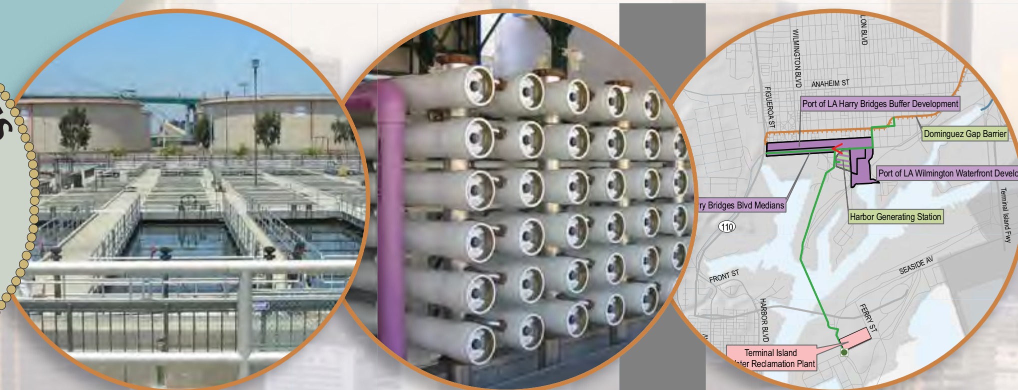
City of Los Angeles

Recycled Water Master Planning

Los Angeles Department of Water and Power
and
Department of Public Works



Terminal Island Water Reclamation Plant Barrier Supplement and Non-Potable Reuse Concepts Report

Prepared by:

RMC in association with CDM Smith

March 2012

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Recycled Water Master Planning

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REGISTERED PROFESSIONAL ENGINEER
THOMAS G. RICHARDSON
No. 35356
Exp. 09-30-13
CIVIL
STATE OF CALIFORNIA

LA DWP

CITY OF LOS ANGELES
SANITATION
DEPARTMENT OF PUBLIC WORKS

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Title:	TIWRP Barrier Supplement and NPR Concepts Report
Prepared For:	John Hinds, Project Manager, LADWP Doug Walters, Project Manager, BOS Lenise Marrero, Task 4 Co-Lead, BOS
Prepared By:	Steve Clary, Task 4 Lead, RMC Brian Dietrick, Task 4 Project Engineer, RMC John Thayer, RMC Greg Bradshaw, RMC Miluska Propersi, RMC Kris Helm, Kris Helm Consulting Chris Harris, Harris & Company
Reviewed By:	Tom Richardson, Project Manager, RMC Heather VanMeter, Deputy Project Manager, CDM Greg Wetterau, CDM Marilyn Bailey, RMC
Contributors:	James Yannotta, DWP Paul Liu, DWP John Hinds, DWP Doug Walters, BOS Roshanak Aflaki, BOS Seung Oh, BOS Michael Sarullo, BOE Slavica Dedovic-Hammond, BOE Lenise Marrero, BOS
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Abbreviations and Acronyms

ADWF	average dry weather flow
AFY	acre-feet per year
AOP	advanced oxidation process
AWPF	Advanced Water Purification Facility
AWTF	Advanced Water Treatment Facility
BOS	City of Los Angeles, Bureau of Sanitation
City	City of Los Angeles
DCTWRP	Donald C. Tillman Water Reclamation Plant
DGB	Dominguez Gap Barrier
EQ	equalization
gpm	gallons per minute
GWR	groundwater recharge
LACDPW	Los Angeles County Department of Public Works
LADWP	City of Los Angeles Department of Water and Power
MBR	membrane bioreactor
MF	microfiltration
mgd	million gallons per day
mg/L	milligrams per liter
MWD	Metropolitan Water District of Southern California
NPR	non-potable reuse
RO	reverse osmosis
RMC	RMC Water and Environment
RWMP	Recycled Water Master Planning
RWAG	Recycled Water Advisory Group
RWQCB	Regional Water Quality Control Board
TDS	total dissolved solids
TIWRP	Terminal Island Water Reclamation Plant
TM	technical memoranda
UV	ultraviolet
WBMWD	West Basin Municipal Water District
WRD	Water Replenishment District
WRP	water reclamation plant

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Executive Summary

The Los Angeles Department of Water and Power (LADWP), in partnership with the Los Angeles Department of Public Works (LADPW) Bureau of Sanitation (BOS) and Bureau of Engineering (BOE), developed the **Recycled Water Master Planning** (RWMP) documents. Specifically, the RWMP process identified projects that will significantly increase the City's recycled water use locally. Recycling more water within the Los Angeles metropolitan area provides a number of benefits. For each acre-foot of recycled water used, an equal amount of imported water is saved. As a local source of water, recycled water is more reliable than imported water and is drought-resistant.

Since the early 1900s, Los Angeles has tapped into a variety of water sources. Today, the City's water comes from Northern California (California Aqueduct); Owens Valley and Mono Lake Basin (Los Angeles Aqueduct); Colorado River (Colorado River Aqueduct); and several local water sources including groundwater aquifers, stormwater capture, and recycled water. But securing water from distant sources has become more restricted and unreliable. LADWP's 2010 Urban Water Management Plan (UWMP) outlines a goal of increasing recycled water to 59,000 acre feet per year (AFY) by 2035 to reduce dependence on imported water.

The RWMP documents include an evaluation of alternatives – strategies that take into account forward-looking groundwater replenishment (GWR) options as well as the more familiar form of recycling water for non-potable reuse (NPR) purposes, such as for irrigation and industry. This Master Planning Report is one element of the RWMP documents. It presents a roadmap for expanding the TIWRP Advanced Water Treatment Facility (AWTF)[1] to maximum production capacity and evaluates the possibility of expanding deliveries to the Dominguez Gap Barrier (DGB) and potential non-potable uses.

The results of this analysis will be combined with findings and recommendations of several other technical studies being completed for the RWMP effort. When implemented, the RWMP will provide project alternatives to deliver 59,000 AFY of recycled water in the near-term to offset imported water and potential implementation strategies for long-term concept projects.

ES.1 Introduction

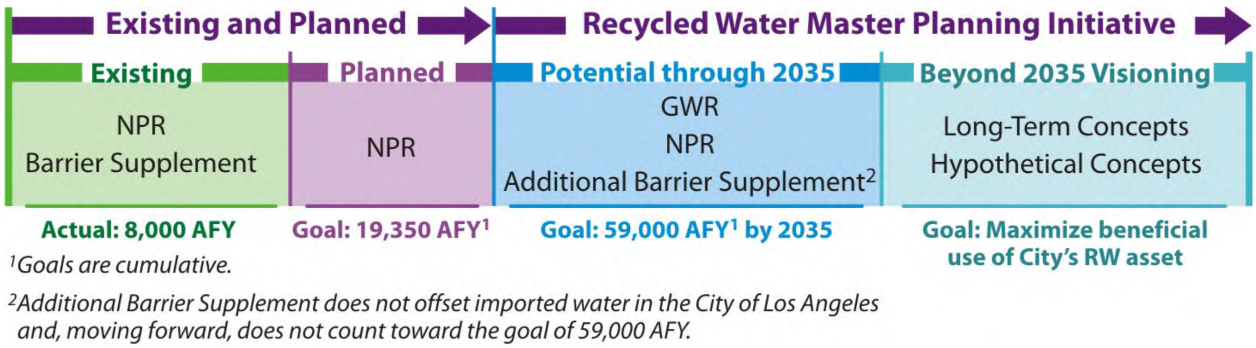
LADWP is implementing its multi-faceted 2010 UWMP to ensure a safe and reliable water supply for future generations of Angelenos. This is a blueprint for L.A.'s water future, and many elements go into such an important plan, such as the RWMP effort.

Figure ES-1 summarizes the City of Los Angeles' RWMP Initiative, which is guiding the development of recycled water planning for the near-term and long-term. The 2010 UWMP includes a near-term goal to develop 59,000 AFY of recycled water use by 2035 as a sustainable source of local water. Of this amount, approximately 8,000 AFY is currently used for NPR and for barrier supplement in the Dominguez Gap Barrier. An additional 11,350 AFY of NPR projects are in development. The focus for the remaining near-term is to develop 39,650 AFY

[1] The existing advanced treatment facility at TIWRP is referred to as the Advanced Water Treatment Facility (AWTF). The first phase (Phase I) uses this term. The facility expansions for Phases II through IV use the term "Advanced Water Purification Facilities (AWPF)" because they include advanced oxidation (AOP).

(30,000 AFY from GWR and 9,650 AFY from NPR) of recycled water in Los Angeles to offset 59,000 AFY of imported water. The focus of the long-term is to offset imported water to the extent possible (up to 168,000 AFY) by 2085, fifty years after 2035.

Figure ES-1: Overview of RWMP Components



TIWRP Barrier Supplement and NPR Concepts Report

The purpose of this Terminal Island Water Reclamation Plant (TIWRP) Barrier Supplement and Non-Potable Reuse (NPR) Concepts Report is to present a roadmap for expanding the TIWRP AWTF/AWPF to maximum production capacity and evaluate the possibility of expanding delivery to DGB and potential non-potable uses. The report also recommends reliability measures consisting of contingency facilities to be utilized when supply to any of these uses is interrupted. Some of the projects identified in this report support LADWP's goal to increase reuse to 59,000 AFY by 2035 and some of the projects support BOS and BOE goal to maximize reuse from TIWRP.

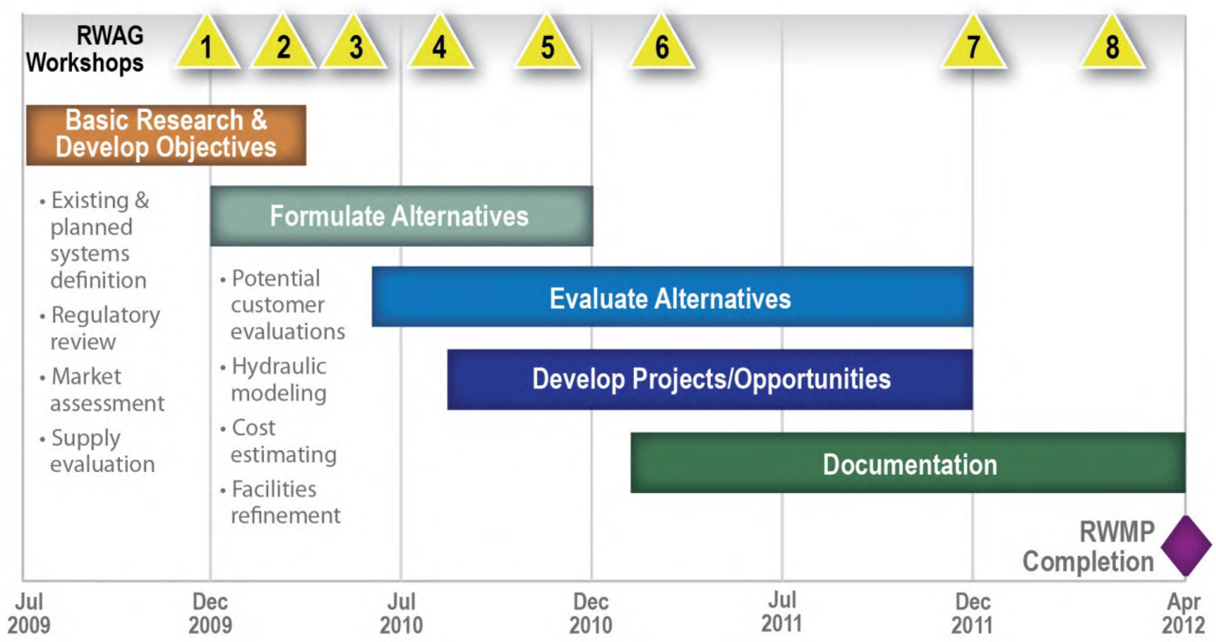
Recycled Water Master Planning Approach

The RWMP multi-year planning process has focused on four major steps:

- Perform basic research and develop planning objectives;
- Formulate alternatives, based upon the research and objectives;
- Evaluate alternatives; and,
- Develop viable projects and opportunities.

Stakeholders have been involved in discussions with the recycled water planning team since late 2009. Their input has been folded into each of these major steps, resulting in viable projects and opportunities that include insights and interests of a very diverse cross-section of the Los Angeles community. **Figures ES-2** illustrates the main RWMP steps and timeline.

Figure ES-2: Recycled Water Master Planning Approach and Schedule



Organization of the TIWRP Barrier Supplement and NPR Concepts Report

The purpose of this report is to present a roadmap for expanding TIWRP AWTF/AWPF to maximum production capacity and to evaluate the possibility of expanding deliveries to the DGB and potential non-potable uses.

The **TIWRP Barrier Supplement and NPR Concepts Report** is organized into the following sections:

- Section 1 – Introduction
- Section 2 – Background Information on Existing TIWRP
- Section 3 – Module Analysis for AWPF Expansion
- Section 4 – Reliability Evaluation
- Section 5 – Dominguez Gap Barrier Considerations
- Section 6 – Probable Capital Cost Ranges
- Section 7 – Implementation
- Section 8 – Conclusions
- Section 9 – References

Summary of Findings

Based on the conceptual analysis in this Report, expanding TIWRP to provide additional barrier water to the DGB is feasible. However, to determine if the project is economically viable, the City will need to perform a comprehensive evaluation of project costs, including potential improvement costs for the DGB. In addition, the City will need to negotiate interagency operational and financial agreements to allow expanded use of TIWRP product water on a long-term basis. The City will also need to determine how to fund providing additional barrier water to the DGB since it provides a regional benefit to Southern California rather than offsetting imported water use within the City to achieve the goals of the 2010 UWMP.

ES.2 Phases

This Report describes a phasing plan and provides a list of required major facilities for the following phases of expansion of the AWTF/AWPF at TIWRP. It should be noted that Phase I uses the term "AWTF" and Phases II through IV use the term "AWPF" (used when AOP facilities are included).

- ***Phase I (5.0 mgd): Recover Existing Rated AWTF Capacity***: Retrofit and improve existing facility to achieve reliable AWTF production capacity of 5.0 mgd. The improvements include microfiltration (MF) membrane and valve replacements, addition of two MF skids, clean in place (CIP) upgrades, and reverse osmosis (RO) membrane replacement. It is planned for Fiscal Year 2011-2012.
- ***Phase II (6.0 mgd): Make Incremental AWPF Improvements***: Add two MF skids, add ultraviolet light (UV) and advanced oxidation (AOP), and implement targeted RO improvements to re-rate the flow capacity of the existing MF system and raise AWPF production capacity from 5.0 mgd to 6.0 mgd.
- ***Phase III (9.0 mgd)***: ***Expand AWPF by 3.0 mgd:*** Increase the AWPF production capacity from 6.0 mgd to 9.0 mgd using the same technology included in Phase II: MF/RO/UV/AOP.
- ***Phase IV (12.5 mgd): Maximize AWPF Production***: Increase the AWPF production capacity from 9.0 mgd to a maximum capacity of 12.5 mgd using the same technology used through Phase III: MF/RO/UV/AOP.

For Phases II through IV, two alternatives for MF units are proposed; and cost estimates are presented for both. The first alternative uses Memcor 90M10C units similar to the existing units at the AWTF. The second alternative uses newer technology that has the benefit of a smaller footprint. A summary of the facilities proposed for each phase is presented in **Table ES-1**.

