THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Potential Regional Recycled Water Program

Feasibility Study

Report No. 1530

November 30, 2016

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Preface

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PREFACE

The Regional Recycled Water Program (RRWP or program) Feasibility Study analyzes the feasibility of a potential program that would create a new water resource with regional benefits for Southern California. The RRWP would include the following: (1) an advanced water treatment (AWT) facility located at the Sanitation Districts of Los Angeles County (Sanitation Districts) Joint Water Pollution Control Plant (JWPCP) in Carson; (2) the production of up to 150 million gallons per day (mgd) of purified water; (3) the conveyance of purified water via approximately 60 miles of pipelines; and (4) delivery of purified water to up to four groundwater basins (Orange County, Central, West Coast, and Main San Gabriel) within the Metropolitan Water District of Southern California's (Metropolitan or MWD) service area. The RRWP would provide up to 168,000 acre-feet per year (AFY) to recharge these basins, replacing existing and projected demand for imported water for recharge, and enabling the basins to serve their vital storage function that helps meet regional water demands during dry periods and emergencies.

Approach

In its simplest definition, "feasible" is understood to mean "capable of being accomplished" — answering the essential questions "Can it be done?" and "What is the cost of doing it?" The evaluation does not attempt to answer questions regarding whether it should be done or if it is more or less cost effective than other alternatives. The feasibility analysis, however, is intended to provide the Metropolitan board with essential information needed to make those decisions.

The approach considers "feasibility" in several dimensions:

1. Engineering, constructability, and operational feasibility
2. Environmental and regulatory feasibility
3. Feasibility of essential institutional arrangements
4. Economic feasibility
5. Public acceptability

In addition, the feasibility analysis also addresses the current state of conditions in the region's groundwater basins as a way to set the stage for the remaining discussion related to overall program feasibility.

The feasibility study was not prepared to meet the criteria of federal and state funding programs. Additional analysis and information would be needed to prepare documentation for grant and loan programs that may be pursued in the future. Further, the feasibility study is not intended to serve as a preliminary design, and many of the assumptions contained in the report will be subjected to additional analysis and confirmation in subsequent planning and design efforts.

Base Case Definition

To establish the feasibility of the RRWP, a "base case" was developed for analysis and evaluation. The base case is defined as an implementable system of program elements, including facilities, infrastructure, institutional arrangements, and financing assumptions (each of which have quantifiable and acceptable levels of risk), that are necessary and sufficient for accomplishing the program's goals. The base case consists of a hypothetical system model that has not yet been designed to achieve optimized performance, but is deemed capable of accomplishing these functional goals.

A detailed description of the base case, including the program goals and assumptions used for the analysis, is provided in Chapter 3 of this report. Note that although the base case facilities would handle a significant amount of flow from the JWPCP, they would not be designed to handle peak flows to the JWPCP. Furthermore, the base case facilities would be expected to periodically reduce deliveries to groundwater basins when conditions warrant. Finally, the base case system should not be considered as either the best or worst case scenario with respect to implementation costs or timelines. It represents a realistic approach to achieving the program's functional goals and is intended to demonstrate feasibility only. The program would likely be implemented in phases, which would be evaluated during conceptual design should the RRWP move forward. Risks that could be associated with the worst case, and opportunities for reduced implementation costs that could lead to a better case, have been identified where possible.

No speculative assumptions (e.g., future improvements in treatment technology efficiencies, future changes in regulatory requirements, or favorable outcomes on negotiated terms and conditions) have been included in the base case. Finally, it is recognized that the base case would be optimized in subsequent phases of design to potentially reduce capital costs, operations and maintenance (O&M) costs, and/or environmental impacts.

Reasonable cost contingencies and ranges for certain values (e.g., interest rates on borrowed funds) have been applied to the analysis. They are considered to be reliable and conservative for the purposes of evaluating overall feasibility.

Advisory Panel

Another important element of the approach involved the participation of an Advisory Panel throughout the evaluation process. Convened in early 2016, the panel of eight subject matter experts provided independent review and input on the scope and direction of the program during the development of both the feasibility study and demonstration facility. The Advisory Panel met several times in a workshop format during 2016 to provide input on overall program feasibility and work plans; design of the demonstration facility; groundwater basins and water delivery assessments; and approaches to program implementation. The panel, within their areas of expertise, unanimously agrees that the program is technically feasible and can be implemented; however, the panel believes there will be challenges in the implementation process which Metropolitan and the Sanitation Districts will face and which will need to be addressed. The panel’s workshop reports are attached as Appendix A, and the panel’s final report and recommendation are included following this preface.

Answering Three Major Questions

Using the base case as the foundation for evaluation, the feasibility analysis focuses on answers to three threshold questions:

1. No fatal flaws: Is it technically, institutionally, and legally possible to implement a 150-mgd indirect potable reuse program using effluent from the JWPCP?

2. Justified and cost effective: Are the costs and benefits of the program consistent with Metropolitan's 2015 Integrated Water Resources Plan (IRP) and other approaches for achieving a comparable amount of recycled water?
3. Impacts on the cost of water to member agencies: How would the cost of water be affected if the base case and its associated assumptions were implemented?

Although the study provides some information regarding the comparative costs of the base case program and other means of producing new conservation and water supply benefits, this study is not intended to serve as an alternatives analysis regarding future conservation and supply investments.

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METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
LOS ANGELES COUNTY SANITATION DISTRICTS
REGIONAL WATER RECYCLING PROGRAM
ADVISORY PANEL

November 14, 2016

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Subject: Final Report of Advisory Committee
Metropolitan Water District/Los Angeles County Sanitation Districts
Potential Regional Recycled Water Program Feasibility Study (Feasibility Study)

Dear Ms. Man and Ms. Robinson-Hyde:

The Advisory Panel (AP) appreciates the opportunity to work with members of the staff of the Metropolitan Water District and the Los Angeles County Sanitation Districts and the design team on this most exciting project. This project, if implemented, will create a new, large-scale, drought-proof water supply that will add to regional reliability through increased storage in regional groundwater basins.

The AP consisted of eight key subject matter experts who provided independent review and critical input on the scope and direction of the program during the development of the feasibility study and demonstration facility. The AP was charged with evaluating the technical studies forming the basis for evaluating Program feasibility and for the recommendations on the proposed next steps.

The AP met with the design team at several times and participated in several conference calls to provide guidance and input on the key elements of the program. (Specific comments are included in AP reports 1 and 2 in Appendix A of the Feasibility Study.) Individual members of the AP provided input and comments within their areas of expertise. The design team incorporated this input in the finalization of the Feasibility Study.

The AP, within their areas of expertise, unanimously agrees that the Program is technically feasible and can be implemented; however, the AP believes there will be challenges in the implementation process which Metropolitan and the Sanitation Districts will face and which will need to be addressed.

Demonstration Plant

The AP unanimously agrees the Demonstration Plant is feasible and can be implemented. The AP concurs with the need for the Demonstration Plant which will provide an opportunity for 1) optimizing costs, 2) demonstrating the process on the Joint Water Pollution Control Plant effluent, 3) conducting public outreach, 4) carrying out operator training, and 5) characterizing the reverse osmosis reject water (brine). The AP cautions that close coordination with the regulatory agencies during the design and development of the operation, monitoring, and testing program is essential. The AP suggests that an oversight panel be formed consisting of technical, scientific, regulatory, and public health professionals, to meet with the project team on a regular basis to provide technical guidance, operational and monitoring review, and technical review of reports submitted to the regulatory agencies.

Full Scale Advanced Water Treatment Facility (AWTF)

The AP unanimously agrees that the full scale AWTF is feasible and can be implemented. As with the Demonstration Plant, the AP cautions that close coordination with the regulatory agencies during the design and the development of the start-up, operation, monitoring, and testing program is essential. The AP suggests that the oversight panel, described above, continue to meet with the project team on a regular basis to review operation, results, and regulatory monitoring submittals – at least until the regulatory agencies are comfortable with the operation.

Conveyance System

The AP unanimously agrees that the implementation of the regional conveyance system is technically feasible, but recognizes that there are significant challenges with the installation of large diameter pipelines in busy city streets. Residences and businesses will be impacted; traffic will need to be re-routed. The fact that there are about thirty individual cities and jurisdictions involved, complicates the permitting; right of way acquisition will be time consuming. Outreach to each of the City Councils, business groups, and the general public is essential.

Regional Groundwater Recharge Program

The AP unanimously agrees that the implementation of the regional groundwater recharge program is technically feasible. The institutional arrangements and their coordination will be the greatest challenge. Additional detailed studies need to be completed to evaluate groundwater plume movement and identify mitigation measures, if needed.

Summary

The AP compliments the staff of the Metropolitan Water District and the Los Angeles County Sanitation Districts and the design team for their excellent work in developing this Feasibility Study. All of the major cost items have been identified. The report is well written and includes necessary supporting documentation.

The AP, within their respective areas of expertise, believes the Program is feasible from a technical standpoint; however, the institutional arrangements are still conceptual and need further definition to support a finding of institutional feasibility at this time. The AP believes that the project unit water cost of about $1,400 to $2,200 per acre-ft is supported by the analysis. This unit cost will be subject to refinement as a result of further studies, staging and phasing opportunities, value engineering activities, and further definition of the institutional requirements. To fund the project construction and operation, Metropolitan will need to finalize financing strategies which are agreeable to Metropolitan's member agencies.

Recommendation

The AP agrees with the findings and recommendations of the Feasibility Study Report and supports moving forward with the next phase.

Sincerely,

Richard Atwater (Chair)

Shivaji Deshmukh

Thomas Harder

David Jenkins

Edward Means

Joseph Reichenberger

Paul Westerhoff

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Chapter 1

Executive Summary

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1.0 EXECUTIVE SUMMARY

The Metropolitan Water District of Southern California (Metropolitan) has evaluated the feasibility of a potential Regional Recycled Water Program (RRWP) to produce up to 150 million gallons per day (mgd) or 168,000 acre-feet per year (AFY) of purified water in partnership with the Sanitation Districts of Los Angeles County (Sanitation Districts). This new source of regional supply would come at a time when local supplies such as groundwater face significant uncertainties and stress. Groundwater basin yields are the result of local rainfall, replenishment with imported supplies, and locally recycled water. The replenishment provided by imported supplies has decreased in recent years due in part to the deteriorating supply reliability of the State Water Project. Natural replenishment has decreased due to years of drought. Supplies of existing recycled water for groundwater recharge have not been able to prevent a decline in the availability of this vital regional supply.

The following Feasibility Study finds that the RRWP is technically feasible, from the advanced water treatment (AWT) process, to the conveyance system, to the necessary recharge facilities. The study also acknowledges that a project of this complexity and geographic scope has considerable institutional challenges, none of which appear to be insurmountable, but will require significant effort to address. In addition, the RRWP can be implemented through the existing regulatory process, making its approval feasible as well.

For Metropolitan and all of Southern California, the RRWP offers potentially significant regional benefits. The production of up to 168,000 AFY of purified water can help to maintain groundwater production in two counties. It can help to prevent a strain on regional water supply reserves. It can complement other Metropolitan initiatives such as the California WaterFix by providing reliable replenishment supplies that free up imported water to be placed in storage as a drought buffer. The RRWP can be integrated into the existing regional system and become part of Metropolitan's network of facilities.

The base case cost estimate for the production, delivery, and recharge of purified water is approximately $1,600 per acre-foot. It is a comprehensive estimate based on an interest rate of 4 percent, no grant funds, and a 35 percent contingency. This cost is within the range of local supply alternatives as identified in Metropolitan's 2015 Integrated Water Resources Plan (IRP) Update. For the base case, the potential cost impact over Metropolitan's 1.70 million acre-feet (MAF) annual sales base would range from $150 to $160 per acre-feet (AF).

The feasibility study recommends next steps, such as the construction of the demonstration plant, continued facility planning, public outreach, and development of agreements with the Sanitation Districts and other entities. Completion of these next steps would enable Metropolitan's board to make an appropriate investment decision at a future date with more comprehensive information at that time.

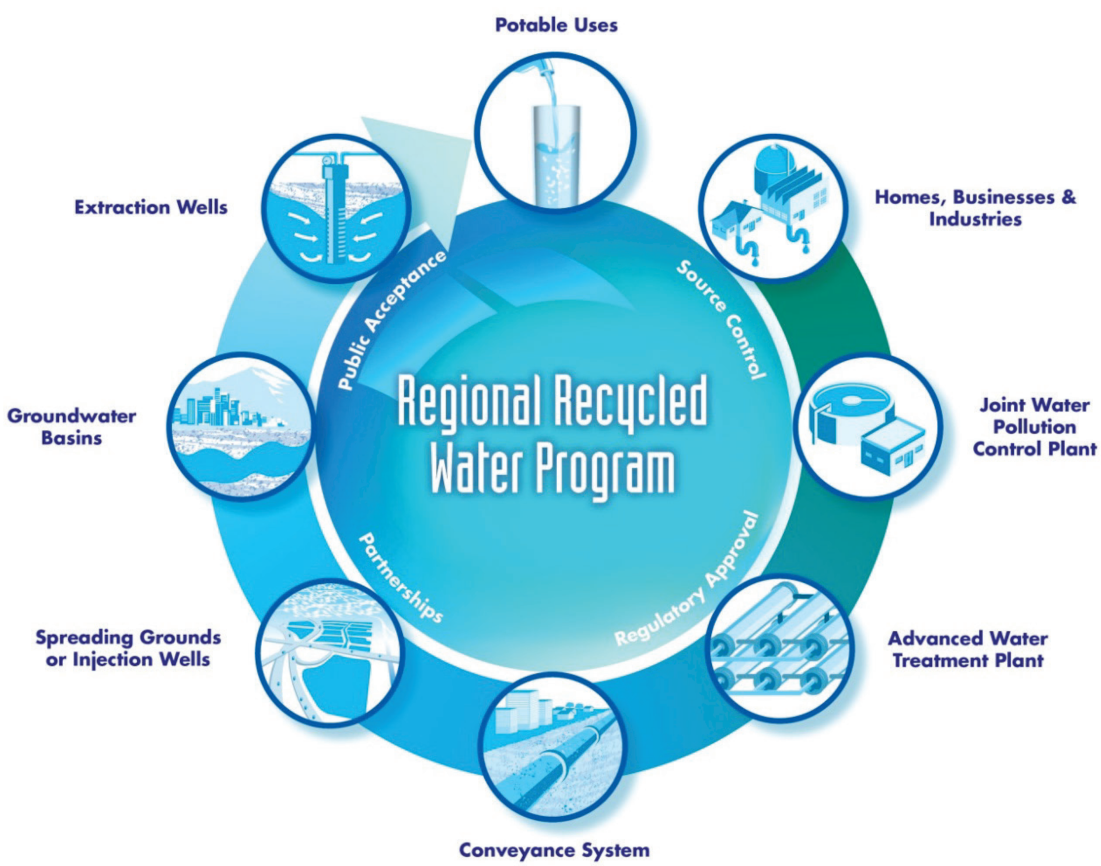
Finally, note that the RRWP is a large-scale, technically challenging project that will require a number of agreements with and permits from multiple agencies in several jurisdictions. The RRWP would span two counties and involve a county wastewater district, a regional water wholesaler, numerous cities, local water wholesalers, water retailers, groundwater management entities, and a number of regulatory agencies. As a regional agency with a regional mission with expertise in working with numerous institutions in multiple jurisdictions, Metropolitan brings a unique advantage to this project. As part of fulfilling its mission, Metropolitan also has significant experience in partnering with agencies and institutions both in and out of its service area. The size and scope of the Sanitation Districts coupled with the regional strength of Metropolitan creates a partnership that is capable of addressing the many technical, regulatory, financial, and institutional issues to make the RRWP a reality.

1.1 Program Concept

Metropolitan, in partnership with the Sanitation Districts, is considering the development of a program to create a water resource with regional benefit for Southern California. The potential RRWP consists of a new AWT facility at the Sanitation District's Joint Water Pollution Control Plant (JWPCP) in Carson. Initially, the facility would produce purified water to provide a reliable source of water to recharge regional groundwater basins that serve a vital function in the region's diversified water resource portfolio. In the future, the facility may provide a source of water for other indirect and direct potable uses. In addition to the facility, the program would include a new conveyance system to deliver the water to four groundwater basins.

With the RRWP, it is estimated that up to 168,000 AFY of purified water could be produced and recharged into the basins, resulting in higher total groundwater levels in the regional storage portfolio. The RRWP concept is shown in Figure 1.1. The concept begins with wastewater collected from homes, businesses, and industries. The collected wastewater then undergoes conventional treatment followed by advanced treatment. The treated water is then conveyed to groundwater basins for recharge. And finally, the treated water can be reused as a potable supply.

Figure 1.1: Program Overview



Actions to Date

For more than 5 years, Metropolitan and the Sanitation Districts have been discussing a regional collaboration to jointly develop recycled water. From June 2010 through July 2012, pilot studies were conducted by Metropolitan and the Sanitation Districts at the JWPCP to evaluate the feasibility of advanced treatment of the JWPCP's secondary effluent. The results of the pilot-scale studies determined that advanced treatment of JWPCP secondary effluent for producing water suitable for indirect potable reuse (IPR) through groundwater recharge is technically feasible.

In November 2015, Metropolitan and the Sanitation Districts entered into an agreement for development of a demonstration facility at the JWPCP. The districts also established a proposed framework of terms and conditions for development of a full-scale RRWP. For the full-scale project, the initial set of terms and conditions were non-binding, however, they set forth key conditions anticipated to be in a future full-scale agreement. Building upon these initial terms and subsequent discussions with the Sanitation Districts in 2016, staff would propose for board approval a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale AWT project at the JWPCP site.

In addition, at its November 2015 monthly meeting, the Metropolitan board authorized staff to design a demonstration facility that would allow Metropolitan to optimize an AWT process for the production of water for groundwater recharge. Although the earlier pilot scale studies indicated that an IPR project was technically viable, Metropolitan and the Sanitation Districts will undertake a demonstration project to refine and demonstrate an alternative treatment process train, which could provide significant capital and operational cost savings. As a value engineering measure, the project team determined that a 0.5-mgd demonstration facility would be sufficient to test, monitor, and optimize the treatment process and produce the water quality data needed to seek the necessary permits. The demonstration facility will also provide a means for Metropolitan and the Sanitation Districts to coordinate operations and serve as an effective tool for public outreach.

In early 2016, Metropolitan and the Sanitation Districts convened a panel of eight subject matter experts to provide independent review and critical input on the scope and direction of the program during the development of this feasibility study and demonstration facility.

Need for Program

Groundwater has always been an important resource for Southern California as it is a key component of regional reliability and integrally related to the management of imported water supplies and surface storage. Groundwater production within the Metropolitan service area averages about 1.3 MAF per year. Groundwater storage levels are also important because they impact how the groundwater basins can be used during times of shortage. If the groundwater storage levels are too low, basins may not be able to serve as a source of water when needed by the region and the basins' demands for imported supplies or surface storage will likely increase. Therefore, maintaining stable higher groundwater levels enables these basins to provide critical supply during shortages or emergencies.

Over the past 30 years, Metropolitan has delivered an average of 213,000 AFY of imported water for groundwater replenishment. Replenishment deliveries in the basins have not been sufficient to maintain groundwater basin water levels. A number of factors contribute to this, including water supply availability due to drought, regulatory restrictions, and replenishment purchase patterns. Due to drought conditions within the service area, groundwater demand has increased, groundwater replenishment has decreased, and groundwater storage has dropped 1.2 MAF since 2005. Without continued replenishment of the groundwater basins, groundwater storage is expected to continue to decline due to increased demand and limitations on other sources for natural and incidental recharge. For the basins to continue to provide benefits for regional reliability, water deliveries to the groundwater basins for recharge are essential.

Consistency with 2015 IRP Update

Through its IRP process, Metropolitan plans for regional water supply reliability. The targets in the 2015 IRP Update identify water supply developments in imported and local water supply and in water conservation that could provide a future without water shortages and mandatory restrictions of water use. The 2015 IRP target for local resources reflects the importance of stable local supplies within the region. By 2040, local supplies are expected to provide about 2.43 MAF of annual water supplies, which will constitute about 42 percent of the total supplies needed to balance regional demands for water supply. Production from the RRWP would significantly contribute to meeting the IRP target of developing and maintaining the 2.43 MAF target.

By providing a new regional supply in addition to the State Water Project (SWP) and Colorado River Aqueduct (CRA), Metropolitan has the opportunity to increase its regional storage to meet normal, dry year, and emergency needs for the entire service area.

Additional Regional Benefits of Program

Additional benefits include economies of scale; reduction in demands for imported water supplies; decreased burden on Metropolitan's infrastructure and reduced system costs; free-up conveyance capacity to the benefit of all system users; consistency with legislative mandate to Metropolitan to expand water recycling and groundwater storage and replenishment measures; improved water quality in the groundwater basins; and reduced vulnerability to climate change.

1.2 Using a Base Case for Analysis

The study's "base case" consists of a hypothetical system model that is deemed capable of accomplishing the program's functional goals. The base case assumes: (1) the production of up to 150 mgd of purified water with a long-term annual average of 147 mgd; (2) the pumping and conveyance of purified water through approximately 60 miles of pipelines; and (3) delivery of water to up to four groundwater basins within Metropolitan's service area. Phasing would be evaluated in the conceptual design of the program. Table 1.1 outlines the operational scenario assumed for the base case analysis.

Table 1.1: Base Case Operational Scenario

Performance	Operational Scenario
	Base Case
Goal	Delivery Flexibility
AWT Production Capacity	150 mgd
Average Daily Delivery	144–150 mgd
Long-Term Annual Average Delivery	147 mgd
Minimum Day Delivery	≥ 110 mgd
Manage Peak Flows to the JWPCP	No

1.3 Groundwater Basin Analysis

The groundwater basin analysis considered four basins: Orange County, Central, West Coast, and Main San Gabriel. These basins were selected based on their proximity to the JWPCP and their ability to accommodate up to 150 mgd (168,000 AFY) of recharge. Assumptions and operational criteria for the demand analysis and groundwater modeling were developed through coordination with member agencies, basin managers, and the Los Angeles County Department of Public Works. Existing groundwater models for each basin were used to aid in evaluating the ability of individual basins to recharge the water and identify possible impacts that the recharge may have.

The groundwater basin analysis considered potential demands, operational issues, facility capacity, and infrastructure needs. The results of the groundwater analysis and modeling confirmed that collectively, the basins have sufficient groundwater recharge demand and capacity for the year-round delivery of up to 150 mgd of purified water through the RRWP. A systemwide analysis determined the locations for groundwater recharge and the estimated recharge flow rates. Due to seasonal or operational issues, one or more of the groundwater basins may not be able to recharge the maximum amounts for short periods. Therefore, the facilities would be designed to accommodate a range of flow conditions and the ability to move water to different groundwater basins when needed. Table 1.2 summarizes the results of the analysis. Table 1.3 presents the estimated range of flows to each basin for groundwater recharge and Figure 1.2 presents the locations and range of flow rates to each of the four groundwater basins.

Table 1.2: Summary of Groundwater Basin Analysis

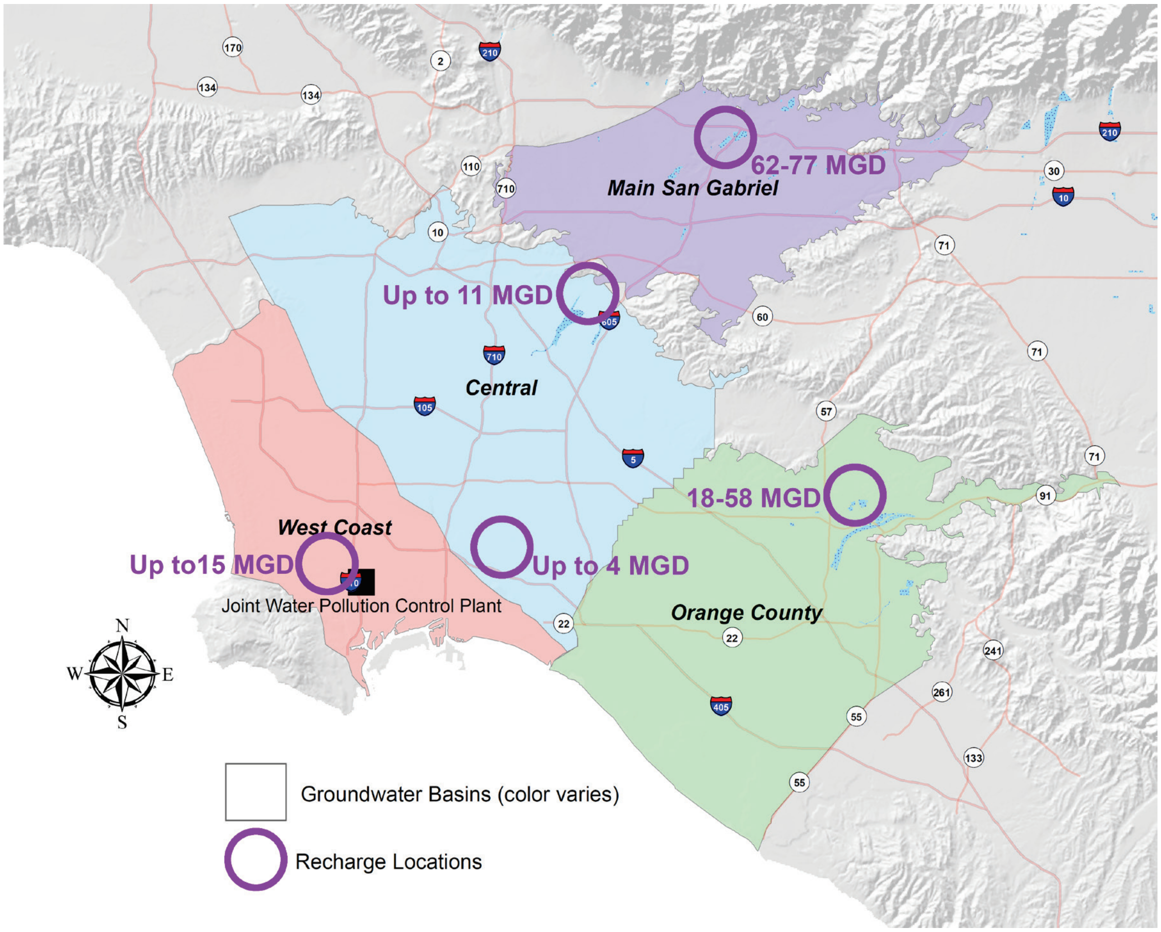
Groundwater Basin	Is there sufficient demand?	Are there operational issues?	Does modeling suggest program is feasible?	What facilities would be required?*
West Coast	Yes	Pumping capacity could be limiting factor	Yes	Up to 15 new injection wells
Central	Yes	None	Yes	Up to 5 new extraction wells (relocated) Up to 13 new injection wells
Main San Gabriel	Yes	None	Yes	Up to 7 new extraction wells (relocated)
Orange County	Yes	Recharge capacity limited in winter	Yes	Up to 1 new extraction well (relocated)

Table 1.3: Base Case Recharge Rates – 150 mgd

	Recharge Rate (mgd)	Recharge Rate (TAFY)
West Coast Groundwater Basin	0–**15**	0–**17**
Central Groundwater Basin	0–**15**	0–**17**
Main San Gabriel Basin	**62**–77	**70**–85
Orange County Groundwater Basin	18–**58**	20–**65**
Total (numbers in **bold** equal total)	**150**	**169**

TAFY = thousand acre-feet per year

Figure 1.2: Base Case Recharge Rates – 150 mgd

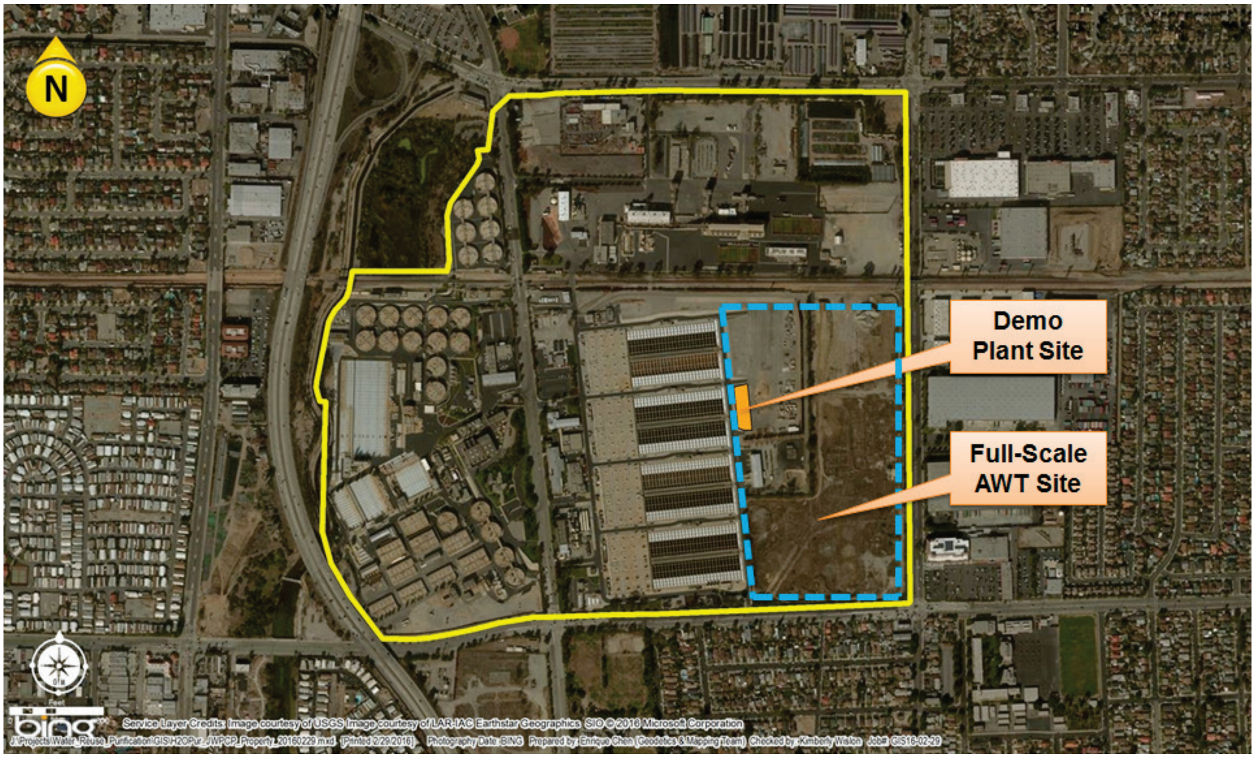


The recharge of groundwater basins with a new water supply can create some challenges and issues that have not been previously encountered. Potential groundwater quality and operational issues and risks that should be evaluated in future studies include impacts to existing groundwater contamination plumes or operable treatment units and potential conflicts with other sources of water, especially in spreading basins where multiple sources of water are spread.

