brine from this treatment process is discharged

[304] CBWCB GBMP DPEIR 2015 p. 3-16, Table 3-5

[305] CBWCB GBMP DPEIR 2015 p. 3-21

[306] California Water Commission. Water Storage Investment Program Concept Paper: West Coast Basin Brackish Water Reclamation project. https://cwc.ca.gov/Documents/2016/WSIP/WRD_WestCoastBasinBrackishWaterReclamationProject.pdf. Accessed 07/21/16

[307] California Water Commission. Water Storage Investment Program Concept Paper: West Coast Basin Brackish Water Reclamation project. https://cwc.ca.gov/Documents/2016/WSIP/WRD_WestCoastBasinBrackishWaterReclamationProject.pdf. Accessed 07/21/16

[308] Initial Study Robert W. Goldsworthy Desalter Expansion Project (pdf) CH2MHILL for WRD. 2013 http://www.wrd.org/Goldsworthy-IS.pdf

[309] Initial Study Robert W. Goldsworthy Desalter Expansion Project (pdf) CH2MHILL for WRD. 2013 p. 1-3 http://www.wrd.org/Goldsworthy-IS.pdf

into the regional wastewater collection and treatment system operated by LA County Sanitation Districts; high salt contents are acceptable as the final discharge is into the Pacific Ocean after treatment at the wastewater treatment plant.[310]

To see complete remediation of the plume, the strategy proposes new extraction wells and the construction of 6 regional desalters to pump and treat 13.4 MGD (15,000 AFY) of saline water to potable standards over a 40-year period.[311] It is expected that the Cities of Torrance and Los Angeles as well as the California Water Services Company (CWSC)-Hawthorne would use up to 13.4 MGD (15,000 AFY) of desalinated water from these new extraction wells.[312] By providing a new potable source of water to these three groundwater pumpers, the project will shift the pumping patterns to allow maximum plume containment and remediation. This project will not only create a new local water supply but also create significant groundwater storage volume.[313]

F. Regulatory Requirements

a. Recycled Water Recharge

Briefly, the Porter-Cologne Act requires an application to the LARWQCB for Waste Discharge Requirements (WDR) before the proposed construction or operation of an injection well, starting with a report of waste discharge (ROWD) which describes the project and context in detail. WDRs for projects overlying groundwater basins must incorporate groundwater water quality objectives and uses. For the majority of groundwater basins included in the Basin Plan, the beneficial uses include municipal and domestic supply.

Basin Plan water quality objectives for groundwater include: coliform concentrations over any seven-day period shall be less than 1.1 per 100 mL; chemical constituents and radionuclides shall be below limits in Title 22; the limit for TDS is 800 mg/L (WCB), for sulfate 250 mg/L, for chloride 250 mg/L, and for boron is 1.5 mg; and taste and odor producing substances must be below concentrations that cause nuisances or affect beneficial uses. The WQO for nitrogen in groundwater basins in the LA Basin Plan as of May 2013 is that nitrogen shall not exceed 10 mg/L as nitrate-nitrogen plus nitrite-nitrogen. Other WQOs for different forms of nitrogen have also been determined for waters with a municipal use designation and are as

[310] Initial Study Robert W. Goldsworthy Desalter Expansion Project (pdf) CH2MHILL for WRD. 2013 p. 3-17 http://www.wrd.org/Goldsworthy-IS.pdf

[311] California Water Commission. Water Storage Investment Program Concept Paper: West Coast Basin Brackish Water Reclamation project.

[312] CBWCB GBMP DPEIR 2015 p. 3-14

[313] California Water Commission. Water Storage Investment Program Concept Paper: West Coast Basin Brackish Water Reclamation project.

follows: 45 mg/L of nitrate,[314] 10 mg/L of nitrate-nitrogen, or 1 mg/L as nitrite-nitrogen.[315] As described below in Section F(c), injected water cannot degrade the quality of the basins as it must also comply with state-wide anti-degradation requirements.

DDW regulates injection wells involving recycled water.[316] To inject recycled water into groundwater, full advanced treatment, including a reverse osmosis and an oxidation treatment process, is required.[317] These requirements include membrane rejection requirements, recovery requirements, influent characteristics (e.g. pH between 6.5 and 8 and sodium chloride concentration of no greater than 2,000 mg/L), permeate requirements, monitoring plans which include at least one form of continuous monitoring, and a demonstration that a sufficient oxidation process has been defined.[318] In addition to implementing sufficient technologies to protect water quality, entities supplying recycled water must also conduct wastewater source control assessments to include fate assessments of various contaminants through the treatment processes, source investigations and monitoring for specific contaminants, outreach to customers to minimize contaminant discharge at the source, and maintain inventories of these contaminants.[319] Recycled water for recharge must receive treatment that receives at least 12-log enteric virus reduction, 10-log Giardia cyst reduction, and 10-log Cryptosporidium oocyst reduction; a 1-log virus reduction will be credited with each month retained underground.[320]

Samples to assess total nitrogen levels must be collected twice a week at least three days apart; if two samples exceed 10 mg / L then the DDW and the RWQCB must be notified within 48 hours of the recycled water supplier receiving lab results and the supplier must investigate the cause, take steps to reduce the nitrogen levels, and initiate monitoring in various parts of the basin for related constituents. If the average of four consecutive samples exceeds 10 mg / L, injection must be stopped until at least two samples in a row are below this concentration.[321]

[314] Table 3-8. The Maximum Contaminant Levels: Inorganic Chemicals (for MUN beneficial use) specified in Table 64431-A of Section 64431 of Title 22 of the California Code of Regulations as of February 2013. P. 3.25

[315] basin plan, cited in Jungreis JN, Water Rights and Regulatory Challenges Associated with Capturing and Injecting Stormwater in the Dominguez Channel Watershed (February 24, 2015), Rutan and Tucker Memo generated for Dominguez Channel EWMP p. 14-16

[316] Jungreis JN, Water Rights and Regulatory Challenges Associated with Capturing and Injecting Stormwater in the Dominguez Channel Watershed (February 24, 2015), Rutan and Tucker Memo generated for Dominguez Channel EWMP p. 17

[317] CCR Title 22 Section 60320.201. Advanced Treatment Criteria.

[318] CCR Title 22 Section 60320.201. Advanced Treatment Criteria. See also the TIWRP AWPF DGB Engineering Report (August 2015) Section 2 for more detailed description of regulatory requirements for groundwater replenishment reuse projects.

[319] CCR Title 22 Section 60320.206. Wastewater Source Control.

[320] CCR Title 22 Section 60320.208 Pathogenic Microorganism Control.

[321] CCR Title 22 Section 60320.210 Nitrogen Compounds Control.

In addition, samples for a selection of inorganic chemicals, radionuclide chemicals, organic chemicals, disinfection byproducts, and lead and copper must be collected quarterly.[322]

Once a year, recycled municipal wastewater must be collected and analyzed for secondary drinking water contaminants.[323] Samples in all cases may be either grab samples or 24-hour composites. Diluent water must either be from a Department-approved drinking water source (e.g., MWD) or diluent water must be monitored quarterly for nitrate and nitrite and a source water evaluation must be conducted.[324] The RWC (which can be as high as 100% recycled water) is the volume of recycled water divided by the sum of recycled water and credited diluent water. This ratio must be calculated on a monthly running average based on the total volume of recycled wastewater and credited diluent water for previous 120 months.[325] TOC levels must be monitored weekly prior to replenishment; levels must be under 0.5 mg / L in both the 20-week running average and the average of the previous 4 samples.[326]

The recycled wastewater must be retained underground for enough time to allow the identification of treatment failures and actions that will protect public health; this response retention time shall be no less than two months.[327] Tracer studies using added or intrinsic tracers, numerical modeling, and analytical modeling are all acceptable to estimate the retention time, but tracer studies with added tracers get the most credit for each month. For example, tracer studies with added tracers get credit for 1 month response time for each month they are underground while analytical modeling studies only get credit for 0.25 months for every month of modeled underground time.[328] Tracer studies must be used after projects start.

Monitoring wells must be constructed before recharge projects begin and are subject to specific requirements as outlined in CCR Title 22.[329] Reports must be submitted to the applicable RWQCB and the DDW within six months of the end of each calendar year which include the project's compliance status, any violations in the previous year, detections of monitored chemicals or contaminants, migration of the recharge water plume, changes in existing or planned operations or facilities, quantity and quality of recycled wastewater and diluent water to applied in the following year, and increases in RWC.[330]

[322] CCR Title 22 Section 60320.212. Regulated Contaminants and Physical Characteristics Control. Specific chemicals and DBPs defined in Tables 64431-A, 64442, 64443, 64444-A, and 64533-A.