Table ES-1: Phasing of TIWRP Reliability Upgrades (Phase I) and Capacity Expansions (Phase II to IV)

Phase	Purpose
Phase I – 5.0 MGD[a]	
MF: membrane and valve replacement, 2 new MF skids, air compressors, CIP	Replace membranes at the end of useful life, expand MF capacity by two units to restore AWTF production capacity to 5.0 mgd
RO: membrane replacement	Replace membranes at the end of useful life to restore performance. RO production capacity is 6.0 mgd (the existing RO system can operate at a higher capacity than the existing MF system)
Product Water Stabilization conversion from lime addition to caustic + $CaCl_2$ addition w/new storage and feed pumps; CO_2 storage and feed at DGB	Reduce turbidity in product water and meet barrier water quality requirements for key parameters: pH, LSI, and MFI[f]
Electrical System: capacitors for MF wet well VFDs, product water pump VFDs, valves for chemical dosing	Allow product water pumping to better match plant production, while reducing start-up time
Maintain existing potable backup supply at effluent pump station wet well	Potable water backup to barrier can be served from existing air gap at TIWRP when AWPF is off-line[b]; can be used in combination with chlorine contact basin converted to storage in Phase II
Modify flow control system for delivery of RW to the DGB [g]	Allows plant to run at continuous delivery to RW users including DGB; solves existing control issues with competing control valves feeding DGB

Capacity or Reliability Feature Added	Purpose
Phase II – 5.0 to 6.0 MGD[a]	
MF: 2 new MF skids[d]	Increase AWPF production capacity to 6.0 mgd
Disinfection: UV + Peroxide (AOP) system	Provide disinfection capacity for 6.0 mgd and provide regulatory-mandated advanced oxidation for injection water when recycled water contributions to DGB are greater than 50%
Convert chlorine contact basin to product water storage	Allows continued delivery of IPR recycled water when AWPF goes offline; provides about 150 minutes of storage at AWPF production of 6.0 mgd
Improve DWP power grid to reduce frequency of voltage sags	Fewer voltage sags will result in less AWPF down-time.
Control System: new PLC system	Reduce start-up time after plant experiences power dips; implement standardized communication protocol for all instrumentation and VFDs
Instrumentation and Controls: upgrade of plant network	Improve and standardize communication protocol for all instrumentation and VFDs
Phase III – 6.0 to 9.0 MGD[a]	
MF: add 6 new MF skids and new canopy[d]	Increase AWPF production capacity to 9.0 mgd
RO: add 3.0 mgd of production capacity and new canopy	Increase AWPF production capacity to 9.0 mgd Upgrade RO transfer pumps and chemical addition system
Equalization: Tertiary[h]	Allow consistent flow rate for MF/RO feed
Product Water Pumps	Increase AWPF production capacity to 9.0 mgd
Product Water Stabilization	Increase AWPF production capacity to 9.0 mgd
Disinfection: AOP system (UV + Peroxide)	Increase AWPF production capacity to 9.0 mgd
Phase IV – 7.0 to 12.5 MGD[a]	
MF: add 7 new MF skids and new canopy[d]	Increase AWPF production capacity to 12.5 mgd
RO: add 3.5 mgd of production capacity and new canopy	Increase AWPF production capacity to 12.5 mgd Upgrade RO transfer pumps and chemical addition system
Equalization	Allow consistent flow rate for MF/RO feed
Product Water Pumps	Increase AWPF production capacity to 12.5 mgd
Disinfection: UV + Peroxide (AOP) system[e]	Increase AWPF production capacity to 12.5 mgd
Product Water Stabilization	Increase AWPF production capacity to 12.5 mgd

a. See Appendix A for cost estimates.
b. Existing 12-inch diameter potable backup connection can supply 2,500 gpm (3.6 mgd) per BOS, TIWRP operation staff (BOS, 2011).
c. Offsite hydraulic control improvement measures for DGB RW delivery were not included in the *TIWRP Capacity and Reliability Study* (CDM, 2011).
d. To assess the feasibility of newer-technology MF units, a preliminary analysis was conducted using information from the recent pre-design work for upgrades at the Donald C. Tillman Water Reclamation Plant (DCTWRP) and the Leo Vander Lans Water Treatment Facility (LVLWRF). The findings are summarized in Section 3 of this report. The analysis demonstrates that it may be possible to site MF facilities for a 12.5-mgd capacity AWPF (approximate MF footprint of 5,300 to 8,500 ft^2) inside the existing MF unit footprint (7,000 ft^2) at TIWRP. Cost estimates for replacing the entire MF system, and for installing the incremental MF expansion from 5.0 mgd to 12.5 mgd of AWPF product water, are included in Section 6 of this report.

e. BOE has suggested that an alternative advanced oxidation process also be investigated: ozone plus hydrogen peroxide, in lieu of UV. BOE is tracking a recent WEFTEC 2011 paper/presentation by Hokanson on the topic.
f. Barrier water quality requirements are: MFI < 1, LSI -0.5 to 0.5, pH 6.5 to 8.5, and NTU < 0.2.
g. Flow control system modifications at DGB need to be confirmed with a hydraulic model and pre-design assessment. The model and assessment should assess the feasibility of the following potential improvements to resolve existing pressure control issues at DGB: a) Control plant delivery by meeting flow set point with variable speed product water pumps; b) De-commission existing LADWP pressure reducing valve on the delivery pipeline to the barrier; c) Add pressure relief valve and pressure transmitter alarms to DGB piping at point of connection; d) Keep Metropolitan Water District pressure reducing valve at north end of DGB in service with downstream pressure set point.
h. According to information obtained from BOS, it may be possible to utilize between 1.0 and 1.5 million gallons of capacity in the existing tertiary effluent channel to provide some of the required EQ volume (BOS, 2012). The usable volume of this channel and its suitability for EQ purposes will need to be verified. This analysis assumes that if the channel is suitable, the 1.2 million gallon EQ proposed for Phase III could be avoided and that only the 1.3 million gallons in Phase IV would need to be constructed. A separate cost estimate is provided in Section 6 that only includes the Phase IV EQ facilities.

ES.3 Potential Reuse

Existing reuse of TIWRP product water is for barrier replenishment at the Dominguez Gap Barrier. Each of the first three phases of TIWRP capacity could supply a combination of DGB and non-potable uses. Delivery to DGB beyond Phase II assumes that the DGB can receive a 100 percent recycled water contribution (RWC) by the time of implementation. LADWP's maximum anticipated demands of the DGB are 8.0[2] mgd.

To maximize reuse from TIWRP to 12.5 mgd may require the consideration of additional DGB deliveries or non-potable uses beyond those considered in the Non-Potable Reuse Master Planning Report, including:

- Delivery to alternative Harbor Service Area private sector users other than irrigation users.
- Interagency transfer of purified recycled water involving blending of TIWRP effluent with a neighboring agency's recycled water distribution system.

Additional DGB deliveries beyond 8.0 mgd would entail "Recharge and Recovery" (or indirect potable reuse [IPR]), which consists of supplying recycled water for increased injection at the DGB and subsequent withdrawal of groundwater in the vicinity of the DGB. This approach also assumes that the DGB is permitted to receive a 100 percent RWC by the time of implementation.

[2] It is possible that groundwater pumping could vary over time due to changes in use patterns and/or pumping rights. A value of 8.0 mgd for DGB demands is used in this TM for planning purposes based on discussions with LADWP. If the demand changes, it may impact the implementation schedule and/or the size of reuse projects supplied by TIWRP.

Acknowledgments

The RWMP process was commissioned in 2009 through the vision of LADWP, in partnership with the BOS and BOE. Critical to the development of the RWMP documents was a diverse team of contributors and reviewers. The following individuals have dedicated significant time and effort to shaping a reliable, sustainable water future for Los Angeles.

City Executive Management

James McDaniel	Glenn Singley	Thomas Erb	Enrique Zaldivar	Traci Minamide	Kenneth Redd
Senior Assistant General Manager for the Water System, LADWP	*Director of Water Engineering and Technical Services, LADWP*	*Director of Water Resources (Retired), LADWP*	*Director, BOS*	*Wastewater Plant Operations & Chief Operating Officer, BOS*	*Deputy City Engineer, Wastewater Program*

Project Leaders		
James Yannotta *Assistant Director of Water Resources, LADWP*		Randy Raines *President, RMC*
Doug Walters, *BOS* Michael Sarullo, *BOE*	Paul Liu, *LADWP* Evelyn Cortez-Davis, *LADWP*	Tom Richardson, *RMC* Heather Boyle VanMeter, *CDM Smith*

Project Team and Contributors

Mark Aldrian, LADWP
Roshanak Alfaki, BOS
Marilyn Bailey, RMC
Brooks Baker, LADWP
Berenice Barajas, LADWP
Jennifer Barrick, LADWP
Al Bazzi, BOE
Danilo Bautista, Dean Ryan Consultants & Designers
Michael Bell, BOS
Patricia Bohlmann, BOS
Greg Bradshaw, RMC
Marie Burbano, CDM Smith
Debbie Burris, DDB Engineering
R. Bruce Chalmers, CDM Smith
Chuen-Shiow Chen, CDM Smith
Nicole Clark, Dakota Communications
Steve Clary, RMC
Teren Correnti, CDM Smith
Donald Cresse, LADWP
Victoria Cross, LADWP
Timeyin Dafeta, BOS
Javier De La Cruz, RMC
Slavica Dedovic-Hammond, BOE
Hampik Dekermenjian, CDM Smith
Chris DeMonbrun, BOS
Brian Dietrick, RMC
Luis Durruty, BOS
Kelley Dyer, CDM Smith
Dave Ebersold, CDM Smith
Jerry Edwards, ID Modeling
Nasir Emami, BOS
Kraig Erickson, RMC
Steve Fan, BOS
Dawn Flores, RMC
Adam Fox, RMC
Jane Galbraith, LADWP
Joshua Gillins, LADWP
Arthur Goh, CDM Smith
Scott Goldman, RMC
Fernando Gonzalez, BOS
Jesus Gonzalez, LADWP
Serge Haddad, LADWP
Chris Harris, Harris & Company
Kris Helm, Kris Helm Consulting
Brian Heywood, CDM Smith
John Hinds, LADWP
David Hokanson, Trussell Technologies
John Huynh, LADWP
Hadi Jonny, LADWP
Bob Kemmerle, E2 Consulting Engineers
Jennifer Kong, BOS
Connie Leonard, CDM Smith
John Lockett, LADWP
Scott Lynch, RMC
Kerman Maddox, Dakota Communications
Lenise Marrero, BOS
Michael Matson, RMC
Regidia Mayrena, BOS
Kerry McCorkle, LADWP
Omar Moghaddam, BOS
Rob Morrow, RMC
Margaret Nellor, Nellor Environmental Associates

Hiddo Netto, BOS
Andy Niknafs, LADWP
Seung-Tag Oh, BOS
George Pantages, BOS
Kaushal Parbhoo, LADWP
Nishant Parulekar, RMC
Meha Patel, CDM Smith
Irene Paul, LADWP
Albert Perez, LADWP
Eloy Perez, LADWP
Ali Poosti, BOS
Arlene Post, CDM Smith
Miluska Propersi, RMC
Hassan Rad, BOS
Joseph Ramallo, LADWP
Abraham Razon, BOS
Elisa Reynolds, LADWP
Dan Rodrigo, CDM Smith
Todd Rother, LADWP
Mihran Sarkisian, BOS
Amanda Schmidt, RMC
Don Schroeder, CDM Smith
Michael Simpson, BOS
Eric Smith, CDM Smith
Persephene St. Charles, RMC
Mark Starr, BOS
Gary Stolarik, LADWP
Bob Sun, LADWP
Brian Tan, LADWP
Rebecca Tejada, ID Modeling
John Thayer, RMC
Jennifer Thompson, CDM Smith
Jorge Toscano, CDM Smith
Bryan Trussell, BOS
Rhodes Trussell, Trussell Technologies
R. Shane Trussell, Trussell Technologies
Yoshiko Tsunehara, LADWP
Jennifer Valdez, LADWP
Anthony Valdivia, RMC
Don Vandertulip, CDM Smith
Loudmilla Vertanessian, BOS
Dariush Vosooghi, LADWP
Adam Walden, LACDPW
Sophie Walewijk, RMC
Eric Wang, RMC
Rachael Wark, RMC
Amy Lee Webb, LADWP
Joe Webb, CDM Smith
Dan Wendell, RMC
Greg Wetterau, CDM Smith
Jeff Woon, CDM Smith
Evelyn You, CDM Smith
Robert Young, RMC
Ken Zimmer, LACDPW
George Zordilla, LADWP

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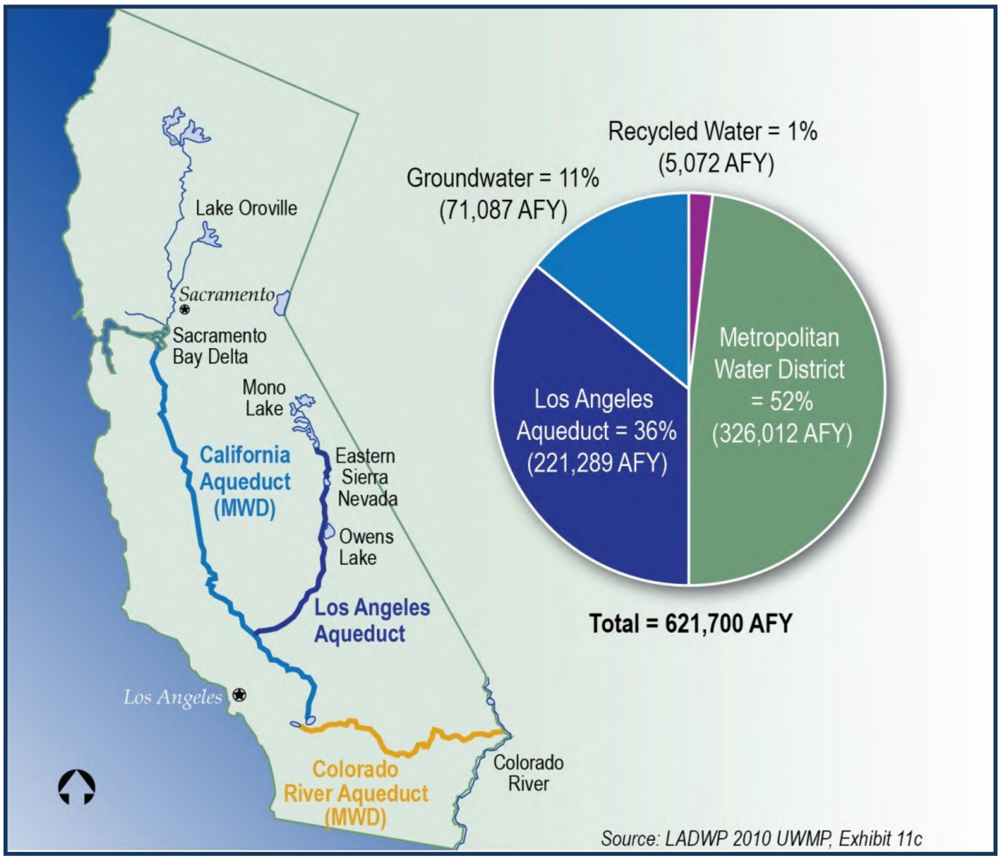
1. Introduction

1.1 Background

The City of Los Angeles (the City), with its location in a naturally dry area with warm temperatures, little rainfall, and few local sources of water, relies heavily on imported water from the Sacramento Delta (California Aqueduct), Eastern Sierra Nevada (Los Angeles Aqueduct), and Colorado River (Colorado River Aqueduct). More recently, local groundwater sources have only accounted for 11 percent of the total supply. These sources of water for the City, and annual average source water distribution for years 2006 to 2010, are illustrated in **Figure 1-1**.

Figure 1-1: Current Sources of Water for City of Los Angeles (FY 2006 to 2010)



The City's imported supplies have been significantly cut in recent years – some by as much as half – due to periods of dry weather and low snowpack, environmental commitments, and judicial decisions. In addition, the City's ability to utilize limited groundwater supplies has been impacted by contamination.

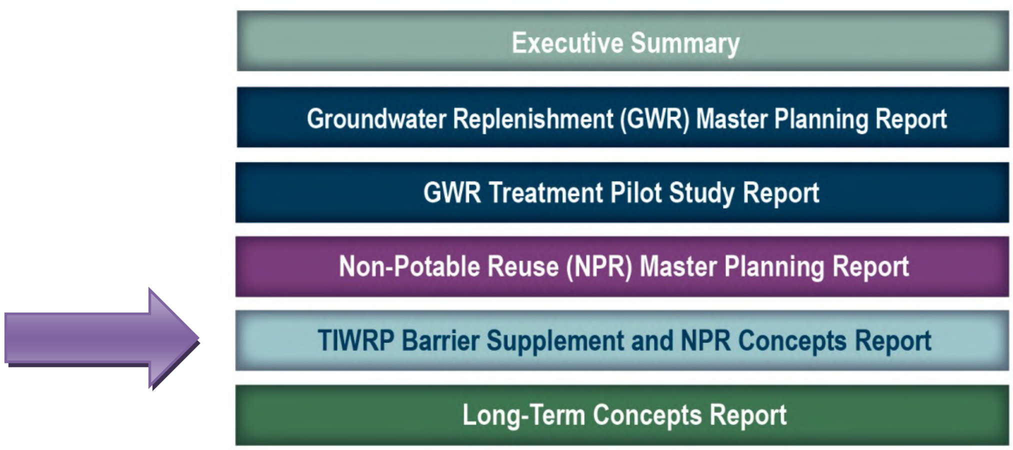
Conservation has helped Angelenos maintain about the same total water use since 1980, despite a population growth of 1 million people. However, conservation alone cannot meet future demands.

The City developed key strategies to secure a more reliable water supply for the City: 1) Increase water conservation, 2) Increase water recycling, 3) Enhance stormwater capture, 4) Accelerate groundwater cleanup, and 5) Green Building Initiatives. These strategies are being implemented through a number of parallel efforts and are documented in the 2010 Urban Water Management Plan (UWMP) for the City. The Los Angeles Department of Water and Power's (LADWP) 2010 UWMP outlines a goal of increasing recycled water to 59,000 acre feet per year (AFY) to offset imported water by 2035. The City currently uses approximately 8,000 AFY for non-potable reuse (NPR) and for barrier supplement in the Dominguez Gap Barrier.

LADWP, in partnership with the City of Los Angeles Department of Public Works (LADPW), Bureau of Sanitation (BOS) and Bureau of Engineering (BOE), developed the Recycled Water Master Planning (RWMP) documents to outline strategies to offset imported water demand by utilizing recycled water. Specifically, the RWMP process identified projects to significantly increase the City's recycled water use. Originally, the RWMP was to identify groundwater replenishment (GWR) and NPR projects to achieve 50,000 AFY. But after adoption of the 2010 UWMP, the goal of the RWMP was modified to identify, evaluate, and set a course for achieving a total use of 59,000 AFY[3] by 2035, as well as developing a plan to maximize reuse.

The RWMP documentation includes a series of volumes comprised of an Executive Summary, GWR Master Planning Report, GWR Treatment Pilot Study Testing Report, NPR Master Planning Report, TIWRP Barrier Supplement and NPR Concepts Report, and Long-Term Concepts Report, as well as a series of supporting technical memoranda (TMs). **Figure 1-2** illustrates the organization of these volumes.

Figure 1-2: RWMP Documentation



[3] LADWP has 8,000 AFY of existing recycled water customers, including both NPR and barrier supplement in the Dominguez Gap Barrier. LADWP has identified 11,350 AFY of new customers (19,350 AFY total), which are a portion of the overall 59,000 AFY goal. Therefore, the RWMP documents identify the additional 39,650 AFY of recycled water to meet the overall 59,000 AFY goal.

Figure 1-3 illustrates the breadth and linkage of the various RWMP components.