1.4 Advanced Water Treatment Facility

The new 150-mgd AWT facility would be located within the existing boundaries of the JWPCP adjacent to the secondary treatment facilities, as shown in Figure 1.3.

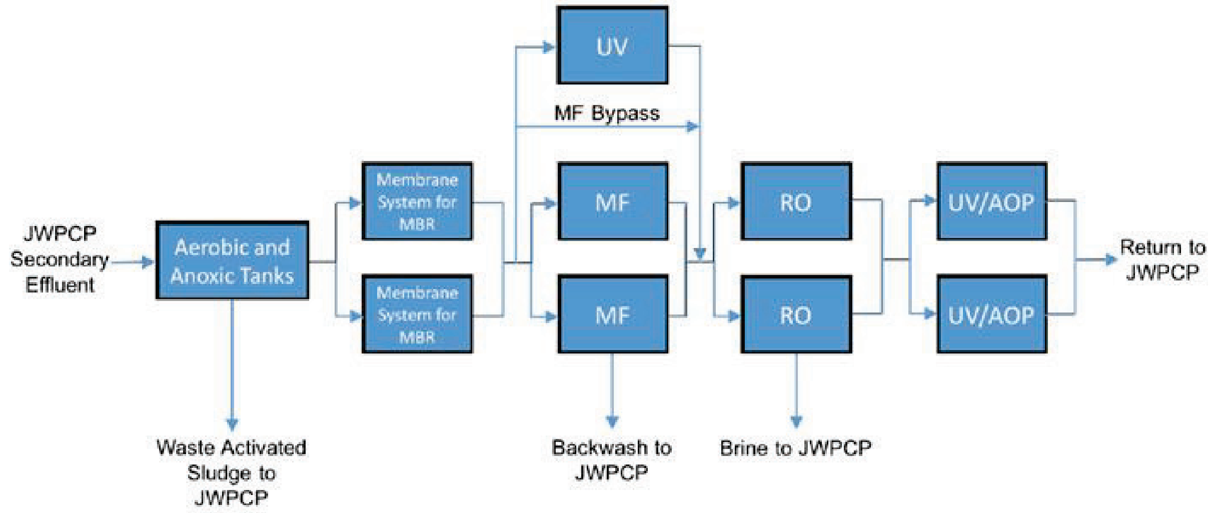
Figure 1.3: Proposed Location of AWT Facilities at JWPCP



The AWT facility would receive unchlorinated non-nitrified secondary effluent from the JWPCP. The JWPCP currently produces an average dry weather flow of 260 mgd (2015 data) of non-nitrified secondary effluent in compliance with its National Pollutant Discharge Elimination System (NPDES) permit limits and mass emission benchmarks. Based on these current flow conditions, flow equalization would be provided to ensure constant feed to the AWT facility. Primarily due to water conservation, the influent flow to the JWPCP is decreasing and the secondary effluent available to the AWT facility would likely decrease further in the future. For 2050, the Sanitation Districts project a minimum influent flow of 100 mgd, average dry weather flow of 247 mgd, and maximum flow (including stormwater inflow/infiltration) of 700 mgd at the JWPCP. The decreasing wastewater flow trend will be further studied during conceptual design of the full-scale AWT facility before finalizing the size of initial flow equalization tanks as well as potential future tank requirements. Wet weather peak flows at the JWPCP generated by storms were not considered to be available for reuse under the RRWP due to the unpredictable nature of their occurrence, large volume, and the lack of on-site storage.

Full advanced treatment (FAT) is currently the industry standard treatment train for IPR, consisting of membrane filtration (MF), followed by reverse osmosis (RO) and an advanced oxidation process (AOP). This treatment train has proven successful in facilities throughout the world, most notably at the largest potable reuse project in the world—the 100-mgd Groundwater Replenishment System (GWRS) facility operated by the Orange County Water District. Metropolitan is testing an alternative process in the demonstration facility that, if approved by the regulators, could result in significant savings in capital and operating costs. Figure 1.4 illustrates the process train that was selected for the 0.5-mgd AWT demonstration plant. The treatment train consists of a membrane bioreactor (MBR), MF through either microfiltration or ultrafiltration, RO, and AOP with ultraviolet (UV) disinfection (UV/AOP).

Figure 1.4: Schematic of Demonstration Plant Process Train

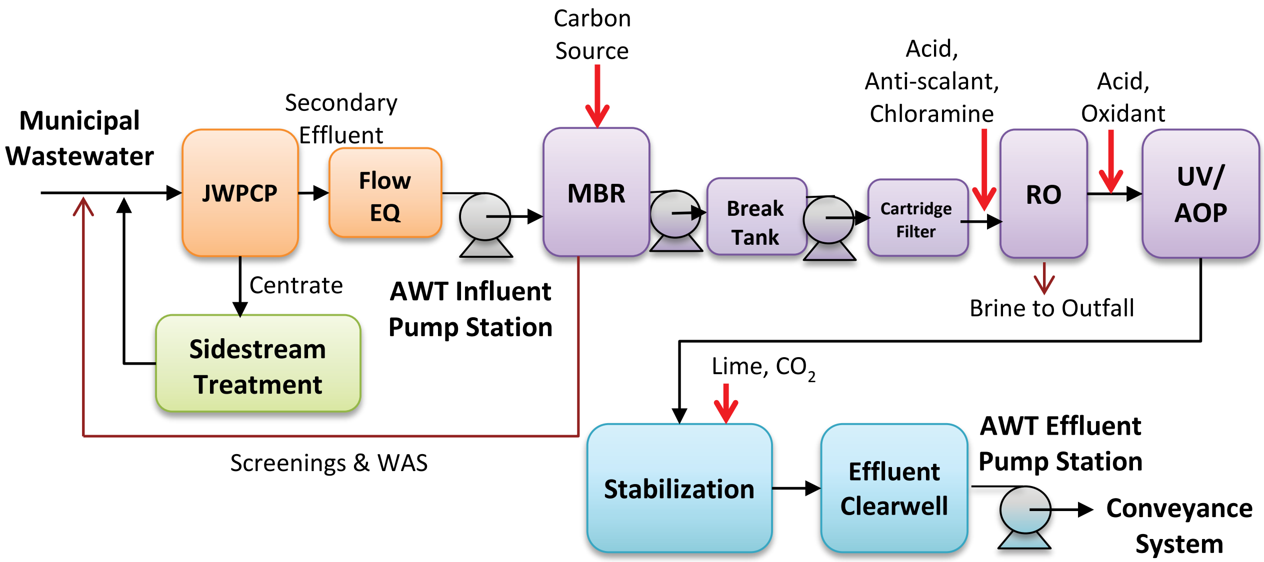


A unique aspect of this IPR demonstration facility is the use of an MBR. Because the JWPCP produces non-nitrified effluent, the MBR nitrification process will help reduce organics and minimize membrane fouling, and the denitrification process in combination with RO will help achieve nitrate levels that meet Water Quality Control Plan objectives for each specific groundwater basin.

The treatment train will include a bypass of the MF process so that the MBR filtrate can be fed directly to the RO unit to determine its performance for *Cryptosporidium* and *Giardia* reduction. If sufficient log reduction credits can be granted by regulators for the MBR process, the MF treatment step could be removed, which could result in significant savings in capital and operating costs (these savings are assumed in the base case evaluation). A key focus area during the demonstration phase will be on protocols for direct integrity testing of the MBR units.

The base case scenario for the full-scale AWT facility includes tertiary MBR followed by RO and UV/AOP. Using this train to achieve the necessary log reduction credits for potable reuse has not yet been demonstrated. The planned demonstration facility would include MF for RO pretreatment in the event that regulatory approval is not obtained for the required log credits by MBR alone. However, based on industry experience in the testing and use of MBR in potable reuse applications and initial positive feedback from the California Division of Drinking Water (DDW), this study assumes that MBR can successfully achieve sufficient pathogen log reduction credit during demonstration testing to eliminate the need for MF for the AWT facility. The process flow schematic for the base case full-scale AWT facility is presented in Figure 1.5.

Figure 1.5: Process Flow Schematic for the Base Case Full-Scale AWT Facility



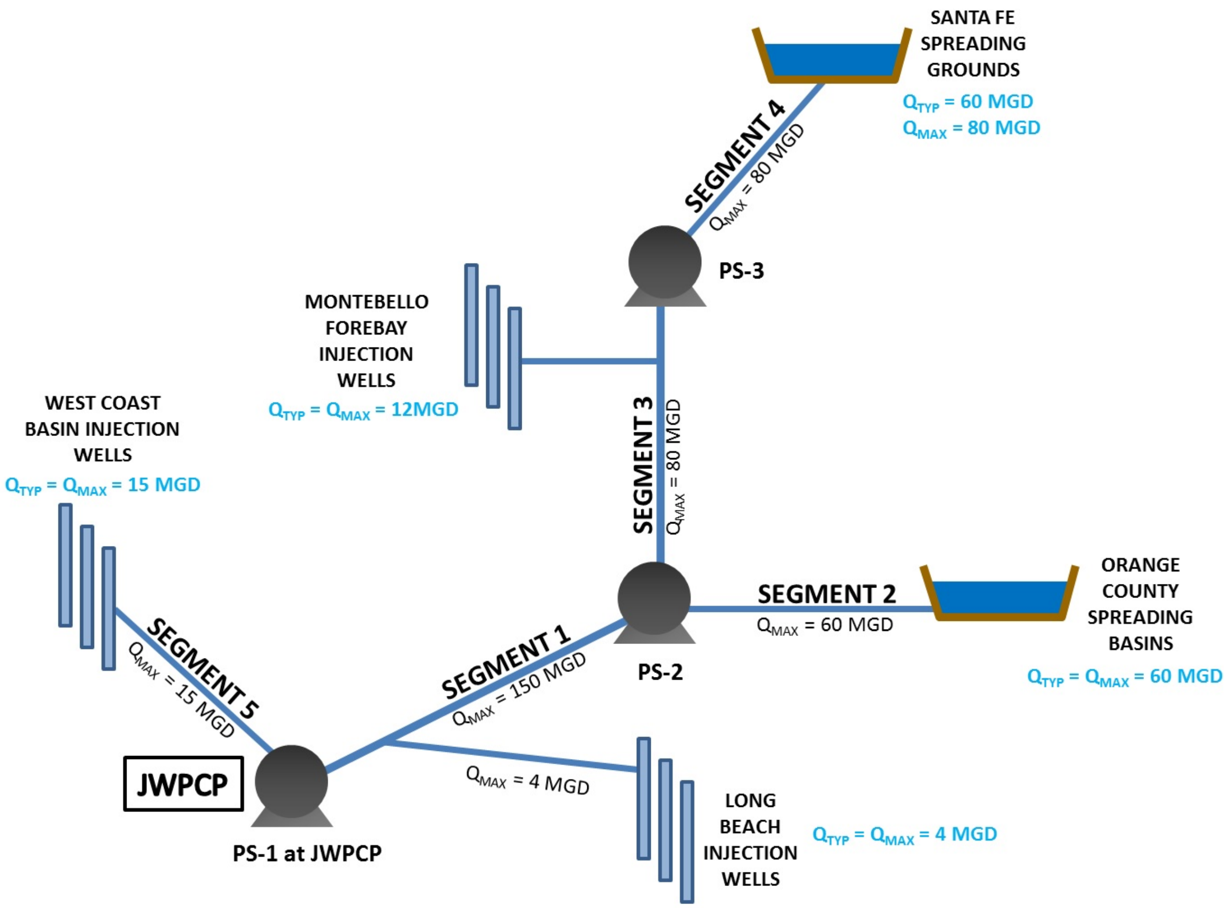
1.5 Conveyance System

The RRWP conveyance system would consist of approximately 60 miles of pipeline and three pumping plants. As shown in Figure 1.6, the system would deliver up to 150 mgd of purified water as far east as the Orange County Spreading Basins in Anaheim, and as far north as the Santa Fe Spreading Grounds in Irwindale. Delivery points would consist of either groundwater spreading basins or injection wells.

Numerous potential pipeline alignments could be selected to deliver purified water from the AWT facility to the various discharge locations. The alignment used for analysis was chosen from multiple identified alignments based on the route that appeared most economical to construct while reasonably minimizing community and environmental impacts and complying with anticipated local municipal and other jurisdictional requirements.

Due to the number of substructures and utilities expected within street rights-of-way, pipeline construction costs within street corridors would likely be significantly higher than within a utility corridor like that held by Southern California Edison or a flood control corridor/channel like that held by the Los Angeles County Flood Control District. Higher costs within these street corridors are anticipated due to the need for utility relocation/protection, traffic diversion/control, and possible business/resident relocations.

Figure 1.6: Conveyance System Schematic



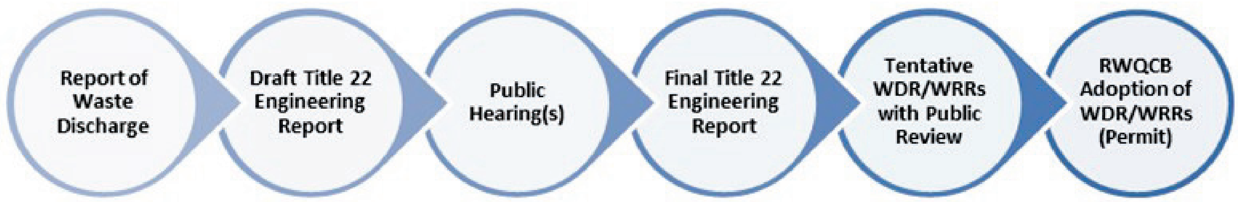
Pipelines would consist of cement mortar-lined welded steel pipe with diameters ranging from 30 to 84 inches. Pipe sizing was initially analyzed to optimize the pipe size based on hydraulic losses. To reduce or eliminate the possibility of corrosion in the pipelines, the interior pipeline lining design will be evaluated with consideration given to the water quality of the purified water from the AWT facility.

1.6 Regulatory Framework

The use of recycled water for IPR is regulated in California to ensure protection of public health and water quality. IPR refers to the augmentation of groundwater or surface water with highly treated recycled water. IPR through groundwater replenishment, the focus of the potential RRWP, has been conducted for decades in California. The groundwater recharge regulations developed in the late 1970s allowed the use of recycled water, but proposed and existing groundwater recharge projects were evaluated on an individual basis. The draft criteria used to evaluate projects evolved over time. The final groundwater replenishment regulations were incorporated into Title 22 of the California Code of Regulations in June 2014.

The state's Water Recycling Criteria and Groundwater Replenishment Regulations are implemented and enforced through water reclamation requirements (WRRs) and waste discharge requirements (WDRs) imposed by the individual Regional Water Quality Control Boards (RWQCBs). For projects involving surface water discharge, an NPDES permit is also required. The RWQCB prescribes WRRs and/or WDRs that reasonably protect all beneficial uses and implement relevant water quality control plans and policies. Any entity proposing to recycle water would file a Title 22 Engineering Report with the DDW and the RWQCB on the proposed use. The demonstration facility will provide the water quality data needed for the Title 22 report. Figure 1.7 summarizes the permit approval process for a water recycling project.

Figure 1.7: Water Recycling Permit Process



1.7 Public Acceptability and Environmental Planning

Implementation of the RRWP will require public outreach on multiple levels beginning with the demonstration facility and continuing through project construction and operations. At the outset, the primary goal of this outreach will be to improve awareness of and achieve public acceptance for the new water supply and its associated treatment and conveyance infrastructure. This will require a coordinated, long-term effort that begins with the demonstration project. If the RRWP moves forward, outreach will continue during environmental review and permitting. Targeted outreach efforts will be needed during construction to inform and assist the neighborhoods and communities directly affected. In addition, local outreach will be needed to help inform the industries, businesses, and residential communities in the vicinity of the JWPCP about the construction and operation of the AWT facility. Once the project begins operating, outreach efforts will continue to help inform community leaders, elected officials, and the general public about the program and its benefits to the region. This long-term outreach approach must be developed and implemented collaboratively with member agencies, basin managers, and the Sanitation Districts using research results, local knowledge, and the outreach experience of the agencies involved.

Implementation of the RRWP would require environmental review under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and possibly permitting under the Clean Water Act, California Fish and Game Code, and/or state and federal Endangered Species Acts. For the potential RRWP, Metropolitan would be the lead agency under CEQA [Public Resources Code (PRC) Section 21067] and is responsible for complying with the requirements of CEQA. The environmental documents for the program would do the following: (1) inform decision makers and the public about the potentially significant environmental effects of the proposed activities; (2) identify the ways that significant environmental effects can be avoided or reduced; (3) prevent significant, avoidable damage to the environment by requiring changes in the program through the use of alternatives or mitigation measures, to the extent that Metropolitan would determine the changes to be feasible (CEQA Guidelines Section 15002; PRC Section 21002.1); and (4) identify compensatory mitigation measures to offset significant unavoidable impacts.

1.8 Implementation Schedule and Cost Evaluation

Schedule

A conceptual level implementation schedule has been developed for the potential RRWP base case. Based on Metropolitan board approval to commence the full-scale program, the overall timeline to design, construct, and start up/commission the entire program facilities comprising the base case could take up to 11 years. It is anticipated that the overall program schedule can be shortened once design activities (conceptual, preliminary, and final design) and opportunities for program optimization and enhancement are identified.

Cost

Cost considerations for the potential program include the capital costs associated with designing and constructing the required facilities to continuously treat and convey the purified water to local groundwater basins, and the costs associated with the operations and maintenance (O&M) of the facilities. A Class 4 Opinion of Probable Construction Cost (OPCC) for treatment, conveyance, and wells was developed in accordance with the American Association of Cost Engineers. The OPCC has an expected range of accuracy of –20 percent to +40 percent.

A summary of the OPCC for the base case scenario, including treatment, conveyance, and well facilities is provided in Table 1.4. A 25 percent additional cost for project management, engineering design, project administration, and construction management is provided in the estimated total capital costs. In addition, a 35 percent project scope contingency was added to encompass uncertainties within the base case and the engineering analyses conducted to date. The estimated total capital cost for the potential program is approximately $2.7 billion.

Table 1.4: Opinion of Probable Construction Cost

	Base Case 150 mgd Capacity (2016 dollars)*
Materials and Construction	
JWPCP Modifications	92,200,000
Advanced Water Treatment Plant	589,400,000
Conveyance Facilities (Pump Stations, Pipelines)	769,700,000
Well Facilities (Including Monitoring and Relocated Wells)	155,000,000
Subtotal Materials and Construction	**1,606,300,000**
Project Management and Engineering	
PM/CM/Design/Administration (25%)	401,600,000
Contingency (35%)	702,800,000
Total Capital (2016 Dollars)	**2,710,700,000**
*Class 4 cost estimate. Expected range of accuracy is –20% to +40%.	

PM = project management; CM = construction management

The estimated annual O&M costs are summarized in Table 1.5. The O&M costs reflect the potential turn-down of the AWT production during wet periods for a long-term annual average of 147 mgd. Reduced production at the AWT facility would lower costs associated with energy consumption for pumping and AWT, as well as with chemical usage and replacement of consumables at the AWT facility. Labor and maintenance costs would not be affected.

Table 1.5: Estimated Annual O&M Costs

	Base Case 150 mgd Capacity (2016 dollars)
Operations and Maintenance	
Advanced Water Treatment*	99,700,000
Conveyance (Pump Stations, Pipelines)*	28,100,000
Well Field and Spreading Facilities	1,200,000
Total Annual O&M Costs	**129,000,000**

*O&M costs shown reflect turndown of equipment during wet periods for long-term average production of 147 mgd.

1.9 Financial Evaluation

The cost impact of the potential RRWP has been estimated for the base case with low-cost, base case, and high-cost scenarios. A cost summary for each scenario is shown in Table 1.6. For the low-cost scenario, the capital cost contingency has been decreased to 25 percent and there is no O&M cost contingency. For the high-cost scenario, the capital cost contingency has been increased to 50 percent and a 25 percent O&M cost contingency has been added to reflect potential increases in power, labor, and material costs. The base case scenario is based on capital facilities sized for 150 mgd and O&M costs based on an annual average flow of 147 mgd.

The estimated capital costs range from $2.5 billion to $3.0 billion with a base case projection of $2.7 billion in 2016 dollars. The projected capital costs cash flow for the base case is shown in Figure 1.8. For purposes of the base case evaluation only, the capital costs cash flow is estimated to start in 2018, peak in 2025, and end in 2028 for an 11-year construction period.

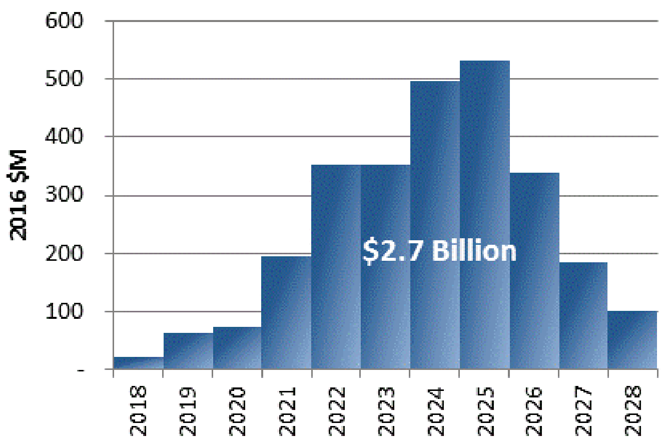
As described above, the low-cost, base case, and high-cost scenarios have differing assumptions on the capital and operational costs. In addition, as shown in Table 1.7, the low-cost scenario assumes $30 million in grant funding (thereby reducing financing needs by $30 million) and an average cost of debt of 2.0 percent while the base case and high-cost scenarios assume no grant funding and an average cost of debt of 4.0 percent for the base case and 5.0 percent for the high-cost scenario. All scenarios assume 100 percent of capital costs, less grant funds, are debt financed annually, based on the capital cost cash flow required. However, some pay-as-you-go funding (PAYGO) might be needed to meet Metropolitan's revenue bond debt coverage and fixed-charge coverage targets.