[323] CCR Title 22 Section 60320.212. Regulated Contaminants and Physical Characteristics Control. Tables 64449-A and 64449-B.

[324] CCR Title 22 Section 60320.214. Diluent Water Requirements.

[325] CCR Title 22 Section 60320.216. Recycled Municipal Wastewater Contribution (RWC) Requirements.

[326] CCR Title 22 Section 60320.218. Total Organic Carbon Requirements.

[327] CCR Title 22 Section 60320.224. Response Retention Time.

[328] CCR Title 22 Section 60320.224. Response Retention Time.

[329] CCR Title 22 Section 60320.226. Monitoring Well Requirements.

[330] CCR Title 22 Section 60320.228. Reporting.

In addition to multi-layered regulatory requirements, projects to inject recycled water can have complex jurisdictional agreements among a wide variety of agencies. The recharge of recycled water into the DGB, for example, includes LASAN, LADWP, LACDPW, WRD, WBMWD, DDW, LARWQCB, and SWRCB. LASAN is responsible for the treatment, monitoring, and reporting requirements as well as owns rights to the Title 22 water that feeds the AWPF, but LADWP is the purveyor of recycled water to the DGB. LACDPW owns, operates, and maintains the wells and infrastructure, and WRD manages the groundwater basins. DDW regulates GWR projects that use recycled water, LARWQCB regulates discharges in the LA region, and the SWRCB protects water quality by setting statewide policies.[331]

b. Stormwater Recharge

Stormwater can be recharged into groundwater basins through surface recharge or through injection. Surface recharge of stormwater is already occurring in WCBCB through incidental recharge (e.g., precipitation falling on unpaved landscape surfaces). Distributed recharge through stormwater BMPs is also occurring. For example, the Broadway Neighborhood Stormwater Greenway Project, which overlies CB, began operation in 2015 in South Los Angeles along 47th street, 47th place, and 48th Street between Broadway and Main Street and along Broadway. It consists of a number of private and public infiltration BMPs that include rain gardens, dry wells and infiltration trenches on 60 parcels, and parkway swales and vegetated curb extensions on 3 residential streets and 2 blocks of commercial streets, and a sub-regional scale infiltration facility for 30 acres of mixed land use.[332] The implementation measure covers a 32-acre tributary area and is expected to capture 30-40 AFY.[333]

Other examples of planned projects to recharge stormwater include the Vermont Avenue stormwater capture project, which overlies WCB and is planned to begin in 2017 for the City of Gardena. This project consists of dedicated open spaces to increase stormwater infiltration (e.g., a median park with biofiltration systems) and is expected to decrease concentrations of S/N in groundwater due to the generally lower concentrations of S/N in stormwater.[334] Another planned project in WCB, 'Improvements to Entradero Storm Drain Channel for Stormwater Infiltration' in the City of Torrance, will result in the replacement of the asphalt bottom and natural sides with pervious material to improve stormwater infiltration.[335]

Space for recharging the groundwater basins through the surface in highly urbanized areas such as LA, however, can be difficult to find. Further, additional research is required to characterize the linkages between shallow groundwater and the deeper basins to identify the actual

331 TIWRP AWPF DGB Engineering Report (August 2015) p. 2-1

332 California Natural Resources Agency, Bond Accountability Website http://bondaccountability.resources.ca.gov/Project.aspx?ProjectPK=2735&PropositionPK=4, accessed on 6/13/2016

333 "Neighborhood-Scale Water Quality Improvements The Broadway Neighborhood Stormwater Greenway Project" Stacy Luell, Geosyntec Consultants Co-Authors: R. Batchelder, W. Tam, M. Hanna, M. Sadeghi; Mar 30 2015; SNMP for Central and West Coast Basin 2015 Appendix J p. 42

334 SNMP for Central and West Coast Basin 2015 Appendix J p. 43

335 expected to begin in 2015, SNMP for Central and West Coast Basin 2015 Appendix J p. 42

impacts on available local water supply of stormwater recharged in this way. Stormwater injection provides a potential pathway to increase the recharge of stormwater in areas of limited space as well as into deeper groundwater basins used for supply. Stormwater injection, however, also carries the potential to introduce contamination into supply basins and thus requires site-specific analyses before implementation and falls under regulations. Regulatory requirements for stormwater injection wells for groundwater recharge are slightly different than those for the recharge of recycled water.

The EPA regulates injection wells through the underground injection control (UIC) program, which regulates subsurface disposal of fluids through constructed conveyances with the intent of leaving the fluid underground and is authorized through the Safe Drinking Water Act.[336] Stormwater injection wells are considered "Class V" wells under the UIC program and the EPA must be provided with an inventory form describing the approximate location and the ownership of the well. Once the inventory has been submitted to the EPA, the well can be operated as "authorized by rule.[337]" However, the well owner is required to respond to any requests for additional information about the well by the EPA, conduct any additional investigations to protect water quality if required by the EPA (potentially based on the location or characteristics of the well, etc.), apply for and comply with an injection permit if it becomes necessary, and close any well that is "suspected or likely to cause contamination of underground sources of drinking water." In addition, injection activities cannot occur where they may move contaminants into underground sources of drinking water.[338]

Further, although California does not have delegation for the UIC program, the SWRCB and the RWQCBs are still enabled under the Porter-Cologne Act to require WDRs for any discharge, including injection wells, which may impair beneficial uses of waters of the state, which includes groundwater.[339] Local governments may also set more stringent requirements than the EPA policies. In addition, as with recycled water recharge, CA's anti-degradation policy must be considered to determine whether the potential benefit to the state (increased

[336] Municipal Stormwater and Ground Water Discharge Regulations in California Draft Guidance. USEPA Region 9 Groundwater Office 2002. https://www3.epa.gov/region9/water/groundwater/uic-pdfs/calif5d-muniguide.pdf

[337] Jungreis JN, Water Rights and Regulatory Challenges Associated with Capturing and Injecting Stormwater in the Dominguez Channel Watershed (February 24, 2015), Rutan and Tucker Memo generated for Dominguez Channel EWMP p. 17

[338] Municipal Stormwater and Ground Water Discharge Regulations in California Draft Guidance. USEPA Region 9 Groundwater Office 2002. https://www3.epa.gov/region9/water/groundwater/uic-pdfs/calif5d-muniguide.pdf

[339] Municipal Stormwater and Ground Water Discharge Regulations in California Draft Guidance. USEPA Region 9 Groundwater Office 2002. https://www3.epa.gov/region9/water/groundwater/uic-pdfs/calif5d-muniguide.pdf

water supply, improved surface water quality) outweigh the potential harms (impact to groundwater quality).[340] In addition, some entities interpret dry wells as falling under the CA Department of Water Resources (DWR) well water regulations.[341] Based on the regulatory uncertainties, the lack of state- or country-wide standard practices, and the potential to introduce contaminants into groundwater, dry wells, a subset of Class V wells, are often left out of stormwater / LID guidelines.[342] Class V wells are defined to be deeper than they are wide, so although infiltration trenches perform similar functions of capturing and infiltrating stormwater, they are not covered under the UIC program.

The USEPA does not have design requirements for dry wells, but does encourage certain design practices such as not constructing wells deeper than the seasonal high water table, utilizing pre-treatment, and performing a site evaluation to prevent spreading contaminants.[343] RWQCBs SUSMP plans can differ in their technical specifications for dry wells, and local enforcement of the requirement to register dry wells with the EPA is mixed. Los Angeles County, for example, enforces registration of dry wells and requires information on their location and design as a part of permitting new development.[344] Examples of standards common in Los Angeles and San Diego SUSMPs and the Placer County LID Manual include a 10-20 foot minimum setback from buildings, 100 foot minimum setback from public supply wells and from each other, 3-10 feet of minimum separation between dry well bottom and seasonal high water table, and a penetration of at least 10 feet into permeable porous soils.[345]

Although care needs to be taken to minimize the risk of introducing new or spreading existing contamination in groundwater basins through the increased use of dry wells, dry wells offer additional benefits beyond reducing stormwater runoff volumes such as increased connectivity to groundwater (correlating to increased likelihood that captured stormwater could make it into a usable aquifer), reasonable construction cost, and a small areal footprint (that

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[340] Dry Wells: Uses, Regulations, and Guidelines in California and Elsewhere, Office of Environmental Health Hazard Assessment, California EPA (OEHHA), 2014. http://www.waterboards.ca.gov/board_reference/2014fall/docs/dry_wells_fs.pdf