Figure 1-3: Overview of RWMP Components

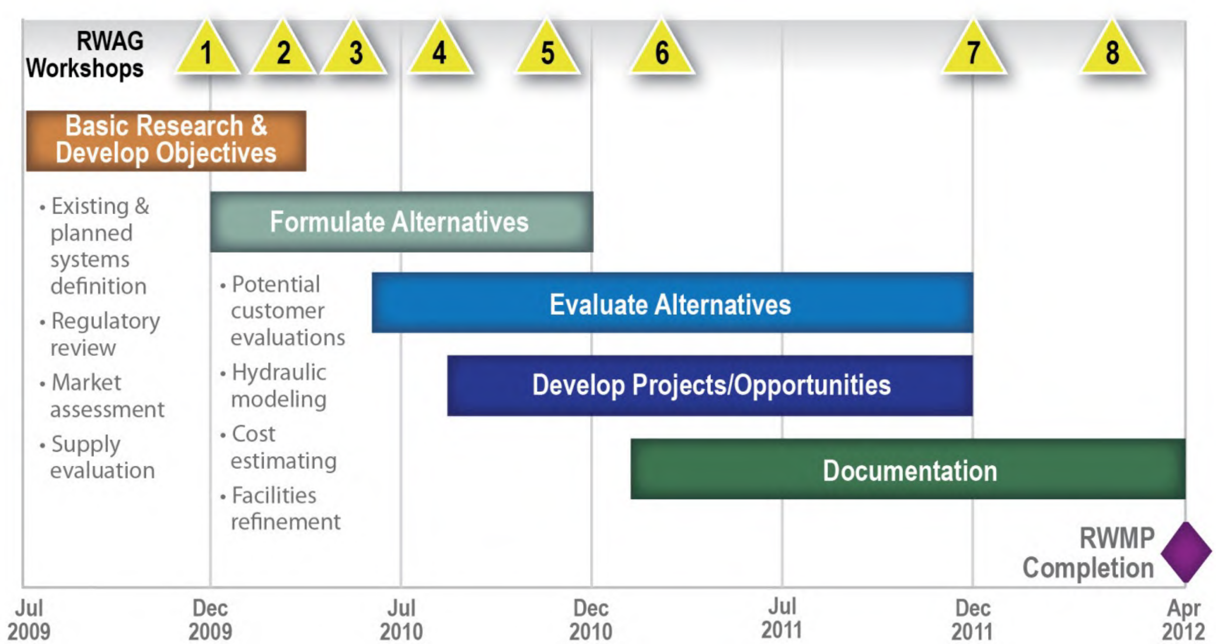
[1]Goals are cumulative.

[2]Additional Barrier Supplement does not offset imported water in the City of Los Angeles and, moving forward, does not count toward the goal of 59,000 AFY.

1.2 Recycled Water Master Planning Approach

The overall approach for the RWMP was to develop objectives, conduct basic research for GWR and NPR, formulate and evaluate integrated alternatives that include varying amounts of GWR and NPR, and from that analysis develop specific projects/opportunities and the associated master planning reports to implement the opportunities. **Figure 1-4** illustrates the main master planning steps and the timeline.

Figure 1-4: Recycled Water Master Planning Approach and Schedule



An important part of the RWMP is including stakeholders in the development process. In parallel to the RWMP, the City established a Recycled Water Advisory Group (RWAG) comprised of key public stakeholders representing neighborhood councils, environmental groups, industry, homeowners associations, and others. At key steps in the RWMP, the team held workshops with the RWAG to present information and seek feedback, which was then incorporated into the RWMP documents. In addition, Recycled Water Forums were held throughout the City to inform and receive input from the general public.

In 2010, the City contracted with the National Water Research Institute (NWRI) to establish an Independent Advisory Panel (IAP). Using an IAP increases the credibility of the project by providing an independent evaluation of the technical, regulatory, and health-related elements of the RWMP projects. By establishing the IAP early in the process, the City will have additional flexibility with the project implementation and facility planning issues that may arise during the engineering report.

1.3 Overview of TIWRP Barrier Supplement and Non-Potable Reuse Concepts Report

The purpose of this Terminal Island Water Reclamation Plant (TIWRP) Barrier Supplement and Non-Potable Reuse (NPR) Concepts Report is to present a roadmap for expanding the TIWRP Advanced Water Treatment Facility (AWTF)[4] to maximum production capacity and evaluate the possibility of expanding delivery to Dominguez Gap Barrier (DGB) and potential non-potable uses. The report also recommends reliability measures consisting of contingency facilities to be utilized when supply to any of these uses is interrupted. Some of the projects identified in this report support LADWP's goal to increase reuse to 59,000 AFY by 2035 and some of the projects support BOS and BOE goal to maximize reuse from TIWRP.

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- Section 2 – Background Information on Existing TIWRP
- Section 3 – Module Analysis for AWPF Expansion
- Section 4 – Reliability Evaluation
- Section 5 – Dominguez Gap Barrier Considerations
- Section 6 – Probable Capital Cost Ranges
- Section 7 – Implementation
- Section 8 – Conclusions
- Section 9 – References

[4] The existing advanced treatment facility at TIWRP is referred to as the Advanced Water Treatment Facility (AWTF). The first phase (Phase I) uses this term. The facility expansions for Phases II through IV use the term "Advanced Water Purification Facilities (AWPF)" because they include advanced oxidation (AOP).

1.4 Related Technical Memoranda and Reports

The following reports and TMs provide additional relevant information for this Report (in chronological order):

- CDM for BOS, 2011. *Capacity and Reliability Study for the Terminal Island Water Reclamation Plant Advanced Water Treatment Facility*.
- Malcom Pirnie for LADWP, 2010. *AWTF Membrane System Performance Evaluation*.
- RMC/CDM for LADWP, 2012. *Long-Term Concepts Report*.
- RMC/CDM for LADWP, 2010. *Terminal Island Advanced Water Treatment Facility Project Water Stabilization Review TM*.
- RMC/CDM, 2009. *Wastewater Flow Projections TM*.
- Carollo for BOE, 2009. *Terminal Island Advanced Wastewater Treatment Facility Membrane Optimization Study, Water Quality and Membrane Performance Evaluation*.
- Malcolm Pirnie for LADWP, 2007. *Advanced Water Treatment Facility Lime Stabilization Alternatives Bench Study*.
- CH2M Hill for BOS, 2006. *Terminal Island Treatment Plant Advanced Water Treatment Facility Equipment, Processes, and Procedures Evaluation Report*.
- BOE, 2004. *Lime Saturator System Draft Predesign Report*.

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2. Background Information on Existing TIWRP

2.1 Existing Facilities

TIWRP is designed to treat an average dry weather flow (ADWF) of 30 mgd and a peak flow of 50 mgd to tertiary standards. The plant has a current average daily influent flow rate of 15.5 mgd (data from 1999 to 2009). Tertiary effluent from the plant is discharged into the harbor outfall. Approximately 4 mgd (on an annual average basis) of tertiary effluent is pumped to the on-site AWTF, which began operating in 2002 and subsequently began supplying water to the DGB in 2006. The AWTF has a nominal production capacity of 5.0 mgd. Flow projections reported in the *Wastewater Flow Projections Draft TM* (RMC/CDM, 2009) project that the average daily influent sewage flow at TIWRP will increase to approximately 16.2 mgd by the Year 2040, with a resulting projected tertiary effluent flow of 16.2 mgd available to the AWTF/AWPF. To achieve this level of production, diurnal flow equalization would be required to bridge low nighttime flows of 4 to 5 mgd (see Section 4.2).

Table 2-1 summarizes existing facilities at TIWRP. All reuse demands discussed in this Report will be supplied with purified recycled water from the AWTF/AWPF. **Figure 2-1** shows the location of TIWRP in the San Pedro Harbor area with existing and planned customers and facilities. **Figure 2-2** shows an overall process flow diagram of the TIWRP facility.

Table 2-1: TIWRP Main Process Facilities

Process	Description	
Headworks	**Screenings Removal**	
	Type	Mechanically Raked Climber
	Number	2 (1 duty, 1 standby)
	Design Capacity	30 mgd (each)
	Aerated Grit Chamber	
	Number	3
	Area	10 ft x 61 ft x 10 ft
	Overflow Rate (2 Chambers)	45,100 gpd/ft^2
	Detention Time (3 chambers)	3.14 min
Primary Clarifiers	Type	Plastic Chain, Sprockets w/ Fiberglass Flights
	Number	6
	Area	20 ft x 250 ft
	Water Depth	11.9 ft
	Surface Overflow Rate	1,000 gpd/ft^2
	Detention Period @ ADF	2.14 hours
	Capacity	30 mgd
Secondary Reactors/ Treatment	**Aeration Tanks**	
	Type	Conventional, 3 pass
	Number	9
	Area	30 ft x 300 ft

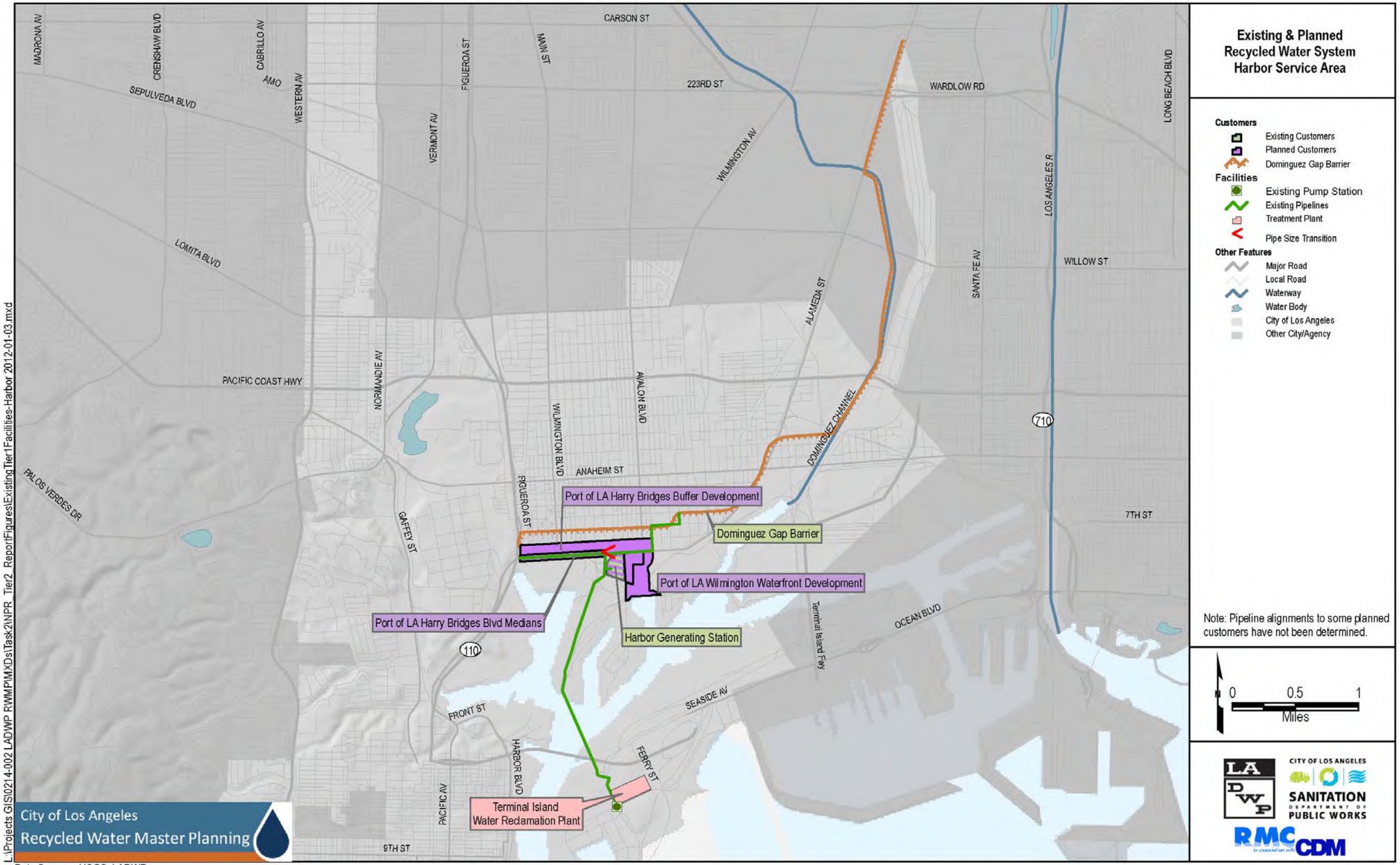
Process	Description	
	Average Water Depth	15 ft
	Sludge Retention Time	5.5 hours
	Design Capacity	30 mgd
	Process Air Blowers	
	Type	Centrifugal
	Number	3 (1 duty, 2 standby)
	Capacity	1500 HP, 39,000 scfm at 9 psig; Blower No. 1 has been modified to deliver 25,000 scfm
Secondary Clarifiers	Number	18
	Area	20 ft x 150 ft
	Side Water Depth	12 ft
	Surface Overflow Rate	555 gpd/ft^2
	Detention Time	2.9 hours
	Design Capacity	30 mgd
Filtration System (Tertiary Treatment)	Type	Multi-media Deep Filter Beds
	Number	16
	Filter Media	Anthracite, Silica Sand, High Density Sand
	Loading Rate	5 gpm/ ft^2 (max.), 2.3 gpm/ ft^2 (avg)
	Design Capacity, ADWF	30 mgd (w/one filter out-of-service)
	Design Capacity, PWWF	65 mgd (w/one filter out-of-service)
	Type	Multi-media Deep Filter Beds
Advanced Treatment	**Microfiltration**	
	Pretreatment	Sodium Hypochlorite Addition
	Number of Installed CMF Units	10
	Model/Type	Memcor 90M10C Polypropylene Hollow Fine Fiber
	Reverse Osmosis (RO):	
	RO Feedwater Pumps	
	Type	Vertical Turbine Can Pumps
	Number	2
	Design Flow Capacity	2600 gpm
	Design TDH	578 ft
	RO Second Stage Booster Pumps	
	Number	2
	Design Flow Capacity	900 gpm
	Design TDH	230 ft
	RO Membranes	

Process	Description	
	Number of RO trains	2
	Nominal Permeate Capacity per Train	2.5 MGD
	Max. RO System Capacity per Train	2.0 - 3.0 MGD
	Number of vessels per Train	98
	Number of membrane elements per vessel	7
	Number of elements per Train	686
	Type	Polyamide
	Model No.	Hydranautics ESPA-2
	RO Design Performance Criteria	
	Maximum RO System Permeate Capacity (Design)	5 MGD
	Range of Permeate Capacity per Train (Design)	2.0 - 3.0 MGD
	Water Flux at Nominal Capacity (Design)	10 gfd
	RO Recovery (Design)	80-85 %
	Maximum RO System Permeate Capacity (Design)	5 MGD
	Post Treatment	
	Number of Lime Storage Silos	1
	Additional equipment	bin activators;
		bag house;
		gravimetric feeders
	Chlorine Contact Tank Volume	622,000 gallons
	Contact Time at Rated Flow	2 hours
	Effluent Total Chlorine Residual Required at 5.0 mgd product water flow	4.17 mg/L
	Product Water Pump Station	
	Number of Installed Pumps	3
	Pump Type	vertical turbine; constant speed
	Capacity of Each Pump	2,100 gpm
Effluent Pumping Plant	**Effluent Pumps**	
	Type	Centrifugal, Variable Speed
	Number	2 (1 duty, 1 standby)
	Capacity	252,000 gpm, each
	Ocean Outfall	
	Capacity	66 mgd
	Pipe Size	72-inch

Process	Description	
	Length	5,875 ft
Sludge Recovery	**Anaerobic Digesters**	
	Type	Egg Shaped Anaerobic Digesters
	Number	4
	Hydraulic Detention Time	15 days
	Hydraulic Capacity	1.38 MG
	WAS Thickener	
	Type	Circular Dissolved Air Flotation Tank
	Number of Tanks	1
	Capacity	183,000 gallons
	Loading Rate	1.27 lbs/hr/ ft^2
	Sludge Dewatering	
	Type	Centrifuges
	Number	4
	Capacity	2@90 gpm, 1@250 gpm
	% Solids in Wetcake	2@22%, 1@25%