Table 1.6: Program Cost Summary in 2016 Million Dollars

	Low	Base	High
Capital Cost			
Treatment Plant	Same as Base	682	Same as Base
Distribution		770	
Injection Wells/Spreading Basins		155	
Total Construction Costs		**1,606**	
Engineering Fees (25%)		402	
Total Construction Costs with Engineering Fees		**2,008**	
Contingency Rate	25%	35%	50%
Contingency	502	703	1,004
Total Capital Construction Cost with Engineering Fees and Contingency	**2,510**	**2,711**	**3,012**
Annual Operations and Maintenance Costs			
Treatment Plant	Same as Base		Same as Base
Power Costs		30.9	
Labor Costs		11.8	
Materials Cost		56.9	
Land Use		0.1	
Sub-total Treament Plant		**99.6**	
Distribution			
Power Costs		20.7	
Labor Costs		5.7	
Materials Cost		1.7	
Sub-total Distribution		**28.1**	
Injection Wells/Spreading Basins			
Power Costs		0.0	
Labor Costs		0.5	
Materials Cost		0.7	
Sub-total Injection Wells/Spreading Basins		**1.3**	
Total			
Power Costs		51.6	
Labor Costs		18.0	
Materials Cost		59.3	
Land Use		0.1	
Total Annual O&M Cost		**129.0**	
Contingency Rate	0%	0%	25%
Total Annual O&M Cost with Contingency	**$ 129.0**	**$ 129.0**	**$ 161.3**

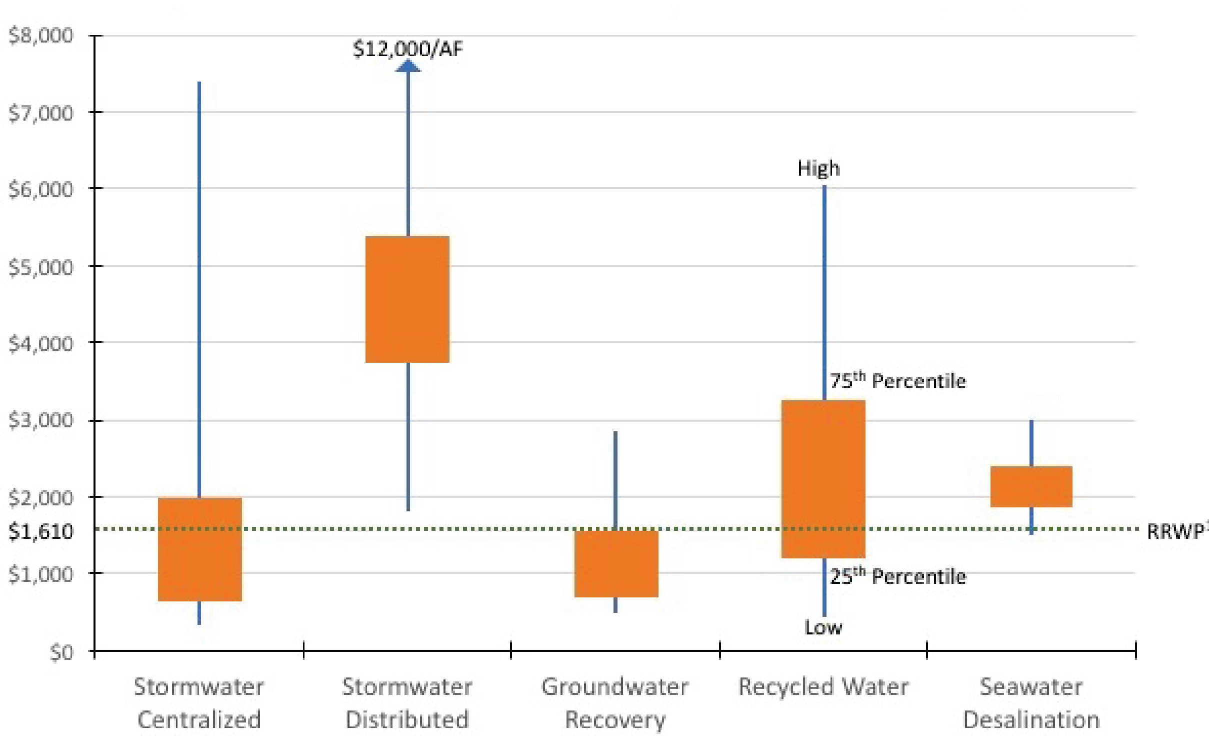
Note: *May not total due to rounding*

Figure 1.8: Capital Costs Cash Flow – Base Case Scenario



As shown in Table 1.7, the potential cost impact over Metropolitan's 1.70 MAF sales base would range from $132 per AF to $195 per AF. The unit cost of the additional annual average flow of 147 mgd (165 TAFY) produced by the RRWP ranges from $1,368 per AF to $2,013 per AF, with a base case value of $1,610 per AF.[1] Figure 1.9 shows the estimated RRWP unit cost compared to forecasted values shown in the Metropolitan IRP 2015 Update.

Figure 1.9: Future Resource Development Unit Costs ($/AF)



Source: Integrated Water Resources Plan 2015 Update

[1] The RRWP would produce up to 150 mgd or 168,000 AFY. Recognizing the need to potentially lower production to a minimum 110 mgd at certain times, the cost analysis uses an estimated long-term average yield of 147 mgd or 165,000 AFY.

Table 1.7: Cost Impact Summary

	Low	Base	High	units
Capital Cost				
Contingency	25%	35%	50%	
Capital Cost	2.51	2.71	3.01	2016 $B
Financing Term	30	30	30	years
Financing Rate	2.00%	4.00%	5.00%	
Grants	30	-	-	2016 $M
Financing Cost	**96**	**136**	**170**	2016 $M/YR
Annual Operations and Maintenance Costs				
Contingency	0%	0%	25%	
Annual O&M	**129**	**129**	**161**	2016 $M/YR
Annual Costs				
Financing Costs (1)	96	136	170	2016 $M/YR
O&M Costs (2)	129	129	161	2016 $M/YR
Total Costs	**225**	**265**	**331**	2016 $M/YR
Unit Cost				
Average Yield	165	165	165	TAF
Capital Costs	584	827	1,033	2016 $/AF
O&M Cost	784	784	980	2016 $/AF
Total Unit Cost	**1,368**	**1,610**	**2,013**	2016 $/AF
Cost Impact (3)				
MWD Overall Cost Increase	**14%**	**17%**	**21%**	
annual cost increase over 10-years	1.4%	1.7%	2.1%	
Average Cost Increase	132	156	195	2016 $/AF

(1) Financing Costs when the project is complete
(2) O&M cost when fully operational
(3) Based on 2016/17 Budget of 1.70 MAF

1.10 Findings, Conclusions, and Recommendations

Investigations found that the 150 mgd RRWP, as described in the base case, is technically feasible and can be accomplished under the specific assumptions used for the analysis. Primary challenges relate to the permitting and institutional arrangements that would be necessary to augment water supplies in multiple groundwater basins. The base case cost estimate for the project is approximately $1,600 per AF. This estimate includes the capital and operations costs of purification at an AWT facility, as well as pumping and pipelines to convey the water to spreading grounds and injection wells in up to four groundwater basins.

In answer to the key questions posed in the study methodology, *a priori* evaluations found that:

1. No technical flaws or deficiencies were identified in the base case that would preempt or prevent its successful completion as described.
2. The RRWP can be implemented within current regulatory and environmental permitting frameworks, if supported by robust public outreach.
3. The RRWP's anticipated regional benefits and costs are consistent with the projections and targets established in Metropolitan's 2015 IRP Update.

Further investigations and studies are needed to confirm the assumptions and conditions associated with these findings regarding feasibility. They include the following:

1. Demonstration to regulators that the pathogen log reduction credits and membrane integrity monitoring associated with the MBR justify elimination of a MF treatment step prior to RO.
2. Completion of detailed analyses of water quality and water management requirements associated with each of the groundwater basins and recharge locations designated to receive product water.
3. Completion of additional technical investigations on the program's treatment and conveyance systems.
4. Negotiation, approval, and execution of final agreements with the Sanitation Districts associated with the roles, responsibilities, costs, and benefits provided by the RRWP.
5. Development of institutional arrangements that would ensure the ability to deliver agreed-upon amounts of recycled water on a near-continuous basis and ensure that regional benefits defined in this report can be secured.

Findings

For the purposes of the evaluation, the feasibility of program components has been characterized according to the following categorization:

1. **Feasible** – Found to have no fatal flaws or deficiencies, limited dependence on other parties, other existing examples of success, and some unknowns.
2. **Likely to be feasible** – Found to have no fatal flaws or deficiencies, significant dependence on other parties, limited comparable existing examples, and many unknowns.
3. **No apparent fatal flaws** – Found to have no apparent fatal flaws or deficiencies but in need of further investigation and studies.

None of the program elements were considered to be not feasible; none of the program elements had fatal flaws or deficiencies that cannot be reasonably mitigated.

Based on the analysis and the assumptions used, the following summarizes the findings for the elements of the RRWP:

1. **Advanced Water Treatment Plant:** The feasibility studies indicate that the successful development of the AWT design, construction, and operations are considered to be feasible.

2. **Conveyance System:** When assessed as a whole, and taking into account the wide variety of construction methodologies that would be considered for use, the investigation concluded that the construction of the conveyance system for the RRWP within the schedule that has been identified in this report is considered likely to be feasible.

3. **Groundwater Basins, Storage, and Extraction:** Based on modeling and other analyses conducted for this report by both Metropolitan and groundwater basin managers, the basins are determined to be capable of using up to 150 mgd of purified water for groundwater recharge on a near-continuous basis, which is considered feasible.

4. **Environmental and Regulatory Feasibility:** The evaluation of regulatory and environmental permitting requirements for the potential RRWP elements did not reveal any challenges that would preempt or prevent approvals and permits needed from authorized regulatory agencies and are considered feasible.

5. **Feasibility of Essential Agreements with the Sanitation Districts:** Based on the existing framework and ongoing collaboration with the Sanitation Districts on the demonstration facility and this feasibility study, the finalization, execution, and approval of agreements needed to proceed with the full-scale program are considered to be feasible.

6. **Feasibility of Essential Institutional Arrangements with the Member Agencies, Groundwater Managers, and Los Angeles County Department of Public Works:** Based on supporting documentation and direct discussions, development of the institutional arrangements needed for the delivery, storage, and extraction of RRWP water in groundwater basins on a near-continuous basis is considered to have no apparent fatal flaws.

7. **Regional Benefits and Consistency with IRP:** The ability of the program to create significant regional benefits that are consistent with the projections and targets established in Metropolitan's 2015 IRP Update is considered to be feasible.

8. **Overall Estimated Program Costs:** The overall unit costs of the program (estimated to be approximately $1,600 per AF) fall within the projected future resource development costs for recycled water facilities developed in the 2015 IRP Update and are considered to be feasible.

9. **Public Acceptability**: If a robust outreach effort is implemented in conjunction with the RRWP, then gaining public acceptance of a new purified water supply for replenishing groundwater basins, completing conveyance system construction, and addressing concerns of the communities near the JWPCP are considered to be feasible.

A discussion of the detailed findings that support the primary conclusions is included in Chapter 11.

Recommendations for Next Steps

The following recommendations regarding next steps are submitted for consideration, should the Metropolitan board accept the determination of this study that the potential 150-mgd RRWP is feasible and warrants further investigation. These efforts would be implemented over approximately 18 months.

1. **Construct and operate the demonstration facility:** The 0.5-mgd demonstration plant will provide critical information for multiple aspects of the full-scale program, including optimizing and refining the treatment processes, providing critical design criteria, refining capital and O&M costs, and providing a platform to secure regulatory approval for the overall treatment process and public outreach. The planned work at the demonstration facility should occur prior to the commencement of final design of the full-scale AWT facility. Design of the demonstration facility will be completed by December 2016, and staff plans to bring a recommendation for the award of a construction contract to the Metropolitan board early in 2017. It is expected that operation of the demonstration plant will provide critical design information and regulatory approvals related to the proposed treatment processes needed for a full-scale project.

2. **Conduct facility planning/engineering to refine treatment, conveyance, and groundwater basin concepts:** Engineering work to date has consisted solely of investigations and analyses required to determine the feasibility of implementing the treatment and conveyance facilities required for the program. The feasibility investigations have identified a number of potential opportunities to reduce the implementation schedule and/or reduce overall program costs, including a potential opportunity to repurpose portions of the Second Lower Feeder into a conveyance pipeline for the RRWP. Additional engineering efforts are now required to select specific project configurations and alignments, and to optimize program components by potentially taking advantage of these program opportunities. Staff should conduct facility planning and engineering efforts to accomplish these objectives. Also, additional groundwater modeling investigations focused on water quality issues and potential groundwater level changes are needed to further facilities and operations planning within the groundwater basins.

3. **Develop agreements with the Sanitation Districts:** The Metropolitan board approved initial term sheets for both the demonstration facility and a potential full-scale recycled water program with the Sanitation Districts in November 2015. For the full-scale project, the initial set of terms and conditions were non-binding, however, they set forth key conditions anticipated to be in a future full-scale agreement. Building on these initial terms and subsequent discussions with the Sanitation Districts in 2016, staff should prepare for Metropolitan board approval a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale AWT project at the JWPCP site.

4. **Develop institutional and financial arrangements for the management and operations of the program:** The operations and management of the program would require a high degree of cooperation among Metropolitan, its member agencies, groundwater basin managers, and other affected parties to ensure the seamless integration of purified water to be stored in groundwater basins. The form and specific nature of these arrangements should be finalized before proceeding to the full-scale project. Metropolitan's IRP 2015 Update and related Metropolitan board discussions regarding the RRWP implementation will inform the development of such

arrangements together with concurrent discussions among potential program participants. These processes are expected to conclude with Metropolitan board direction and approval prior to moving forward, in order to ensure a viable and successful program.

5. **Develop the outreach plan for the demonstration facility:** The demonstration facility is a core element of the outreach effort to gain public acceptance of a new water supply for the region. It is designed to facilitate public presentations and tours, and to provide a means to share information about the RRWP. To effectively use this facility for outreach, it will need a project identity, informational materials, signage, and other elements to enhance the visitors' experience. The strategies and tools would be part of a comprehensive outreach plan for the demonstration facility that is developed in collaboration with the Sanitation Districts, member agencies, retail agencies, and basin managers. The outreach plan for the demonstration facility would create the foundation for future outreach for the full-scale program should the RRWP move forward.

Chapter 2

Concept, Need, and Benefit

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2.0 CONCEPT, NEED, AND BENEFIT

2.1 Program Concept

Metropolitan, in partnership with the Sanitation Districts, is considering the development of a program to create a new water resource with regional benefit for Southern California. The potential RRWP consists of a new regional conveyance system and an AWT facility at the Sanitation District's JWPCP in Carson. Initially, these facilities would produce and deliver a reliable source of purified water to recharge regional groundwater basins. These groundwater resources are vital to the region's diversified portfolio and currently rely, in part, on imported water for replenishment. In the future, the program may provide a source of water for other indirect and direct potable uses.

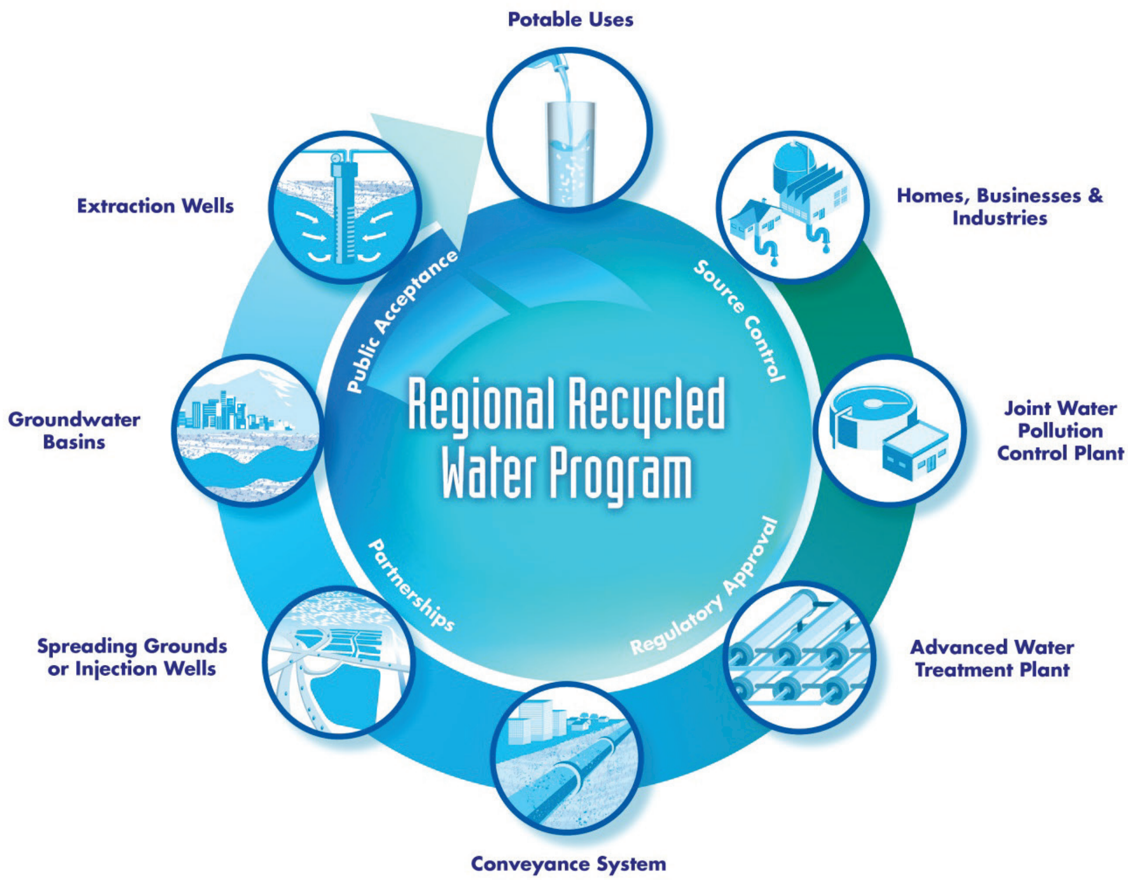
It is estimated that, through the RRWP, up to 150 mgd (168,000 AFY) of purified water could be produced and recharged into the basins, resulting in higher total groundwater levels in the regional storage portfolio and reduced demands on imported water for replenishment. The imported water that would have been used for replenishment would be available to Metropolitan's member agencies or for storage in other Metropolitan programs, further increasing the region's reliability. This reduced reliance on imported water for replenishment and higher, more stable groundwater levels provide increased supply reliability for the region and all Metropolitan member agencies, particularly in dry years or during other shortage conditions. The RRWP would also provide emergency storage benefits by making the basins a more reliable water supply during emergencies when in-region storage and uninterrupted recycled supplies are critical. The 2015 IRP target for local resources underscores that stable local supplies for the region are essential. The program would help achieve the IRP target, as well as provide the regional benefits that are discussed in Section 2.5.

An overview of the RRWP concept is shown in Figure 2.1. The concept begins with wastewater collected from homes, businesses, and industries. The collected wastewater then undergoes conventional treatment followed by advanced treatment. The treated water is then conveyed to groundwater basins for recharge. And finally, the treated water can be reused as a potable supply.

As mentioned above, this new water resource would require two major infrastructure components: an AWT facility located within the existing JWPCP site and a new regional water conveyance system to deliver the water from the AWT facility to the groundwater basins. The treatment facility would be designed to produce up to 150 mgd (168,000 AFY) of water with a quality that meets the requirements for indirect potable reuse through groundwater recharge. The water quality would be achieved through the collaborative efforts of Metropolitan and the Sanitation Districts using source control measures and advanced water purification technologies.

The new conveyance system would include a network of pipelines and pump stations to deliver the water from the AWT facility in Carson to existing spreading basins and new and existing injection wells that will help recharge four groundwater basins: Main San Gabriel, Orange County, Central, and West Coast. Metropolitan would own and operate the AWT facility and the conveyance system. It would cooperate with the operators of the spreading basins, allowing variability in the volume and timing of deliveries to accommodate facility maintenance and storm events.

Figure 2.1: Program Overview



Source of Water for RRWP

Water for the program would originate from the JWPCP, which serves approximately 3.5 million people throughout Los Angeles County. The JWPCP, located in Carson, began operation in 1928 as a relatively small wastewater treatment facility to service the growing population of Los Angeles County. Today, it is one of the largest wastewater treatment plants in the United States and the largest in the Sanitation Districts' system. It provides primary and secondary treatment for approximately 260 mgd (2015 data) of wastewater and has a total permitted capacity of 400 mgd. In the 1940s, rather than expanding the JWPCP, which operated as an ocean discharge plant, the Sanitation Districts began investigating the possibility of building satellite treatment facilities upstream of the JWPCP to treat more suburban, less industrial wastewater, and to produce recycled water closer to the intended use (e.g., golf courses and groundwater recharge). Over the decades since, the Sanitation Districts have constructed seven satellite water reclamation plants (WRPs) upstream of the JWPCP within the Joint Outfall System (JOS). These WRPs provide water reclamation for beneficial reuse. Total recycled water contractual allocations from the JOS WRPs are now approaching or exceeding current production. Actual recycled water usage is rapidly approaching current production at the Pomona, San Jose Creek, and Whittier Narrows WRPs. Most of the flow produced at the La Canada and Long Beach WRPs is reused. The Los Coyotes WRP in Cerritos, which currently produces approximately 20 mgd, does have some allocated, but unused recycled water supplies that are available for beneficial reuse but not in amounts necessary for a large regional-scale project.

The success of the Sanitation District's current reclamation program has led to most, if not all, of the currently produced reclaimed water being committed for beneficial reuse through long-term contracts for use at more than 800 sites upstream of the JWPCP. Therefore, the JWPCP was identified as the largest untapped potential source of recycled water available in the region, since all of the JWPCP flows are currently discharged to the ocean. Though the JWPCP source water contains approximately 19 percent industrial component and higher salt concentrations than the upstream plants, cost-effective technologies are now available to treat this flow to produce recycled water for beneficial reuse. Furthermore, the Sanitation Districts operate an extensive source control and pretreatment program that strictly regulates the quantity and types of materials that can be disposed of in the collection system upstream of the JWPCP. Collectively, these proactive procedures and rigorous secondary treatment processes assist in ensuring that the JWPCP continuously produces high-quality source water for an indirect potable reuse program such at the one proposed in this program. Consequently, a significant amount of secondary effluent could be further treated and reused to benefit the region from the JWPCP.

Potable Reuse

At this time, the focus of the RRWP is on *indirect potable reuse* (IPR) through groundwater recharge. IPR refers to the augmentation of groundwater (or potentially surface water) with highly treated recycled water and is regulated in California to ensure protection of public health and water quality. IPR through groundwater recharge has been conducted for decades in California. The groundwater recharge regulations developed in the late 1970s allowed the use of recycled water but both proposed and existing groundwater recharge projects were evaluated on an individual case basis. Draft criteria were used to evaluate projects; the criteria evolved over time until they were codified in 2014. Given the well-established practice of groundwater recharge in this region, the regulatory certainty/precedent in permitting an IPR project, the critical need for a reliable water supply to recharge our region's groundwater basins, and the regional benefits realized, it was determined that the feasibility assessment of the RRWP should focus on IPR through the recharge of some of the region's largest groundwater basins.

Direct potable reuse (DPR), although currently not regulated in California, has received much attention in recent years. DPR is the direct connection of advanced treated water (without an intervening groundwater basin or surface water reservoir as an environmental buffer) to some point in the potable water system. In September 2016, the State Water Resources Control Board's (SWRCB's) Division of Drinking Water (DDW) released a draft report of the feasibility of developing regulatory criteria for DPR[1]. Incorporating input from an Expert Panel and stakeholder Advisory Group, the DDW acknowledged the technical feasibility of developing criteria for DPR while identifying several public health research and knowledge gaps that needed to be addressed.

Metropolitan will continue to monitor and engage in research, technical assessments, and the regulatory development of DPR for consideration of future application in its service area. At this time, however, the potential IPR project described in this feasibility study would provide critical recharge supplies that would otherwise be served with imported water. The potential IPR project would thus increase and stabilize the levels of regional groundwater basins within Metropolitan's service area. This feasibility study identifies the need to maintain the long-term stability of these basins through the proposed IPR project, which would replace the water currently imported by Metropolitan to recharge the basins and

[1]http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/rw_dpr_criteria/draft_report_to_legislature_dpr_public_review.pdf

would also increase the amount of water Metropolitan can supply to those basins. Thus, the need for recharge will continue even with the advent of DPR.

2.2 Actions to Date

Metropolitan and the Sanitation Districts have been discussing a regional collaboration to jointly develop recycled water for more than 5 years.

Pilot-Scale Studies

In March 2010, Metropolitan's board authorized staff to collaborate with the Sanitation Districts to study a regional IPR program and to perform pilot-scale treatment studies to evaluate the feasibility of advanced treatment of the JWPCP's secondary effluent. Between June 2010 and July 2012, these pilot studies were conducted jointly by the two districts using two 18-gallon-per-minute (gpm) pilot facilities located at the JWPCP. The pilot-scale studies also evaluated how Metropolitan could meet then-draft Title 22 Groundwater Replenishment Regulations administered by the California Department of Public Heath (now the DDW). The results of the pilot-scale studies demonstrated that advanced treatment of JWPCP secondary effluent for producing water suitable for IPR through groundwater recharge is technically feasible.

Development of Terms and Initial Agreement

In 2015, Metropolitan and the Sanitation Districts entered into an agreement for development of a demonstration facility at the JWPCP. The districts also established a proposed framework of terms and conditions for development of a full-scale RRWP. The objectives of this framework are to enable the reuse of up to 150 mgd of treated effluent from the JWPCP; share potential costs and investments; establish responsibilities between Metropolitan and the Sanitation Districts; reserve the use of a Sanitation Districts site for the AWT facility; and ensure that this program avoids conflict or duplication with other recycled water plans. The agreement and framework of terms and conditions for a full-scale facility are included in Appendix B. For the full-scale project, the initial set of terms and conditions were non-binding, however, they set forth key conditions anticipated to be in a future full-scale agreement. Building on these initial terms and subsequent discussions with the Sanitation Districts in 2016, staff would propose for board approval a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale AWT project at the JWPCP site.

Demonstration Facility

In November 2015, Metropolitan's board authorized staff to design a demonstration facility that would allow Metropolitan to optimize an AWT process for the production of water for groundwater recharge. Although the earlier pilot-scale studies indicated that an IPR project was technically viable, Metropolitan undertook a demonstration project to refine and demonstrate an alternative treatment process train, which could provide significant capital and operational cost savings. In addition, the demonstration project will provide an opportunity for both districts to better understand how to manage nitrogen in the secondary effluent and gain practical operating experience with the RO process and ultraviolet/advanced oxidation (UV/AOP) process. As a value engineering measure, the project team determined that a 0.5-mgd demonstration facility would be sufficient to test, monitor, and optimize the treatment process and produce the water quality data needed to seek the necessary permits. The demonstration facility will also provide a means for Metropolitan and the Sanitation Districts to coordinate operations and train operating personnel. Furthermore, it will serve as an effective tool for public outreach.

Metropolitan issued a competitive Request for Proposals (RFP-PL-1116) to select a consultant for design and operation of the demonstration facility. The contract was awarded to MWH Americas, Inc., in March 2016. In August 2016, Metropolitan issued a Request for Qualifications (RFQ No. 1137) to pre-qualify vendors providing treatment equipment to the demonstration facility. Final design of the demonstration facility is currently underway and anticipated to be completed in December 2016. In early 2017, Metropolitan plans to recommend award of a construction contract for the demonstration facility to a contractor selected through a competitive bid process.

Construction and startup of the demonstration facility is anticipated to take 1 year. The demonstration facility will then be operated for at least 1 year to compile information needed for regulatory review and approval.

Coordination with Regulatory Agencies

Metropolitan and the Sanitation Districts have been collaborating with the regulatory agencies concurrent with the development of both the demonstration facility and this feasibility study. The agencies involved include the DDW, the Los Angeles Regional Water Quality Control Board (RWQCB), and the Santa Ana RWQCB. Through a series of meetings in 2016, Metropolitan and the Sanitation Districts have sought the regulatory agencies' input and guidance on the potential program, including the treatment process for the demonstration facility. The regulatory agencies were informed of and amenable to rescaling the facility to 0.5 mgd to meet the demonstration project's desired objectives. Metropolitan and the Sanitation Districts plan to engage the regulating agencies in the development of testing and monitoring protocols for the demonstration period, as well as in the future work to be developed for ultimate permitting of the proposed program if the RRWP goes forward.

Advisory Panel

In early 2016, Metropolitan and the Sanitation Districts convened a panel of eight subject matter experts to provide independent review and critical input on the scope and direction of the program during the development of the feasibility study and demonstration facility. The Advisory Panel met several times in a workshop format during 2016 to provide input on overall program feasibility and work plans; design of the demonstration facility; groundwater basins and water delivery assessments; and ideas and approaches to program implementation.

The eight-member panel included the following experts in advanced water treatment and recycled water programs:

- Richard Atwater, Co-Chair: Former Executive Director of the Southern California Water Committee and an expert on recycled water programs.
- Margie Nellor, Co-Chair: President of Nellor Environmental Associates, Inc., and an expert on recycled water reuse programs, pretreatment, and related regulatory issues. (Ms. Nellor retired from the panel effective August 22, 2016.)
- Shivaji Deshmukh: Assistant General Manager of West Basin Municipal Water District and an expert on recycled water engineering and operation of AWT facilities.
- Thomas Harder: President of Thomas Harder and Company and a hydrogeology expert on Southern California's groundwater basins.
- David Jenkins: Professor Emeritus at the University of California, Berkeley, and an expert on biological wastewater treatment processes and water and wastewater chemistry.