[341] Dry Wells: Uses, Regulations, and Guidelines in California and Elsewhere, Office of Environmental Health Hazard Assessment, California EPA (OEHHA), 2014. http://www.waterboards.ca.gov/board_reference/2014fall/docs/dry_wells_fs.pdf

[342] Dry Wells: Uses, Regulations, and Guidelines in California and Elsewhere, Office of Environmental Health Hazard Assessment, California EPA (OEHHA), 2014. http://www.waterboards.ca.gov/board_reference/2014fall/docs/dry_wells_fs.pdf

[343] Dry Wells: Uses, Regulations, and Guidelines in California and Elsewhere, Office of Environmental Health Hazard Assessment, California EPA (OEHHA), 2014. http://www.waterboards.ca.gov/board_reference/2014fall/docs/dry_wells_fs.pdf

[344] Dry Wells: Uses, Regulations, and Guidelines in California and Elsewhere, Office of Environmental Health Hazard Assessment, California EPA (OEHHA), 2014. http://www.waterboards.ca.gov/board_reference/2014fall/docs/dry_wells_fs.pdf

[345] Dry Wells: Uses, Regulations, and Guidelines in California and Elsewhere, Office of Environmental Health Hazard Assessment, California EPA (OEHHA), 2014. http://www.waterboards.ca.gov/board_reference/2014fall/docs/dry_wells_fs.pdf

could be placed easily in heavily urbanized areas such as Los Angeles). The SWRCB is conducting and has funded multiple research efforts through its "Strategy to Optimize Resource Management) to support the management of stormwater as a resource. Some of these efforts will include studies to promote stormwater capture and use and eliminate barriers and also may include guidance on specific technologies such as dry wells.[346]

c. Salt and Nutrient Management Plans

As described in more detail in the previous Ballona Creek Watershed report, the statewide CA recycled water policy further requires that salt and nutrient management plans (SNMPs) must be completed and submitted to the RWQCB within five years for groundwater basins and sub-basins in California to address the need to achieve or maintain compliance with water quality objectives and maintain the protection of beneficial uses. SNMPs must be designed to address local water quality concerns, as well as include stormwater recharge to balance the typically higher nutrients and salts in recycled water. These plans are intended to be used to manage salt and nutrient issues regionally, and to manage nutrient and salt sources to the groundwater basin as a whole rather than through imposing requirements on individual recycled water projects as they are proposed.

To assess potential impacts of increased recycled water recharge into groundwater basins, SNMPs must contain analyses which show that the implementation of planned projects will maintain compliance with the two relevant anti-degradation policies in California**,** the Statement of Policy with Respect to Maintaining Higher Quality Waters in California (Resolution 68-16),[347] and the Sources of Drinking Water Policy (Resolution 88-63).[348] Resolution 68-16 requires that waters that are of higher quality than required by existing policies must be maintained unless the change is consistent with maximum benefits to the state, won't unduly affect present and future uses, and won't degrade the water quality below the existing WQS.[349] Much of WCB and CB are designated as suitable or potentially suitable for municipal and domestic supply as defined by Resolution 88-63[350] and must be protected as such.

Keeping anti-degradation requirements in mind when considering increased injection or spreading of recycled water is important as recycled water could either increase or decrease water quality in each groundwater basin depending on the level to which the recycled water is treated and the existing conditions in the basin. For example, baseline groundwater measurements indicate that groundwater is negatively impacted by salt concentrations due to historical seawater intrusion near the DGB in WCB. Recharging advanced treated recycled water in this area has the potential to lessen the salt concentrations; groundwater monitoring conducted by

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[346] See generally: http://www.waterboards.ca.gov/water_issues/programs/stormwater/storms/

[347] SWRCB Resolution 68-16, October 28, 1968

[348] SWRCB Resolution 88-63 (as revised by Resolution No. 2006-0008), Adoption of Policy Entitled "Sources of Drinking Water". Adopted May 19, 1988 and amended February 1, 2006

[349] SWRCB Resolution 68-16, October 28, 1968

[350] SWRCB Resolution 88-63 (as revised by Resolution No. 2006-0008), Adoption of Policy Entitled "Sources of Drinking Water". Adopted May 19, 1988 and amended February 1, 2006

WRD since 2006 to monitor the impact of the recharged advanced treated recycled water on groundwater quality has shown that the injection of recycled water has improved water quality in the vicinity of the injection wells.[351]

One of the potential benefits of developing SNMPs for groundwater basins is that characterizing planned projects and potential impacts on salts and nutrients on this scale may highlight opportunities to co-locate stormwater infiltration projects with recycled water projects to dilute the nutrients and salts in recycled water with low-nutrient and salt stormwater. At the same time, recycled water could also dilute constituents potentially found in stormwater; while stormwater is low in salts and nutrients there is a potential it could contain other regulated constituents which would be lower in recycled water. Further, SNMPs could offer opportunities for other parties such as the City to locate stormwater capture projects in such a way that they minimize degradation of the groundwater even further. WRD completed its WCBCB SNMP in 2015, with a planning horizon of 2025, to identify the potential impacts of planned projects on S/N concentrations in the groundwater.

G. Potential to Expand Groundwater Recharge and Extraction

There are several opportunities through which the City can increase their utilization of WCBCB within the groundwater landscape described above. First, the City must increase its capacity to extract the entirety of these groundwater pumping rights from WCBCB. As described above, the LADWP UWMP defined strategies to increase its capacity to pump its full groundwater pumping rights from CB through, for example, improvements at the Manhattan and 99th St. Well Fields.[352] LADWP is additionally evaluating opportunities to extract even greater volumes from CB given the potential to accrue storage and intends to study options to restore groundwater pumping in WCB to be able to pump water from WCB again.[353]

As the City's ability to pump groundwater from these basins increases, the City can purchase or lease pumping rights from other rights holders in the groundwater basins to increase their groundwater pumping rights in WCBCB. The City has recently purchased pumping rights from other rights holders; in the last few years, the City's APA in CB has increased first from 15,000 AFY to approximately 16,500 AFY and then again to just over 17,000 AFY.[354] An additional management strategy that the City could pursue, offering recycled water to industrial users for a lease on their groundwater pumping rights, was described in the WRD WCBCB GBMP. Approximately 29,000 AFY (25.9 MGD) of industrial rights were described in this potential WCBCB opportunity, including 22,500 AFY (20.1 MGD) of unused industrial rights and 6,600 AFY (5.9 MGD) of currently used industrial rights.[355] It may be possible to

[351] Order No. R4-2003-0134-A03 (File No.97-208) Amending Waste Discharge Requirements and Water Recycling Requirements for Harbor Water Recycling Project, Dominguez Gap Barrier Project P. 3

[352] draft LADWP UWMP 2015 P. 6-15, 6-16

[353] draft LADWP UWMP 2015 P. 6-15, 6-16

[354] draft LADWP UWMP 2015 P. 6-13 and LADWP UWMP groundwater section

[355] WRD WCBCB GBMP draft PEIR 2015 p. 3-13, 3-14

lease the unused industrial rights without providing in lieu recycled water as those rights are not currently necessary for operations at those properties.

Further, the City can take advantage of opportunities to increase its storage capacity through individual storage space in WCB or to increase its capacity to extract additional groundwater from WCBCB through proposing water augmentation projects in which all rights holders in these groundwater basins would have the opportunity to participate. Identifying projects that would facilitate working with other jurisdictions with established City relationships through the DC EWMP process such as Carson, LA County, El Segundo, Hawthorne, Inglewood, Lawndale, and Lomita, would increase the potential volume of additional individual pumping rights (including additional storage rights of 200% to 250%) in WCB to approximately 26,000 AFY.[356]

Water augmentation projects provide additional opportunities to increase the conjunctive use of these basins through providing an avenue to establish partnerships with potentially all other rightsholders in the groundwater basins. Partnerships are critical to implement these multi-benefit projects so that both the costs and benefits can be shared among parties. A 2012 study by WRD examined the feasibility of stormwater recharge through distributed and sub-regional stormwater projects and identified multiple catchments in which potential water supply benefits were the greatest and potential constraints were the lowest.[357] Pilot catchments resulted in the identification of multi-agency collaborations, one of which turned into the Broadway Neighborhood Stormwater Greenway Project in CB, and serves as an excellent example of potential partnerships that can result in implementing these types of projects.