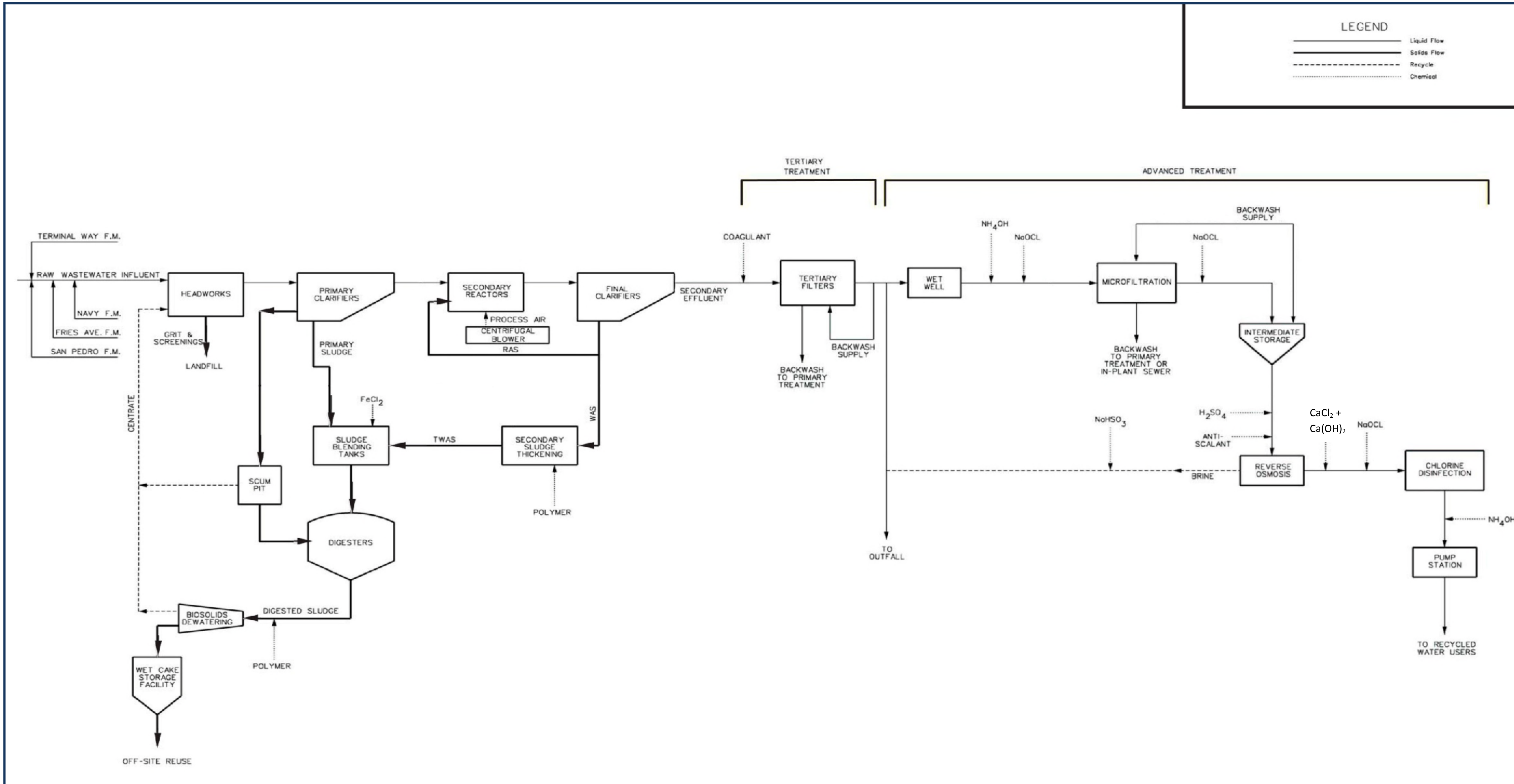
Source: City of Los Angeles Water-Wastewater Integrated Resources Plan (IRP), 2005

Figure 2-1: TIWRP Existing and Planned Recycled Water Facilities and Customers



Data Sources: USGS, LADWP

Figure 2-2: TIWRP Existing Process Flow Diagram



2.2 Capacity

Despite the 5.0 mgd nominal design production capacity of the AWTF, the *TIWRP Capacity and Reliability Study* (CDM, 2011) determined that the actual production capacity of the AWTF as it exists today is between 3.8 and 4.0 mgd, due to operational issues related to product water stabilization, membrane condition, low RO recovery, and the fact that the maximum reliable flux rate through the MF membranes is less than the maximum design flux. These deficiencies have been previously documented in the TMs and reports listed in Section 1.2.

2.3 Operational Issues and Planned Enhancements to Existing Facility

2.3.1 Mechanical and Process Enhancements

The mechanical features and enhancements recommended in the *TIWRP Capacity and Reliability Study* (CDM, 2011) to restore the capacity to 5.0 mgd are summarized as follows. These improvements constitute Phase I of the expansion phases discussed in more detail in Section 3.

Microfiltration

- Replace all MF membranes in existing skids
- Replace all valves, actuators, and o-rings on MF skids
- Replace the compressors (2 @ 732 actual cubic feet per minute (acfm), 150 horsepower each)
- Modify the clean-in-place (CIP) system for inline dosing of cleaning chemicals
- Construct two new MF units (skids), one added to each existing MF train

Reverse Osmosis

- Replace all RO membranes
- Revise controls to maintain minimum concentrate flow of 450 gpm per train

Product Water Stabilization System

- Discontinue use of lime
- Use calcium chloride and caustic soda for stabilization, with possible post-addition of carbon dioxide to lower pH

These improvements will allow the plant to meet LSI requirements consistently, while preventing turbidity spikes. This in turn will eliminate the need to pump potable water into the product water wet well.

2.3.2 Electrical, Instrumentation, and Power Supply Recommendations

The electrical, instrumentation and power supply recommendations in the *TIWRP Capacity and Reliability Study* (CDM, 2011) to achieve a reliable capacity of 5.0 mgd are summarized as follows:

- Replace current programmable logic controller (PLC) system with new system capable of utilizing a standardized communication protocol that is shared with instrumentation and variable frequency drives (VFDs)

- Replace the capacitors in the three microfiltration wet well pump Robicon VFDs and install a protocol communication system to connect these VFDs to the new PLC system
- Add new VFDs to finished water pumps
- Install normally closed electric valves on critical dosing systems that stop the material flow after a power failure
- Replace all chlorine analyzers with analyzers that utilize the new communication protocol
- Remove the separation between the two control systems (PL5 and SL5) at TIWRP and combine the systems together to facilitate more efficient plant operation
- Replace the current instrumentation with a consistent single source manufacturer on an as needed basis. All new instrumentation should use a communication protocol compatible with the new PLC system.
- Ensure the VFDs are capable of communicating with the new PLC system communication protocol. Increase the data shared from the VFDs to the PLC system to inform the plant personnel of a wider array of conditions at the pump.

These improvements will help prevent complete AWTF/AWPF shutdowns due to power sags, while reducing start-up times after a shut-down which currently can last for 2.5 hours.

2.4 Summary of Customer Requirements

Table 2-2 shows water quality requirements for DGB and irrigation use of TIWRP AWTF/AWPF product water. The West Basin Municipal Water District (WBMWD) distribution system water quality requirements are also included for comparison purposes.

Table 2-2: Water Quality Requirements for Various Potential Customers of TIWRP

Constituent	Dominguez Gap Barrier [a]	Irrigation Customers [b]	Existing WBWMD Distribution System
TDS mg/L	<800	<1,000 [c]	800
Turbidity, NTU	<0.2	0.2	0.29
Total Fecal Coliform MPN per 100 mL	<2.2	<2.2	<2.2
pH	6.5 to 8.5	6.5 to 8.5 [d]	6.5 to 8.5
Langelier Saturation Index	-0.5 to +0.5	N/A	N/A
Modified Fouling Index	<1	N/A	N/A

a. DGB water quality per LA RWQCB permit from "Final TITP Future Utilization Concept Report" (MWH, 2007).
b. Recycled water for irrigation customers will meet Title 22 Regulations for unrestricted reuse.
c. There is currently no limit on TDS values for irrigation uses. However, numerous groundwater basins across California contain high levels of salinity and many reuse applications throughout the State limit the TDS of applied irrigation water to 1,000 mg/L, or less. It would be a challenge to LADWP to market recycled water with TDS > 1,000 mg/L.
d. pH range obtained from Donald C. Tillman WRP NPDES Permit No. CA0056227 and Water Recycling Requirements No. R4-2007-0009.

2.5 Potable Water Backup Connection

The existing Product Water Pump Station wet well located at TIWRP currently has a 12-inch diameter potable backup connection. This connection is designed to provide up to 2 mgd of potable water backup to maintain appropriate hydraulic conditions in the pump station wet well for the constant-speed pumps. This connection is also occasionally used to blend potable water with the AWTF water to reduce the Modified Fouling Index (MFI), as needed for barrier injection. According to TIWRP staff, the connection is capable of delivering a maximum flow of approximately 2,500 gpm, which is consistent with a flow velocity of approximately 7 feet per second (BOS, 2011). This flow rate translates to a potential 3.6 mgd of potable backup supply that could be utilized as a reliability measure in combination with product water storage capability.[5]

This potable backup provides DWP a means of introducing potable water to DGB in the event that MWD can't supply potable water to the DGB. However, this may not be economical as a recurring source of potable water to the DGB. The purchase price of MWD water at the AWTF, plus the cost of pumping to the DGB injection wells, is more expensive than introducing potable water to the DGB using the existing MWD connection at the northern terminus of the DGB. By contrast, supplying potable water to the DGB from the MWD connection doesn't require pumping.

Historically the potable backup connection at TIWRP has been used on a regular basis to maintain hydraulic conditions in the pump station wet well for the constant-speed pumps. Is has also been used infrequently to improve product water quality. While the stabilization chemical system improvements are intended to address these water quality issues, the potable backup remains as a water quality reliability measure in the event of intermittent interruptions involving stabilization and permit compliance for MFI, LSI, turbidity, and pH.

[5] In addition, the potable water backup connection could potentially be used to provide some degree of product water stabilization by blending if it can be demonstrated that the potable water has a Langelier Saturation Index (LSI) at or near zero compared to the AWPF water. This concept is not evaluated further in this TM.

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3. Module Analysis for AWPF Expansion

The following sections describe the treatment process expansions for each phase. The process expansions would generally be constructed using the proposed facility layouts in **Appendix B**.

3.1 Approach and Assumptions

The proposed strategy for expanding TIWRP is to first maximize the capacity and the reliability of the existing facility prior to investing in new expansion facilities. Other strategies include maximizing DGB demand, identifying opportunities to eliminate non-brine discharges to the Harbor, and supplying irrigation customers with recycled water.

Approach

Specifically, this Report divides the expansion of TIWRP into four distinct phases:

- ***Phase I: Maximizing Reliable Production of Existing Facility to 5 mgd*** by replacing MF and RO membranes, installing two additional MF skids, modifying the stabilization system, and making other miscellaneous mechanical and electrical improvements in Fiscal Year 2011-2012. This would increase the reliable production capacity of the facility to 5.0 mgd.
- ***Phase II: Increasing Existing Production Capacity to approximately 6 mgd*** by adding two additional MF skids (in addition to the two new units required for Phase I), disinfection replacement with advanced oxidation (AOP as UV/H_2O_2), installing a new concentrate valve, and making other mechanical improvements to maximize the production of the existing RO trains. This would increase the reliable production capacity of the facility to 6.0 mgd. Once mechanical improvements are made, flow testing of the existing RO trains may produce results that warrant re-rating the existing RO system to a production capacity as high as 6.5 mgd. If the RO capacity is found to be 6.5 mgd, the ability of the feed pumps to supply 6.5 mgd to the RO membranes would need to be assessed.

  The increase in capacity could be used to expand the RWC at the DGB to over 50 percent. If the TIWRP supplies an RWC over 50 percent to the DGB, AOP (UV/H_2O_2) would be required to meet California Department of Public Health's (CDPH) notification levels for NDMA and 1,4-dioxane.
- ***Phase III: Expanding the AWPF to 9 mgd*** by new MF trains with the option of MF replacement, new RO process trains, expanding the stabilization system, and installing AOP (UV plus peroxide).
- ***Phase IV: Maximizing TIWRP AWPF to 12.5 mgd*** by MF replacement and new RO process trains, expanding the stabilization system, and UV disinfection to maximize available capacity based on a projected future build-out influent flow of 16.2 mgd.[6]

[6] Assumes a recovery rate of 77% for MF and RO based on *TIWRP Opportunities TM* (RMC/CDM 2012). MF backwash is routed to the primary treatment facilities. Guaranteed recoveries for existing facilities are 87% for the MF and 80% for the RO (70% overall).

Assumptions

The modules of expansion for TIWRP are based on the following assumptions:

Dominguez Gap Barrier Demands

- Water purchase records for the DGB between 2006 and 2010 indicate an average monthly demand of 6.7 mgd for total water injected into the barrier, with a maximum monthly demand of 10.1 mgd and a minimum monthly demand of 1.2 mgd (WRD, 2011). For the purposes of this study and based on discussions with LADWP, the maximum DGB demand is estimated at 8.0 mgd. This analysis assumes that 8.0 mgd will be delivered to the DGB whenever possible, that recycled water would be phased in according to allowable recycled water contributions (RWCs), and that the barrier demand does not fluctuate significantly throughout the year. [7]
- Recycled water supplies to the DGB will be maximized whenever possible, limited by the constraints of RWC requirements, the AWPF capacities of the various phases, and the maximum assumed capacity of the DGB. RWQCB Order No. R4-2010-0183 currently limits the total volume of recycled water recharged at the DGB to 5.0 mgd and 50 percent of the total injected water (RWQCB, 2010). Expansions beyond these constraints would require revisions to the permit.
- Additional DGB deliveries beyond 8.0 mgd would entail "Recharge and Recovery" (or indirect potable reuse [IPR]), which consists of supplying recycled water for increased injection at the DGB and subsequent withdrawal of groundwater in the vicinity of the DGB. This approach also assumes that the DGB is permitted to receive a 100 percent RWC by the time of implementation.
- Because LADWP does not currently consider barrier demands to offset imported potable supplies, the estimates in Section 6 do not include capital costs for new production wells or for lateral pipelines that would serve groundwater to the potable distribution system.

Non-Potable Demands

- Potential non-potable demands of up to 2.0 mgd average and 3.0 mgd peak day were identified in the Non-Potable Reuse Master Planning Report (NPR MPR).
- Existing, planned, and potential non-potable demands assumed for Phase II total an average of 0.5 mgd. This includes planned and some potential irrigation customers from the NPR MPR. A peaking factor of 2.0 is assumed for maximum day irrigation demands such that peak day demand is 1.0 mgd and zero demand is assumed during winter months.
- There are two potential options to expand the NPR uses, beyond those identified in the NPR MPR, to get to 12.5 mgd of reuse.
    - Delivery to alternative Harbor private sector users other than irrigation users.
    - Interagency transfer of recycled water involving blending of TIWRP effluent with a neighboring agency's recycled water distribution system.

[7] Actual demands for the DGB are influenced significantly by the amount of groundwater pumping that takes place in the West Coast Basin, particularly in the vicinity of the barrier. It will be necessary to coordinate recycled water planning efforts at the DGB with the West Coast Basin watermaster and the Los Angeles County Department of Public Works to verify the demand profile throughout a given year and over multiple years.

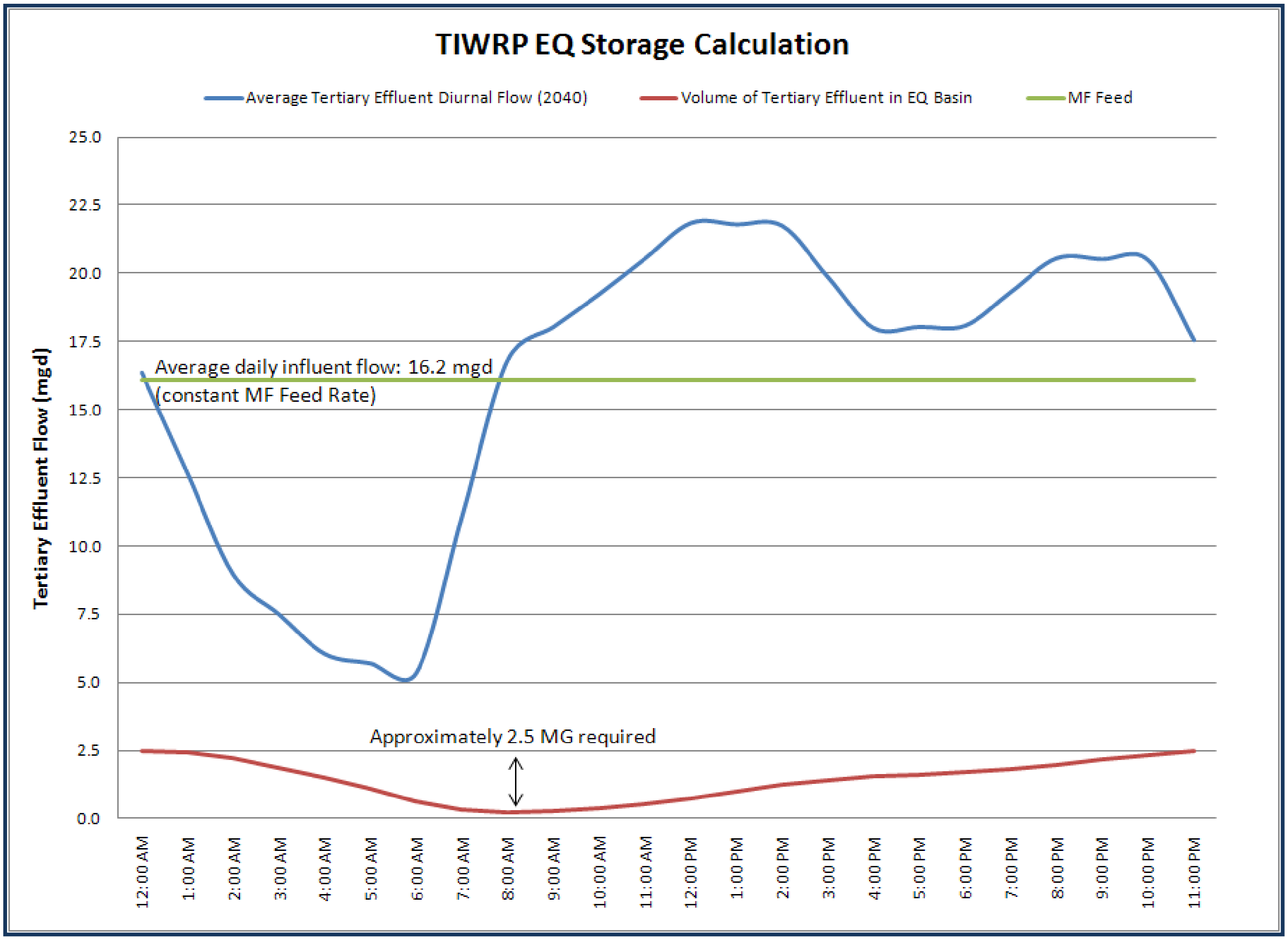
AWTF/AWPF Operations

- For Phase I, the AWTF could provide recycled water to DGB for several years at a RWC greater than 50%. This would be possible because the RWC during the first six years of barrier operation was typically much lower than 50%, making the 5-year average also lower. See Section 5.2 for a detailed analysis of historical and projected RWCs at DGB.
- For non-potable demands in Phases II through IV, the AWPF could be operated at a constant flow rate throughout a 24-hour cycle without product water storage. This would be accomplished by adjusting flows to the DGB to supply the necessary flows for non-potable demands. This assumes that supply to the DGB could be reduced during evening hours, when irrigation demands increase, and that supply could be increased during daytime hours, when irrigation demands decrease. This assumption needs to be verified with the Los Angeles County Department of Public Works (LACDPW).
- For Phases II through IV, the AWPF could be operated below full capacity during winter months (if need be) because irrigation demands will be essentially zero while the DGB demands are assumed to be relatively constant (up to 8.0 mgd). During the summer months when irrigation demands are highest, the AWPF could be operated at full capacity. (Note: If the DGB can accept higher flows during winter months, the AWPF could operate closer to full capacity throughout the year)
- For Phases I and II, recovery rates are based on the *TIWRP Capacity and Reliability Study* (CDM, 2011). This TM indicates an overall recovery rate of 68 to 70 percent with 85 percent for MF, 80 percent for Phase I RO, and 82 percent for Phase II RO.
- For Phases III and IV, recovery rates are based on the *TIWRP Opportunities TM* (RMC/CDM 2012). This TM indicates an overall recovery rate of 77 percent, with 90 percent for MF and 85 percent for RO. It is assumed that recovery rates for Phases III and IV could feasibly be higher than Phases I and II due to improvements in membrane technology that will likely become available by the time these phases are implemented. (Guaranteed recoveries for existing facilities are 87% for the MF and 80% for the RO [70% overall]).