- Edward Means: President of Means Consulting LLC and an expert on water quality and water resources management.
- Joseph Reichenberger: Professor at Loyola Marymount University and an expert on water, wastewater, and recycled water systems and treatment.
- Paul Westerhoff: Professor at Arizona State University and an expert on AWT processes.

The workshop discussions and panel comments were considered and implemented as appropriate by the project technical team during design of the demonstration facility and the preparation of this feasibility study. Summaries of the panel input were compiled into reports that are attached as Appendix A. The panel's final report and recommendation are included in this study's preface.

Consultations with Member Agencies and Groundwater Management Agencies

Metropolitan staff has met periodically with the member agencies and groundwater management agencies that would be directly affected by the program. The discussions provided opportunities to explore how this water resource could be incorporated into the region's water storage portfolio given each basin's unique operating regime and requirements. The meetings also included conceptual discussions on potential arrangements for delivery and use of the water, including potential arrangements with member agencies, groundwater management agencies, and groundwater pumpers. During the 2016 study period, Metropolitan contracted with the groundwater management agencies to conduct groundwater modeling, which was specifically configured to identify the potential for the program to recharge the subject basins. Metropolitan is only determining program feasibility at this time, so no commitments were requested or provided by Metropolitan, the member agencies, or the groundwater management agencies as a result of these discussions and investigations.

2.3 Need for Program

Metropolitan's Interest in Groundwater Resources

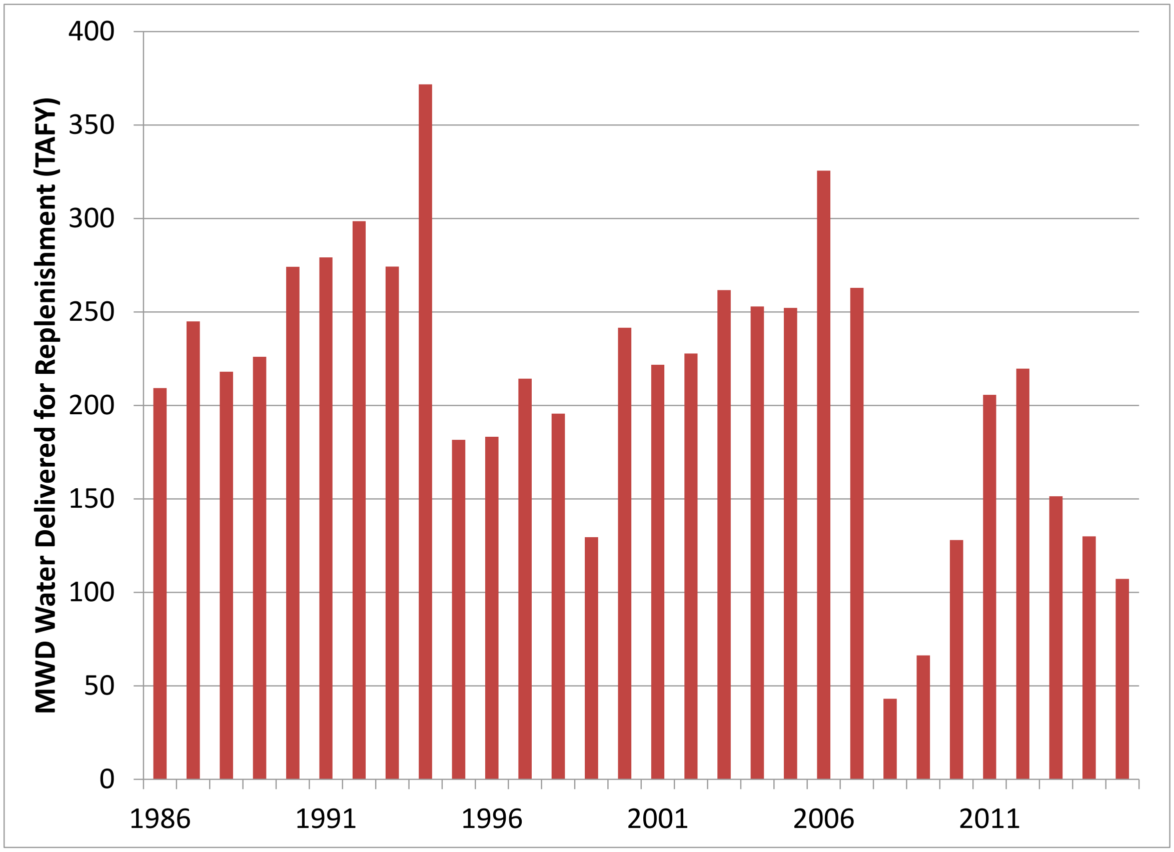
Groundwater has always been an important resource to Southern California because it is a key component of regional reliability and integrally related to the management of imported water supplies and surface storage.[2] Groundwater production in the Metropolitan service area averages about 1.3 million acre-feet per year (MAFY). Groundwater storage levels are also important because they impact how the groundwater basins can be used during times of shortage. If the levels are too low, basins may not serve as a source of water when needed for the region and the demands for imported supplies or surface storage will be greater. Therefore, maintaining stable, higher levels enables these basins to provide critical supply during shortages or emergencies.

Over the past 30 years, Metropolitan has delivered an average of 213,000 AFY of imported water for groundwater replenishment (see Figure 2.2). Replenishment deliveries in the groundwater basins have not been sufficient to maintain basin water levels. A number of factors contribute to this, including water supply availability due to drought, regulatory restrictions, and replenishment purchase patterns. Due to drought conditions in the service area, groundwater demand has increased, groundwater replenishment has decreased, and groundwater storage has dropped by 1.2 million acre-feet (MAF) since 2005. Without continued replenishment of the groundwater basins, groundwater storage is expected to continue to decline

[2] In a Statement of Policy adopted on January 9, 1931, Metropolitan affirmed: "The District intends to use underground storage whenever possible."

due to increased demand and limitations on other sources for natural and incidental recharge. For the basins to continue providing benefits for regional reliability, they require reliable water deliveries for recharge.

Figure 2.2: Historical Metropolitan Deliveries for Groundwater Replenishment

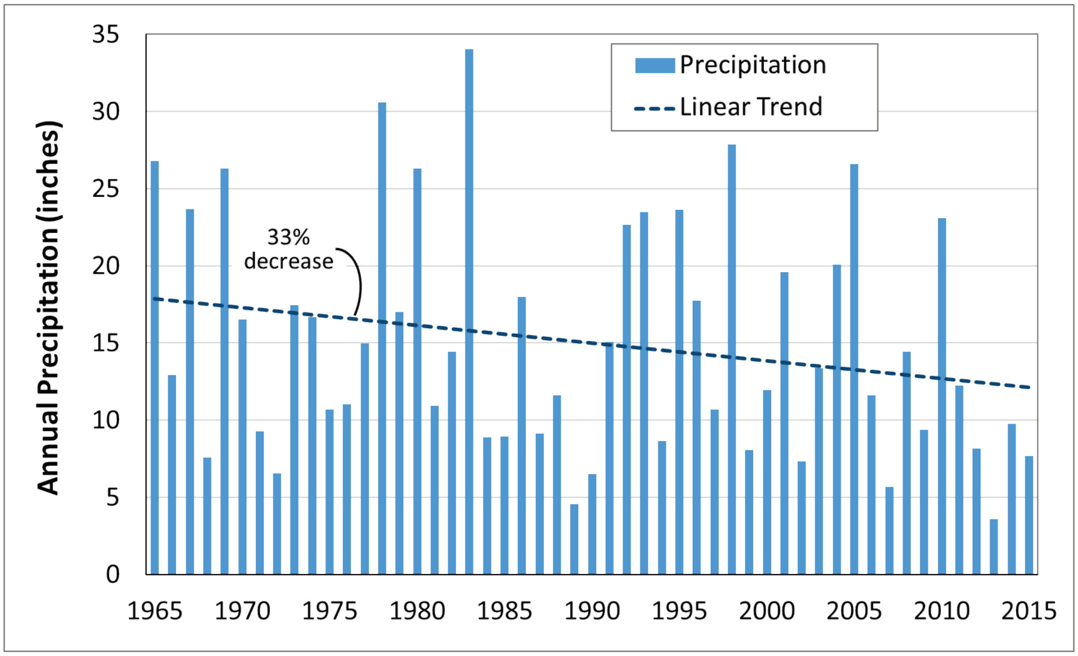


MWD = Metropolitan Water District of Southern California
TAFY = thousand acre-feet per year

Groundwater Basin Conditions

The largest groundwater basins in this region are Central, Main San Gabriel, and Orange County. These three basins alone produce an average water supply of 750,000 AFY. The ability of these basins to continue to perform as a vital resource in Metropolitan's service area depends on increasing groundwater storage levels and stabilizing the long-term balance between pumping and recharge. The storage levels of several groundwater basins in Metropolitan's service area have been on a decreasing trend since the 1970s due to several factors. First, natural safe yields for many of the groundwater basins in the region were established in the late 1950s and 1960s when urban land use was significantly different from today. As more impervious development occurred (buildings, road pavement, parking lots), less incidental groundwater recharge from rainfall occurred. Second, population growth and increased water demands have put additional pressure on groundwater supplies. And third, rainfall patterns are changing, as shown in Figure 2.3. Regional precipitation shows a decreasing trend over the past five decades.

Figure 2.3: Annual Precipitation at Los Angeles Civic Center Weather Station



To deal with reduced incidental recharge, lower rainfall, and urbanization, several actions have been taken to improve basin stability. These include the following: (1) development of centralized spreading grounds to facilitate greater recharge of captured stormwater by channeling runoff to areas with high soil permeability; (2) using imported water from Metropolitan for supplemental groundwater recharge; (3) using highly treated recycled water as a resource for groundwater recharge; and (4) implementing water conservation and water-use efficiency practices to reduce pumping demands. The RRWP addresses both the expected demands for recharge water from Metropolitan and the increased reliance on recycled water.

The following discussion focuses on the trends in groundwater storage levels in the Main San Gabriel Basin and the Orange County Basin. Additional information regarding the West Coast Basin and the Central Basin is presented in Chapter 4 and Appendix C.

Main San Gabriel Basin

The Main San Gabriel Basin is a large groundwater basin situated at the foothills below the San Gabriel Mountains in Los Angeles County. The basin is mainly recharged by water flowing from the mountains and down the San Gabriel River. Spreading basins in and around the Santa Fe Dam and Rio Hondo Channel and unlined portions of the rivers facilitate increased groundwater recharge from surface runoff. The rivers are interconnected to facilitate optimal movement of water flows for both flood control and water replenishment. The Los Angeles County Flood Control District manages the river system for flood control and water replenishment. Incidental recharge of the basin also occurs from local rainfall percolating into the deep aquifer.

The Main San Gabriel Basin is adjudicated by the Main Basin Judgment (Judgment) with a court-appointed Watermaster. The Watermaster annually establishes an operating safe yield for the basin, which is then allocated to each groundwater producer based on its rights in the basin. No restrictions on extraction quantities are required by the Judgment; rather, the Judgment focuses on establishing a methodology for annually replacing water extracted beyond the operating safe yield. Pumpers extracting water in excess of their annual allocation must pay an assessment to cover the cost of obtaining replacement water. The Watermaster purchases water from one of three agencies: Upper San Gabriel Valley Municipal Water District (a Metropolitan member agency), Three Valleys Municipal Water District (a Metropolitan member agency), and San Gabriel Valley Municipal Water District.

Establishment of the annual operating safe yield is influenced by local hydrogeological conditions, including rainfall, storage in local reservoirs, production, runoff, and local water replenishment. The average operational yield in the Main San Gabriel Basin from 1970 to 2010 was approximately 198,000 AFY, which is substantially greater than the estimated 1967 operational safe yield of 157,000 AFY established during the Judgment. Increased regional spreading facilities, along with replenishment from Metropolitan-imported water, are cited as the reasons that the average operational safe yield is greater than the Judgment safe yield.

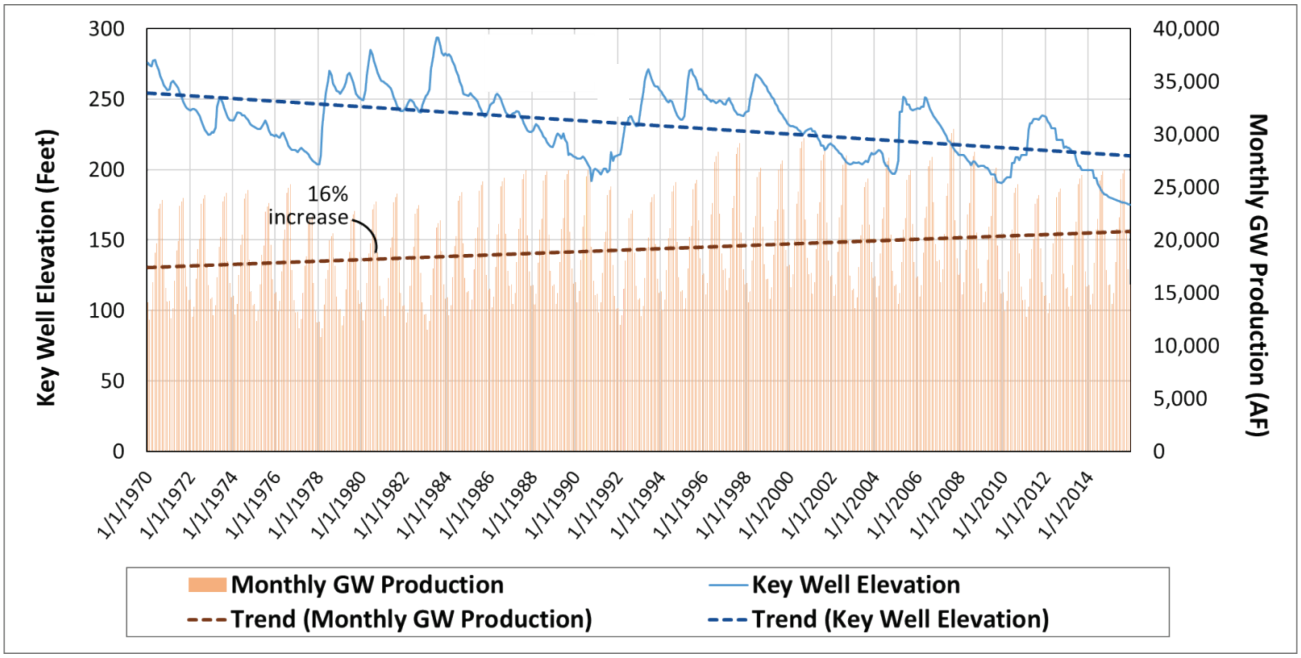
To assess the groundwater levels of the Main San Gabriel Basin, groundwater elevations at the key well are monitored. The Judgment specifies that the Watermaster shall spread replacement water, to the extent practicable, to maintain the water level at the key well above a 200-foot elevation. Figure 2.4 shows monthly groundwater production (in AFY) and key well groundwater elevations (in feet above mean sea level) from 1970 to 2015. As shown in Figure 2.4, a 45-year linear trend indicates that groundwater production has increased by 16 percent, while groundwater levels at the key well have decreased. The key well groundwater elevation of 175 feet observed in 2015 is the lowest recorded since the Judgment. The groundwater elevation could have been substantially lower without the efforts of the Watermaster and its many stakeholders to manage the basin for regional water supply reliability through conservation, storm water capture, and other programs.

Orange County Basin

The Orange County Basin is one of the largest groundwater basins in Metropolitan's service area. The Santa Ana River, which originates in the San Bernardino Mountains, carries both storm and base flows into Orange County to recharge the basin. Historically, the sources of replenishment for the basin came from the following: (1) Santa Ana River base flow; (2) Santa Ana River storm flow; and (3) incidental recharge. The recharge from captured Santa Ana River storm flow and incidental recharge are extremely variable due to year-to-year variations in local rainfall and hydrology. Base flows consist primarily of tertiary treated wastewater effluent from upstream discharges in San Bernardino and Riverside counties. To augment natural recharge of the basin, deliveries of imported water from Metropolitan for replenishment began in 1949.

Santa Ana River base flow is a function of population growth (more people results in greater wastewater flows), the economy, water conservation, and upstream water reuse. Santa Ana River base flow into the basin peaked in the late 1990s at about 155,000 AFY. As a result of water conservation and greater water reuse upstream, base flow started decreasing and is currently averaging about 70,000 AFY. According to the Santa Ana River Judgment, base flow into Orange County cannot go below 34,000 AFY. A realistic range for future Santa Ana River base flow into Orange County, considering the desire to use recycled water in Southern California, is between 40,000 AFY and 60,000 AFY.

Figure 2.4: Historical Groundwater Production and Key Well Groundwater Elevations for the Main San Gabriel Basin



GW = groundwater

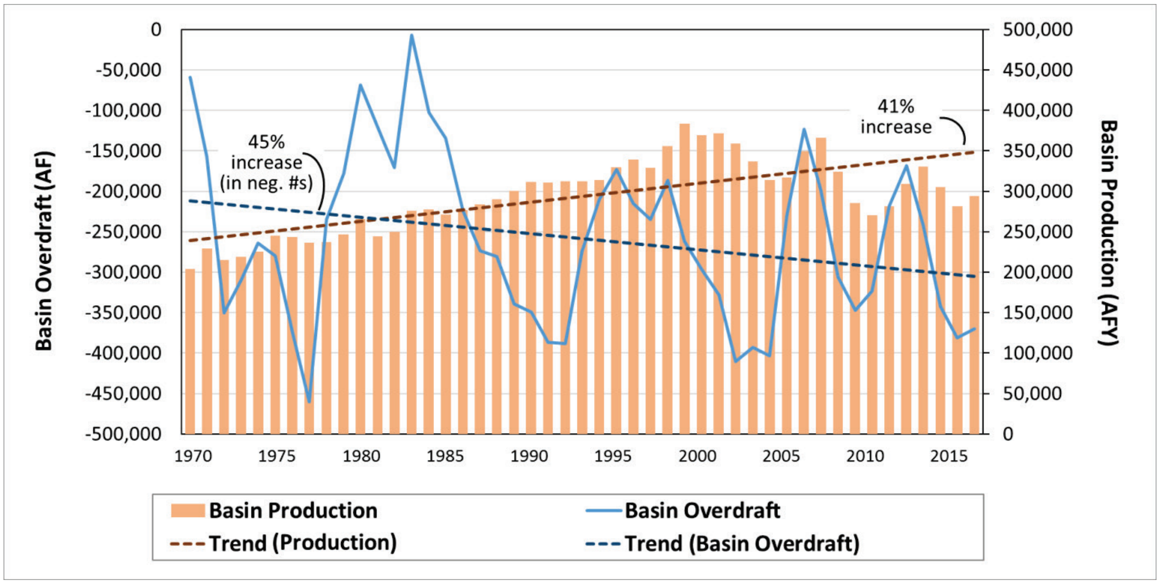
Established in 1933, the Orange County Water District (OCWD) is charged with sustainably managing this basin and the portion of the Santa Ana River that travels through Orange County. In 2008, OCWD began replenishing the basin through the OCWD Groundwater Replenishment System (GWRS) using advanced water purification technology to treat recycled water for groundwater replenishment. Currently about 100,000 AFY of water is recycled and recharged into the basin from the GWRS. By 2022, the GWRS expansion is expected to increase recharge to the basin to approximately 130 mgd (145,000 AFY).

To assess the groundwater levels of the Orange County Basin, OCWD determines the accumulated overdraft of the basin at the end of each water year. The accumulated overdraft of the basin represents the amount of dewatered storage from a full-basin condition and is estimated by measuring and contouring groundwater levels throughout the basin. The resulting change in groundwater storage represents the difference between all basin outflows (such as pumping and basin losses) and all basin inflows (managed and incidental recharge). Accumulated overdraft is expressed as a negative number from 0 (full basin) to –500,000 AF. Figure 2.5 shows annual groundwater production (in AFY) and basin overdraft (in AF) from 1970 to 2016. As shown in this figure, the accumulated overdraft has ranged from

0 to about –450,000 AF. A 45-year linear trend shows that groundwater production has increased by 41 percent, while accumulated overdraft has increased.

To maintain sufficient available storage capacity for Santa Ana River storm flow and other sources of potential replenishment into the basin during a wet year while maintaining sufficient groundwater in storage for a drought, OCWD's goal is to keep the basin's accumulated overdraft within the range of approximately –100,000 AF and –250,000 AF. Current accumulated overdraft is about –380,000 AF.

Figure 2.5: Historical Groundwater Production and Basin Overdraft for the Orange County Basin



2.4 Consistency with 2015 IRP Update

Through its IRP process, Metropolitan plans for regional water supply reliability. The targets in the 2015 IRP Update identify water supply developments in imported and local water supply and in water conservation that could provide a future without water shortages and mandatory restrictions of water use. The 2015 IRP target for local resources reflects the importance of stable local supplies within the region. By 2040, local supplies are expected to provide about 2.43 MAF of annual water supplies, which will constitute about 42 percent of the total supplies needed to balance regional demands for water supply. Table 2.1 shows the balances of demands and supply development described in the 2015 IRP.

Table 2.1: 2015 IRP Update Total Level of Average-Year Supply Reliability Targets (AF)

	2016	2020	2025	2030	2035	2040
Retail Demands Before Conservation	4,878,000	5,219,000	5,393,000	5,533,000	5,663,000	5,792,000
Total Conservation Target	1,034,000	1,096,000	1,197,000	1,310,000	1,403,000	1,519,000
Retail Demands After Conservation	**3,844,000**	**4,123,000**	**4,196,000**	**4,223,000**	**4,260,000**	**4,273,000**
Minimum CRA Diversion Target	900,000	900,000	900,000	900,000	900,000	900,000
Average Year SWP Target	1,202,000	984,000	984,000	1,213,000	1,213,000	1,213,000
Total Local Supply Target	2,199,000	2,307,000	2,356,000	2,386,000	2,408,000	2,426,000
Total Supply Reliability Target	**4,301,000**	**4,191,000**	**4,240,000**	**4,499,000**	**4,521,000**	**4,539,000**

Notes: CRA: Colorado River Aqueduct owned and operated by Metropolitan

SWP: State Water Project owned and operated by the California Department of Water Resources; assumes a successful outcome in California WaterFix and California EcoRestore efforts

The potential RRWP would support a number of areas that are beneficial to the regional reliability objective of the IRP. First, as a recycled water project that falls under the State of California's definition of Water Use Efficiency, supply production goes toward the regional goal of increasing potable water use efficiency and decreasing the regional potable gallons per capita per day (GPCD) usage as defined by California's "20 by 2020" water use efficiency legislation. Second, being located in the Southern California area, the project adds to the total local supplies within the region. Production from the RRWP would significantly contribute to meeting the IRP target of developing and maintaining the 2.43 MAF total local supply. Third, by providing a new local supply, the project would also support the development of a supply buffer against the risk of future reductions in the region's existing local supply base.

Additionally, like Metropolitan's local water resource development and conservation programs, production of recycled water through the RRWP would do the following:

- Help meet future demand consistent with the State Senate Bill 60 (SB60) directive to Metropolitan to "expand water conservation, water recycling, and groundwater recovery efforts" and "place increased emphasis on sustainable, environmentally sound, and cost-effective water conservation, recycling, and groundwater storage and replenishment measures"[3]
- Decrease and avoid operating and capital maintenance and improvement costs, such as costs for repair of and construction of additional or expanded water conveyance, distribution, and storage facilities that are required when developing resources outside of Metropolitan's service area
- Free up capacity in Metropolitan's system to convey both Metropolitan water and water from non-Metropolitan sources

2.5 Regional Benefits of Program

Unlike local water recycling projects, the RRWP would be a regional project between Metropolitan (a regional wholesale water provider) and the Sanitation Districts (a regional wastewater service provider). The regional benefits would derive from the regional structure already built into each of these participants. Additionally, the RRWP would provide benefits specific to the nature of the proposed project.

Economies of Scale

The RRWP differs from other locally developed water recycling projects in Southern California. Many local water recycling projects produce non-potable water that is provided only to non-potable and lower-value end uses, such as irrigation and industrial uses. Because non-potable recycled water requires a separate distribution system, the high cost of distribution means that the availability of nearby customers who are willing to accept non-potable water is often the limiting constraint to the recycled water project's capacity. The RRWP, on the other hand, demonstrates economies of scale that overcome the distribution system limitation of local recycled water projects. The RRWP is intended initially for groundwater replenishment, allowing for a steady recharge of water produced by the program.

Water Supply Reliability

One of the RRWP's significant benefits is increased reliability. The potential program would provide direct diversification of the region's resource portfolio by adding a new alternative with different resource attributes. Furthermore, adding to the amount of water recharged into groundwater basins in each year

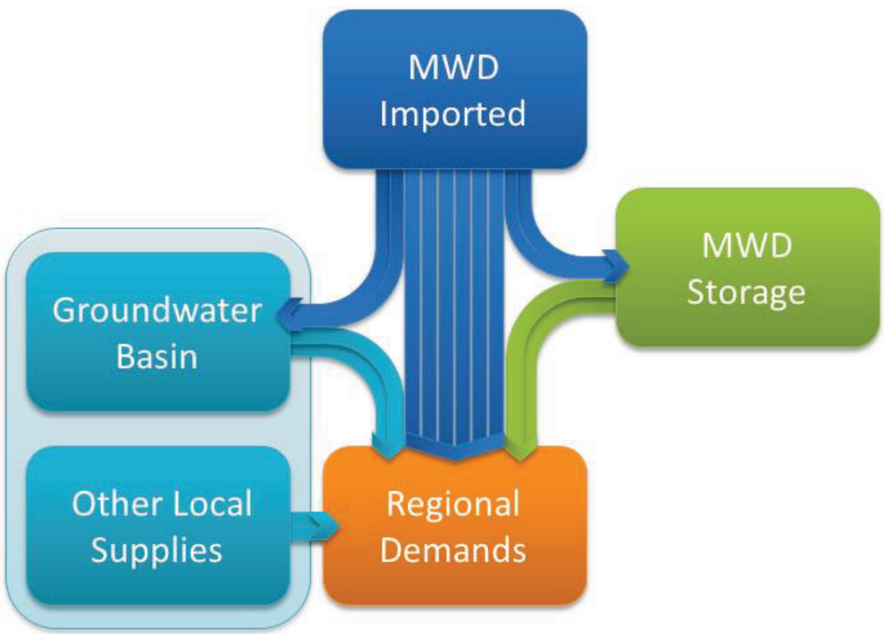
[3]Metropolitan Water District Act, Section 130.5, subd. (a)(2), (b).

increases the water available for a myriad of uncertain circumstances such as short-term dry conditions and multi-year droughts, emergency curtailments on imported water systems, and distribution system outages, among others. The ability to increase reliance on groundwater basins under certain conditions reduces reliance on Metropolitan's imported water supplies to meet such conditions. Imported supplies would be available for use by other member agencies or for other Metropolitan regional storage programs.

Because the entire service area benefits from Metropolitan's regional water delivery system, improved water reliability is shared by all. Improved reliability is a non-excludable benefit; once the benefit exists, there is no effective way to keep entities from using and benefitting from the service. An increase in reliability for one water agency results in improved reliability for all water utilities, especially in a regional system.

The regional reliability benefits of this new water resource are a result of the way in which the program would be integrated with Southern California's overall water systems. Figure 2.6 illustrates how regional demands in Metropolitan's service area are currently supplied (without the RRWP).

Figure 2.6: Meeting Regional Demands without the Program



Regional demands are the total water demands of the residential, commercial/industrial, and agricultural customers in the service area. Regional demands are met through a combination of sources including supplies produced from local projects and groundwater basins; Metropolitan-imported supplies; and Metropolitan's regional storage portfolio. In addition to the consumptive demands of the region, Metropolitan's imported supplies also are needed to recharge local agency groundwater basins to maintain stable basin levels and support groundwater pumping.