The Broadway Neighborhood Stormwater Greenway Project was the result of a collaboration between LASAN, BoE, LADWP, WRD, and others, and began operation in 2015 in South Los Angeles along 47th street, 47th place, and 48th Street between Broadway and Main Street and along Broadway. It consists of a number of private and public infiltration BMPs that include rain gardens, dry wells and infiltration trenches on 60 parcels, and parkway swales and vegetated curb extensions on 3 residential streets and 2 blocks of commercial streets, and a sub-regional scale infiltration facility for 30 acres of mixed land use.[358] The implementation measure covers a 32-acre tributary area and is expected to capture 30-40 AFY from this combination of residential, commercial and sub-regional BMPs.[359] The additional priority catch-

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[356] rights and storage capacities from WCB adjudication; DC EWMP compiled APA's to discuss potential water supply benefits of injected stormwater.

[357] The Council for Watershed Health, Geosyntec Consultants, and Santa Monica Bay Restoration Commission for WRD. Stormwater Recharge Feasibility and Pilot Project Development Study August 20, 2012 (Stormwater Recharge Feasibility Study 2012)

[358] California Natural Resources Agency, Bond Accountability Website http://bondaccountability.resources.ca.gov/Project.aspx?ProjectPK=2735&PropositionPK=4, accessed on 6/13/2016

[359] "Neighborhood-Scale Water Quality Improvements The Broadway Neighborhood Stormwater Greenway Project" Stacy Luell, Geosyntec Consultants Co-Authors: R. Batchelder, W. Tam, M. Hanna, M. Sadeghi; Mar 30 2015; SNMP for Central and West Coast Basin 2015 Appendix J p. 42

ments described in the 2012 WRD study provide an excellent starting point to plan future projects and identify partnerships that will provide the highest potential water supply benefit for early distributed or sub-regional stormwater projects.

Finally, the legacy saltwater plume in WCB offers a twofold opportunity to the City and the region. The first opportunity is extracting and treating this groundwater for use slowly over time. Example scenarios to remediate the plume include projects that could extract 15,000 to 20,000 AFY over the next 30 to 40 years. The second opportunity comes as this groundwater space is freed up for additional storage in WCB. The total estimated volume of this plume is approximately 600,000 AF (which is not currently included in the additional storage space identified through the adjudications in WCBCB). In the future as the plume is remediated, at least some of this additional space could be utilized for storing additional water, whether it be recycled water, increased stormwater, or LA aqueduct water during wet years.

It is important to note that all of the above scenarios are subject to regulatory requirements described throughout this report to protect water quality, both in surface waters and groundwater, and will require partnerships and interactions among the multitude of jurisdictions that are involved in these projects. Site-specific constraints such as proximity to structures or utilities, existing contamination, risk for soil liquefaction, steepness, groundwater levels, or dewatering activities must also always be considered before implementing on-site projects.[360]

However, implementing these types of projects will become easier over time as best practices emerge, results are monitored, and partnerships are established. Even now, projects exist that have been permitted for the recharge of recycled water into the groundwater basins through the barrier projects, and captured stormwater is being quantified from a water supply lens at the Broadway Neighborhood Stormwater Greenway Project. As these projects become more common, the regulatory and permitting framework will become clearer, practices more established for how to quantify the groundwater recharge benefits of increasing stormwater capture at a variety of scales, and collection and management of data will improve. Increased monitoring of these projects will be critical to better understand the impact of these projects on water quality as well as water supply for the City and others who wish to participate in these multi-benefit projects.

VI. Conclusions

- Meeting copper and zinc TMDL requirements in Dominguez Channel and nutrient TMDL requirements in Machado Lake will be extremely challenging. The presented modeling efforts demonstrate that capturing and/or treating the 85th percentile storm alone will provide significant water quality benefits but may not be adequate to ensure that receiving water quality standards are met in DC. For Machado Lake, eliminating eutrophication impairments is the priority. The establishment of appropriate, site-specific, and attainable biodiversity and ecosystem health objectives that are linked to appropriate nutrient, DO, and chlorophyll-a targets is needed.

[360] Stormwater Recharge Feasibility Study 2012 P. 13

- A monitoring program that provides adequate surface water quality and flow data, and an assessment of potential contributions from sources higher (Machado Lake) or lower (Dominguez Channel) in the watershed than the current monitoring locations is a critical next step to implementing more successful source reduction approaches. Additional monitoring planned via the DC CIMP and the ML monitoring system will support developing the data needed to improve the understanding of the watershed.

- Reducing the pollutant loads entering Dominguez Channel and Machado Lake that stem from external sources (stormwater runoff from the watershed) will be critical to meeting water quality standards.

- The City currently plans to fully reuse the current flows through TIWRP (approximately 13-15 MGD) and there is substantial additional demand for recycled water in that service area that could be served if more flow is channeled to TIWRP.

- West Coast and Central Groundwater Basins offer multiple opportunities to increase the storage and reuse of recycled water and captured stormwater. These include a 600,000 AF brackish plume due to historical seawater intrusion in WCB that offers both short-term (through remediating this plume) and long-term (potential to store additional freshwater in this space as the brackish water is remediated and used) water supply opportunities. Water Augmentation projects in both West Coast and Central Basins offer the opportunity for rightsholders in the basins to recharge and extract water on an annual basis beyond their adjudicated and stored pumping rights in the basins.

- Moving forward with an integrated water management approach that will further both water quality and local water supply goals will require great collaboration but can offer multiple benefits and must be aggressively pursued.

VII. Appendix A – City modeling efforts in Machado Lake

The Machado LWQMP also assessed the ability of the City to achieve compliance with the Nutrients TMDL through a Lake Water Quality model which incorporated the impacts of lake dredging, adding recycled water instead of potable water to replace evaporative losses, installing an oxygenation system and a phosphorus removal system, and building an off-line treatment wetland.[361] Although the other BMPs described above are expected to generate water quality benefits as well, they were not modeled as there is a lack of sufficient data on the actual reductions produced by these BMPs.

Predictions of summer water quality in the Machado LWQMP were generated for one, five, and ten years after the planned BMP implementation timeframe (2014, 2018, and 2024) to capture the critical conditions in summer.[362] Based on just the BMP implementation, total nitrogen (TN) and total phosphorus (TP) will not meet TMDL requirements; nitrogen will be at 1.22 mg / L (numeric target 1.0 mg / L) and phosphorus will be at 0.16 (numeric target 0.1 mg / L).[363] However, LWQMP modeling efforts indicate that if the responsible parties in the 87% of the watershed which is not under City's jurisdiction meet their TMDL WLAs, then the external loading would be much reduced and the BMPs described would be sufficient to meet ML numeric targets (See Table 23).[364]

An additional modeling effort, the TAF No.16: TIWRP Recycled Water Opportunity Analysis – ML Analysis (TAF) was recently conducted by the City to continue the work begun in the LWQMPs and look specifically at the impacts on water quality compliance of putting TIWRP AWPF water into ML.[365] In-lake water quality data from 2006 to 2013 showed a strong seasonal peak in TP levels in the lake; TP levels were consistently higher in summer than winter, indicating the presence of internal loading processes that peak during the summer dry season. This pattern was less clear for TN, which lead to greater uncertainty with TN predictions than with TP in the TAF modeling efforts.[366]

The TAF modeling efforts included an assessment of the impacts of various volumes of TIWRP AWPF water entering ML on TN, ammonia, TP, chlorophyll *a*, and DO levels in the lake and identified opportunities to dechlorinate AWPF prior to discharge into ML using a variety of assumptions.[367] In the TAF, TN levels in AWPF water were set to 1 mg/L, and TP levels were set to 0.05 mg/L. Other assumptions included: sediment in ML would be dredged

[361] Machado Lake LWQMP p. 5-3

[362] Machado Lake LWQMP p. 5-4

[363] Machado LWQMP p. 5-5

[364] Machado LWQMP p. 5-7

[365] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015.