3.2 Equalization

TIWRP diurnal flows vary from an average of 8 to 9 mgd during the nighttime hours to an average of 13.5 to 18.4 mgd during daytime hours (January 1999 through July 2009) (RMC, 2012). In addition, TIWRP has been experiencing periodic low influent flows around 4to 5 mgd at night. This has further contributed to reduced AWTF production because there is no equalization (EQ) at the plant. Tertiary effluent equalization upstream of the AWTF/AWPF would maximize production and performance since the AWTF/AWPF could then operate at a constant rate. The site layout in Appendix B assumes that an EQ basin would be installed between the tertiary filters and the AWTF/AWPF. Alternatively, EQ could be placed downstream of the primary tanks to achieve base loading of influent flows to the secondary aeration tanks; but this may be unnecessary since the existing secondary facilities have a rated capacity of 30 mgd, providing a significant buffer in maintaining nitrification/denitrification performance during diurnal peaks. Also, primary EQ could present operational challenges such as biosolids accumulation and odors. **Figure 3-1** illustrates the diurnal curve and volume of equalization needed for an average daily influent flow of 16.2 mgd and a product water flow of 12.5 mgd.

Figure 3-1: Diurnal Flow Projections and EQ Need



The diurnal curve in **Figure 3-1** is based on hourly data from April 12, 2011 to May 13, 2011 obtained from BOS. Recently, TIWRP staff reported low nighttime flows of 4 to 5 mgd that occur two to three times monthly. The curve shown in **Figure 3-1** is revised to incorporate these low flow values into the average day diurnal curve such that the average influent daily flow rate remains 16.2 mgd. This curve represents a conservative scenario where extremely low nighttime flows occur on the same day as the 16.2 mgd average flow rate.

Table 3-1 summarizes the AWTF/AWPF production that could be recovered with EQ at each phase of expansion under the low flow profile shown in **Figure 3-1**. The volumes in **Table 3-1** are determined by calculating the area under the curve in **Figure 3-1** for the amount of AWTF/AWPF feed water required in each phase.

Table 3-1: Capacity Recovered at TIWRP AWTF/AWPF with Equalization

Phase	AWTF/AWPF Production Water	AWTF/AWPF Feed Water Required	Potential Volume Recovered with EQ
Phase I	5.0 mgd	7.4 mgd	213,000 gal/day
Phase II	6.0 mgd	8.6 mgd	480,000 gal/day
Phase III	9.0 mgd	11.7 mgd	1,000,400 gal/day
Phase IV	12.5 mgd	16.2 mgd	2,284,000 gal/day

Equalization could be phased as the plant expands. The actual installed size of the facility would be somewhat greater than the recovered volumes indicated in Table 3-1. The cost estimates summarized in Section 6 assume that 1.2 million gallons of EQ will be constructed in Phase III and an additional 1.3 million gallons in Phase IV, for a total of 2.5 million gallons.

Potential Use of Existing Tertiary Effluent Channel

According to information obtained from BOS, it may be possible to utilize between 1.0 and 1.5 million gallons of capacity in the existing tertiary effluent channel to provide some of the required EQ volume (BOS, 2012). The usable volume of this channel and its suitability for EQ purposes will need to be verified. This analysis assumes that if the channel is suitable, the 1.2 million gallon EQ proposed for Phase III could be avoided and that only the 1.3 million gallons in Phase IV would need to be constructed. A separate cost estimate is provided in Section 6 that only includes the Phase IV EQ facilities.

3.3 Microfiltration Modules

The primary, secondary, and tertiary facilities have a design capacity of 30 mgd. Therefore there is adequate treatment capacity to serve the current AWTF capacity and future AWPF expansions to 12.5 mgd (product water) as defined in this Report. However, as discussed previously, flow equalization will be needed. Based on the *TIWRP Capacity and Reliability Study* (CDM, 2011), BOS is planning to install two new MF skids in 2012. **Table 3-2** and **Table 3-3** describe the current and near future improvements consisting of MF and RO membrane replacement, MF expansion by two skids, and a balance of improvements to achieve a 5.0 mgd capacity. Detailed design criteria may be found in *TIWRP Capacity and Reliability Study* (CDM, 2011).

Table 3-2: Existing MF and RO System Parameters

Description	Values
Current Max MF Filtrate Flow per skid	550 gpm [a]
Current Reliable Sustainable MF Filtrate Flow per skid	482 gpm [b]
Number of Existing MF skids	10
Current Max Attainable RO Product Water Flow	3.8 - 4.0 mgd

a. Microfiltration skids are currently programmed for maximum filtrate flow of 550 gpm.
b. The recommendation to re-rate the MF skids to 482 gpm was based on Section 2.1 following reference: CDM, 2011. *Capacity and Reliability Study for the Terminal Island Water Reclamation Plant Advanced Water Treatment Facility*.

Table 3-3: Planned Expansion of the MF and RO Systems at TIWRP (Phase I)

Description	Values
Number of Additional MF skids required to attain plant production of 5.0 mgd	2 [a]
MF Filtrate Production Following installation of 2 new MF skids	6.25 mgd
RO Max Product Water Flow with 2 new MF skids installed	5.0 mgd [b]
RO Max Product Water Flow with 4 new MF skids installed	6.0 mgd [c]

a. These two skids are slated for installation in 2012.
b. Assumes 80% recovery of 6.25 mgd microfiltration filtrate supply
c. This assumes that additional microfiltration skids will be added in the future. It is also possible that once mechanical improvements are made to the existing RO trains that flow testing will demonstrate the ability to reach an RO production capacity as high as 6.5 mgd.

Improvements to the MF process are summarized in **Table 3-4**, along with the assumed number of units that would be out of service for backwashing, cleaning, or maintenance at any given time. To achieve a 12.5 mgd AWPF capacity, 27 installed MF skids (matching the individual capacity of the existing skids) with an assumed daily production capacity of 482 gpm each are necessary, except for Alternative B in which tertiary water is being blended with RO permeate, requiring only 26 installed MF units. The 482 gpm flow rate assumes use of more Memcor M10C modules matching the existing installation. **Table 3-4** assumes expansion with the existing style of MF units, but the limited remaining service life of the existing units may necessitate full MF replacement within ten to fifteen years.

Table 3-4: TIWRP Microfiltration Phases (Phases I – IV)

Phase	MF Filtrate Flow Requirement	Number of MF Skids				
		Duty	Backwash	CIP	Offline for Maintenance[1]	Total
Phase I	6.25 mgd	9	1	1	1	**12**
Phase II	7.5 mgd	11	1	1	1	**14**
Phase III	10.7 mgd	16	1	1	2	**20**
Phase IV	14.6 mgd	22	1	1	3	**27**

1. Assumes approximately 10% of skids offline for maintenance at any given time.
2. Assumes MF system is expanded with new MF units identical to the existing.

Alternative to Memcor 90M10C MF Units

Given ongoing improvements in membrane technology and efficiency, there are potential membrane selection alternatives to Memcor 90M10C MF units that could be used to expand the MF capacity. Moreover, there may even be reason to consider full replacement of the existing 90M10C units within ten to fifteen years because the membrane blocks have already experienced cracking; and the long-term viability of the units is uncertain based on cracking of similar older units observed industry-wide.

Another reason to consider newer MF technology (as the AWPF expands) is footprint size. There is limited available space for additional MF units, and creating more space at the site would require installation of deep foundations. [8] With higher-capacity, smaller footprint technology, a system

[8] Deep foundations were required for the original AWTF construction due to the potential at this site for soil liquefaction.

with a much larger capacity could potentially fit into the same area that is currently occupied by the existing MF units. In other words, it might be possible to site MF units for a 12.5-mgd capacity AWPF in the same footprint that currently contains MF units for the 5.0-mgd capacity AWTF (within the limits of the existing canopy that covers the MF system). This would allow the City to avoid costly installation of deep foundations associated with an expanded footprint.

To assess the feasibility of newer technology MF units, a preliminary analysis was conducted using information from the recent pre-design work for upgrades at the Donald C. Tillman Water Reclamation Plant (DCTWRP) and the Leo Vander Lans Water Treatment Facility (LVLWRF). The analysis demonstrates that it may be possible to site MF facilities for a 12.5-mgd capacity AWPF (approximate MF footprint of 5,300 to 8,500 ft^2) inside the existing MF unit footprint (7,000 ft^2). The findings are summarized in **Table 3-5.** Cost estimates for replacing the entire MF system, and for installing the incremental MF expansion from 5.0 mgd to 12.5 mgd of AWPF product water, are included in Section 6.

Table 3-5: Alternative MF Technologies

WRP	MF Units	MF Footprint		
		Per mgd of AWPF Production Capacity[1]	For 5.0-mgd AWTF Capacity	For 12.5-mgd AWPF Capacity
TIWRP	Memcor 90M10C	1,400 ft^2/mgd	7,000 ft^2	17,500 ft^2
DCTWRP[2]	Pall Microza or Siemens Memcor CP (PVDF)	425 ft^2/mgd	2,100 ft^2	5,300 ft^2
LVLWRF[3]	Pall Microza (PVDF)	680 ft^2/mgd	3,400 ft^2	8,500 ft^2

1. Square footage includes membrane racks only. Does not include ancillary equipment.
2. Source: RMC/CDM, 2012a
3. Source: CH, 2011

3.4 Reverse Osmosis Modules

Expansions to the RO process are summarized in **Table 3-6**. To maximize the capacity of the existing reverse osmosis units, upgrades to the RO feed pumps and a new concentrate valve may be required. Of particular concern is the lack of an existing redundant feed pump, which is a common attribute for most other recycled water AWPFs. Without a redundant feed pump, the loss of one of the duty pumps could result in a serious drop in plant production lasting several weeks.

Table 3-6: TIWRP Reverse Osmosis Phases

Phase	Percent Recovery[1]	RO Permeate Production
Phase I	80	5.0 mgd
Phase II	82	6.0 mgd[2]
Phase III	85	9.0 mgd
Phase IV	85	12.5 mgd

1. Recovery rates for Phases I and II are based on recommendations from the *TIWRP Capacity and Reliability Study* (CDM, 2011). Recovery rates for Phases III and IV are based on the *TIWRP Opportunities TM* (RMC/CDM 2012).
2. Once mechanical improvements are made, flow testing of the existing RO trains may produce results which warrant re-rating the existing RO system to a production capacity as high as 6.5 mgd. If the RO capacity is found to be 6.5 mgd, the ability of the feed pumps to supply 6.5 mgd to the RO membranes would need to be assessed.

3.5 Advanced Oxidation and Stabilization Modules

As the plant increases in RO capacity from 6.0 mgd to 12.5 mgd, AOP and stabilization are recommended for all types of end users. The AWPF product water will serve DGB, irrigation customers, and other recycled water users that may include industrial customers.

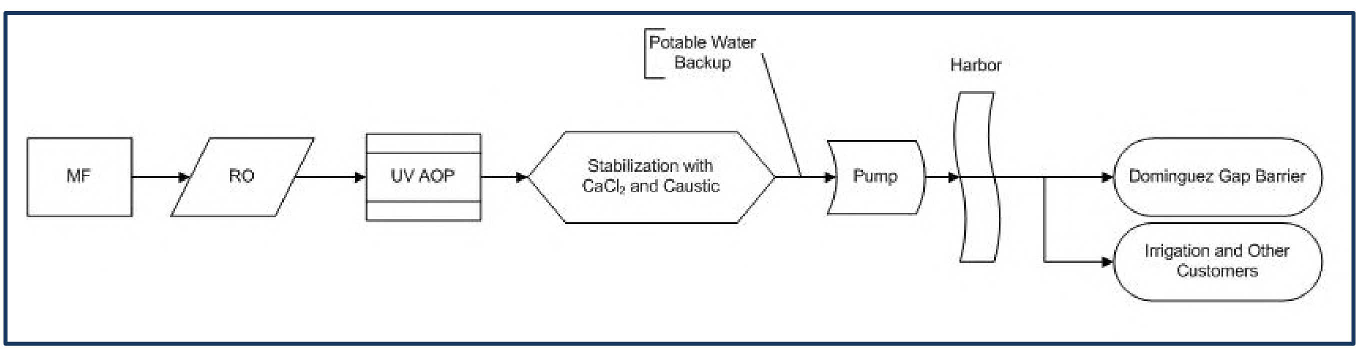
The processes required for AOP and stabilization include:

- AOP Process with new closed reactor ultraviolet units installed on top of the existing chlorine contact tank (future product water storage tank) and liquid hydrogen peroxide storage and addition facilities. At plant flows less than 6.0 mgd, the existing chlorine contact tank provides adequate CT to meet the requirements of the existing Title 22 permit. A change to AOP would be necessary when RWC to the DGB reaches 50 percent, which is projected to occur as early as 2015 if the plant ramps up production to 5.0 mgd immediately following the Phase I MF and RO improvements. Furthermore, the existing chlorine contact tank is production-limited and does not have enough volume to provide Title 22 disinfection at flows above 6.0 mgd.
- Stabilization with $CaCl_2$ addition to increase the LSI of the product water to a range of -0.5 to +0.5 to provide stabilized water required by the RWQCB for the DGB and to protect mortar-lined recycled water pipeline mains
- Further pH control with the addition of NaOH to raise the pH to approximately 6.5 to 8.5 to meet RWQCB requirements for DGB and general guidelines for horticultural irrigation[9]

Because the DGB, mortar- lined recycled water pipelines, and irrigation users require nearly the same degree of pH control and LSI stabilization, the stabilization facilities would be located at the TIWRP as part of a consolidated facility at that site.

Figure 3-2 shows the modified TIWRP treatment train following implementation of AOP and stabilization improvements.

Figure 3-2: Treatment Schematic for TIWRP Expansion

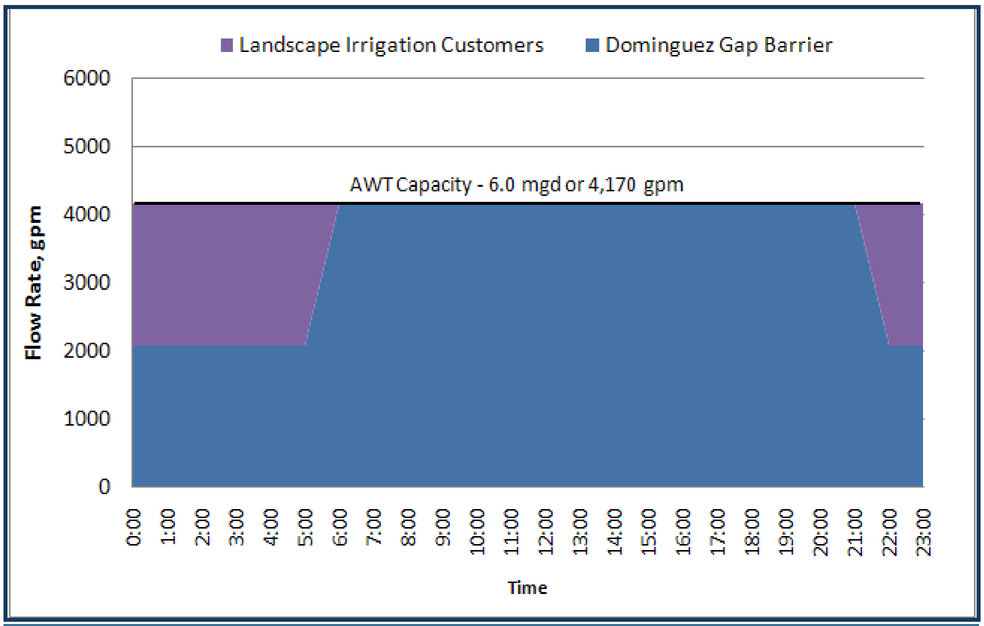


[9] High pH's above 8.5 are often caused by high bicarbonate (HCO_{3-}) and carbonate ($CO_{3,2-}$) concentrations, known as alkalinity. High carbonates cause calcium and magnesium ions to form insoluble minerals leaving sodium as the dominant ion in solution. This alkaline water could intensify sodic soil conditions (Colorado State University, 2011).