During wet years in which imported supplies are available in quantities over and above what is needed for regional demands and groundwater recharge, surplus water supplies are stored in Metropolitan storage programs[4]. Conversely, in dry years where available imported supplies are below what is needed for regional demands and groundwater recharge, water supplies have to be withdrawn from Metropolitan storage programs to meet those demands. If conditions are severe enough that water supply is insufficient from both imported sources and Metropolitan storage programs, and recharge water cannot be delivered to the local agency groundwater basins, then those basins may reach levels that result in the reduction of groundwater pumping available to meet regional demands.

These challenging supply conditions are also likely to coincide with years of lower natural groundwater replenishment from precipitation, further affecting local agency groundwater basin levels. For those cases in which supplies are inadequate to meet demands, additional water must be withdrawn from Metropolitan storage programs. As these programs are depleted, the risk of shortages and unreliability for the entire region increases.

By providing a new source of supply that keeps water for recharge flowing to the local agency groundwater basins, the program would increase the water supply reliability to all of Metropolitan's member agencies. Figure 2.7 illustrates how regional demands in Metropolitan's service area would be met with the addition of the potential RRWP.

Figure 2.7: Meeting Regional Demands with the Program

[4]Metropolitan's water storage capacity, which includes reservoirs, conjunctive use and other groundwater storage programs within Metropolitan's service area and groundwater and surface storage accounts delivered through the State Water Project or CRA, is approximately 5.83 MAF. Programs for the CRA include the Desert/Coachella Valley Water District Advance Delivery Account and Lake Mead Intentionally Created Surplus. State Water Project programs include the Mojave Storage Program, Arvin-Edison Storage Program, Semitropic Storage Program, and the Kern Delta Storage Program, among others. Member agency storage programs include cyclic storage, conjunctive use, and supplemental storage. Surface storage facilities within Metropolitan's service area include Diamond Valley Lake, Lake Mathews and Lake Skinner.

With the program, deliveries of imported water that would have gone toward meeting local agency groundwater recharge demands would be replaced by the new supply. The stable year-to-year deliveries of the new supply for groundwater recharge help to address the regional supply reliability challenges that exist without the program. With the program, imported supplies that would have gone toward meeting local agency groundwater recharge demands would instead be available to meet other regional demands or to go into Metropolitan storage programs. By implementing the program, storage levels in Metropolitan's regional storage portfolio are likely to be higher over most or all conditions.

This increase in storage in Metropolitan storage programs provides the primary regional reliability benefit for all of Metropolitan's member agencies. Increased storage in Metropolitan storage programs means more available storage supplies for all agencies in dry years. It also means a reduction in the frequency and severity of Metropolitan water supply allocations, which have historically been tied to maintaining sufficient storage reserve levels. The program also would help to ensure higher and more stable groundwater basin levels, minimizing the risk of reduced groundwater pumping in dry years. Higher and more stable levels increase the likelihood of local agencies maintaining and potentially increasing stable groundwater pumping for meeting regional demands.

Impacts of Additional Local Supply on Regional Water Supply Shortages

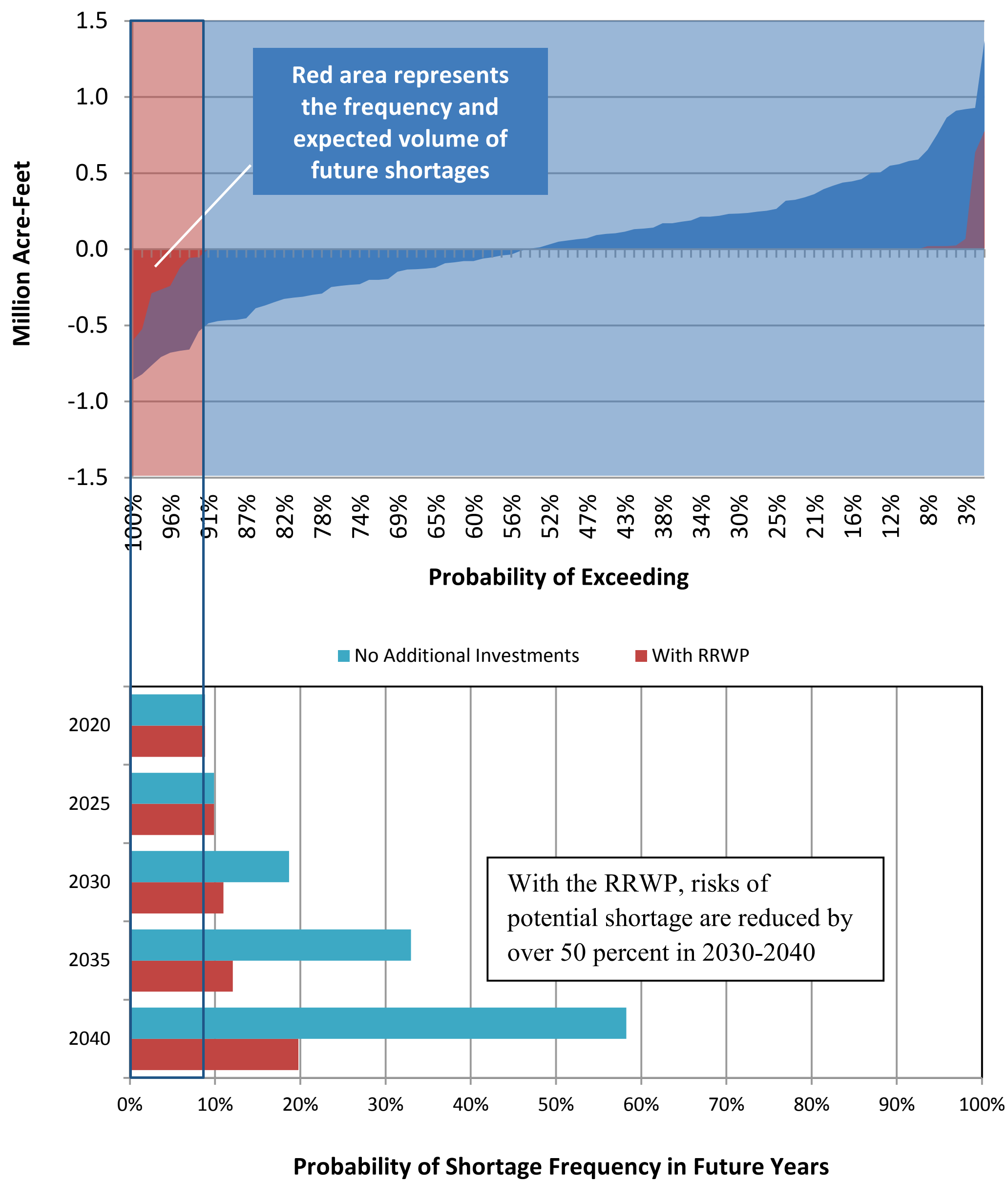
The regional reliability benefits for all of Metropolitan's member agencies can be seen by analyzing the impacts of the additional supply that the program would provide. In the 2015 IRP Update, two standard probabilistic water resource simulation modeling analyses were used to show the need for and impact of additional supply development for the region. The first analysis examined water supply shortages that could occur with and without improvements to supply. Figure 2.8 shows the probabilistic range of regional water balances in 2020. The areas above the 0.0 axis show the frequency and quantity of surplus water supplies above regional demands. The areas below the 0.0 axis show the frequency and quantity of shortages of water supplies below regional demands. The shaded red area highlights the area showing the frequency of shortages after withdrawals from storage reserves.

Under a base case with no new investment in water supply and storage capacity, the region is estimated to experience shortages of water supplies 9 percent of the time up to amounts exceeding 500,000 AF. The lower bar chart in Figure 2.8 summarizes the shortage probabilities in 5-year increments with and without the RRWP.

As regional demands for water grow, existing supplies and storage capacity become increasingly insufficient. Estimates of the probability of shortage are 19 percent of the time in 2030, 33 percent of the time in 2035, and 58 percent of the time in 2040. Adding the anticipated water supply from the program significantly reduces the projected probabilities of regional supply shortages.

Assuming that the RRWP is online and available by 2028, the improvements in reliability can be seen after 2030. Estimates of the probability of shortage with the program, compared to without the program, show decreases to 11 percent of the time in 2030 (a decrease of 8 percentage points), 12 percent of the time in 2035 (a decrease of 21 percentage points) and 20 percent of the time in 2040 (a decrease of 38 percentage points). These significant reductions in the probability of regional supply shortages are direct reliability benefits for all of Metropolitan's member agencies that would result from the program's new water supply and the improvements that it provides for regional storage levels.

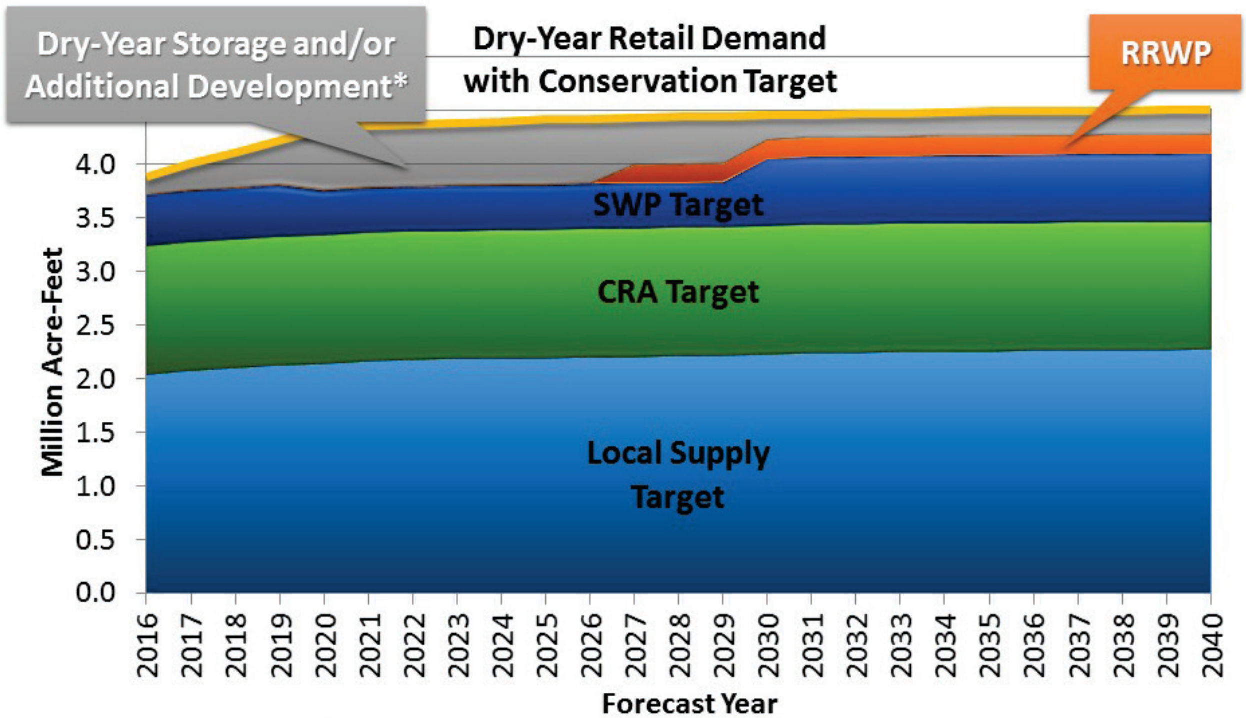
Figure 2.8: Regional Water Balances in 2020



Note that this analysis is intended to isolate the marginal benefits offered by the potential RRWP compared to a "No Additional Investment in Water Supply and Storage" baseline for illustrative purposes. The 2015 IRP calls for additional investments (including the California WaterFix), which together with the RRWP and other actions, would achieve the overall IRP reliability targets.

Figure 2.9 shows the balance of dry-year supplies and demands through 2040 with full development of Metropolitan's 2015 IRP Update targets and the RRWP. The top yellow line shows the forecast of dry-year retail demands assuming all conservation savings targeted in the 2015 IRP Update are achieved. The blue and green areas show the build-up of supplies available locally, and from the State Water Project and Colorado River Aqueduct to meet dry-year retail demands. The forecasts of supplies available include all of the supply development targeted in the 2015 IRP Update, including the California WaterFix which would increase dry-year supplies from the State Water Project. The RRWP, shown in orange, provides an additional supply that would go towards filling the gap between dry-year supplies and demands in the future. The remaining gap, shown in gray, would be managed using Metropolitan's storage portfolio, or through the development of additional local supplies and conservation beyond what is targeted in the 2015 IRP Update.

Figure 2.9: RRWP Dry-Year Supplies with IRP Targets



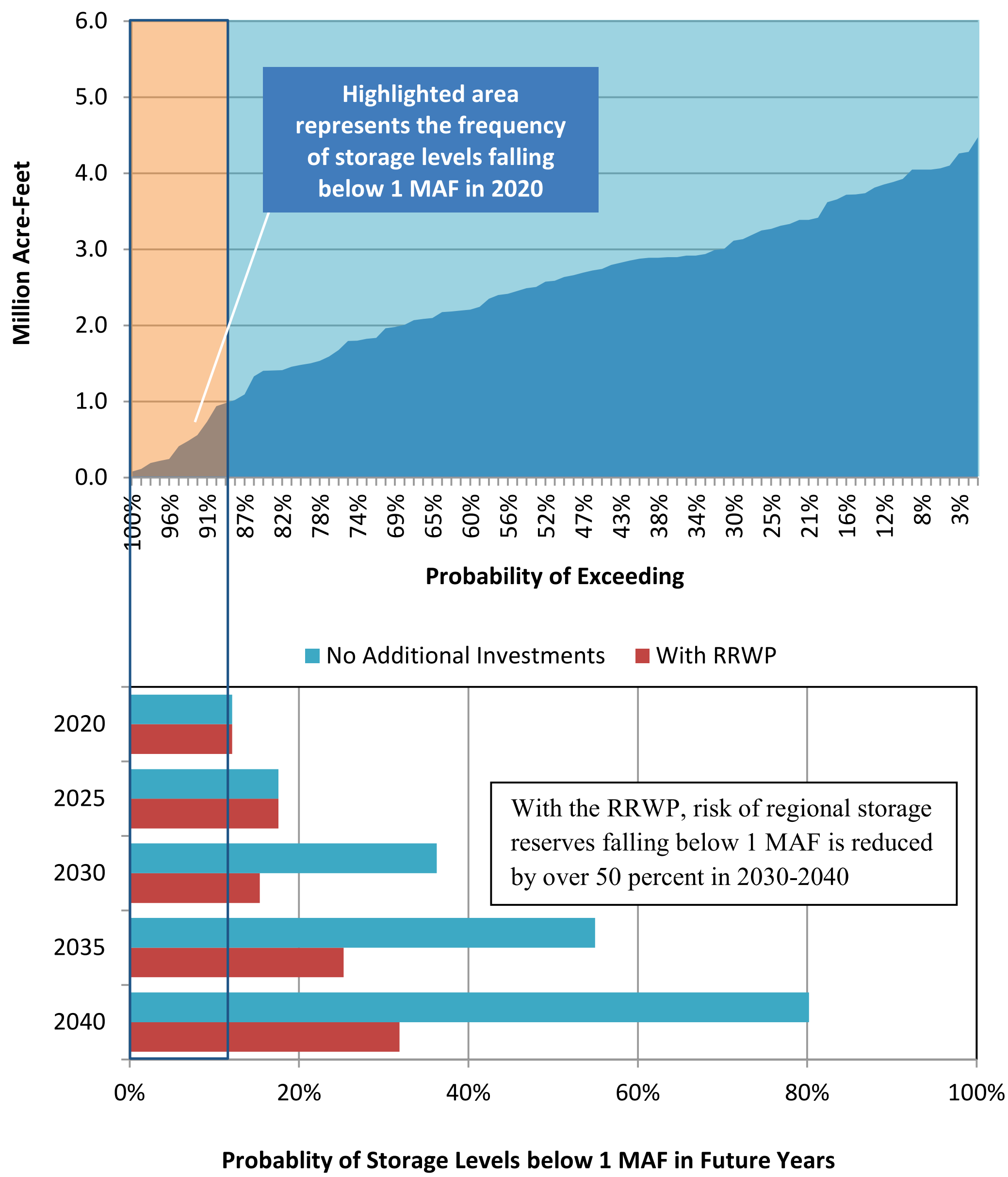
*Additional Development of Local Supplies or Conservation Beyond IRP Targets

Impacts of Additional Local Supply on Regional Storage and Water Supply Allocations

A second analysis provided in the 2015 IRP is directly related to storage reserves in Metropolitan programs and the reserves' impact on mandatory imported water supply allocations on Metropolitan's member agencies. While the previous analysis on water supply reliability shows the probabilities of truly being short of water supply, overall storage levels within Metropolitan's storage programs give an indication of when Metropolitan may impose mandatory water supply allocations in order to manage resources through an ongoing drought. In the 2015 IRP, Metropolitan storage levels of less than 1 MAF were assumed to be a threshold level for the consideration of mandatory water supply allocations. Figure 2.10 shows the frequency and quantity of storage in Metropolitan programs. The shaded orange area highlights the area showing the frequency of Metropolitan storage reserves falling below 1 MAF in the year 2020.

The lower bar chart in Figure 2.10 summarizes the shortage probabilities in 5-year increments. Under a base case with no new investment in water supply and storage capacity, Metropolitan storage reserves are estimated to fall below a threshold of 1 MAF 12 percent of the time, meaning that there would be a 12 percent chance that the region would be facing mandatory water supply allocations.

Figure 2.10: Frequency and Quantity of Metropolitan Storage Levels



The bar chart illustrates that as regional demands for water grow, the probability of having Metropolitan storage reserves fall below a 1 MAF threshold increases significantly without additional investments in water supply and deliveries. Estimates of the probability of storage reserves being low enough to necessitate Metropolitan declaring a mandatory allocation are 36 percent of the time in 2030, 55 percent of the time in 2035, and 80 percent of the time in 2040.

Adding the anticipated water supply from the potential program would have a significant effect on the projected probabilities of low Metropolitan storage reserves and mandatory water supply allocations.

Assuming that the project is online and available by 2028, the improvements in Metropolitan storage reserves can be seen after 2030. Estimates of low Metropolitan storage reserves and mandatory water supply allocations with the project decreases to 15 percent of the time in 2030, 25 percent of the time in 2035, and 32 percent of the time in 2040. These significant reductions in the probability of low Metropolitan storage reserves and mandatory water supply allocations benefit all of Metropolitan's member agencies.

Potential Emergency Storage Benefits

Another area of potential regional benefit resulting from the program is the effect on Metropolitan's emergency storage reserves. Metropolitan has an emergency storage requirement policy that maintains enough emergency storage reserves to meet a 6-month outage of all of the region's imported supplies (SWP, CRA, and Los Angeles Aqueduct), assuming full deliveries of local supplies. The program would positively affect the region's emergency storage preparedness in two ways. First, through the consistent annual groundwater recharge that the program would provide, groundwater basins would be more likely to have adequate water in storage to support continued production. This means that groundwater, which is assumed to constitute the majority of in-region local supplies available during an emergency outage of imported supplies, would be more likely to be able to continue at full production. These local supplies would be less dependent on other Metropolitan storage reserves, thus freeing up those reserves for other member agencies. Second, by providing a new local supply source, total Metropolitan storage reserves would be higher than if the program were not in place. Higher total Metropolitan storage provides an additional buffer of storage supplies on top of emergency storage reserves, and thus extends the length of time that the region can withstand an emergency outage of imported supplies.

Embedded Energy and Greenhouse Gas Footprint

For the purpose of this analysis, the embedded energy associated with the advanced water treatment and the distribution of purified water are presented separately. Beginning with treatment, the embedded energy resulting from the base case AWT processes is estimated at approximately 1,250 kWh per AF. The additional embedded energy contributed by the conveyance system to deliver purified water is estimated to be approximately 840 kWh per AF, bringing the total estimated kWh per AF for both treatment and delivery of purified water to 2,090 kWh per AF.

To put these values in perspective, Metropolitan's estimate of the energy intensity (a net value that incorporates both energy used and energy generated) of its untreated imported supplies was 1,892 kWh per AF for 2014. The energy embedded in treated imported supplies (including conveyance) for 2014 was 1,938 kWh per AF. While, the embedded energy for both conveyance and treatment is approximately 8 percent higher for purified water, note that the water quality is considerably higher as well. When compared to SWP-imported supply (which has water quality more desirable for groundwater replenishment), the embedded energy of recycled water is comparable. These results suggest that the program can produce significant water quality and supply benefits with comparable embedded energy and greenhouse gas emissions.

Helps Meet Legislative Mandate on Recycled Water and Other Local Resource Development

Like Metropolitan's local water resource development and conservation programs, production of recycled water through the RRWP would help meet future demand consistent with SB60's directive to Metropolitan to "expand water conservation, water recycling, and groundwater recovery efforts" and "place increased emphasis on sustainable, environmentally sound, and cost-effective water conservation, recycling, and groundwater storage and replenishment measures."

Flexibility to Accommodate Direct Potable Reuse

The alignment of the base case pipeline to the Orange County Basin is in close proximity to Metropolitan's Diemer Water Treatment Plant. With future development of regulatory criteria and if DPR is determined feasible for Metropolitan's system, the pipelines could be extended from the current planned termini to the Diemer plant and/or Weymouth plant. Under this dual environmental barrier approach, potential sources of additional purified water to meet DPR demands could include an expanded AWT facility at the JWPCP and/or the future Hyperion AWT facility. While sufficient demand exists for recharge water to fully use the conveyance system capacity described in the base case, additional consideration for DPR demands could be evaluated in future facilities planning studies after regulations for DPR are adopted. Figure 2.11 shows potential future program components.

Reduced Use and Burden on Conveyance System

The availability of locally produced water would decrease and avoid operating and capital maintenance and improvement costs, such as costs for repair of and construction of additional or expanded water conveyance, distribution, and storage facilities that are required when developing resources outside of Metropolitan's service area. Locally produced water also frees up capacity in Metropolitan's system to convey both Metropolitan water and water from non-Metropolitan sources.

Coastal to Inland Conveyance System

Similar to the flexibility that the program provides to address future DPR opportunities, the provision of a large-scale conveyance system from the coastal zone to inland communities could be considered for other uses. The system provides the potential for pumping and conveyance of other coastal sources of new supply including additional recycled water and desalinated ocean water. In addition, it has been suggested that the conveyance system design should consider incorporating inland-to-coastal brine lines within the conveyance pipeline alignment, so as to complement other recycled water projects in the region. These possibilities and opportunities could also be evaluated in future facilities planning studies.

Water Quality Improvements in Groundwater Basins

The purified water produced from advanced water treatment for IPR in groundwater basins could produce long-term basin water-quality benefits exceeding those resulting from recharge with imported sources. The program is expected to contribute to the accomplishment of recycled water optimization goals included in basin salt and nutrient management plans.

Reduced Vulnerability to Climate Change and Environmental Constraints

The effective detachment of new purified water supplies from the hydrologic cycle results in two areas of benefit: (1) the availability of deliveries under all weather conditions; and (2) the production of water supplies outside of critical habitat that could be adversely affected by climate change and export restrictions. Together, these protections against drought and climate change introduce a water security benefit not available with other Metropolitan sources.

Other Groundwater Basin Storage Opportunities

In Metropolitan's earlier report entitled "Potential Recycled Water Supply Program: Historical Review and 2015 Update (Version 1.8),[5]" additional groundwater recharge opportunities were identified in the Chino Basin and the Raymond Basin Eaton Wash Spreading Grounds. In the event that the additional coastal sources described above become available, the proposed base-case conveyance system could be extended to reach both the Raymond Basin and the Chino Basin to accommodate additional storage requirements. These additional storage opportunities would also increase system operational flexibility and enable higher assured production capacity. As with the other opportunities described above, these considerations would be evaluated in future facilities planning studies. Figure 2.11 shows potential future program components.

Repurposing of Existing Facilities

During the feasibility study investigations, it was suggested that Metropolitan explore repurposing its Second Lower Feeder (SLF), a pipeline that currently delivers treated water from the Diemer Water Treatment Plant in Orange County southwest to Los Angeles County. If repurposed, the SLF would convey purified water in the reverse direction from the JWPCP to the Orange County Basin. This concept requires careful consideration regarding its operational consequences and the associated modifications required to maintain current levels of service. Should those studies indicate the feasibility of repurposing portions of the SLF, net benefits could be associated with the following: time and cost savings, and reduced construction disturbance when compared to a new large-diameter pipeline installed along a similar alignment; and the opportunity to use Metropolitan's existing assets at a higher level of efficiency.

Reduction of Ocean Discharges

The program described in the base case scenario beneficially reuses water currently discharged to the ocean. Although the brine created during the advanced treatment process will be discharged to the ocean via the existing JWPCP tunnel and outfall system, overall less flow will be discharged to the ocean. At this time, the existing tunnel system has reliability issues that are proposed to be addressed with construction of a new tunnel. Construction of a more reliable tunnel system will ensure that the treatment residuals and brine created by the advanced treatment facility can be reliably managed.