[366] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 3-2

[367] Pg 10 of revised draft memorandum in TAF

to a depth of 6 feet, lake water would recirculate through the wetlands at 1 cfs during the critical period of March through November, and DO concentrations would be 5 mg / L after implementation of an advanced oxidation process (based on TIWRP pilot testing).[368] The volume required to replace evaporative losses during the critical period of March through November was determined to be 140 AFY (0.2 MGD); the addition of any greater volume [up to 2,570 AFY was modeled (3.1 MGD)] resulted in overflow to the freshwater marsh and through the Harbor outfall into the Harbor.[369]

TAF modeling efforts also assessed the impact of the compliance of upstream parties with their WLAs on in-lake water quality conditions at ML as only 13% of the ML Watershed is under the City's jurisdiction.[370] Even though the City has no direct management control over the remaining 87% of the watershed, assessment of compliance effectiveness of other cities and the county is critical to develop strategies that will result in ML TMDL compliance in ML. Briefly, the TAF modellers set EMCs at TMDL WLAs (1 mg / L and 0.1 mg / L for TN and TP, respectively) to model 100% upstream compliance. EMCs for 0% compliance were set to the following: wet weather TN, 3.5 mg / L; dry weather TN, 2.3 to 2.6 mg / L; wet weather TP 0.86 mg / L; dry weather TP 0.44 to 0.75 mg / L. 50% and 25% compliance was modeled through adjusting the 0% and 100% EMCs.[371]

TAF modeling results for TP compliance were consistent with the earlier LWQMP modeling as the only modeling scenario in which ML was in compliance for TP levels 10 years after project completion was the scenario in which 100% of the upstream jurisdictions were also in compliance with their WLAs.[372] Predicted TAF in-lake TN levels were lower than those in LWQMP efforts with the addition of TIWRP AWPF water; TN was predicted to be under 1 mg / L regardless of upstream WLA implementation.[373] Generally, both TN and Chlorophyll *a* WQS were achieved in the majority of scenarios even if other jurisdictions were not meeting their WLAs.[374] If 100% of all the upstream permittees were in compliance with their WLAs, then TAF modeling efforts showed that TN, TP, and Chlorophyll *a* would all be in

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[368] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 2-4, 3-5, 3-6

[369] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 1-3, 5-1.

[370] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-6

[371] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P. 306

[372] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-13

[373] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. P-3-13

[374] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-14

compliance with the WQS.[375] TAF modeling efforts found that DO levels met water quality standards in all scenarios with TIWRP AWPF water at DO levels above 5 mg / L.[376]

VIII. Appendix B West Coast and Central Basins

i. Storage Rights

For the City, and other rightsholders in WCBCB, the introduction of storage rights into WCB would allow them to extract up to additional water from both WCB and CB.[377] Briefly, 120,000 AF and 330,000 AF of available dewatered space was identified in WCB and CB, respectively. In both basins, the available dewatered space is divided into 'adjudicated storage capacity,' which is separated into slightly different categories in WCB and CB, and 'basin operating reserve.' The adjudicated storage in WCB is divided into Individual Storage Allocation, Community Storage Pool, and Regional Storage Allocation. The adjudicated storage in CB is separated into Individual Storage Allocation and a Community Storage Pool [of which 23,000 AF are reserved through a second-priority right for the Regional Disadvantaged Communities Incentive Program (RDCIP), Figures 40,41)].[378]

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[375] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 3-14

[376] CDM Smith for LASAN, Final Summary Report TAF No.16: TIWRP Recycled Water Opportunity Analysis – Machado Lake Analysis. November 2015. p. 4-6

[377] Case of *Central and West Basin Water Replenishment District v Adams et al.* (1965, amended 2013) Los Angeles Superior Court Case No. 786656 (Central Basin Adjudication)

[378] CB adjudication, p.28, 45, 55.

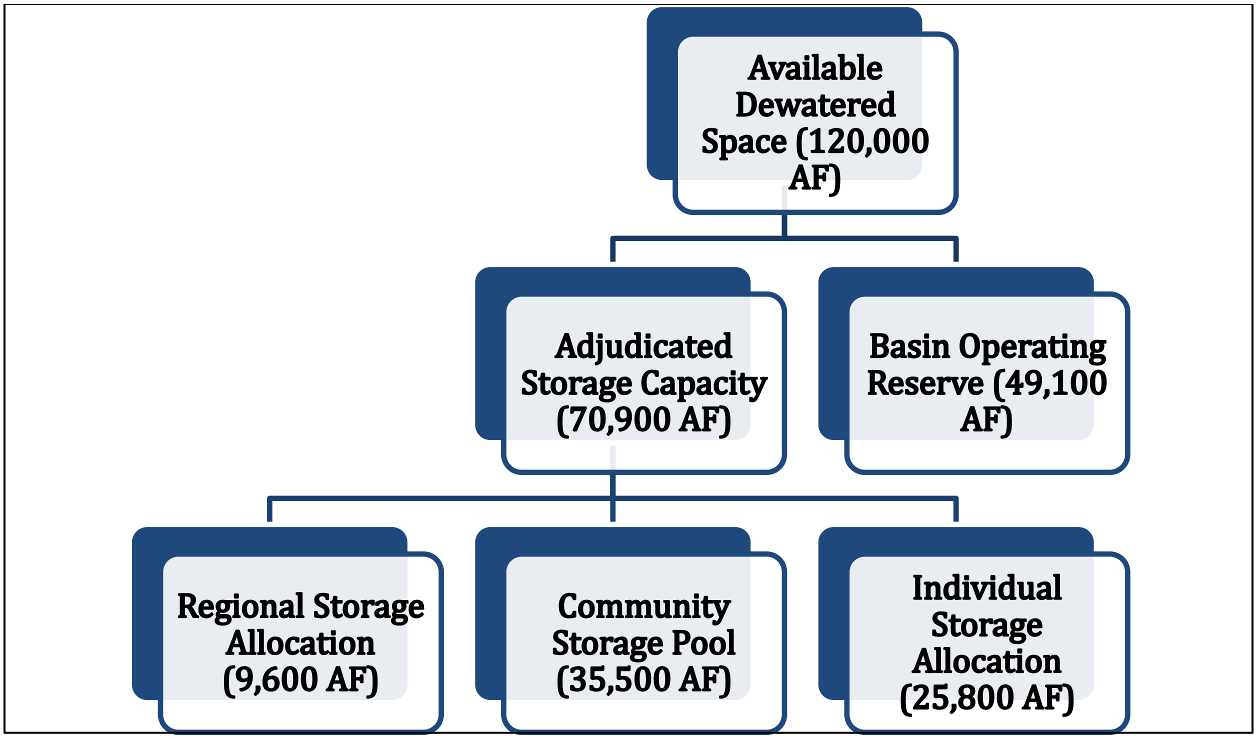

Figure 40. Division of available dewatered space in WCB under amended adjudication.

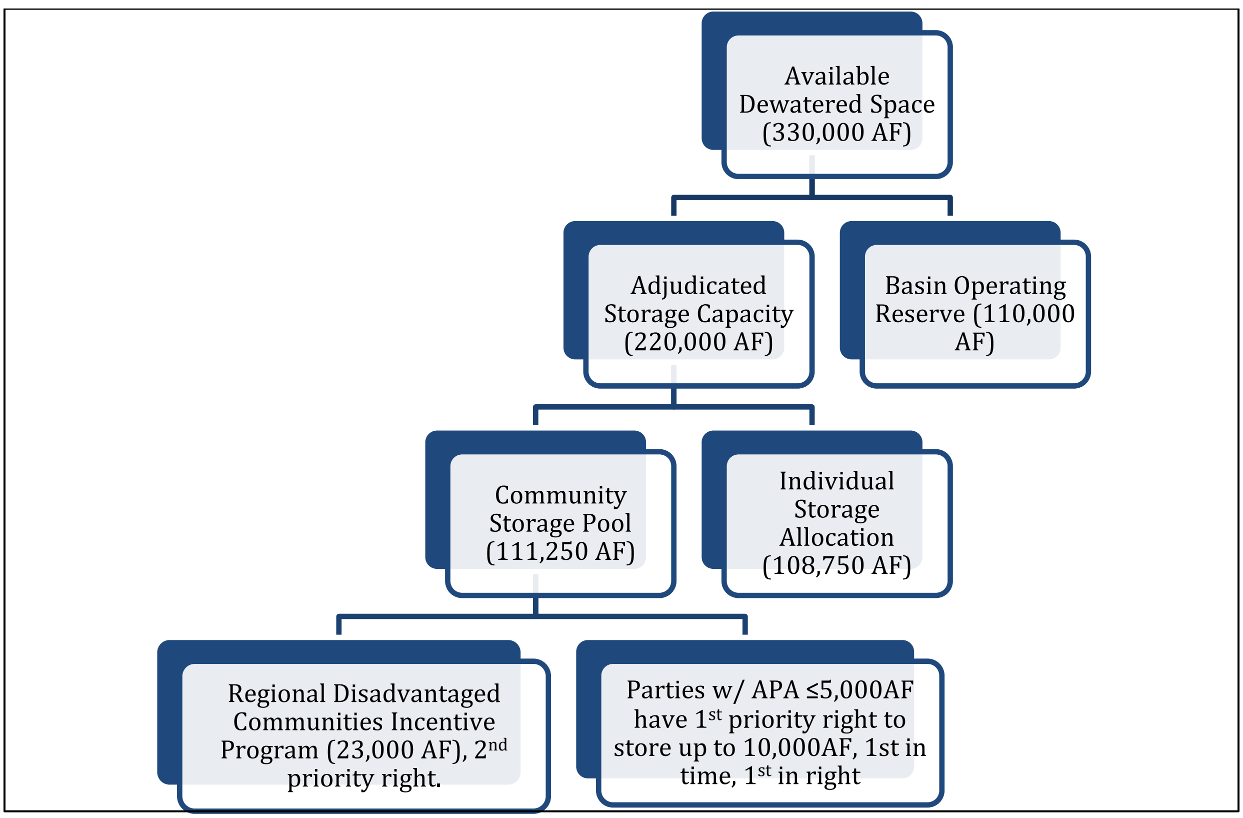

Figure 41. Division of available dewatered space in CB under amended adjudication.