3.6 Accommodating Diurnal Fluctuations in Irrigation Demands

Figure 3-3 illustrates a hypothetical example of the hourly variation of DGB delivery and irrigation deliveries from the plant. This example shows the assumed customer hourly flow demand over a peak day (assumed 1.0 mgd) in expansion Phase II when the capacity of the AWT is 6.0 mgd. It is assumed that supply to the DGB can be varied over a 24-hour period to adjust for irrigation demands which occur primarily at night. If flows can be adjusted between DGB demands and irrigation demands effectively, then the need for additional storage will be reduced or eliminated. The cost estimates in Section 6 assume that no additional storage is necessary to manage product water flows and that hydraulic control improvements to the DGB are implemented under a separate agency budget.

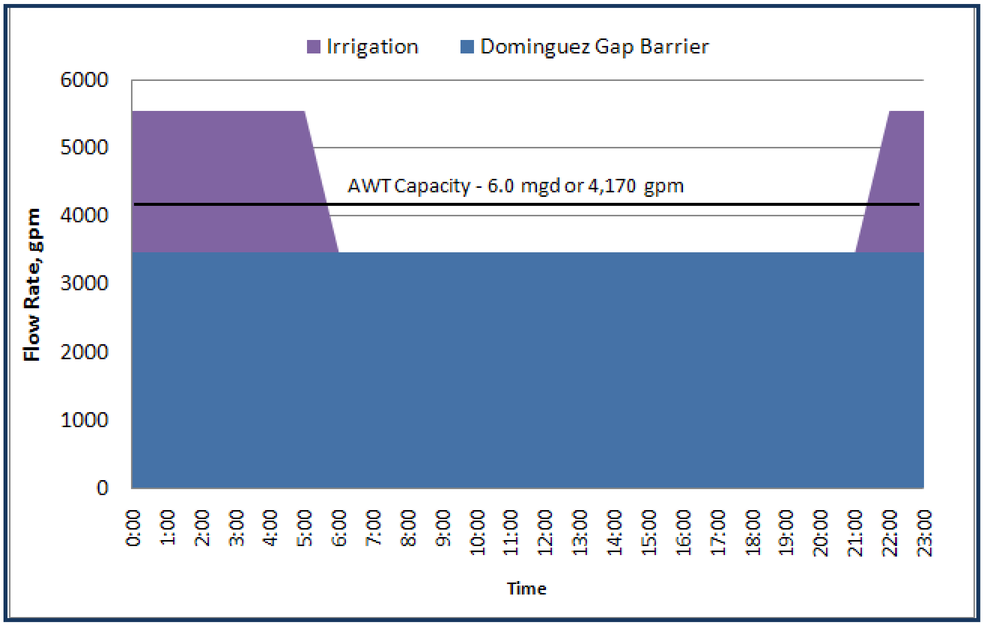
Figure 3-3: Max Day Hourly Flow to DGB and Irrigation Customers from TIWRP AWPF Assuming Supply to DGB Can Be Varied Over a 24-Hour Period (6 mgd capacity)



Note: Example figure assumes peak conditions of 5.0 mgd to DGB and 1.0 mgd to irrigation customers.

If recycled water flows to the DGB and irrigation customers cannot be adjusted throughout a diurnal cycle to match nighttime irrigation demands, it may be necessary to provide storage capacity for effluent flow equalization purposes. This storage could be provided at the plant or in the recycled water distribution system. Approximately 667,000 gallons of storage would be needed to fully serve the nighttime irrigation and DGB demands, as shown in **Figure 3-4**.

Figure 3-4: Max Day Hourly Flow to DGB and Irrigation Customers from TIWRP AWPF Assuming Constant Supply to DGB Over a 24-Hour Period (6 mgd capacity)



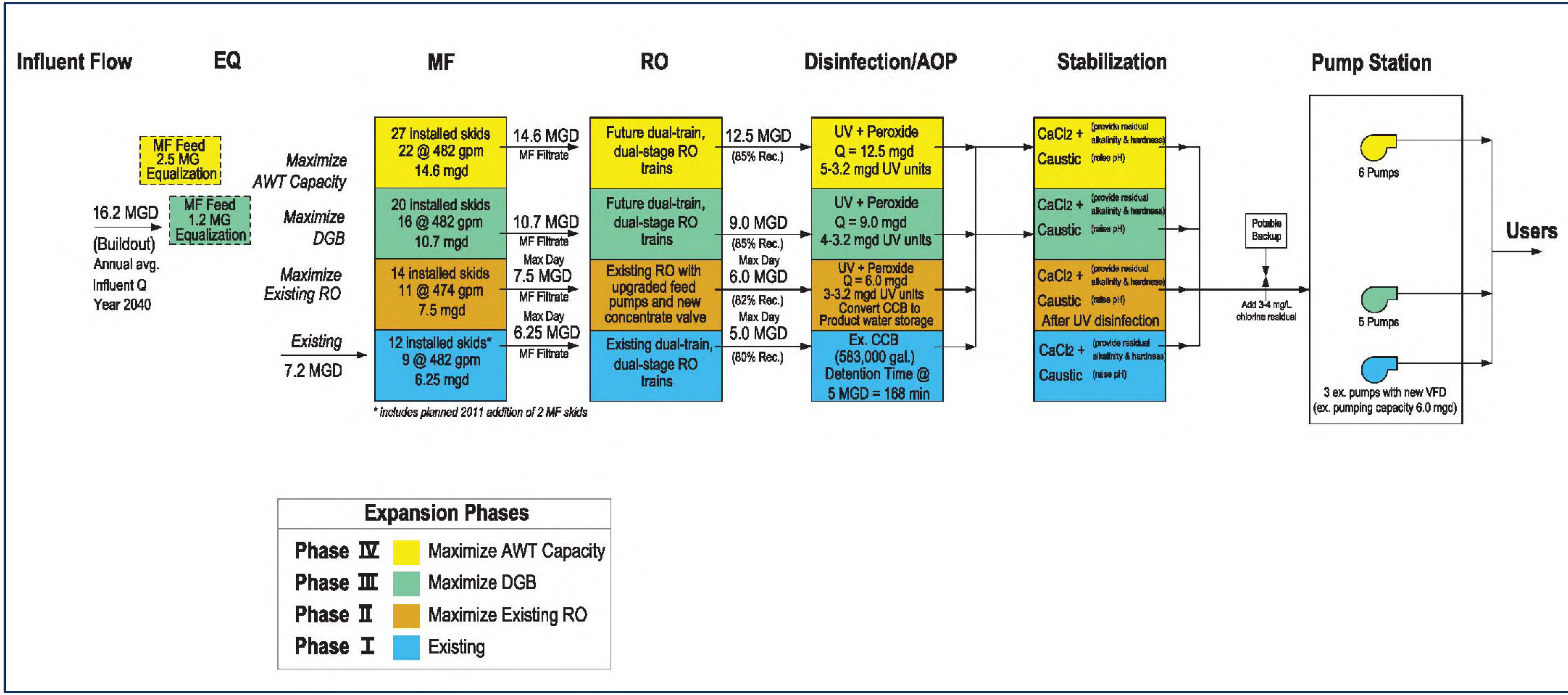
Note: Example figure assumes peak conditions of 5.0 mgd to DGB and 1.0 mgd to irrigation customers.

The existing chlorine contact basin cannot be used for this purpose since it has been recommended that the basin be used to provide 2.5 hours of product water storage at 6.0 mgd for reliability purposes (in the case of a power dip). Moreover, the volume that would be needed for product water equalization is larger than the chlorine contact basin volume at 583,000 gallons. As stated above, this analysis assumes that product water equalization is not necessary and that a flow control valve and actuator can be used to modulate flows to the DGB and irrigation customers throughout a 24-hour cycle.

3.7 Overall Treatment Schematic

Figure 3-5 illustrates a more detailed process flow diagram showing each expansion phase reaching a maximum AWT product water capacity of 12.5 mgd. The buildout facility consists of 15 new MF units (from 12 skids to 27 skids), increased MF capacity from 5.0 mgd to 12.5 mgd, increased RO capacity from 6.0 mgd to 12.5 mgd, five-3.2 mgd UV AOP units, four-4.5 mgd decarbonation units, three new vertical turbine pumps, and stabilization with calcium chloride.

Figure 3-5: Schematic of TIWRP AWPF Expansion Phases



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4. Reliability Evaluation

This section describes measures that increase reliability. It includes a list of reliability measures as well as a discussion of product water storage used in conjunction with the potable water backup supply for reliability purposes.

4.1 Reliability Treatment and Conveyance Elements for Each Expansion Phase

Measures have been developed in each phase of expansion to ensure that recycled water is a reliable supply to the customer. Reliability measures for the TIWRP expansion phases can be placed in the following categories:

- Redundant capacity
- Improved effluent water quality
- Improved control measures
- Use of potable backup supply
- Use of product water storage
- Diversification of end uses

Table 4-1 explains the improvements in each phase. It should be noted that all phases include redundant treatment capacity for MF, RO, product water stabilization, and disinfection.

Table 4-1: TIWRP Reliability Treatment and Conveyance Features Added by Each Phase

Phase	Reliability Feature Added	Purpose
Phase I (5.0 mgd)	Product Water Stabilization conversion from lime to caustic – $CaCl_2$ storage and feed pumps, NaOH storage and feed pumps	Reduce turbidity in product water and meet barrier water quality requirements for key parameters such as pH, modified fouling index and Langelier saturation index
	Electrical System – capacitors for MF wetwell VFDs, product water pump VFDs, valves for chemical dosing	Allow product water pumping to better match plant production, while reducing start-up time
	Maintain existing potable backup supply at effluent pump station wet well	Potable water backup to barrier can be served from existing air gap at TIWRP when AWT is off-line[a]; can be used in combination with CCB converted to storage in Phase II
Phase II (6.0 mgd)	Convert CCB to product water storage	Allows continued delivery of recycled water when AWT goes offline
	Improve DWP power grid to reduce frequency of voltage sags	Fewer voltage sags will result in less AWT down-time.
	Electrical System – new PLC system	Reduce start-up time after plant experiences power dips; implement standardized communication protocol
	Instrumentation and Controls – upgrade of plant network and new chlorine analyzers	Improve and standardize communication protocol for all instrumentation and VFDs
Phase III (9.0 mgd)	Expand reliability measures implemented in Phases I & II	Same purposes
Phase IV (12.5 mgd)	Expand reliability measures implemented in Phases I & II	Same purposes

a. Existing 12-inch diameter potable backup connection can supply 2,500 gpm (3.6 mgd) per BOS operations staff (BOS, 2011)

4.2 Product Water Storage

As discussed in Section 3, this analysis assumes that product water storage is not necessary for equalization purposes. However, as was also previously discussed, the existing chlorine contact basin (CCB) could have potential value if converted to a product water storage tank for reliability purposes.

The 583,000 gallon basin could provide approximately 2.5 hours of storage time for an effluent flow rate of 6.0 mgd.[10] Since the typical duration of a shutdown period from power dips in the electrical system is also approximately 2.5 hours, this would provide adequate storage to make the plant reliable.

[10] Conversion of the CCB to product water storage for reliability purposes is recommended during Phase II (CDM, 2011).

Another reliability measure that could be used in conjunction with the CCB is the potable water backup connection at the pump station wet well. Using the potable backup to provide 3.6 mgd of supply effectively reduces the amount of storage volume that would be needed during a shutdown period because it would allow the CCB to be drained at a slower rate than the full plant capacity of 6.0 mgd. Moreover, as other reliability measures such as the electrical upgrades and the new PLC system are installed and implemented, the required shutdown time after a power dip would likely be reduced from 2.5 hours to 1.0 hour or less. This would also have the effect of reducing the amount of storage volume that would be needed during a plant shutdown.

The amount of storage volume required in the CCB is a function of:

- The duration of the expected typical shutdown period
- The available potable backup supply that can offset the required flow rate from the CCB

An analysis of this relationship is shown in **Table 4-2** and **Figure 4-1**. Table 4-2 shows the required storage volumes, both with and without potable water backup, for each expansion between Phases II and IV. The table indicates the required volume as the typical shutdown time decreases from 150 minutes (required for 6.0 mgd with existing 2.5 hour shutdown period) to 30 minutes.

As the shutdown duration time is decreased, the required volume to provide product water storage also decreases. The required storage volume decreases even more if the potable water backup supply is used in combination with other plant improvements that shorten the typical shutdown duration.

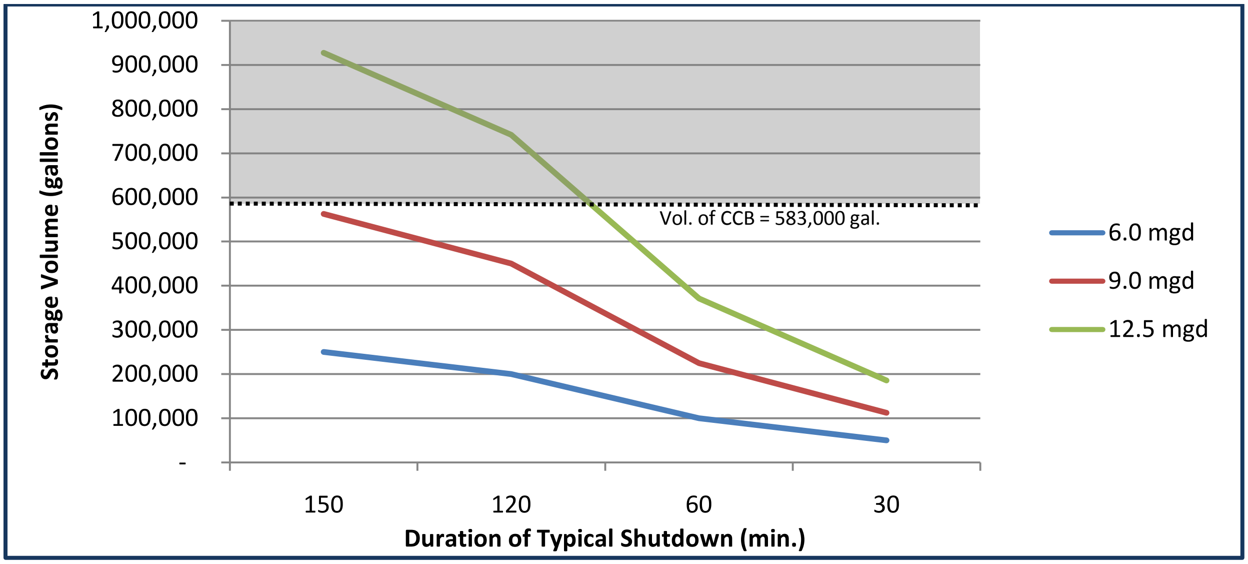
Table 4-2: Required Product Water Storage Volumes for Reliability Purposes (Phases II – IV) with and without Potable Water Backup

Typical Shutdown Time	Required Storage Volumes (gallons):					
	For 6.0 mgd:		For 9.0 mgd:		For 12.5 mgd:	
	w/o backup	w/ backup	w/o backup	w/ backup	w/o backup	w/ backup
150 min.	625,000	250,000	937,500	562,500	1,302,083	927,083
120 min.	500,000	200,000	750,000	450,000	1,041,667	741,667
60 min.	250,000	100,000	375,000	225,000	520,833	370,833
30 min.	125,000	50,000	187,500	112,500	260,417	185,417

Note: Existing CCB volume is 583,000 gallons.

Figure 4-1 shows the information in **Table 4-2** graphically, but it only includes the required storage volumes with potable water backup.

Figure 4-1: Required Product Water Storage Volumes for Reliability Purposes (Phases II – IV) with Potable Water Backup



Conversion of the CCB to product water storage is an effective reliability measure when the plant capacity is 6.0 mgd. As the duration of plant shutdowns decreases due to other plant improvements, product water storage is also effective for plant capacities up to 12.5 mgd. Furthermore, the potable water backup can be used in combination with the converted 583,000 gallon CCB to provide an additional reliability measure for plant shutdowns. For the maximum 12.5 mgd flow rate, the CCB (with potable backup) may be able to provide adequate volume for reliability purposes if the typical shutdown duration could be decreased to less than approximately 90 minutes.

5. Dominguez Gap Barrier Considerations

The DGB is an intrusion barrier that uses potable and recycled water injected into the ground to prevent the movement of seawater in to the West Coast Basin. It contains 94 injection wells and 232 observation wells along a 4.3-mile length near the coast between the Los Angeles Harbor and the Long Beach Harbor. Potable water is supplied from the north by WBMWD and recycled water is supplied from TIWRP through 24- and 36-inch diameter pipelines from the south. BOS is responsible for operating the treatment and pumping facilities, LADWP is responsible for delivery of recycled water, the Water Replenishment District of Southern California (WRD) is responsible for groundwater monitoring compliance, and the LACDPW is responsible for operation of the barrier wells.

5.1 Barrier Improvements

The DGB is an important part of the ultimate expansion of TIWRP since it is the largest end user of AWT recycled water. As larger quantities of recycled water are delivered from TIWRP to the barrier, some improvements may be necessary to make these deliveries possible.

The DGB was originally designed for potable water to be introduced at the northern end of the barrier near Sepulveda Blvd. and Alameda Street. The pipe diameters generally decrease from the north end of the barrier to the south end. Recycled water is currently delivered from the AWT to the barrier through a 36-inch diameter pipeline that conveys the water under the Harbor and a 24-inch diameter pipeline that conveys it to a connection point at Banning Avenue and E Street. The 24-inch pipeline has a capacity of approximately 10 to 14 mgd, depending on an assumed flow velocity between 5 and 7 feet per second. Potable water is still introduced at the northern end of the barrier to meet blending requirements for allowable RWC, and the potable water has historically made up the majority of the water injected at DGB (see **Table 5-1**).