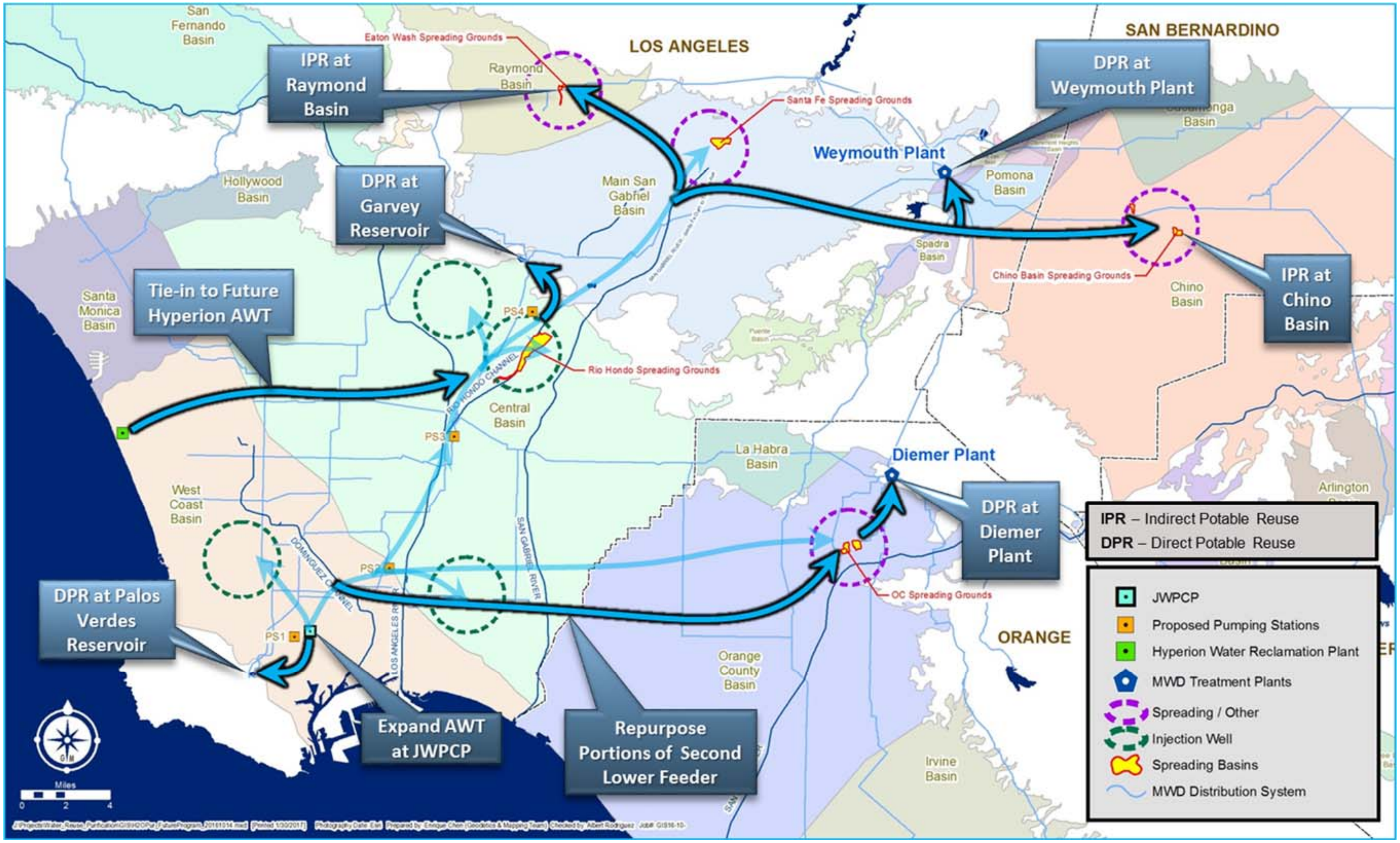
Other Indirect Benefits

The RRWP would potentially offer other indirect benefits including economic benefits such as the following:

- **Regional Economic Impact:** Increased employment and economic activity during the initial project construction as well as ongoing operations and preservation of "renewable" industry employments
- **System Efficiencies**: Using more fully regional capacity for transportation, treatment, and storage
- **Financing Efficiencies:** Potential for lower financing costs due to the project size or Metropolitan's credit rating
- **Shared Risks**: Spreading out risks from economic and financial forces

[5]Available at http://mwdh2o.com/PDF_About_Your_Water/Draft%20-%20Recycled%20Water%20Supply%202015%20Update-v1.8.pdf

Figure 2.11: Potential Future Program Components (beyond 150 mgd and with DPR regulations)



Chapter 3

Base Case and Assumptions

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3.0 BASE CASE AND ASSUMPTIONS

This chapter presents the base case scenario used for the feasibility analysis and an overview of the major facilities and infrastructure that would be needed to treat and deliver the purified water. It also includes an introduction to the groundwater basin analysis that was conducted to evaluate potential demands for recharge water. This analysis was used to establish the size and configuration of the base case. Lastly, this chapter includes the key assumptions that were used for the analysis, as well as the risks if the actual conditions differ from the assumptions, potential mitigation for the risks, and the consequences if a risk cannot be mitigated.

3.1 Base Case Scenario

The base case is defined as an implementable system of program elements that are necessary and sufficient for accomplishing the program's goals:

1. Create a new large-scale, drought-proof water supply that will add to regional reliability through increased storage in regional groundwater basins.
2. Beneficially reuse water currently discharged to the Pacific Ocean.
3. Purify secondary effluent from the JWPCP to IPR water quality standards.
4. Maintain stable regional groundwater basins through regular recharge with purified water.
5. Comply with all current legal and regulatory requirements.
6. Ensure regional benefits and consistency with Metropolitan's 2015 IRP.

The program elements include facilities, infrastructure, institutional arrangements, and financing assumptions, each of which has quantifiable and acceptable levels of risk. The base case consists of a hypothetical system model that has not yet been designed to achieve optimized performance but is deemed capable of accomplishing the program's functional goals. Note that although the base case facilities would handle a significant amount of flow from the JWPCP, they would not be designed to handle peak flows to the JWPCP. Furthermore, the base case facilities would be expected to provide delivery flexibility, so that deliveries to groundwater basins could be periodically reduced when conditions warrant (e.g., when maintenance or other short-term outages occur).

Although the program would likely be implemented in phases, the base case scenario focuses on a 150 mgd AWT facility and the conveyance facilities required to deliver this amount of purified water to groundwater basins in Los Angeles and Orange counties. Phasing would be evaluated in the conceptual design of the program. Table 3.1 outlines the operational scenario assumed for the base case analysis.

Table 3.1: Base Case Operational Scenario

Performance	Operational Scenario
	Base Case
Goal	Delivery Flexibility
AWT Production Capacity	150 mgd
Average Daily Delivery	144–150 mgd
Long-Term Annual Average Delivery	147 mgd
Minimum Day Delivery	≥ 110 mgd
Manage Peak Flows	No

3.2 Overview of Facilities for Base Case Scenario

The base case scenario assumes the following: (1) the production of up to 150 mgd of purified water with a long-term annual average of 147 mgd; (2) the conveyance of purified water via approximately 60 miles of pipelines; and (3) delivery of purified water to up to four groundwater basins (Orange County, Central, West Coast, and Main San Gabriel) within Metropolitan's service area. The annual average production flow is based on the assumption that demand for recharge water will require the production of 150 mgd of purified water approximately 85 percent of the time with the need to lower production, to a minimum of 110 mgd, up to 15 percent of the time. For the purposes of the analysis, the estimated annual average production flow is 147 mgd. A new AWT facility would be constructed at the Sanitation Districts' JWPCP in Carson to treat secondary effluent, and new conveyance facilities (including pump stations and pipelines) would be constructed to deliver the purified water to the basins. Both spreading facilities and injection wells would be used to recharge the groundwater basins. A schematic overview of the base case facilities and infrastructure is presented in Figure 3.1.

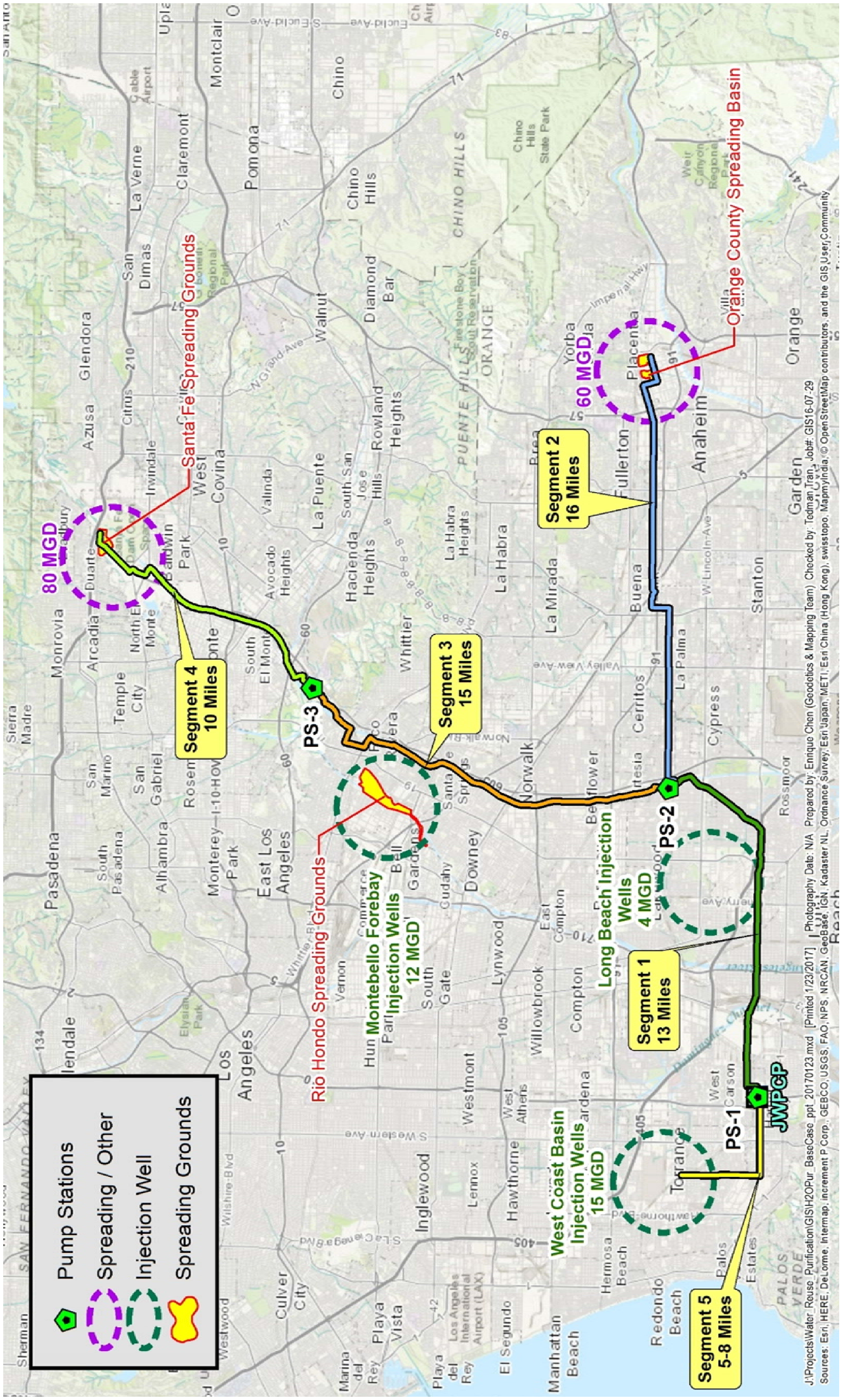
The base case defined above should not be considered as either the best or worst case scenario with respect to implementation costs or timelines. It represents a realistic approach to achieving the program's functional goals and is intended to demonstrate feasibility only. Risks that could be associated with the worst case, and opportunities for reduced implementation costs that could lead to a better case, have been identified where possible. Finally, it is recognized that the base case would be optimized in subsequent phases of design to potentially reduce capital costs, O&M costs, and/or environmental impacts.

3.3 Overview of Groundwater Analysis

The size and configuration of the base case scenario were established following an evaluation of potential demands for recharge water in the Orange County, Central, West Coast, and Main San Gabriel basins. An extensive analysis of these basins was conducted to answer the following questions:

1. **Demand Analysis:** What is the demand for the purified water in each basin?
2. **Operational Assessment:** Do operational issues limit how much water can be recharged?
3. **Groundwater Modeling:** How does recharge and extraction of program water affect water levels and travel times to potentially affected wells?
4. **Facility Needs:** Are new facilities required or is the existing infrastructure sufficient to support the program goals?

Figure 3.1: Schematic Overview of Facilities and Infrastructure for Base Case



The groundwater analysis evaluated conditions for each of the groundwater basins during both wet and dry periods. Modeling was used to evaluate the capacity of each basin to receive the purified water on a year-round basis. The results of the analysis and modeling confirmed that groundwater recharge demand and capacity are sufficient in the basins for the year-round production of up to 150 mgd as described in the base case. Existing and projected replenishment needs in the basins comprise most of the demand for the purified water. For these demands, the purified water produced through the potential RRWP would replace existing imported water deliveries from Metropolitan. A systemwide analysis determined feasible locations for groundwater recharge and the estimated flow rates. The locations and flow rates were used in developing both the base case and the sizing of facilities, such as pump stations, pipelines, and injection wells. The feasibility analysis and the results of the groundwater modeling are presented in Chapter 4.

3.4 Base Case Assumptions

The feasibility analysis was conducted using a set of conditions and assumptions for the base case. No speculative assumptions (e.g., future improvements in treatment technology efficiencies, future changes in regulatory requirements, or favorable outcomes on negotiated terms and conditions) were included. Table 3.2 summarizes the key assumptions for the base case scenario along with the potential risks, risk mitigation, and consequence if the risk cannot be mitigated. These assumptions and conditions were used in the analysis of the groundwater basins, full-scale treatment facility, conveyance system, regulatory process, public acceptance, cost, and schedule.

Table 3.2: Key Assumptions

Base Case Assumptions	Risks	Risk Mitigation	Consequence (if not mitigated)
Groundwater Basins			
Institutional arrangements could be executed for delivering an agreed-upon amount of purified water for groundwater recharge.	Agencies are not willing to commit to take the purified water every year.	Potentially reduce size of the program.	If institutional arrangements cannot be executed to provide commitment for delivery of up to 150 mgd, the program may not feasible. *Lower delivery quantities may result in higher-than-planned unit costs to produce the purified water or reduce the optimal AWT plant capacity.*

Base Case Assumptions	Risks	Risk Mitigation	Consequence (if not mitigated)
Consumptive demand is sufficient for the groundwater agencies to extract the stored water.	Water levels could increase to above operating ranges for the basins, causing recharge capacity to decrease.	Construct new wells to extract and export water to other basins if allowed.	Full capacity of the treatment plant may not be used. *Lower delivery quantities may result in higher-than-planned unit costs to produce the purified water.*
Recharge capacity is sufficient to store 110 to 150 mgd of purified water.	Due to operational issues during the rainy season or maintenance issues, the spreading basins may not be able to be used. Other projects may limit the ability to recharge the basins with program water.	Construct new injection wells or spreading basins. Reduce size of the treatment plant.	Full capacity of the treatment plant may not be used. *Lower delivery quantities may result in higher-than-planned unit costs to produce the purified water.*
No endangered species or other environmental issues would preclude the use of proposed spreading basins.	An endangered species reduces the time or location where spreading can occur.	Construct new injection wells or spreading basins.	Full capacity of the treatment plant may not be used. *Lower delivery quantities may result in higher-than-planned unit costs to produce the water.*
Recharge with purified water would not cause significant adverse water quality issues.	Potential adverse water quality issues include: not meeting basin-specific standards; leaching and possible mobilization of undesirable constituents; moving or changing conditions of existing contaminant plumes (significantly altering existing groundwater cleanup efforts).	Consider the basin-specific assimilative capacity. Adjust purified water quality to reduce leaching potential. Change the location and method for recharge of purified water in the basins.	Adverse water quality issues could result in increased treatment costs or costs to change location or method of recharge. *Changes to the treatment process, facilities, or infrastructure could increase program cost.*

Base Case Assumptions	Risks	Risk Mitigation	Consequence (if not mitigated)
Full Scale AWT Facility			
Testing conducted at the demonstration facility can successfully demonstrate that MBR pretreatment will: (1) minimize membrane fouling in the AWT process and meet nitrate objectives for the groundwater basins; and (2) achieve regulatory approval for necessary log-reduction credits for *Cryptosporidium* and *Giardia* that could enable flow from the MBR process to go directly to RO. As a result, MF would not be needed in the full-scale AWT facility. The base case full-scale AWT processes include MBR, RO, and UV/AOP.	DDW, through its current regulatory authority, does not grant pathogen reduction credits for MBR. Or, on a lesser impact, DDW may request additional data that could extend the demonstration testing period.	Work closely with DDW to develop sound demonstration testing/monitoring plan. Test and monitor throughout demonstration phase (process monitoring and integrity testing are key). Collect data sufficient to meet DDW requirements.	MF would have to be included as part of the full-scale treatment process. Sufficient on-site space exists to allow this. *Changes to the treatment process and facilities could increase program cost. Extending the demonstration testing period could affect the design/permitting schedule.*
Flow equalization will be required to ensure production rates at or near 150 mgd on a continuous basis. Existing JWPCP tankage will be modified to maintain a constant feed to the AWT facility.	Without flow equalization, continuous production rates from the AWT facility would be reduced.	The Sanitation Districts identified potential use of one secondary clarifier train at the JWPCP for flow equalization during low diurnal flow periods.	New tanks would be required elsewhere on or adjacent to the site. *Changes to the treatment facilities could increase program cost or lower delivery quantities and may reduce the optimal AWT plant capacity.*
Some of the soil excavated during construction is expected to be contaminated.	Site remediation efforts may take longer than planned, causing construction to be delayed.	The Sanitation Districts will handle and dispose of any contaminated soils encountered that cannot be used for backfill or is excess.	Construction cannot start until site is remediated and approved for intended use. *Remediation could delay construction schedule and potentially increase program cost.*

Base Case Assumptions	Risks	Risk Mitigation	Consequence (if not mitigated)
A combination of source control for boron in the JWPCP sewer-shed and RO in AWT processes will eliminate the need for additional boron treatment to meet the MSG Basin Plan objective.	Source control efforts do not successfully identify and mitigate boron levels entering the JWPCP. The LA RWQCB maintains requirement for boron MSG Basin Plan objective to be met at the AWT discharge.	Effective/thorough boron source investigation and control efforts by the Sanitation Districts.	Additional treatment (e.g., ion exchange at satellite location) would be required for portion of AWT flow to meet boron objective in MSG Basin. *Changes to the treatment facilities and infrastructure could increase program cost.*
Nitrogen management approach considers sidestream de-ammonification of the centrate stream from JWPCP dewatering centrifuges, and nitrification and partial denitrification of non-nitrified secondary effluent from the JWPCP with a tertiary MBR system. Remaining nitrogen can be removed via the RO process.	Sidestream nitrogen removal is not as effective as planned.	Additional nitrogen will have to be removed in the tertiary MBR system.	Additional treatment (e.g., increased carbon to achieve desired level of denitrification) would be required to meet nitrate objective in the Orange County Basin. *Changes to the treatment process and facilities could increase program cost.*
Conveyance System			
Conveyance systems can be located within the public ROWs and other utility corridors, including SCE and LA County Flood Control District ROWs.	Public ROW or utility corridors are not available for pipeline alignments.	Identify other viable alternative pipeline alignments.	Property acquisition or potentially less efficient alignments may be required. *Changes to the infrastructure could increase program cost.*
Regulatory Approval			
A permitting timeline (including approval of Title 22 Engineering Report) can be achieved as presented in Chapters 7 and 9.	Delays in development or approval of key permitting elements, including the Title 22 Engineering Report and brine disposal.	Work closely with DDW and RWQCBs throughout the demonstration phase and development of the Title 22 Engineering Report.	Permit approval could be delayed. *A longer permit approval process could affect the project schedule.*

Base Case Assumptions	Risks	Risk Mitigation	Consequence (if not mitigated)
Public Acceptance			
The public will accept this new source of supply into the groundwater basins. The communities in the vicinity of the JWPCP will accept increased operations at the site. Communications regarding construction of a new conveyance system are transparent, timely, and targeted to the local areas directly impacted.	The public objects to the project due to lack of information or misinformation. Environmental justice issues are raised. The MSG Basin has never recharged recycled water, so it does not have the same experience as other basins with purified water.	A comprehensive multicultural, multilingual outreach effort is implemented to inform the public about the program and its benefits. The demonstration facility is used as an educational outreach tool. Targeted outreach is provided to communities near the JWPCP and those areas affected by construction.	The Metropolitan board will consider public concern/ opposition. *Public concerns or opposition could affect program schedule*.

AOP = advanced oxidation process
AWT = advanced water treatment
DDW = California Division of Drinking Water
JWPCP = Joint Water Pollution Control Plant
LA = Los Angeles
MBR = membrane bioreactor
MF = membrane filtration
MSG = Main San Gabriel
RO = reverse osmosis
ROW = right-of-way
RWQCB = Regional Water Quality Control Board
SCE = Southern California Edison
UV = ultraviolet

Chapter 4

Groundwater Basins

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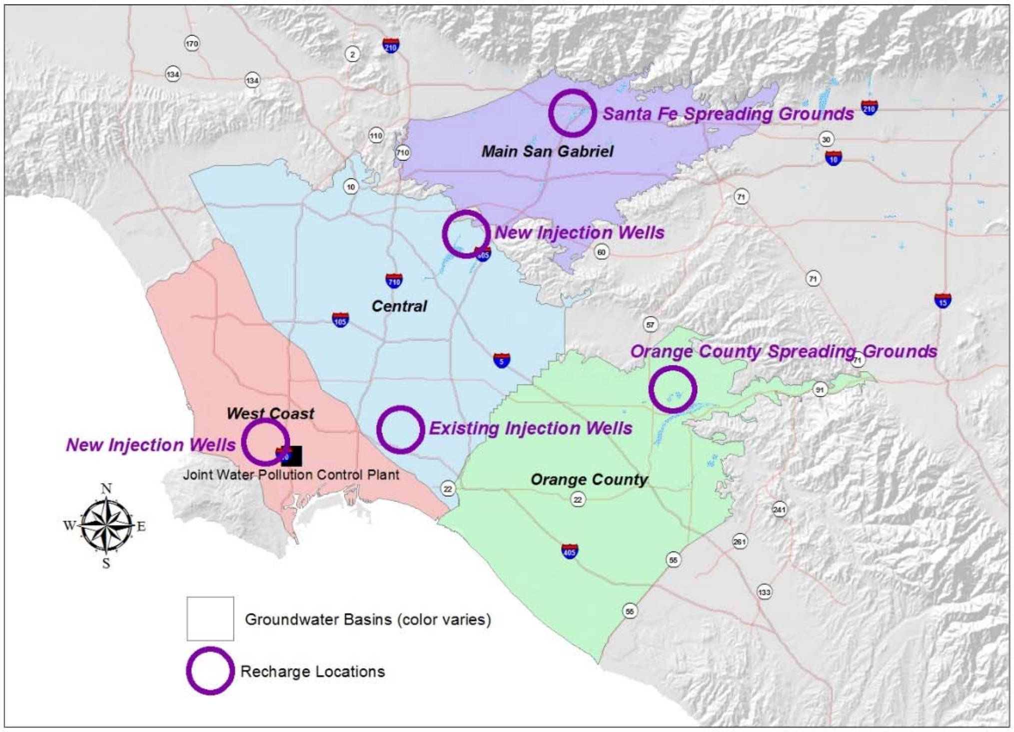
4.0 GROUNDWATER BASINS

4.1 Introduction

This chapter describes the base case scenario pertaining to recharge and extraction of RRWP water in the groundwater basins. Topics in this chapter include a general description of the groundwater basins, demand analysis, groundwater modeling, and facility requirements in support of the 150-mgd (168,000 AFY) base case scenario. More detail for each of these topics is presented in Appendix C. The groundwater basin analysis focused on demand analysis, operational issues, impacts to existing and planned basin operations, and infrastructure. It does not include water quality analyses, including changes to existing basin water quality as a result of the potential program; water quality analysis will be addressed in future studies.

Figure 4.1 shows the groundwater basins – Central, West Coast, Main San Gabriel, and Orange County – that are included in this study and proposed locations for recharge. These basins were selected based on their proximity to the JWPCP and their ability to accommodate up to 150 mgd (168,000 AFY) of recharge water. Other basins such as the Chino Basin and Raymond Basin could be considered in future phases of the program.

Figure 4.1: Groundwater Basins and Recharge Locations



To develop the base case scenario and assumptions for delivery of up to 150 mgd of purified water to groundwater basins, Metropolitan conducted a demand analysis to determine the projected need for RRWP water in each of the basins to support future groundwater pumping. Existing groundwater models for each basin were used to aid in evaluating the ability of individual basins to receive the water and identify possible effects that the recharge may have on them. The analysis was conducted to answer the following questions:

1. **Demand Analysis:** What is the demand for RRWP water in each basin?
2. **Operational Assessment:** Do operational issues such as recharge capacity or extraction capability limit how much water can be recharged or extracted?
3. **Groundwater Modeling:** How does recharge and extraction of program water affect water levels and travel times to potentially impacted wells?
4. **Facility Needs:** Are new facilities required or is the existing infrastructure sufficient to support the program goals?

Assumptions and operational criteria for the demand analysis and groundwater modeling were developed through coordination with member agencies, basin managers, and the Los Angeles County Department of Public Works.

4.2 Demand and Operational Analysis

This section provides a summary of the demand, operational assessment, and groundwater modeling for the four basins in this study. Demand data are from Metropolitan's 2015 IRP Update. Demand for RRWP water may include the following: (1) existing replenishment demand currently provided by imported water; (2) consumptive demand that is currently served by imported water that could be converted to groundwater; and (3) additional replenishment supplies above historical deliveries that will be needed for overdraft control or projected future demand.

Central Basin

The Central Basin lies within central Los Angeles County. It underlies the service areas of the following Metropolitan member agencies: Central Basin Municipal Water District (MWD), West Basin MWD, the City of Compton, the City of Los Angeles, and the City of Long Beach.

The Central Basin was adjudicated in October 1965. In December 2013, the Central Basin Judgment was amended, declaring water rights and providing provisions for the storage and extraction of stored water. Metropolitan has conjunctive use programs with the cities of Compton, Long Beach, and Lakewood. The total storage amount of these programs is 18,889 AF.

Demand Analysis

The needs analysis provides the range of demand for RRWP water in the Central Basin. Projections are from Metropolitan's Integrated Resources Planning Simulation Model (IRPSIM; Sales Model 25d1). About 21 TAFY of imported water is currently delivered to the Montebello Forebay in the Central Basin for replenishment. The Water Replenishment District of Southern California's (WRD's) Groundwater Reliability Improvement Program (GRIP) is anticipated to replace the current imported water deliveries with advanced treated water from the San Jose Creek Water Reclamation Plant. In addition, about 4 TAFY of imported water replenishment demand is anticipated in the Long Beach area and 10 TAFY of imported water replenishment demand is anticipated in the Los Angeles Forebay area due to projected pumping in these areas. In the event that the RRWP does not go forward, these demands would be met with imported water.

Central Basin MWD's consumptive demand for imported water from Metropolitan ranges from 40 to 80 TAFY. Of that, about 3 TAFY of imported demand could be met with increased groundwater production from existing production wells. The total RRWP water potential in the Central Basin is 17 TAFY.

Operational Assessment and Facility Needs

The capacity of the Montebello Forebay Spreading Grounds (Rio Hondo Spreading Grounds and San Gabriel Coastal Spreading Grounds) is about 336 TAFY (300 mgd). About 100 TAFY of recycled water from the San Jose Creek Water Reclamation Plant, imported water from Metropolitan, and stormwater are currently spread at the Montebello Forebay. Space is available for additional recharge 96 percent of the time. The spreading basins may not be available at times due to operational rules for these basins. Therefore, to evaluate the worst case scenario, the analysis assumes the use of injection wells for the Montebello Forebay.

West Coast Basin

The West Coast Basin lies within western Los Angeles County along the Pacific Coast. It underlies the service areas of four Metropolitan member agencies: West Basin MWD, City of Los Angeles, City of Torrance, and City of Long Beach.

The West Coast Basin adjudication (Judgment) was finalized in 1961. In December 2014, the West Coast Basin Judgment was amended, declaring water rights and providing provisions for the storage and extraction of stored water. Groundwater pumping in the West Coast Basin is currently below the full adjudicated rights in the basin.

Demand Analysis

Metropolitan demand projections for the West Coast Basin are based on Metropolitan's IRPSIM forecast (Sales Model 25d1). Current Metropolitan replenishment demand for the West Coast Basin is entirely for the seawater barriers, which is projected to be met entirely by local recycled water. This basin has no additional Metropolitan replenishment demand. Any demand met by the RRWP would be consumptive demand currently met by Metropolitan or other parties in the basin.

The Metropolitan consumptive demand for the City of Torrance and West Basin MWD ranges from 100 to 120 TAFY. Using existing well capacity, there is potential to increase groundwater production in the West Coast Basin by about 18 TAFY. The producers in this basin would need to increase their groundwater production above current levels and take less water from Metropolitan. Refineries that pump groundwater in the West Coast Basin are also a potential demand that could be converted to RRWP water. The refineries (Shell Oil, Phillips 66, Exxon Mobil, and Tesoro) pump an average of about 10 TAFY from this basin. Due to variations in deliveries, these refineries could take about 5 TAFY on a continuous basis.