In CB, a party's extraction rights include their allowed pumping allocation (APA), contractual rights acquired from other parties through lease or other agreement, and stored or carryover water. The amount of water that can be withdrawn annually is capped at 140% of the party's APA and leased water, but more can be extracted with the approval of the Storage Panel.[379] In WCB, annual extractions are capped at 120% of the party's Adjudicated Right without approval of the Storage Panel to extract more.[380] In both CB and WCB, carryover water can be converted over to stored water upon payment of the replenishment assessment.[381]

All rightsholders in WCB have a 1st priority right to use a volume of individual storage space up to 40% of their Adjudicated Right.[382] After that space has been filled, rightsholders have a first-in-time, first-in-right opportunity to store water in the community space, up to 200% of Adjudicated Right (and up to 250% with the approval of the Storage Panel), as long as there is space available in the Community Storage Pool.[383]

The relative prioritization of storage spaces in WCB is outlined (Figure 42). Increased storage and use of the available space can continue as described in the adjudication for both basins unless evidence of material physical harm develops, in which case the watermaster will need to file that information as well as recommendations on how to alleviate the identified harms.[384] Both individual storage allocations and community pool storage must be filled to capacity before basin operating reserve space becomes available for Space-Available storage. WRD has a first priority right to the basin operating reserve to manage the replenishment needs of the basin but this space can also be used temporarily for 'space-available storage' by other parties in the basin if all other storage spaces are at capacity and the space is not being occupied by WRD.[385]

[379] Central Basin Adjudication, p. 15

[380] WCB adjudication, p.24

[381] WCB Adjudication, p. 13;

[382] WCB Adjudication, p. 13

[383] WCB Adjudication, p.14

[384] CB adjudication, P. 17

[385] CB adjudication p. 71

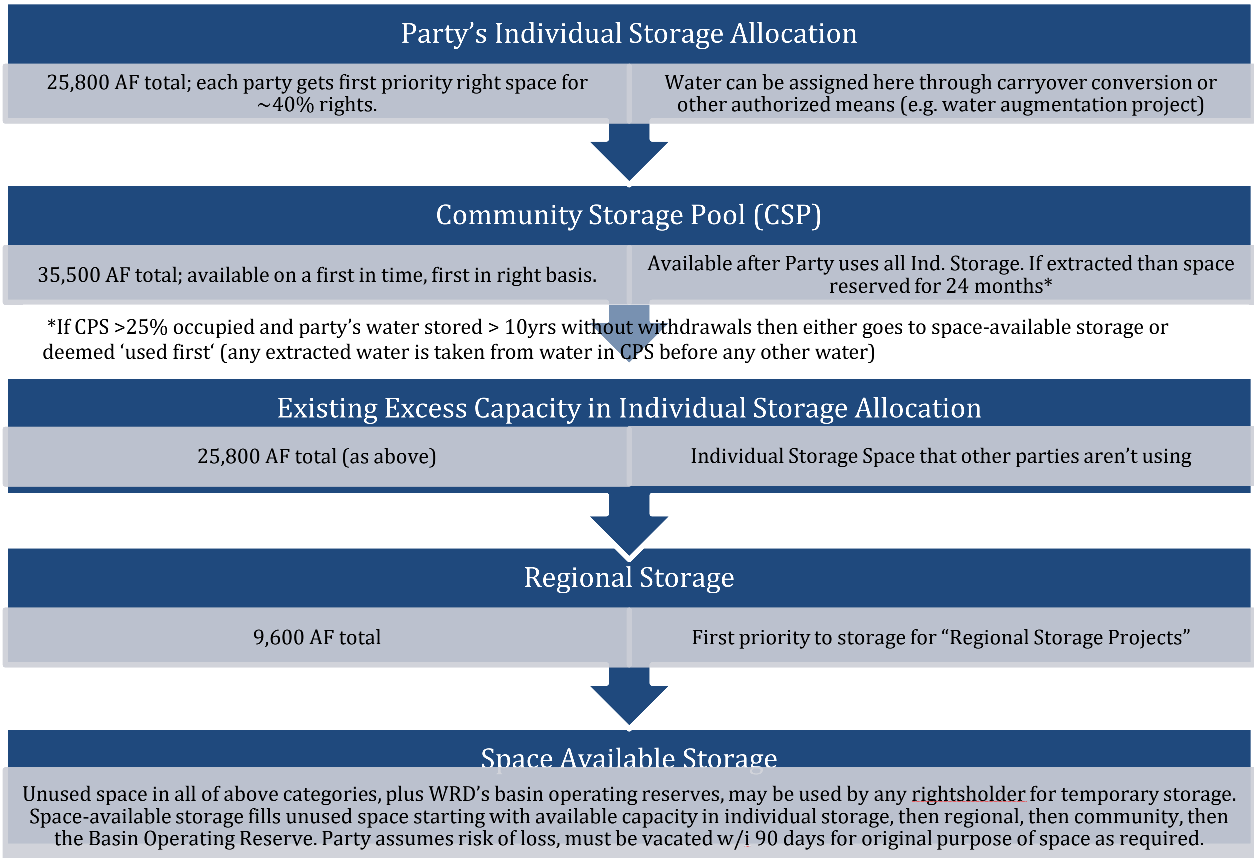

Figure 42. Storage Prioritization in WCB[386]

In addition to the individual and community storage spaces, the WCB amendments allocated 9,600 AF as Regional Storage, which is intended to store water from projects that do not enhance the long-term reliable yield but will decrease the cost and volume required for WRD to replenish the basins. Further, these projects must require storage capacity above the party's individual storage allocation and Community Storage Pool capacity.[387] Regional projects require pre-approval by the Storage Panel, and offer an opportunity for entities without an adjudicated right to enter into the adjudication and utilize groundwater space as approved regional storage projects have a priority right to this space.[388] An appendix in the DC EWMP identified at least one of the proposed stormwater injection sites, which is in close proximity to a WRD seawater intrusion barrier, as a potential regional storage project if it reduces the amount of water WRD would need to obtain for barrier replenishment even if it is too far west to increase basin yield.[389]

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[386] WCB adjudication, p.19

[387] West Coast Basin adjudication, p.15

[388] WCB Adjudication, p.15

[389] Jungreis JN, Water Rights and Regulatory Challenges Associated with Capturing and Injecting Stormwater in the Dominguez Channel Watershed (February 24, 2015), Rutan and Tucker Memo generated for Dominguez Channel EWMP p. 10

ii. Water Augmentation Projects

An additional opportunity for the City to both inject and extract additional volumes of groundwater in WCBCB lies in proposing and creating water augmentation projects in these basins. To increase opportunities to fully utilize the available dewatered space, amendments to both the WCB and CB adjudications also created a category of projects, water augmentation projects, intended to increase recharge into and extraction from these basins. Parties to the adjudications, including the City, can create water augmentation projects that would increase the long-term sustainable yield of the basin and allow participating parties to inject and subsequently extract additional water on an annual basis.[390] The water added through augmentation projects is intended to be extracted within the same year; WCBCB adjudications explicitly state 'because water made available for Water [Rights] Augmentation will be produced annually, fluctuations in groundwater levels will be temporary, minimal, and managed within the Basin Operating Reserve."[391]

Unlike the storage opportunities that are described in the previous section, water augmentation projects are not capped at or based on the volume of a party's adjudicated rights in these basins, and thus provide an opportunity for the City to increase its use of WCBCB above the current rights through proposing water augmentation projects. Under both WCB and CB, any party may propose a water augmentation project and must offer all other parties an opportunity to participate. Any party which chooses to participate in the water augmentation project will share in the costs of the project (or provide another benefit on which the other parties have agreed) and will receive a commensurate increase in extraction rights based on the amount of increased yield (new water) that the Storage Panel determines will result from the project long-term. These projects must all be pre-approved by the Storage Panel.[392]

Under CB, parties can treat projects either as a water augmentation project (which will, if approved, result in an increase in their extraction rights) or as a storage project to store water in any of the available storage spaces described above.[393] In WCB, the right to extract augmented water will be accounted for separately from the adjudicated rights.[394] For both WCB and CB, this new water cannot be extracted until after it has been introduced into the basin and projects must be monitored to demonstrate the amount of new water being added by this project. Further, if less new water results than is expected, parties involved in the project must provide make-up water or payment to make up the difference, and extraction rights can be reduced to match the actual volume of new water created as needed.[395] In CB, any extraction of augmented water will not be charged a Replenishment Assessment Fee as the water injected by parties does not need to be replenished

[390] Central Basin Adjudication; Case of *California Water Service Company et al. v City of Compton et al.*, (1961, amended 2014) Los Angeles Superior Court No. 506806. (West Coast Basin adjudication)

[391] water rights augmentation in CB Adjudication, p. 67; water augmentation in WCB Adjudication, p. 20&21

[392] CB adjudication p. 65-66, WCB adjudication p. 19-21

[393] CB adjudication, p. 66.