Figure 5-1 shows the existing configuration for recycled water conveyance to DGB. To serve 100 percent of the barrier demands, it may be necessary to install a new recycled water pipeline toward the north end of the barrier from the existing connection point. This would potentially make recycled water available to the entire barrier as opposed to just the southern portion.

New Pipeline to DGB

Figure 5-1 also shows a conceptual pipeline alignment to convey recycled water to the DGB distribution header. This pipeline would be 24-inches in diameter and 11,500 feet long. The proposed pipeline would begin at Banning Ave. and E Street (at the existing connection point); then travel in E Street to Alameda Street. The pipeline would then travel north in Alameda St., turning west on Pacific Coast Highway and continuing to the barrier. The proposed pipeline could connect to the DGB without crossing the Dominguez Channel.

Other Potential Solutions

Instead of a new pipeline, there are other potentially less expensive solutions that could provide the DGB with a 100 percent recycled water contribution. These include the following:

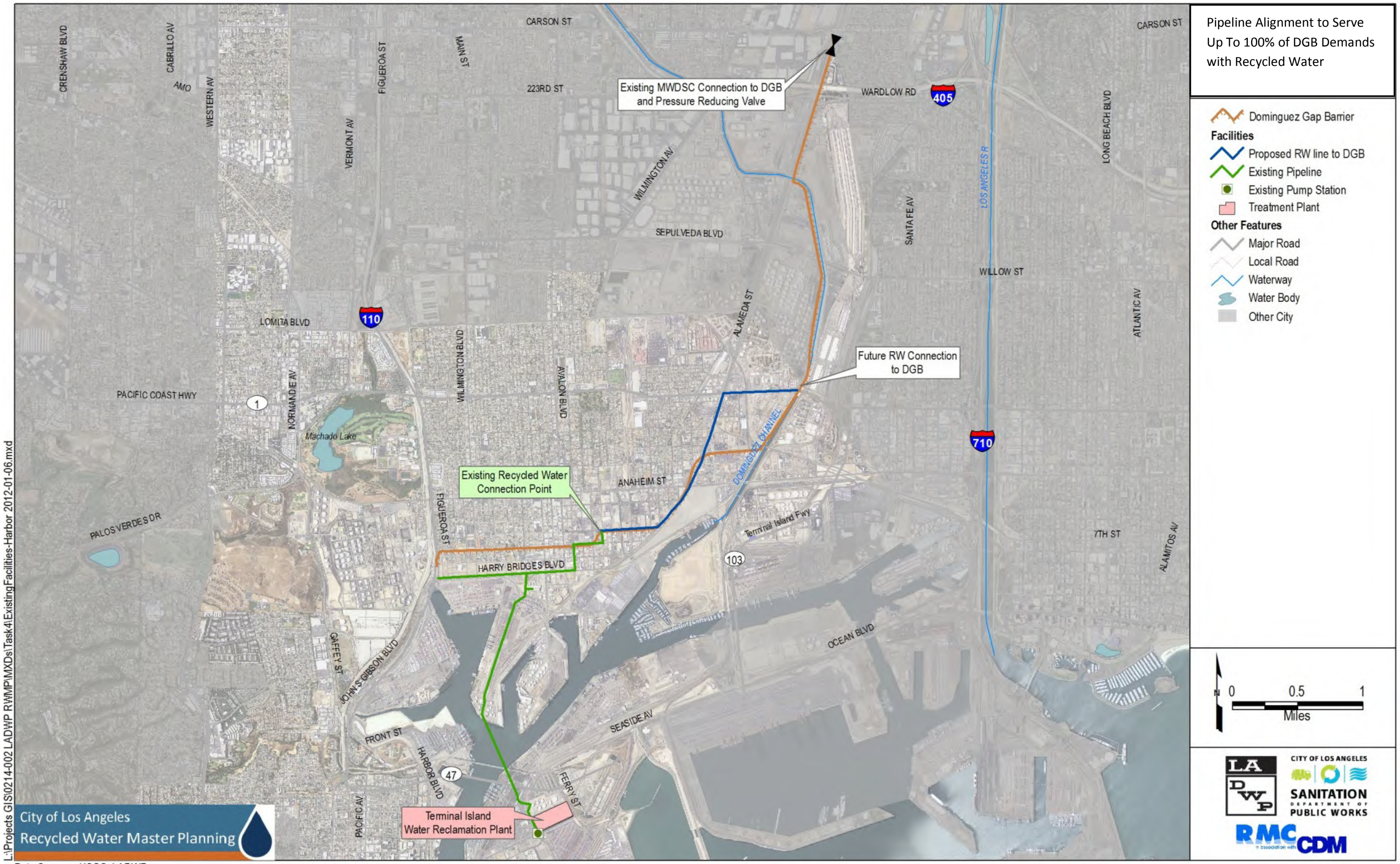
- Make modifications to the well valves and serve increased DGB demands through the existing point of connection at Banning Avenue and E Street
- Adjust valves (e.g., add instrumentation enabling communication between the Metropolitan Water District (MWD) flow control valve at the north end of the DGB and the LADWP control valve on E Street between Banning and Quay, allowing the two valves to modulate simultaneously. This would also allow the LACDPW to discontinue the current practice of using valve closures to isolate the barrier into two separate hydraulic regimes).
- Move the RW connection point further north from the existing location to avoid the hydraulic constrictions of the DGB header pipelines. The exact location of the new connection point would need to be determined and confirmed in a pre-design study that incorporates hydraulic calculations and/or hydraulic modeling.

It is uncertain at this time what the maximum flow through the existing connection point is and whether a new pipeline to the north end of the barrier will be necessary. This analysis conservatively assumes that a new pipe would be necessary and provides a separate cost estimate.

Flow control system modifications at DGB need to be confirmed with a hydraulic model and pre-design assessment. The model and assessment should assess the feasibility of the following potential improvements to resolve existing pressure control issues at DGB: a) Control plant delivery by meeting flow set point with variable speed product water pumps; b) De-commission existing LADWP pressure reducing valve on the delivery pipeline to the barrier; c) Add pressure relief valve and pressure transmitter alarms to DGB piping at point of connection; d) Keep MWD pressure-reducing valve at north end of DGB in service with downstream pressure set point.

Currently, LACDPW is conducting a condition assessment of the DGB that will investigate some of these options and provide an updated hydraulic model for the barrier. The condition assessment will allow a more thorough evaluation of alternative solutions for providing a 100 percent recycled water contribution at DGB.

Figure 5-1: Conceptual Pipeline Alignment to Serve Dominguez Gap Barrier



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Data Sources: USGS, LADWP

5.2 Recycled Water Contribution for Barrier Injection during Phase I

DGB historical deliveries from 2006 to 2010 (WRD, 2011) and projected deliveries up to 2014 are summarized in Table 5-1. The percent recycled water contribution (RWC) has fluctuated between 20 and 40 percent between 2006 and 2010. Because the recycled water contribution has been less than 50 percent over the past 5 years, DWP can supply the barrier with over 50 percent recycled water until the 5-year running average exceeds 50 percent. To supply more than 50 percent recycled water to the barrier, AOP will be needed to reduce NDMA and 1,4-dioxane concentrations to less than 0.01 micrograms/litre and 1 microgram/litre, respectively, to be below the California Department of Public Health notification levels for these compounds. This can be achieved using UV disinfection with addition of liquid hydrogen peroxide.

RWC ratios from 2011 to 2014 cannot be precisely forecasted. However, assuming that the two new MF skids are on line at the beginning of 2012 and that the plant produces 5.0 mgd on a reliable basis starting in 2012, the recycled water contribution ratios at the barrier could increase over time as shown in Table 5-1. Based on this calculation, TIWRP could deliver 5.0 mgd (4.5 mgd going to DGB and 0.5 mgd going to irrigation customers, on average) until 2015. In that year, the disinfection system would have to be upgraded from chlorine contact to an advanced oxidation process such as ultraviolet light plus hydrogen peroxide because in that year the 5-year running average for recycled water contributions would exceed 50 percent.

Table 5-1: Historic and Potential Future Recycled Water Contributions to DGB[a,b,c,d]

Year	Potable LADWP (AFY)	Potable WBMWD (AFY)	TIWRP AWT RWC (AFY)	RWC (mgd)	Total to DGB (AFY)	Percent RW to DGB	5-year Running Average
2006	1,107	6,034	1,825	1.63	8,966	20%	--
2007	455	4,226	1,510	1.35	6,191	24%	--
2008	301	3,979	2,734	2.44	7,014	39%	--
2009	992	4,231	2,365	2.11	7,587	31%	--
2010	152	4,061	1,867	1.67	6,464	29%	29%
2011 (est)	*772*	*4,000*	*2,460*	*2.20*[e]	*7,232*	*32%*	*31%*
2012 (est)	*0*	*3,920*	*5,040*	*4.5*	*8,960*	*56%*	*37%*
2013 (est)	*0*	*3,920*	*5,040*	*4.5*	*8,960*	*56%*	*41%*
2014 (est)	*0*	*3,920*	*5,040*	*4.5*	*8,960*	*56%*	*46%*
2015 (est)	*0*	*3,920*	*5,040*	*4.5*	*8,960*	*56%*	*51%*
	Buildout	*0*	*8,960*	*8.0*	*8,960*	*100%*	

a. Data from 2006 to 2010 provided by Water Replenishment District staff.
b. Data from 2011 to 2014 projected. Potable water contributions are used to supplement up to the maximum capacity of the DGB after allowable RWC is supplied.
c. Recycled water contributions to barrier in 2011 estimated based on volume of recycled water sent to barrier from 1/1/2011 to 6/1/11 provided by TIWRP operations staff.
d. Assumes maximum DGB capacity of 8.0 mgd (8,960 AFY).
e. RW contribution of 2.20 mgd in 2011 was estimated based on initial supplies provided to the DGB for 2011 (Source: TIWRP operations staff).

6. Probable Capital Costs

6.1 Phases I - IV

Appendix A contains conceptual capital cost estimates for the different phases of expansion at TIWRP. These cost estimates conform to the cost criteria established in the *Cost Estimating Basis for Recycled Water Master Planning TM* (RMC/CDM, 2012b) (Appendix E in Non-Potable Reuse Master Planning Report) in addition to costs developed in *TIWRP Capacity and Reliability Study* (CDM, 2011). Projected total project cost ranges expressed in 2011 dollars are summarized in **Table 6-1**.

The third column of **Table 6-1** reports the capital costs assuming that additional Memcor 90M10C units are used to expand the MF capacity of the AWPF. The last column reports capital costs assuming that newer MF technology is used to expand the MF capacity. Expansion phases that require new space on the site to be used (i.e., RO and Memcor 90M10C units) include the cost of soil stabilization and deep foundations. Deep foundations are assumed to be present only under existing MF and RO facilities.

Table 6-1: Cost Summary for TIWRP Phases

Phase	Added/Restored Production Capacity, mgd	Capital Costs (Memcor 90M10C)	Capital Costs (Pall Microza or Siemens Memcor CP)
Phase I – restore 5.0 mgd Capacity[a]	1.0	\$5.4M	\$5.4M
Phase II – expand from 5.0 mgd to 6.0 mgd Capacity	1.0	\$5.4M	\$5.3M
Phase III – 9.0 mgd Capacity	3.0	\$30.0M (\$19.8M)[b]	\$32.8M (\$22.1M)[b]
Phase IV – 12.5 mgd Capacity[c]	3.5	\$33.7M	\$36.5M
Pipeline	**Capacity, mgd**	**Capital Costs**	
New pipeline to DGB[d]	8.0	\$8.5M	
New pipeline to Adjacent Agency / Other NPR[e]	3.5	\$6.8M	

a. Phase 1 is not an expansion; this phase restores the AWTF production capacity to 5.0 mgd.
b. If construction of 1.2 million gallons of EQ can be avoided during Phase III (as described in Section 3.2), the capital costs of Phase III should be reduced by approximately \$10M (including markups and contingencies).
c. Production wells and lateral pipelines serving groundwater to the potable distribution system are not included.
d. The conceptual pipeline to DGB is not included in the Phase I- IV costs. It is likely that the pipeline would need to be constructed to serve Phase II or Phase III, depending on system hydraulics as the RWC to DGB increases.
e. Pipeline to adjacent agency/other NPR is assumed to be 14-inch diameter and approx. three miles in length.

6.2 Replacement of Existing MF Units

The estimated cost to replace the existing MF units with newer MF technology (to support a 5.0-mgd AWTF product water capacity) is approximately \$18M, including electrical, instrumentation/controls, contractor overhead and profit, construction cost factor, and implementation cost factor.

7. Implementation

Should the City decide to proceed with Phases II, III, or IV, the following implementation schedule shown in **Table 7-1** applies. Phase I does not include any plant expansion activities.

Table 7-1: Implementation Schedule for Each Phase

Implementation Steps	Estimated Duration
Pre-Design	6 months
Final Design	12 months
Bidding and Award	6 months
Construction	24 months
Total	**4 years**

It should be noted that Phases II though IV could be designed and constructed in sequence, requiring up to twelve years to complete. Another approach would be to design and construct the expansions without sequential phasing, potentially requiring only four years to complete. The timing of construction for the treatment facilities is not dependent on one phase being completed before another. It is more likely that phasing would be determined by the permit requirements for RWC and the availability of additional industrial customer demand, other agency demand, and/or recharge and recovery demand.

8. Conclusions

Based on this conceptual analysis, expanding TIWRP to provide additional barrier water to the DGB is feasible. However, to determine if the project is economically viable, the City will need to perform a comprehensive evaluation of project costs, including potential improvement costs to the DGB. In addition, the City will need to negotiate interagency operational and financial agreements to allow expanded use of TIWRP product water on a long-term basis. The City will also need to determine how to fund providing additional barrier water to the DGB since it provides a regional benefit to Southern California rather than offsetting imported water use within the City to achieve the goals of the 2010 UWMP.

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Appendix A

Cost Estimates

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ASPECT: Phases I - IV Date: January 27, 2012

DESCRIPTION: TIWRP - Alternative A - Other Customers (assuming Memcor 90MC10 units)

Item	Qty	Units	Unit Cost	Cost	Notes
Phase I - 5.0 mgd					
Microfiltration				$ 3,091,000	Includes repl. membranes, new MF skids, valves, actuators, o-rings, air compressors, CIP, elec. & control
Reverse Osmosis				$ 770,000	Includes repl. membranes
Product Water Stabilization				$ 648,000	Includes CaCl2 storage, feed pumps, NaOH storage, feed pumps
Electrical System				$ 719,000	Includes capacitors for MF wetwell VFDs, product water pump VFDs, valves for chem. dosing
Flow Control Valve[3]				$ 200,000	Includes 24" valve, actuator, power, SCADA, vault, installation
			Total Capital Cost	**$ 5,428,000**	Includes 30% markup for general conditions, overhead, profits and 30% construction contingency
Phase II - 6.0 mgd					
Microfiltration				$ 1,560,000	Includes new MF skids
Disinfection/ Product Water Storage				$ 2,230,000	Includes UV/peroxide system
Electrical System				$ 1,500,000	Includes PLC System
Instrumentation and Controls				$ 90,000	Includes upgrade of plant network, chlorine analyzers
			Total Capital Cost	**$ 5,380,000**	Includes 30% markup for general conditions, overhead, profits and 30% construction contingency
Phase III - 9.0 mgd					
Microfiltration	6	skids	$362,330	$ 2,174,000	Costs for 2 MF skids developed by CDM, May 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Reverse Osmosis	3.0	mgd	$825,493	$ 2,476,000	2000 bid values for TIWRP, $6.195 M for 5 mgd escalated to 2011 dollars. Includes chemical facilities Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Canopy for MF/RO/UV Processes	7,500	sqft	$100	$ 750,000	City of Malibu WW treatment predesign estimate - 2010. Calculated area is from Task 4.2.2 TIWRP Draft TM, Figure 3-3 proposed facility layouts, apportioned by flow rate.
Equalization Basin	1,200,000	gallon	$4.00	$ 4,800,000	per LABOS for below ground structure
Product Water Pumps	2	pump	$239,510	$ 479,000	VFD $125,000 per CDM Apr 2011 report plus, cost of pump per Floway Mfg 5-19-11, add 35% instalation plus $15,000/pump for concrete modifications and $15,000/pump for new discharge piping and valves.
UV Disinfection/ Peroxide System	3.0	mgd	$168,332	$ 505,000	CDM Costs for UV Disinfection system at 6.0 mgd May, 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Stabilization	3.0	mgd	$48,914	$ 147,000	$540,000 per CDM report for 5.0 mgd production, April 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Deep Foundations/Vibroflotation	3.0	mgd	$948,106	$ 2,844,000	Required due to soil liquefaction; foundations are assumed necessary for both MF and RO unit expansions; based on 2000 bid values for TIWRP, $3.449M for 5 mgd escalated to 2011 dollars. Costs exclude all markups and contingencies.
			Construction Subtotal	**$ 14,175,000**	
Electrical	1	% of installed costs	11%	$ 1,200,000	
Instrumentation/Controls	1	% of installed costs	7%	$ 800,000	
			Subtotal	**$ 16,175,000**	
Contractor Overhead and Profit	1	% of installed costs	10%	$ 1,600,000	
			Subtotal	**$ 17,775,000**	
		Construction Cost Factor	30%	$ 5,300,000	
			Construction Total	**$ 23,075,000**	
		Implementation Cost Factor	30%	$ 6,900,000	Includes design construction mgmt, admin, legal, environmental, etc.
			Total Capital Cost	**$ 29,975,000**	

Item	Qty	Units	Unit Cost		Cost	Notes
Phase IV - 12.5 mgd						
Microfiltration	7	skids	$362,330	$	2,536,000	Costs for 2 MF skids developed by CDM, May 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Reverse Osmosis	3.5	mgd	$825,493	$	2,889,000	2000 bid values for TIWRP, $6.195 M for 5 mgd escalated to 2011 dollars. Includes chemical facilities Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Equalization Basin	1,300,000	gallon	$4.00	$	5,200,000	per LABOS for below ground structure
Canopy for MF/RO/UV Processes	8,500	sqft	$100	$	850,000	City of Malibu WW treatment predesign estimate - 2010. Calculated area is from Task 4.2.2 TIWRP Draft TM, Figure 3-3 proposed facility layouts, apportioned by flow rate.
Product Water Pumps	1	pump	$239,510	$	240,000	VFD $125,000 per CDM Apr 2011 report plus, cost of pump per Floway Mfg 5-19-11, add 35% instalation plus $15,000/pump for concrete modifications and $15,000/pump for new discharge piping and valves.
UV Disinfection/ Peroxide System	3.5	mgd	$168,332	$	589,000	CDM Costs for UV Disinfection system at 6.0 mgd May, 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Stabilization	3.5	mgd	$48,914	$	171,000	$540,000 per CDM report for 5.0 mgd production, April 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Deep Foundations/Vibroflotation	3.5	mgd	$948,106	$	3,318,000	Required due to soil liquefaction; foundations are assumed necessary for both MF and RO unit expansions; based on 2000 bid values for TIWRP, $3.449M for 5 mgd escalated to 2011 dollars. Costs exclude all markups and contingencies.
			Construction Subtotal	**$**	**15,793,000**	
Electrical	1	% of installed costs	11%	$	1,400,000	
Instrumentation/Controls	1	% of installed costs	7%	$	900,000	
			Subtotal	**$**	**18,093,000**	
Contractor Overhead and Profit	1	% of installed costs	10%	$	1,800,000	
			Subtotal	**$**	**19,893,000**	
		Construction Cost Factor	30%	$	6,000,000	
			Construction Total	**$**	**25,893,000**	
		Implementation Cost Factor	30%	$	7,800,000	Includes design construction mgmt, admin, legal, environmental, etc.
			Total Capital Cost	**$**	**33,693,000**	

Notes:

1. Costs for Phases I and II are obtained from CDM recommendations in *Capacity and Relibility Study for TIWRP (* CDM, May 2011).
2. Costs for Phases III and IV were developed using the Task 2 Cost Estimating Basis for Recycled Water Master Planning TM, Revised Draft (RMC/CDM, May 2011).
3. Not included in CDM TM (CDM, May 2011)
4. MF costs based on Memcor 90M10C existing units installed in 2000.
5. Costs without EQ in Phase III were estimated by setting Phase III EQ line item cost to zero.