In 2015, West Basin MWD delivered about 35 TAFY of recycled water for irrigation, industrial processes, and groundwater replenishment in the seawater barriers. Five different types of advanced treated recycled water are produced at the Edward C. Little Water Recycling Facility in El Segundo, which produces up to 45 TAFY (40 mgd) of recycled water. West Basin MWD is also looking at desalination in the West Coast Basin to replace some of the imported water demand. It is not anticipated to affect the program because there is more than 100 TAFY of Metropolitan demand in the West Coast Basin, more than enough to accommodate both projects.

Operational Assessment and Facility Needs

Spreading basins are not feasible in the West Coast Basin so the base case assumes that up to 15 new injection wells will be required. The use of injection wells is not affected by hydrology so recharge through injection wells can be used when spreading capacity is limited in other areas.

Groundwater Effects for Central and West Coast Basins

The WRD constructed and calibrated the groundwater model for the Central and West Coast basins. Both basins are incorporated into the same groundwater model, so the discussion below addresses both.

Groundwater Modeling

The existing WRD model was used for the groundwater modeling analyses. The model uses the United States Geological Survey (USGS) MODFLOW program (McDonald and Harbaugh, 1988; Harbaugh and McDonald, 1996), which was tailored to the Central and West Coast basins by the USGS. The model includes separate layers for the basins' four main aquifer systems.

Model Assumptions

The baseline scenario simulated groundwater conditions within both basins with existing levels of production and the inclusion of the WRD GRIP. Results from this modeling scenario (presented in Appendix C) were used to simulate groundwater conditions without the potential RRWP.

The model period of 1970–2010 was selected as the baseline scenario for the analysis. This provided for a long-term simulation of how the basin would respond to additional recharge during both wet and dry periods. A comparison between the baseline and base case scenarios assumptions is provided in Table 4.1.

Table 4.1: Summary of Baseline and Base Case for Central and West Coast Basins

Category	Baseline	Base Case
Time Period	1970–2010	1970–2010
Groundwater Production	Existing	Existing + 30 mgd
Groundwater Recharge	Existing	Existing + 30 mgd
Includes WRD GRIP	Yes	Yes

Central Basin Assumptions

The base case was used to simulate groundwater conditions in both basins with the inclusion of the potential RRWP on top of the baseline scenario. Although it is assumed that spreading capacity in the Montebello Forebay will be available for the proposed program, thirteen new injection wells (producing 13 TAFY) were modeled to evaluate the worst case scenario. The modeled location for the injection wells was in the deeper aquifer between the existing Rio Hondo and San Gabriel spreading grounds. In addition, the existing four Long Beach injection wells were modeled as injecting 4 TAFY.

Extraction was modeled as production from the Los Angeles Forebay area (10 TAFY from the LA Manhattan well field, which will happen with or without the project), Montebello Forebay Area (3 TAFY near the Montebello Forebay area from Liberty Water Company, Golden State Water Company, and California Water Service wells), and the Long Beach area (4 TAFY).

West Coast Basin Assumptions

The base case for the West Coast Basin includes up to 15 new injection wells near the JWPCP at a combined rate of 17 TAFY (15 mgd). The 17 TAFY would be extracted by the City of Torrance and sub-agencies of West Basin MWD.

Model Results

From the results of groundwater modeling for the Central and West Coast basins, it appears that the basins are capable of recharging 33 TAFY (30 mgd) of RRWP water. Figure 4.2 shows that the base case provides a general increase in groundwater elevation of up to 40 feet in the deep aquifer where water is recharged (shown in hydrographs C-4, C-7, and W-8 in Figure 4.2). Areas of water levels near well C-26 are shown as declining over the model period. This is because the increased production from the Manhattan well field, which will happen with or without the project, is not included in the baseline.

Travel Time Estimates

As shown in Figure 4.3, up to 5 production wells may have to be relocated in the Montebello Forebay if injection wells are used for recharge due to their proximity to the travel time envelope. At this time, the travel time requirement that will be approved is unknown, therefore 3-, 6-, and 12-month travel time envelopes are provided. If the existing spreading basins can be used, an opportunity to reduce the number of wells that will need to be replaced could exist. No wells would have to be replaced in the Long Beach area or the West Coast Basin well field.

Figure 4.2: Change in Groundwater Elevation from Baseline – Base Case

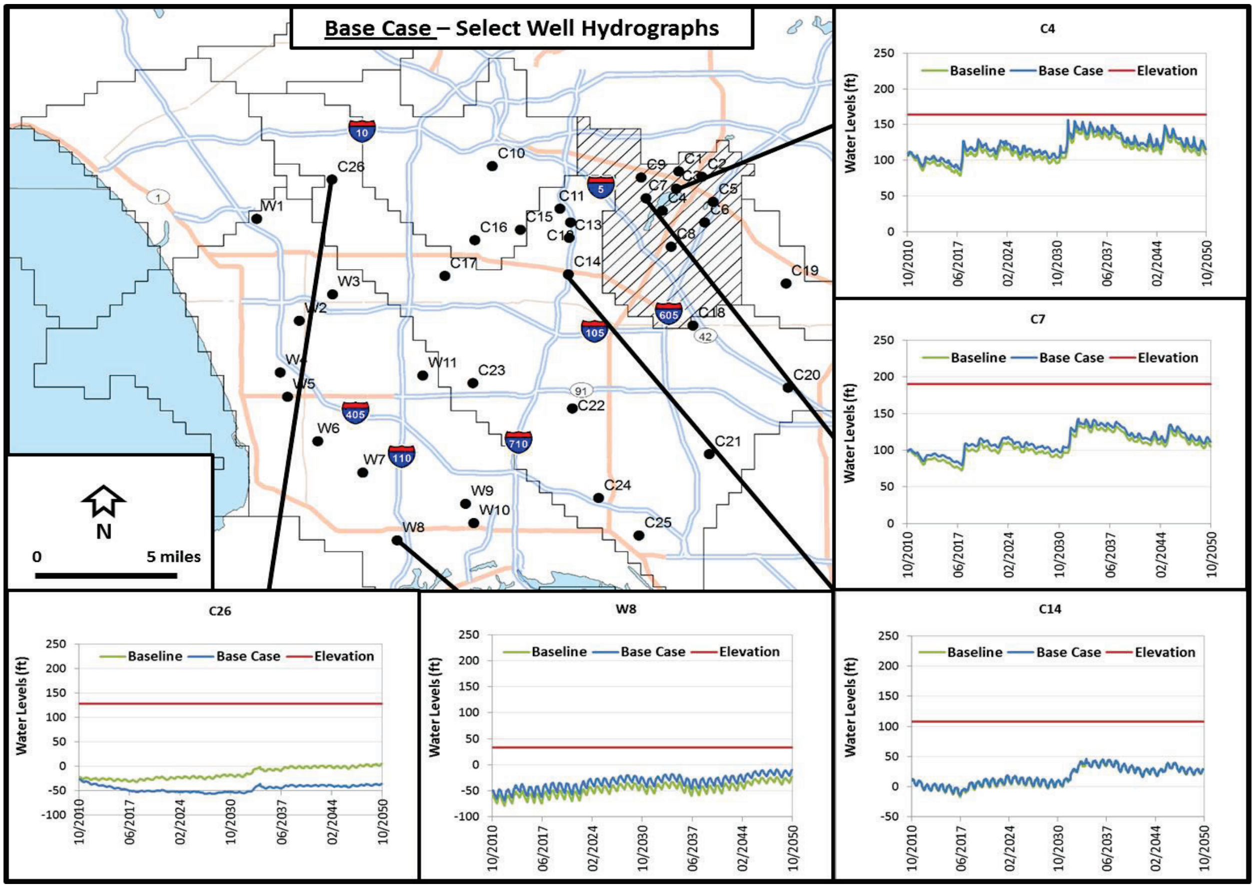
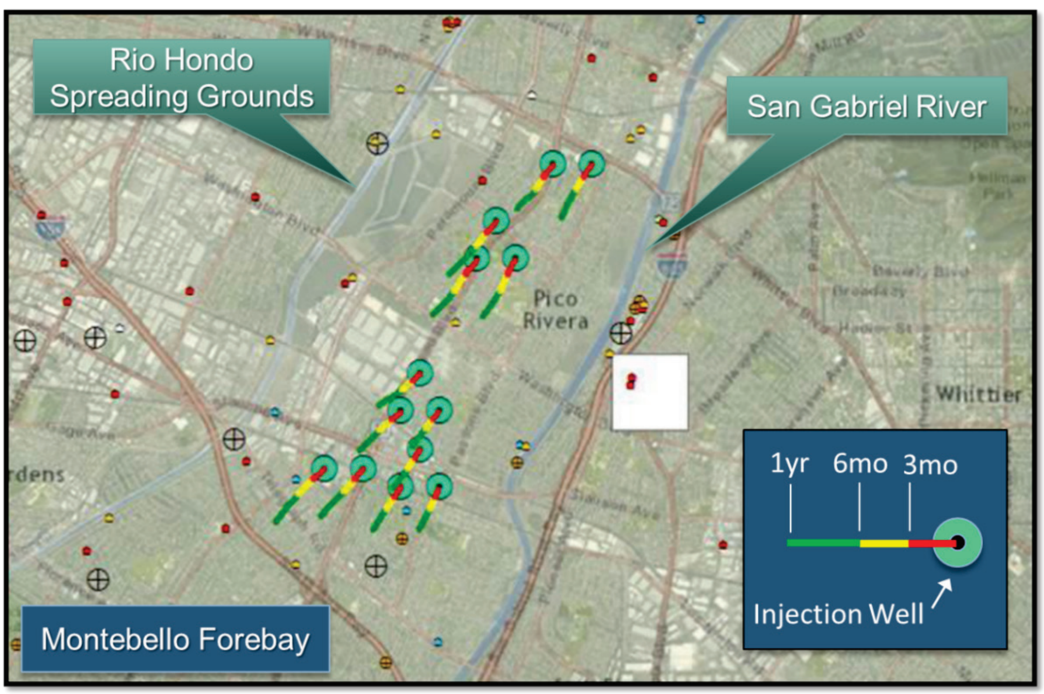


Figure 4.3: Travel Time Estimates for Montebello Forebay Area – Base Case



Main San Gabriel Basin

The Main San Gabriel Basin (Main Basin) lies in eastern Los Angeles County. Metropolitan member agencies overlying the Main Basin include the following: Upper San Gabriel Valley MWD (Upper District), Three Valleys MWD (Three Valleys), and the City of San Marino. San Gabriel Valley MWD (SGVMWD), a non-Metropolitan agency also overlies the Main Basin.

The Main Basin was adjudicated in 1973. Since the Main Basin Judgment was originally entered, it has been subsequently amended to extend and clarify the Watermaster's role.

Demand Analysis

Current deliveries of imported water to the Main Basin for groundwater replenishment are about 45 TAFY. However, the basin's water elevation continues to be in long-term decline. An additional 25 TAFY is anticipated to be required to maintain storage in the basin. Therefore, replenishment needs for the Main Basin are projected to be about 70 TAFY (62 mgd). In the event that the RRWP does not go forward, this demand will continue to be fulfilled by imported water from Metropolitan.

Operational Assessment and Facility Needs

About 100 TAFY of stormwater and about 45 TAFY of imported water from Metropolitan are currently spread in the Main Basin. The base case assumption for this basin is 70 TAFY (62 mgd) of spreading at the Santa Fe Spreading Grounds. The base case includes an additional 15 mgd (maximum total delivery of 77 mgd) to be delivered to the basin for up to 3 months per year when other spreading basins may be unable to accept additional recharge. Upper District is also considering an 11 TAFY (10 mgd) recycled water project using water from the San Jose Creek Water Reclamation Plant, which could reduce the demand for water from the potential program. The Upper District project is still in the early stages of development.

The Santa Fe Spreading Grounds has a long-term capacity of about 200 TAFY (178 mgd). Capacity is sufficient for spreading up to 86 TAFY (77 mgd) at Santa Fe at least 94 percent of the time. Unlike the other basins, recycled water has not been recharged in the Main Basin before.

During the late 1970s and early 1980s, significant groundwater contamination associated with various volatile organic compounds (VOCs) was discovered in the Main Basin. The US Environmental Protection Agency (USEPA) established operable units for areas within the basin that have been contaminated by VOCs and require groundwater cleanup. The operation of these operable units is key to the health of the basin. Detailed analysis to assess the potential for the RRWP to affect cleanup operations in operable units is beyond the scope of this feasibility study, but will be analyzed in future studies.

Groundwater Effects

Groundwater Modeling

Description of Model

For the modeling, the existing Main San Gabriel Watermaster model was used. The Watermaster's Groundwater Basin Flow Model was developed by Stetson (Stetson, 1997). The model is a two-dimensional finite-difference model, which uses a modified version of the Prickett-Lonquist Aquifer Simulation Model code.

Model Assumptions

The model period for this analysis is fiscal years 1998–2015. This period includes both wet and dry times, which provide a good estimate of the long-term feasibility of storing water in the basin. The following model runs were performed for the Main Basin:

- Baseline – This scenario evaluates the application of recharge water on a continuous basis at a rate equal to the long-term average imported replenishment demand.
- Base Case – This scenario evaluates the quantity of additional water that the groundwater basin could receive on a long-term continuous basis while maintaining groundwater elevations within a specific operational range.

A summary of Baseline and Base Case information for the Main San Gabriel Basin is provided in Table 4.2.

Table 4.2: Summary of Baseline and Base Case for the Main San Gabriel Basin

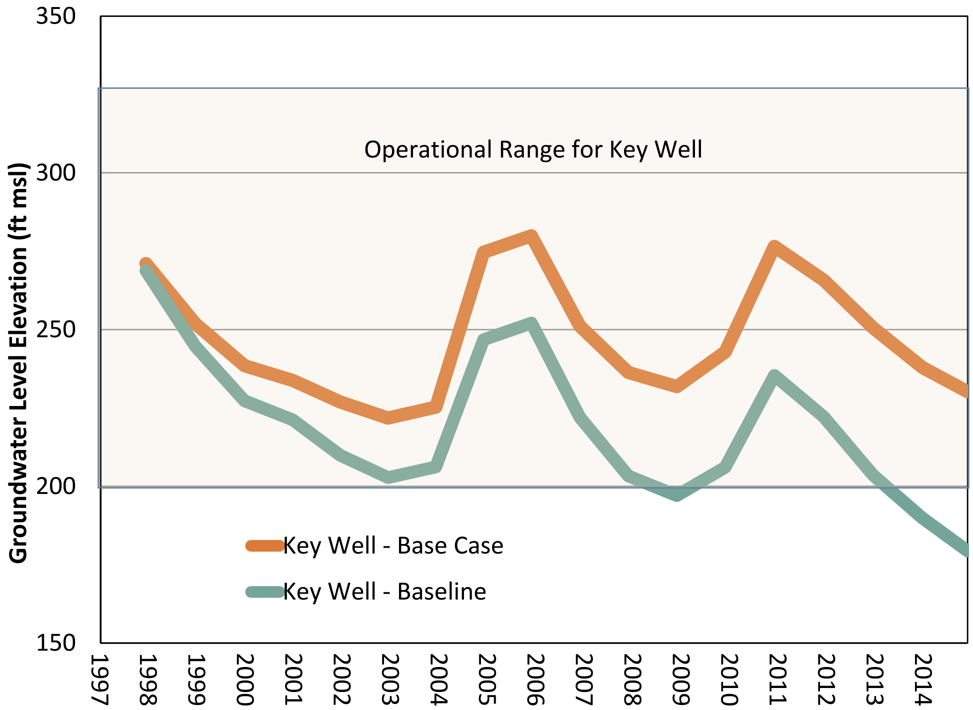
Category	Baseline	Base Case
Time Period	1998–2015	1998–2015
Groundwater Production	Existing	Existing
Groundwater Recharge	Existing	Existing + 22.5 mgd at Santa Fe

Model Results

Water Levels

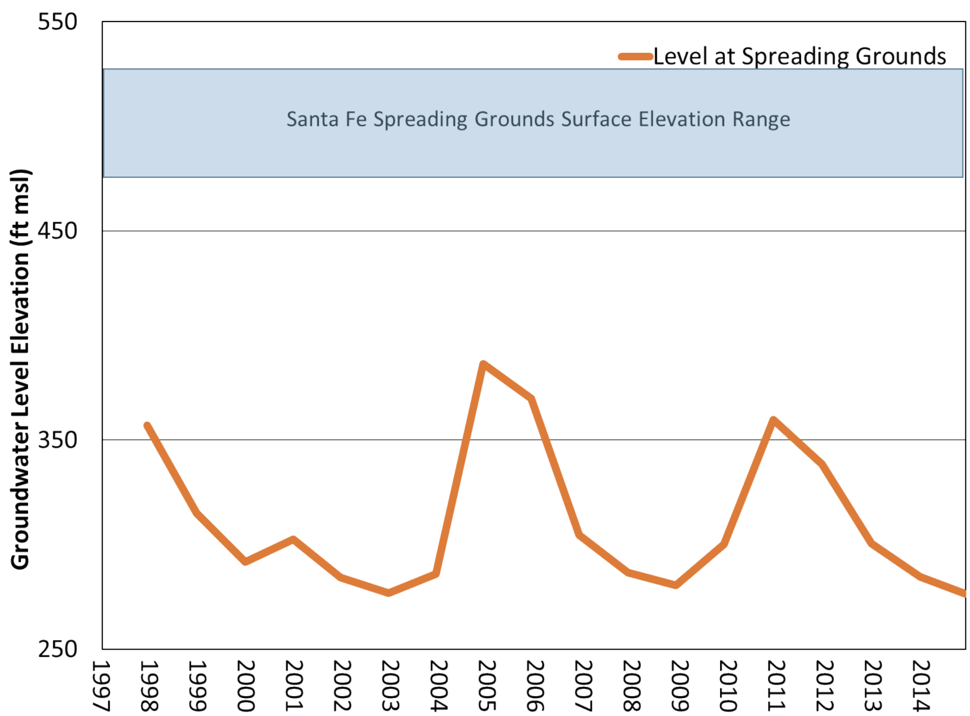
The following section provides the water level at the Baldwin Park Key Well and below the spreading grounds. The results are presented in Figure 4.4 and Figure 4.5.

Figure 4.4: Baldwin Park Key Well Model Results Long-Term Average Period – Base Case



msl = mean sea level

Figure 4.5: Santa Fe Spreading Grounds Model Results –
Base Case Level Below Spreading Grounds



msl = mean sea level

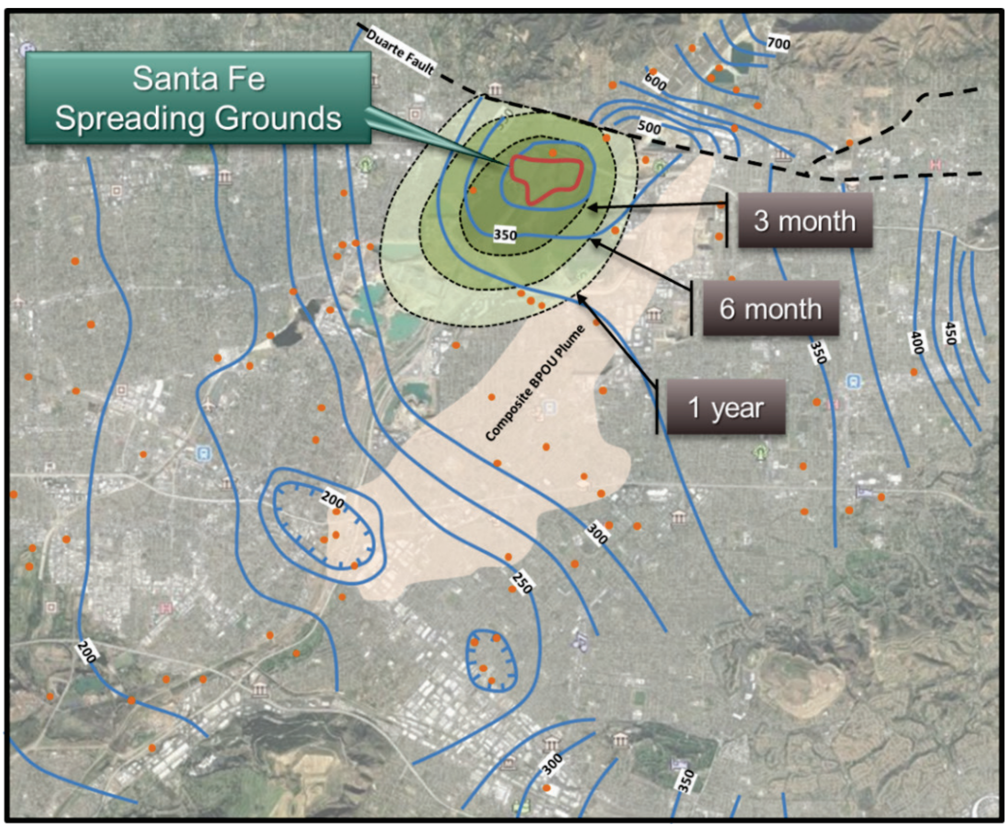
The long-term modeling results indicate that the groundwater basin can accommodate the recharge over the 18-year modeled period. The continuous recharge of 70 TAFY (62.5 mgd) could result in a cumulative increase in water level of about 50 feet, which is well within the operating range. It is important to note that with the additional recharge, the modeled water level at the key well at the end of the model period is 40 feet below the starting point in the model run. In addition, water levels are 100+ feet below the spreading grounds and are not expected to be high enough to affect recharge.

Travel Time Estimates

The travel time estimates are shown in Figure 4.6. As many as seven wells within the 12-month travel time envelope may have to be relocated.

From the results of groundwater modeling for the Main Basin, it appears that the basin is capable of receiving the full 70 TAFY (62.5 mgd) of RRWP water for recharge with the occasional application of 86 TAFY (77 mgd) during wet periods or when other spreading areas are unable to recharge water. The changes in water level are within the range of water levels seen in the past and are not anticipated to affect producers or the operable units in the basin. Future studies will analyze the water quality effects of recharge to the operable units.

Figure 4.6: Travel Time Estimates for the Main San Gabriel Basin – Base Case



Orange County Basin

The Orange County Basin is located in north and central Orange County within the lower Santa Ana River watershed. Metropolitan member agencies that overlie this basin include the cities of Anaheim, Fullerton, and Santa Ana, and the Municipal Water District of Orange County. The Orange County Water District (OCWD) has managed the basin since 1933 pursuant to a special act of the state Legislature.

Metropolitan also has a conjunctive use account in the Orange County Basin. Total storage amount in this program is 66,000 AF. Imported water from Metropolitan is stored during times when available and extracted when needed.

Demand Analysis

The current amount of imported water delivered for replenishment in the Orange County Basin is 65 TAFY, which could be supplied through the RRWP. If the RRWP does not move forward, imported water from Metropolitan would continue to meet this demand, as imported water is still available. OCWD is continuing to look at a variety of other local projects.

Operational Assessment and Facility Needs

Currently, the OCWD spreads about 37 TAFY of recycled water from its Groundwater Replenishment System (GWRS) facility and about 150 TAFY of stormwater from the Santa Ana River into the Orange County Basin. The OCWD expects to purchase about 65 TAFY (58 mgd) of imported water from Metropolitan going forward. Spreading basins owned by the OCWD have the capacity to receive all of the 65 TAFY of additional recharge from the RRWP during normal and dry periods, particularly during the summer months. However, during wet periods and some winter months, the existing spreading basins (Mira Loma, Kraemer, Miller, and La Palma) may be limited to 22 TAFY (20 mgd) of additional recharge. An additional spreading basin was used for modeling purposes, however, the flexible operations included in the base case scenario would allow Metropolitan to maximize use of available recharge capacity within existing spreading facilities for the Orange County Basin.

Groundwater Effects

Groundwater Modeling

Description of Model

The OCWD's basin model encompasses the entire basin and extends approximately 5 miles into the Central Basin in Los Angeles County. The widely accepted computer program MODFLOW, developed by the USGS, was used as the base modeling code for the mathematical model.

Model Assumptions

To evaluate the worst-case impacts on the Orange County Basin, the model run for Orange County Basin simulated the recharge of 17 TAFY (15 mgd) of RRWP water in the OCWD's existing spreading basins with the remaining 48 TAFY (43 mgd) of RRWP water recharged through a simulated additional spreading basin. The model baseline also includes the additional recharge from the Phase 3 GWRS. A 10-year wet period (1990–2000) was used to simulate conservative basin capacity to receive purified water.

A summary of Baseline and Base Case information for the Orange County Basin is provided in Table 4.3.

Table 4.3: Summary of Baseline and Base Case for Orange County Basin

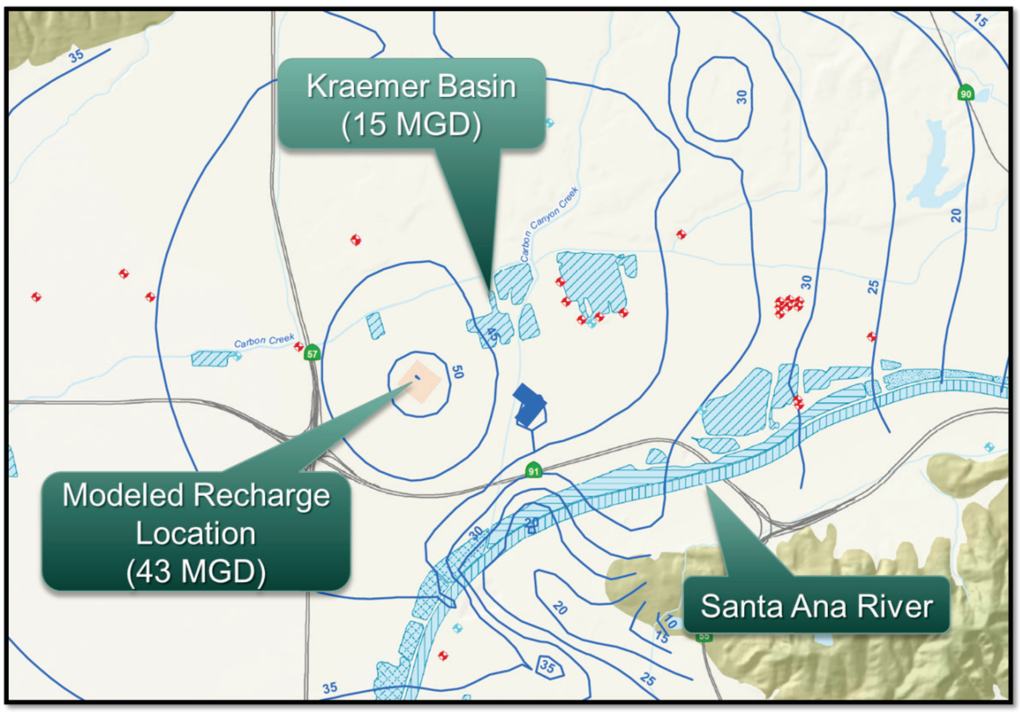
Category	Baseline	Base Case
Time Period	1990–2000	1990–2000
Groundwater Production	Existing	Existing
Groundwater Recharge	Existing (including Phase 3 GWRS Expansion)	- Same as existing except water is delivered continuously - Simulated spreading basin added as modeling location

Model Results

<u>Water Levels</u>

Figure 4.7 illustrates the effect of additional recharge in the Orange County Basin. The groundwater mound attributed to the program is approximately 50 feet near the area of the simulated spreading basin. The model also shows water level increases of about 20 to 30 feet near the Santa Ana River.