[394] WCB adjudication, p. 21

[395] CB adjudication, p. 67

by WRD.[396] No water will be considered lost unless all 330,000 AF of dewatered space is full; in that case parties will be provided time to extract the water. If it is not extracted, it will be considered part of the basin operating reserve.[397]

In WCB, if the community storage pool is at least 25% full and a party has stored water for 10 consecutive years, they must either convert that water to space-available storage or the stored water will be considered extracted first above all other rights.[398] As in CB, replenishment fees are not charged in WCB for extracting stored water as these fees have either been collected at time of conversion (e.g. carryover) or do not represent water which needs to be replenished by WRD (water stored in individual, community, or regional storage by parties for extraction).[399]

While space-available storage can be utilized by any party in WCB or CB, they may be required to evacuate that water if another party with higher priority rights to that space needs it or if the Storage Panel determines that the party is using excess available dewatered space.[400] As the City is a party to both WCB and CB, it is eligible to extract its WCB pumping rights from CB in each administrative year (within the limitation that no eligible party under this exception can exceed 5,000 AF).[401]

To get approval for this or any other storage or water augmentation project, any required CEQA documents must be completed and provided. The Storage Panel must consider such topics as nearby facilities, existing contamination, effects on groundwater elevation nearby, proximity to drinking water wells, etc. to verify that these projects won't cause "material physical harm."[402] In memos exploring pumping rights and regulatory challenges to capturing stormwater in the DC EWMP, incorporating factors such as groundwater modeling and other required components into the CEQA analysis is recommended as a potential method of expediting the process of approval by the Storage Panel and controlling costs as sufficient analyses done by the party may preclude the need for the Storage Panel conducting its own analyses to demonstrate that these projects will not cause any material harm to the basin.[403]

Gathering data and creating a detailed, high-resolution surface to groundwater model which provides robust guidance on where stormwater falling on the surface ends up upon after infiltration across various regions of the watershed is an important piece of implementing these projects. This type of model, if vetted and approved by all agencies involved in the process of quantifying the volume of stormwater augmenting aquifer supplies and increasing maximum sustainable yield of

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[396] CB adjudication, p. 58

[397] CB adjudication p. 59

[398] WCB adjudication, p.14

[399] WCB adjudication, p. 17

[400] WCB adjudication, p.18

[401] CB adjudication, p. 60

[402] Compiled from brief description in DC EWMP February 2016 and more detail from the adjudications.

[403] Jungreis JN, Water Rights and Regulatory Challenges Associated with Capturing and Injecting Stormwater in the Dominguez Channel Watershed (February 24, 2015), Rutan and Tucker Memo generated for Dominguez Channel EWMP p. 11

groundwater, could also be used to identify the most promising areas to target for increased infiltration to maximize water supply benefits and pollutant load reduction. The model would need to incorporate detailed information on the water quality of both existing groundwater and stormwater to be infiltrated, hydrology, recharge rates, travel times, changes in climatic conditions, etc.

iii. WRD Replenishment to meet full extraction of groundwater pumping rights

The following management strategies and projects work toward the goal of Concept A in WCB, which is to additively provide enough local replenishment water to enable complete extraction of the full adjudicated rights volume. WRD needs to recharge an additional 16.1 MGD (18,000 AFY) to facilitate the sustainable extraction of the complete adjudication of 57.6 MGD (64,468 AFY).[404] Water used for injection at the barrier projects has historically been a combination of recycled water and imported water. The RWCs, however, at West Coast Basin Barrier Project (WCBBP) and the Dominguez Gap Barrier Project (DGBP) have recently been increased from a 50 percent recycled water contribution (RWC) to a 100 percent RWC. Therefore, up to 15.2 MGD (17,000 AFY) from the ELWRF could be injected at WCBBP; DGBP is anticipated to inject 4.5 MGD (5,000 AFY) of recycled water.[405]

TIWRP is currently undergoing onsite expansion. After construction of the advanced water treatment facility and pipeline, TIWRP will be able to produce an additional 2.2 MGD (2,500 AFY) of advanced treated recycled water for injection at the DGBP.[406] ELWRF could also produce an additional 13.4 MGD (15,500 AFY) of recycled water for injection at WCBBP but it would require a 13.8 MGD (15,456 AFY) capacity increase either on existing facility property or adjacent property.[407] This plan would also necessitate the construction of two pipelines, one from HWRP to ELWRF to convey the necessary additional source water and another one to increase the capacity of conveyance from ELWRF to the WCBBP injection wells.

One of the key management strategies described in the GBMP to facilitate the extraction of the full volume of adjudicated rights in WCB, and which could be an opportunity for the City, and other rightsholders with recycled water supplies, to increase their pumping in WCB involves a shift in industrial groundwater use, particularly from oil refineries. The City could offer recycled water to industrial users in exchange for a lease on their groundwater pumping rights and thus increase their groundwater pumping for potable use. An estimated 5.9 MGD (6,600 AFY) of industrial pumping rights are currently being used in the Long Beach/San Pedro area which could be redistributed to municipal pumpers upon supply of recycled water to the industrial rightsholders.[408] If municipal purveyors maintain the current industrial use pumping rate, it would increase water supplies in WCB without requiring direct replenishment and there would be no net increase

[404] CBWCB GBMP DPEIR 2015 p. 3-7

[405] CBWCB GBMP DPEIR 2015 p. 3-12 and p. 3-13

[406] CBWCB GBMP DPEIR 2015 p. 3-13

[407] CBWCB GBMP DPEIR 2015 p. 3-13

[408] CBWCB GBMP DPEIR 2015 p. 3-13

in extraction. Beyond the industrial rights currently being utilized, there are 20.1 MGD (22,500 AFY) of unused rights that could also be transferred to municipal pumpers through this type of approach. If the total adjudication for these industrial users is utilized, pumping in WCB could be increased by approximately 25.9 MGD (29,000 AFY).[409] This plan would require treatment plant upgrades, and the construction of pipelines and pump stations to produce and convey recycled water to the industrial users.

In CB, the following management strategies and projects work toward the goals of Concept A (to provide enough local recharge water to enable complete use of adjudication). CB requires an additional replenishment of 10.7 MGD (12,000 AFY) to enable the full extraction of its 194.1 MGD (217,367 AFY) adjudication. Several projects that could fulfill a total new replenishment volume up to 24.1 MGD (27,000 AFY) are described as a list of potential options to reach the 8.9 MGD (10,000 AFY) replenishment goal at MFSG. [410] Current replenishment at MFSG consists of 44.6 MGD (50,000 AFY) of tertiary-treated water, 50.9 MGD (57,000 AFY) of local runoff, and 18.8 MGD (21,000 AFY) of imported water.[411] The addition of 8.9 MGD (10,000 AFY) of tertiary-treated or advanced treated recycled water (or a combination of both) is proposed through a number of options, one of which involves the increased production at LACSD's San Jose Creek WRP (SJCWRP). Other options include a new AWT facility within the Montebello Forebay. Projects C3 and C4 involve new treatment facilities at Los Coyotes WRP (LCWRP), new recycled water pipelines, and new injection wells.[412]

CB's Concept A management strategy includes the implementation of the Groundwater Reliability Improvement Program (GRIP). Through implementing GRIP, WRD plans to replace the current use of 18.8 MGD (21,000 AFY) of imported water at the MFSG with a combination of tertiary-treated and advanced treated recycled water for groundwater replenishment.[413] 9.8 MGD (11,000 AFY) of the tertiary-treated recycled water will be supplied by LACSD's SJCWRP through an existing underground outfall pipeline.[414] WRD plans to construct a new AWTF to supply the remaining 8.9 MGD (10,000 AFY) of advanced treated recycled water to MFSG; the water will be conveyed through the same existing outfall pipeline.[415] The new AWTF is expected to start operation in 2018. The AWTF site is located along the San Gabriel River Parkway within the city of Pico Rivera.[416] Construction of the GRIP has begun and funding for the project has been secured. When GRIP is completed in the summer of 2018, WRD's current demand for imported water for replenishment in the MFSG will be eliminated.