ASPECT: Phases I - IV | Date: January 27, 2012

DESCRIPTION: TIWRP - Alternative A - Other Customers (assuming New MF Technology)

Item	Qty	Units	Unit Cost	Cost	Notes
Phase I - 5.0 mgd					
Microfiltration				$ 3,091,000	Includes repl. membranes, new MF skids, valves, actuators, o-rings, air compressors, CIP, elec. & control
Reverse Osmosis				$ 770,000	Includes repl. membranes
Product Water Stabilization				$ 648,000	Includes CaCl2 storage, feed pumps, NaOH storage, feed pumps
Electrical System				$ 719,000	Includes capacitors for MF wetwell VFDs, product water pump VFDs, valves for chem. dosing
Flow Control Valve[3]				$ 200,000	Includes 24" valve, actuator, power, SCADA, vault, installation
			Total Capital Cost	**$ 5,428,000**	Includes 30% markup for general conditions, overhead, profits and 30% construction contingency
Phase II - 6.0 mgd					
Microfiltration				$ 1,500,000	Based on $1.5M/mgd AWTF capacity estimate for Pall Microza and Siemens Memcor CP units proposed for DCTWRP and LVLWRF; excludes building costs, canopy costs, implementation costs, and contingencies.
Disinfection/ Product Water Storage				$ 2,230,000	Includes UV/peroxide system
Electrical System				$ 1,500,000	Includes PLC System
Instrumentation and Controls				$ 90,000	Includes upgrade of plant network, chlorine analyzers
			Total Capital Cost	**$ 5,320,000**	Includes 30% markup for general conditions, overhead, profits and 30% construction contingency
Phase III - 9.0 mgd					
Microfiltration				$ 4,500,000	Based on $1.5M/mgd AWTF capacity estimate for Pall Microza and Siemens Memcor CP units proposed for DCTWRP and LVLWRF; excludes building costs, canopy costs, implementation costs, and contingencies.
Reverse Osmosis	3.0	mgd	$825,493	$ 2,476,000	2000 bid values for TIWRP, $6.195 M for 5 mgd escalated to 2011 dollars. Includes chemical facilities Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Canopy for MF/RO/UV Processes	7,500	sqft	$100	$ 750,000	City of Malibu WW treatment predesign estimate - 2010. Calculated area is from Task 4.2.2 TIWRP Draft TM, Figure 3-3 proposed facility layouts, apportioned by flow rate.
Equalization Basin	1,200,000	gallon	$4.00	$ 4,800,000	per LABOS for below ground structure
Product Water Pumps	2	pump	$239,510	$ 479,000	VFD $125,000 per CDM Apr 2011 report plus, cost of pump per Floway Mfg 5-19-11, add 35% instalation plus $15,000/pump for concrete modifications and $15,000/pump for new discharge piping and valves.
UV Disinfection/ Peroxide System	3.0	mgd	$168,332	$ 505,000	CDM Costs for UV Disinfection system at 6.0 mgd May, 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Stabilization	3.0	mgd	$48,914	$ 147,000	$540,000 per CDM report for 5.0 mgd production, April 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Deep Foundations/Vibroflotation	3.0	mgd	$474,053	$ 1,422,000	Required due to soil liquefaction; foundations are assumed necessary for RO unit expansions only (it is assumed that new MF units can fit in existing footprint; approximately half of expansion footprint is MF and half is RO); based on 2000 bid values for TIWRP, $3.449M for 5 mgd escalated to 2011 dollars. Costs exclude all markups and contingencies.
			Construction Subtotal	**$ 15,079,000**	
Electrical	1	% of installed costs	11%	$ 1,500,000	
Instrumentation/Controls	1	% of installed costs	7%	$ 1,000,000	
			Subtotal	**$ 17,579,000**	
Contractor Overhead and Profit	1	% of installed costs	10%	$ 1,800,000	
			Subtotal	**$ 19,379,000**	
		Construction Cost Factor	30%	$ 5,800,000	
			Construction Total	**$ 25,179,000**	
		Implementation Cost Factor	30%	$ 7,600,000	Includes design construction mgmt, admin, legal, environmental, etc.
			Total Capital Cost	**$ 32,779,000**	

Item	Qty	Units	Unit Cost	Cost	Notes
Phase IV - 12.5 mgd					
Microfiltration				$ 5,250,000	Based on $1.5M/mgd AWTF capacity estimate for Pall Microza and Siemens Memcor CP units proposed for DCTWRP and LVLWRF; excludes building costs, canopy costs, implementation costs, and contingencies.
Reverse Osmosis	3.5	mgd	$825,493	$ 2,889,000	2000 bid values for TIWRP, $6.195 M for 5 mgd escalated to 2011 dollars. Includes chemical facilities Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Equalization Basin	1,300,000	gallon	$4.00	$ 5,200,000	per LABOS for below ground structure
Canopy for MF/RO/UV Processes	8,500	sqft	$100	$ 850,000	City of Malibu WW treatment predesign estimate - 2010. Calculated area is from Task 4.2.2 TIWRP Draft TM, Figure 3-3 proposed facility layouts, apportioned by flow rate.
Product Water Pumps	1	pump	$239,510	$ 240,000	VFD $125,000 per CDM Apr 2011 report plus, cost of pump per Floway Mfg 5-19-11, add 35% instalation plus $15,000/pump for concrete modifications and $15,000/pump for new discharge piping and valves.
UV Disinfection/ Peroxide System	3.5	mgd	$168,332	$ 589,000	CDM Costs for UV Disinfection system at 6.0 mgd May, 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Stabilization	3.5	mgd	$48,914	$ 171,000	$540,000 per CDM report for 5.0 mgd production, April 2011. Costs have been reduced to exclude markups, overhead, profit, 30% construction contingency, implementation costs.
Deep Foundations/Vibroflotation	3.5	mgd	$474,053	$ 1,659,000	Required due to soil liquefaction; foundations are assumed necessary for RO unit expansions only (it is assumed that new MF units can fit in existing footprint; approximately half of expansion footprint is MF and half is RO); based on 2000 bid values for TIWRP, $3.449M for 5 mgd escalated to 2011 dollars. Costs exclude all markups and contingencies.
			Construction Subtotal	**$ 16,848,000**	
Electrical	1	% of installed costs	11%	$ 1,700,000	
Instrumentation/Controls	1	% of installed costs	7%	$ 1,100,000	
			Subtotal	**$ 19,648,000**	
Contractor Overhead and Profit	1	% of installed costs	10%	$ 2,000,000	
			Subtotal	**$ 21,648,000**	
		Construction Cost Factor	30%	$ 6,500,000	
			Construction Total	**$ 28,148,000**	
		Implementation Cost Factor	30%	$ 8,400,000	Includes design construction mgmt, admin, legal, environmental, etc.
			Total Capital Cost	**$ 36,548,000**	

Notes:

1. Costs for Phases I and II are obtained from CDM recommendations in *Capacity and Relibility Study for TIWRP (* CDM, May 2011).
2. Costs for Phases III and IV were developed using the Task 2 Cost Estimating Basis for Recycled Water Master Planning TM, Revised Draft (RMC/CDM, May 2011).
3. Not included in CDM TM (CDM, May 2011)
4. MF costs based on Pall Microza (LVLWRF) and Pall Microza/Siemens Memcor CP (DCTWRP) pre-design criteria.
5. Costs without EQ in Phase III were estimated by setting Phase III EQ line item cost to zero.

ASPECT: **Phases I - IV** Date: January 27, 2012

DESCRIPTION: TIWRP - Pipeline to DGB

	Dia	Qty	Units	Unit Cost		Cost	Notes
Expansion Stage - 5.0 mgd							
Conveyance							
Open Cut	24	11,500	in-dia*LF	$18	$	5,000,000	length of pipe from ex. Connection point to north of Sepulveda
				Construction Subtotal	**$**	**5,000,000**	
			Contingency Costs	30%	$	1,500,000	
				Construction Total	**$**	**6,500,000**	
			Implementation Costs	30%	$	2,000,000	Includes design construction mgmt, admin, legal, etc.
				Total Capital Cost	**$**	**8,500,000**	

DESCRIPTION: TIWRP Reliability - Pipeline to Adjacent Agency or New NPR

	Dia	Qty	Units	Unit Cost		Cost	Notes
Expansion Stage - 12.5 mgd							
Conveyance							
Open Cut	14	15,840	in-dia*LF	$18	$	4,000,000	assume 3-mile length; 14-inch pipe (@6 fps)
				Construction Subtotal	**$**	**4,000,000**	
			Contingency Costs	30%	$	1,200,000	
				Construction Total	**$**	**5,200,000**	
			Implementation Costs	30%	$	1,600,000	Includes design construction mgmt, admin, legal, etc.
				Total Capital Cost	**$**	**6,800,000**	

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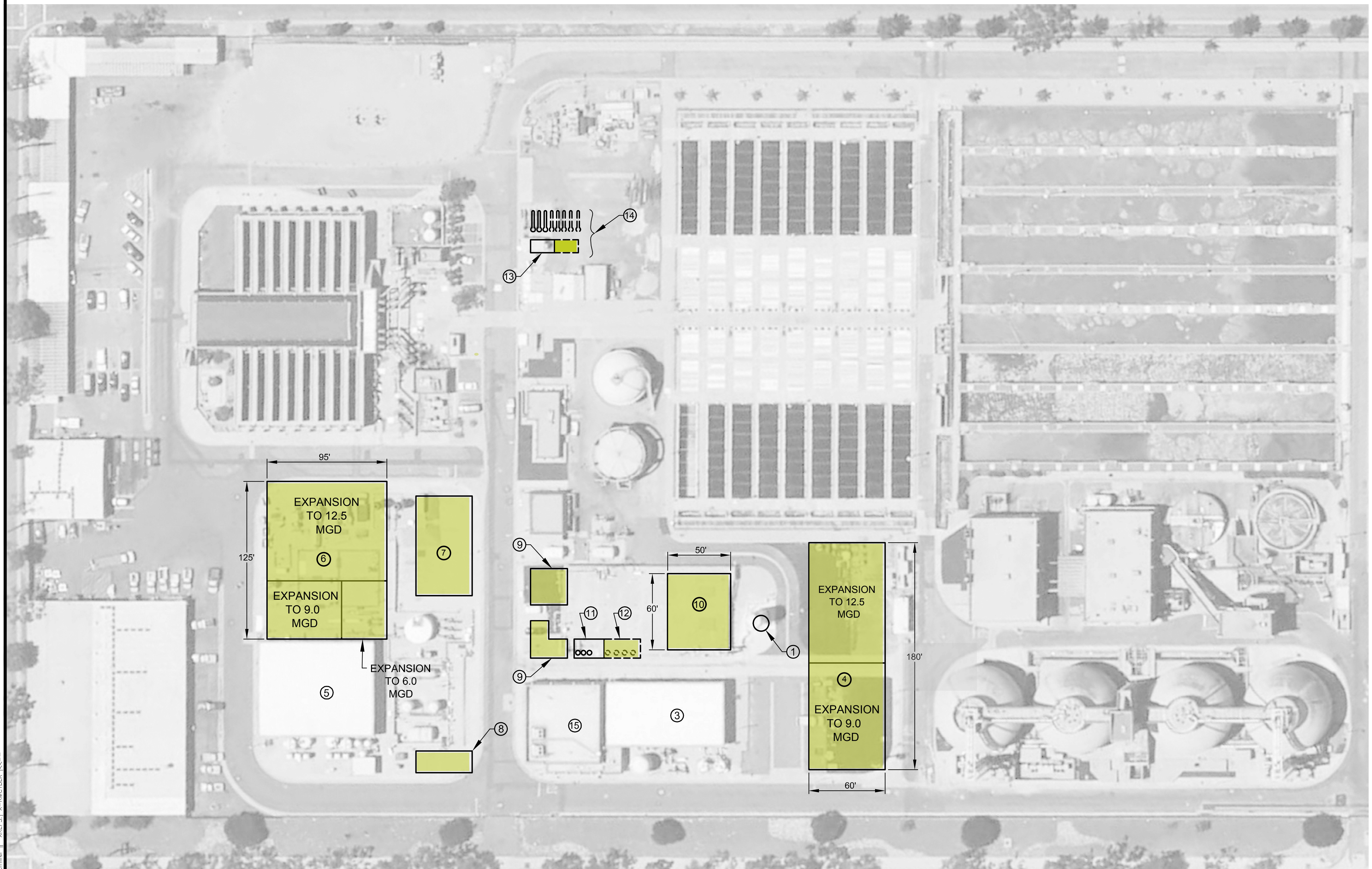
Appendix B

MF/RO/AOP Site Layout



PLAN

APPROX SCALE: 1" = 80'-0"
(AT HALF SIZE)

0 40' 80'
APPROX SCALE: 1" = 80'-0"
(AT HALF SIZE)

LEGEND

TIWRP PRELIMINARY
AWTF LAYOUT

1. EXISTING LIME SILO / REPLACE W/ $CaCl_2$
3. EXISTING RO MEMBRANES
4. PROPOSED RO MEMBRANES AND RO ELECTRICAL ROOM. 2.5 MG EQ BASIN BELOW GRADE (60'x180'x30')
5. EXISTING MF MEMBRANES
6. PROPOSED MF MEMBRANES AND MF ELECTRICAL
7. PROPOSED CHEMICAL STORAGE/HYPOCHLORITE/ CITRIC/SULFURIC/BREAK TANK
8. PROPOSED CHEMICAL STORAGE AREA - SULFURIC/CITRIC/ HYPOCHLORITE/ THRESHOLD INHIBITOR
9. PROPOSED CHEMICAL STORAGE AREA - HYDROGEN PEROXIDE AND AMMONIA
10. UV UNITS PLUS UV ELECTRICAL ON TOP OF EXISTING CHLORINE CONTACT BASIN. INSTALL STRUCTURAL CANOPY OVER UV UNITS.
11. EXISITING PRODUCT WATER PUMP STATION
12. EXPANDED PRODUCT WATER PUMP STATION
13. EXISTING MF FEED PUMP STATION
14. EXPANDED MF FEED PUMP STATION
15. EXISTING MF/RO ELECTRICAL BLDG.

PROPOSED FACILITIES

PRELIMINARY

P:\0214 - LADWP RWMP\TERMINAL ISLAND FIGURES\TI SITE PLAN.DWG
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LAST PRINTED: 7/1/2011 2:49 PM
XREFS: X-RMCTBLK

0" 1"
VERIFY SCALES
BAR IS ONE INCH LONG ON FULL SIZE DRAWING. IF NOT ONE INCH LONG ON THIS DRAWING, ADJUST SCALES ACCORDINGLY

RMC Water & Environment

REV	DATE	BY	APVD	DESCRIPTION

DESIGNED
DRAWN
CHECKED

SUBMITTED: RMC PROJ ENGR C
APPROVED: RMC ENGR C

Figure 3-3

Terminal Island Water Reclamation Plant
MF/RO/AOP Site Layout

DWG NO	
SHEET NO	1 OF 1
PROJ NO	0000-000
DATE	July 2011

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Prepared by:

RMC in association with CDM Smith

LA DWP Los Angeles Department of Water & Power

CITY OF LOS ANGELES SANITATION DEPARTMENT OF PUBLIC WORKS

BUREAU OF ENGINEERING

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