[409] CBWCB GBMP DPEIR 2015 p. 3-14

[410] CBWCB GBMP 2016 p. 5-12

[411] CBWCB GBMP DPEIR 2015 p. 3-19

[412] CBWCB GBMP 2016 p. 5-12 to 5-15

[413] CBWCB GBMP DPEIR 2015 p. 3-19

[414] CBWCB GBMP DPEIR 2015 p. 3-19

[415] CBWCB GBMP DPEIR 2015 p. 3-19

[416] WRD Groundwater Replenishment Improvement Program Supplemental Recharge Wells Project Draft Supplemental Environmental Impact Report 2016 p. ES-4

Further, WRD developed the GRIP Supplemental Recharge Wells Project to accept AWT when MFSG cannot; this project is an addition to the GRIP project. The volumes in this project were not be considered in WRD's GBMP Concept A goals. The project proposes 3 storage wells and 3 monitoring wells near the AWTF site. Storage wells in this context refer to wells that inject and store AWT for replenishment and later use by other groundwater users.[417] The purpose of these wells is to allow the AWTF to operate and inject AWT at a constant minimum when MFSG is unavailable during the wet season. Each storage well will have the capacity to inject 1.5 MGD (1,680 AFY), for a total of 4.5 MGD (5,040 AFY).[418] Since WRD expects to operate these wells on average a minimum of 3 months per year, the annual storage volume is estimated to be approximately 137 million gallons per year per well (420 AFY).[419] This could be higher if wells are operated more than three months per year. The total storage volume of all three wells would be 411 million gallons per year (1,260 AFY).[420] The storage wells are proposed to be mainly gravity operated requiring negligible amount of operational energy. This operation would allow maximum groundwater recharge while simultaneously minimizing the unit cost of producing recycled water. The 3 monitoring wells would be used to monitor groundwater levels and quality, which is subject to permitting requirements of LARWQCB and DDW.

The Alamitos Gap Barrier Project (AGBP) is currently transitioning to 100% RWC and is expected to inject 7.1 MGD (8,000 AFY) of recycled water (Project C0-B).[421] The recycled water will be supplied by LVLWTF through recently expanded production capacity. On average during WY 2000-2009, 5.4 MGD (6,000 AFY) was injected at AGBP; the anticipated rate of 7.1 MGD (8,000 AFY) would result in 1.8 MGD (2,000 AFY) volume of new replenishment.[422] Another plan to increase recharge in CB is through Project C5, Aquifer Recharge and Recovery Facilities (ARRF). These facilities would divert stormwater from the Los Angeles River to spreading basins near the river along the 710 Freeway. The stormwater would be initially treated through the soil into the shallow aquifer and then pumped from this aquifer and injected into a deeper aquifer of the Los Angeles Forebay. It is estimated that these facilities could replenish up to 4.5 MGD (5,000 AFY) of stormwater into CB.[423] This plan would require the new spreading basins along the 710 Freeway, 7 extraction wells in these spreading basins, and 8 injection wells.

iv. WRD Replenishment to meet extraction beyond groundwater pumping rights

The following management strategies and projects work toward the goals of Concept B in WCB, to provide an additional 26.8 MGD (30,000 AFY) for replenishment that would enable an increase of pumping rights by the same amount. Total permitted extraction in WCB under this

[417] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. 2-5

[418] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. ES-1

[419] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. ES-5

[420] WRD GRIP Supplemental Recharge Wells Project DSEIR 2016 p. ES-5

[421] CBWCB GBMP DPEIR 2015 p. 3-19

[422] CBWCB GBMP DPEIR 2015 p. 3-16 Table 3-5

[423] CBWCB GBMP DPEIR 2015 p. 3-20

scenario would be 84.3 MGD (94,468 AFY). Part of the strategy utilizes existing seawater intrusion barrier injection well capacities and additional recycled water production opportunities. Recycled water injections at the DGBP and the WCBBP are each expected to increase by 6.7 MGD (7,500 AFY) above Concept A amounts to 11.6 MGD (13,000 AFY) and 35.7 MGD (40,000 AFY), respectively.[424] DGBP is expected to receive the necessary additional source water from TIWRP and approximately 1.8 MGD (2,000 AFY) from a proposed new AWTF at JWPCP.[425] ELWRF (or a new offsite facility) could supply WCBBP. Construction of conveyance pipelines and pump stations would be required to send the recycled water from the plants to the barrier wells.

Additional replenishment is also proposed through the installation of a new injection well system inland of the existing injection barriers in WCB. The construction of the new AWTF at LACSD's JWPCP described above is also expected to supply the new injection well system with 13.4 MGD (15,000 AFY) of advanced treated water.[426] Up to 16 new extraction wells with wellhead treatment facilities in addition to new pipelines, pump stations, and injection wells would be required for this project.[427]

Concept B projects and management strategies in CB could provide additional local water for replenishment to facilitate the extraction of an additional 92.2 MGD (103,250 AFY) to allow a total extraction of up to 286.3 MGD (320,617 AFY).[428] If the proposed projects replenish the maximum expected amount of water, as much as 96.4 MGD (108,000 AFY) could be injected in CB.[429] The Groundwater Basin Optimization Pipeline (GBOP), project C6, would allow MFSG to take advantage of an estimated 15.2 MGD (17,000 AFY) of stormwater that currently flows to the ocean during heavy precipitation events.[430] The limiting factor in the MFSG is availability of storage space during the winter months. To remedy this, the GBOP proposes the installation of new extraction wells that would pump 22.3 MGD (25,000 AFY) of water to four users (Santa Fe Springs, Golden State Water Company, Paramount, and Long Beach) in the south; new pipelines and pump stations would also be required.[431] This plan would reduce groundwater levels and create space for stormwater recharge.

Another strategy to increase injection at MFSG involves the construction of new wells in the Montebello Forebay area. As part of this strategy, LACSD would alter the existing sewage collection system in the Whittier Narrows WRP area and reroute wastewater flow from JWPCP to SJCWRP (project C7). It is estimated that SJCWRP has the capacity to treat an additional 24.6 MGD (27,580 AFY) of wastewater that could be treated to recycled water standards (most likely

[424] CBWCB GBMP DPEIR 2015 p. 3-18

[425] CBWCB GBMP DPEIR 2015 p. 3-18

[426] CBWCB GBMP DPEIR 2015 p. 3-18

[427] CBWCB GBMP DPEIR 2015 p. 3-18

[428] CBWCB GBMP DPEIR 2015 p. 3-20

[429] CBWCB GBMP DPEIR 2015 p. 3-16, Table 3-5

[430] CBWCB GBMP DPEIR 2015 p. 3-20

[431] CBWCB GBMP DPEIR 2015 p. 3-20; CBWCB GBMP 2016 p. 5-16

tertiary treated water from SJCWRP) and sent to MFSG as recharge.[432] The wastewater flow that is currently treated at JWPCP would also be recharged at the Montebello Forebay instead of being discharged into LACSD's ocean outfall off the coast of Palos Verdes.[433]

An additional project includes 17 new injection wells in the Montebello Forebay that could receive 16.2 MGD (18,190 AFY) of advanced-treated recycled water.[434] The advanced-treated recycled water would be supplied by new AWTFs installed at MF, project C8, and Los Coyotes WRP, project C9. While no new conveyance pipelines would be required for the facilities built at MF, connecting recycled water pipelines would be necessary from Los Coyotes WRP to MFSG.

Project C10 involves the construction of a new satellite water reclamation facility in eastern Los Angeles that could supply up to 40.6 MGD (45,480 AFY) of AWT for recharge at the LA Forebay.[435] This facility would further treat wastewater from the Hyperion WRP collection system. New pipelines, pump stations, up to 50 new injection wells and 21 new extraction wells would need to be installed to connect the new treatment facility to the injection wells and the extraction wells to the LADWP potable water distribution system.

[432] CBWCB GBMP DPEIR 2015 p. 3-21

[433] CBWCB GBMP DPEIR 2015 p. 3-21

[434] CBWCB GBMP DPEIR 2015 p. 3-21

[435] CBWCB GBMP DPEIR 2015 p. 3-21