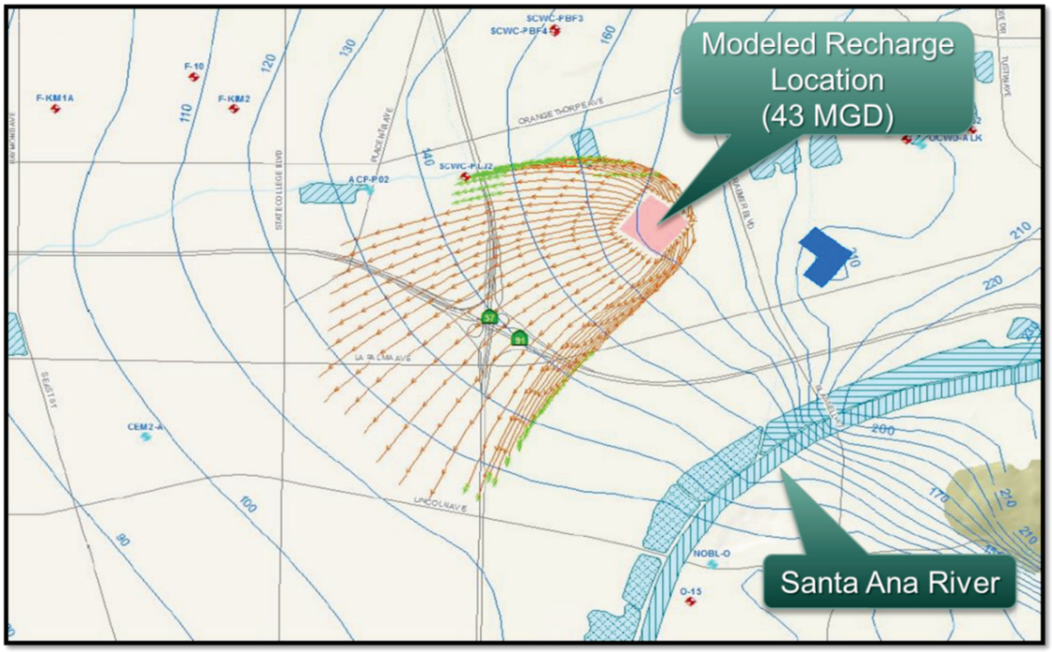
Figure 4.7: Change in Groundwater Elevation Contours Attributed to Potential RRWP



<u>Travel Time Estimates</u>

The travel time estimates are shown in Figure 4.8. Only one groundwater production well appears to be within a travel time of up to 12 months from the simulated spreading basin.

Figure 4.8: Travel Time Estimates for Orange County Basin – Base Case



Note: Each arrow represents approximately 1 month of travel time. The orange arrows are travel time in the shallow aquifer and the green arrows are travel times in the deep aquifer.

Summary

Defining the Base Case Scenario

The base case was determined from an evaluation of potential demands for recharge water in four groundwater basins (Orange County, Central, West Coast, and Main San Gabriel). The analysis determined locations for groundwater recharge and the estimated flow rates. The recharge demand, locations, and flow rates were used to estimate the sizing of facilities for the base case scenario, including the AWT facility, pump stations, pipelines, injection wells, and spreading basins.

The base case includes primarily existing or projected replenishment water needs as shown in Table 4.4. Eighty-eight percent of the proposed recharge amounts would meet existing recharge needs. The remaining 12 percent is consumptive demand that could be converted from imported water to RRWP water.

The base case of up to 150 mgd (summarized in Figure 4.9 and Figure 4.10) assumes constant output from the AWT facility would be allocated among the four groundwater basins as shown in Table 4.4.

Table 4.4: Base Case Recharge Rates – 150 mgd

	Recharge Rate (mgd)	Recharge Rate (TAFY)
West Coast Groundwater Basin	0–**15**	0–**17**
Central Groundwater Basin	0–**15**	0–**17**
Main San Gabriel Basin	**62**–77	**70**–85
Orange County Groundwater Basin	18–**58**	20–**65**
Total (numbers in **bold** equal total)	**150**	**169**

Metropolitan recognizes that occasionally one or more of the groundwater basins might not be able to recharge water for short periods of time. For this reason, the base case scenario includes flexible operations. The AWT facility was assumed to be operated in a range between 110 to 150 mgd with maximum production about 85 percent of the time. This provides flexibility in other areas of the system.

Figure 4.9: Base Case Recharge Rates – 150 mgd

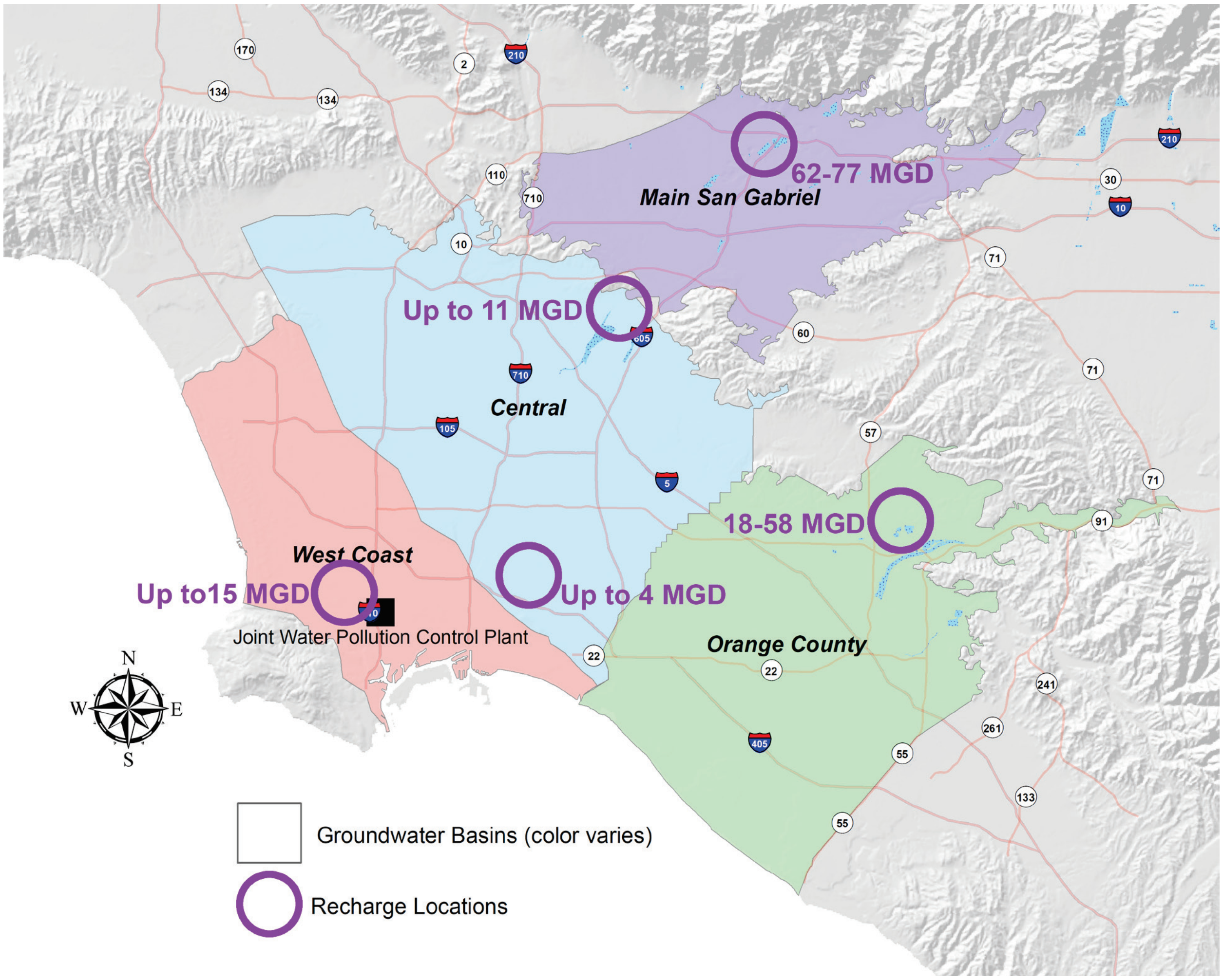
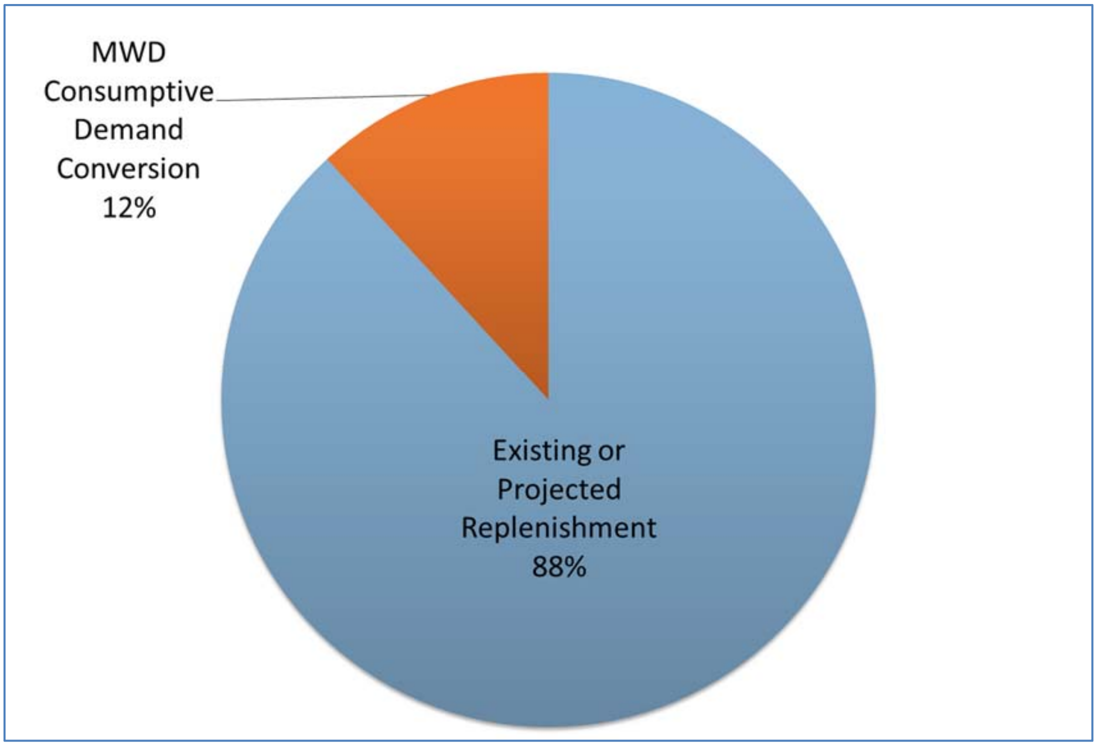


Figure 4.10: Type of Demand in the Base Case



Facilities Required for Groundwater Basins

Each of the groundwater basins was evaluated relative to the existing facilities and capabilities to recharge the basin with purified water from the potential RRWP. The results of the groundwater modeling were also used to determine the need for new facilities to recharge and extract water from the groundwater basins with this new source of water on a year-round basis. Table 4.5 summarizes the facilities, both new and existing, needed for the base case.

Table 4.5: Facilities Needed for Groundwater Recharge

Groundwater Basin	Facilities Needed
West Coast	• Up to 15 new injection wells • Up to 6 monitoring wells
Central	• Up to 13 new injection wells • Existing injection wells in Long Beach • Up to 5 new extraction wells relocated • Up to 6 monitoring wells
Main San Gabriel	• Existing Santa Fe Spreading Grounds • Up to 7 new extraction wells relocated • Up to 6 monitoring wells
Orange County	• Existing Orange County Spreading Grounds • Up to 1 new extraction well relocated • Up to 6 monitoring wells

4.3 Summary of Groundwater Basin Analysis

The groundwater basin analysis considered demand, operational issues, and facility capacity and needs. The results are summarized in Table 4.6.

Table 4.6: Summary of Groundwater Basin Analysis

Groundwater Basin	Is there sufficient demand?	Are there operational issues?	Does modeling suggest program is feasible?	What facilities would be required?
West Coast	Yes	Pumping capacity could be limiting factor	Yes	Up to 15 new injection wells
Central	Yes	None	Yes	Up to 5 new extraction wells (relocated) Up to 13 new injection wells
Main San Gabriel	Yes	None	Yes	Up to 7 new extraction wells (relocated)
Orange County	Yes	Recharge capacity limited in winter	Yes	Up to 1 new extraction well (relocated)

The results of the groundwater analysis and modeling confirmed that collectively, the basins have sufficient groundwater recharge demand and capacity for the year-round delivery of up to 150 mgd of purified water through the RRWP. A systemwide analysis determined the locations and estimated flow rates for groundwater recharge. Due to seasonal or operational issues, one or more of the groundwater basins may not be able to recharge the maximum amounts for short periods. Therefore, the facilities should be designed to accommodate a range of flow conditions and have the ability to move water to different groundwater basins. Table 4.4 presents the estimated range of flows to each basin for groundwater recharge and Figure 4.9 presents the locations and range of flow rates to each of the four basins.

4.4 Institutional Arrangements

Institutional arrangements for the storage, recharge, and extraction of RRWP water, as well as the acquisition of regulatory approvals and permits, are an important part of the proposed program. The arrangements can be complex and may involve multiple parties with multiple points of view. Therefore, engagement with these parties early on in the process is important. Institutional arrangements that may be required for each groundwater basin are outlined in Table 4.7.

Table 4.7: Summary of Institutional Arrangements

Basin	County	Agencies	Arrangements/Permits Needed
Central Basin	Los Angeles	WRD	Groundwater Modeling Agreement Coordination of Recharge
		Central Basin MWD	Institutional Arrangements
		California Water Service Golden State Water Company Liberty Water Company	Groundwater Pumping Arrangements
		City of Long Beach	Institutional Arrangements
		City of Los Angeles	Institutional Arrangements
		Los Angeles County Public Works	Operating Agreement
		Los Angeles RWQCB, Region 4	NPDES Permit Water Recycling Requirements/Permit
		DDW	Water Recycling Requirements/Permit
		Central Basin Watermaster	Approval of Storage and Extraction
West Coast Basin	Los Angeles	WRD	Groundwater Modeling Agreement Coordination of Recharge
		West Basin MWD	Institutional Arrangements
		California Water Service Golden State Water Company City of Inglewood City of Lomita City of Manhattan Beach	Groundwater Pumping Arrangements
		City of Torrance	Institutional Arrangements
		City of Los Angeles/Refineries	Institutional Arrangements
		Los Angeles RWQCB, Region 4	NPDES Permit Recycled Water Recharge Permit
		DDW	Recycled Water Recharge Permit
		West Coast Basin Watermaster	Approval of Storage and Extraction
Main San Gabriel Basin	Los Angeles	Main San Gabriel Watermaster	Approval of Storage and Extraction (a supplemental storage arrangement is required – could be part of cyclic storage) Groundwater Modeling Agreement
		Upper San Gabriel Valley MWD	Institutional Arrangements
		Three Valleys MWD	Institutional Arrangements
		SGVMWD	Institutional Arrangements
		Los Angeles County Public Works	Coordination of Recharge
		Los Angeles RWQCB, Region 4	NPDES Permit Recycled Water Recharge Permit
		DDW	Recycled Water Recharge Permit
Orange County Basin	Orange	OCWD	Approval of Storage and Extraction Groundwater Modeling Agreement
		Municipal Water District of Orange County	Institutional Arrangements
		Santa Ana RWQCB, Region 8	NPDES Permit Recycled Water Recharge Permit
		DDW	Recycled Water Recharge Permit

4.5 Potential Risks

The recharge of groundwater basins with a new water supply can create some challenges and issues that have not been previously encountered. The groundwater analysis conducted for this study concluded that there is sufficient demand and capacity in the groundwater basins for the base case scenario. However, potential groundwater quality and operational issues and risks should be evaluated in future studies. Chapter 11 includes a recommended next step to conduct additional groundwater modeling investigations focused on water quality issues. These studies are needed to further facilities and operations planning within the groundwater basins.

Groundwater Quality

The feasibility analysis performed for this study did not analyze the impacts to existing groundwater contamination plumes or operable treatment units. The highest impact and risk could be in the Main San Gabriel and Orange County basins, where the most water is being recharged. There have been successes in recharging recycled water in the Central, West Coast, and Orange County basins for many years. This long history of successful recycled water recharge reduces the risk of an outcome where contamination plumes would be impaired.

There is also a risk of water quality incompatibility between the purified water and local groundwater, particularly in injection wells and/or recharge areas that have never received recycled water. Potential effects due to the introduction of this new water supply include biofouling, clogging, reduced injection and/or spreading rates, and aquifer leaching. Water quality tests and modeling could be performed in the future to evaluate the compatibility of water supplies in the groundwater basins.

Operational Issues

Potential conflicts exist with other sources of water, especially in spreading basins where multiple sources of water are spread. In the Central and Orange County basins, imported water, stormwater, and recycled water are all currently spread. All of these activities will require coordination among the respective agencies to ensure that the spreading operations for each of these water sources are achieved. There could also be competing interests for spreading operations. As an example, in the Montebello Forebay, stormwater capture is a priority. Thus, during rainfall events, all supplemental recharge operations that are not stormwater are suspended.

The potential program also hinges on the willingness of partnering agencies to enter into institutional arrangements to store and extract RRWP water. For the program to work, the agencies must pump out the water that is stored via the program. In the West Coast Basin and within the City of Los Angeles' service area, adjudicated groundwater rights have not been pumped for years. There is a risk that the agencies that are not pumping now will not do so under the potential program. These risks can be mitigated with the execution of institutional arrangements for the recharge and extraction of RRWP water.

Chapter 5

Advanced Water Treatment Facility

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5.0 ADVANCED WATER TREATMENT FACILITY

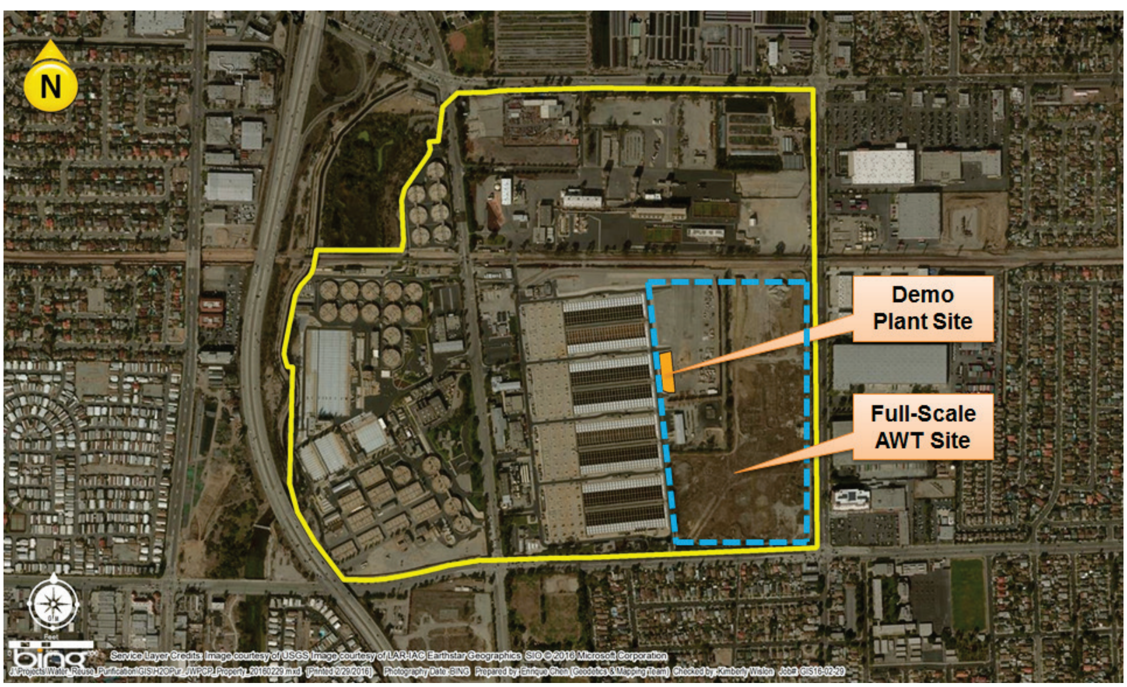
5.1 Overview

The new full-scale AWT facility would receive unchlorinated non-nitrified secondary effluent from the JWPCP. Flow equalization would be provided for the secondary effluent to ensure a constant feed to the AWT facility. The design capacity (product flow) of the base case AWT facility is 150 mgd. As shown in Figure 5.1, AWT facilities would be located adjacent to the secondary treatment facilities at the JWPCP.

Pilot testing of advanced treatment processes was conducted jointly by Metropolitan and the Sanitation Districts at the JWPCP between 2010 and 2012. The testing successfully demonstrated treatment of JWPCP secondary effluent with advanced processes such as a membrane bioreactor (MBR), reverse osmosis (RO), and advanced oxidation processes (AOP) to produce high-quality recycled water that consistently met the water quality criteria for groundwater recharge and other applicable regulatory limits. The MBR in particular is effective in removing biodegradable organic matter and provides necessary pretreatment to reduce downstream membrane fouling. Additional discussion on the pilot study is included in Chapter 7.

A demonstration facility is currently under design and will build on the successes and lessons learned from the pilot study to further refine and optimize the design, operation, and monitoring needs for the proposed advanced treatment processes. The results of the demonstration testing will be used to obtain regulatory approval for achieving the required pathogen log reduction credits with the MBR and to establish the basis of design for the AWT facility, which would be the largest potable reuse facility in the United States treating non-nitrified secondary effluent. As described in Chapter 8, the demonstration facility will also serve as an important educational and public outreach tool.

Figure 5.1: Proposed Location of AWT Facilities at JWPCP



5.2 JWPCP Overview

JWPCP is the largest facility within the Sanitation Districts' Joint Outfall System (JOS), with an average dry-weather design capacity of 400 mgd. Existing wastewater treatment processes include bar screens, grit chambers, primary sedimentation, pure-oxygen activated sludge secondary treatment, secondary clarification, anaerobic digestion, and sludge dewatering. These unit processes are designed and operated to ensure that the plant effluent quality meets ocean discharge permit requirements. Treated wastewater is disinfected with sodium hypochlorite prior to discharge to the Pacific Ocean.

Solids generated from primary and secondary treatment are processed in anaerobic digesters where bacteria break down organic material and produce methane gas, which is used to produce power and heat. The on-site cogeneration facility produces the electricity to support all JWPCP operations. Digested solids are dewatered and hauled off-site for composting and land application, or combined with municipal solid waste for co-disposal.

JWPCP Flows

JWPCP receives wastewater from approximately 3.5 million residents, numerous commercial businesses, and more than 1,500 permitted industrial users. Approximately 19 percent of the flow entering the JWPCP is from industrial sources. The average annual industrial contribution in terms of chemical oxygen demand (COD) loading (lb/yr COD) is about 30 percent of the total, based on monthly average flows and concentrations. Four of the six largest industrial dischargers are oil refineries. Other major types of discharge include food, textile, and steel manufacturing; water treatment; and oil production fields. Discharges into the JOS from the permitted discharges are regulated and monitored by the Sanitation Districts to ensure satisfactory operation of the JWPCP treatment process and collection system in compliance with state and federal regulations on discharge and effluent requirements.

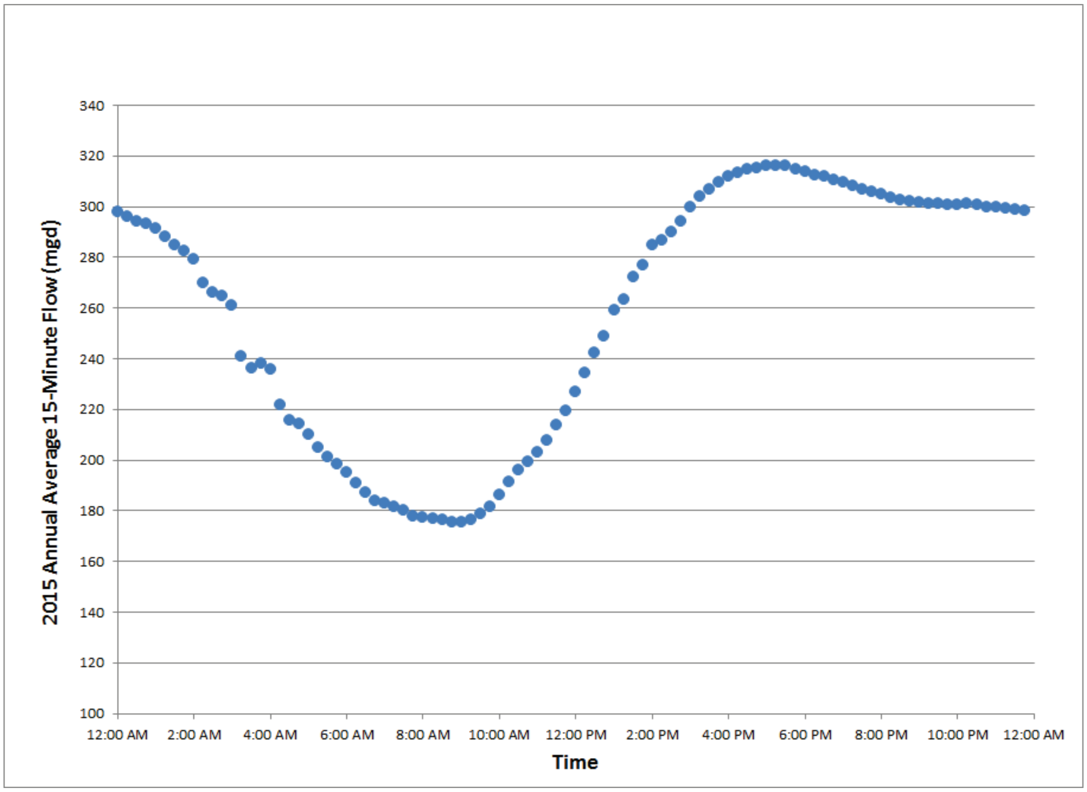
JWPCP currently produces an average dry weather flow of 260 mgd (2015 data) of non-nitrified secondary effluent in compliance with its National Pollutant Discharge Elimination System (NPDES) permit limits and mass emission benchmarks. Primarily due to water conservation, the influent flow to the JWPCP is decreasing and the secondary effluent available to the AWT facility would likely decrease further in the future. For 2050, the Sanitation Districts project a minimum influent flow of 100 mgd, average dry weather flow of 247 mgd, and maximum flow of 700 mgd, including stormwater inflow/infiltration, at the JWPCP. The decreasing wastewater flow trend will be further evaluated during conceptual design of the full-scale AWT facility before finalizing the facility sizing.

Wet weather peak flows at the JWPCP generated by storms were not considered to be available for reuse under the RRWP due to the unpredictable nature of their occurrence, large volume, and the lack of on-site storage.

Flow Equalization

Based on an estimated overall recovery rate of 79 percent through the AWT processes, the AWT facility would require a constant supply of nearly 190 mgd of secondary effluent from the JWPCP in order to produce 150 mgd of purified water. As shown in Figure 5.2, the JWPCP has a diurnal flow pattern with low flows typically occurring in the morning, from 6 a.m. to noon. The Sanitation Districts evaluated the diurnal flow data between January 1, 2015, and December 31, 2015, recorded at 15-minute intervals using Venturi flow meters in the secondary effluent discharge channel.

Figure 5.2: JWPCP Diurnal Flow Cycle



Source: Sanitation Districts of Los Angeles County, August 2016

The JWPCP would have been able to supply the minimum flow needed to produce 150 mgd of product water for approximately 68 days out of the year in 2015 without flow equalization. Some amount of flow equalization would have been required during low-flow periods in the diurnal cycle for approximately 297 days out of the year[1]. Consequently, the base case assumes that flow equalization would be needed upstream of the AWT facility to maintain the 150-mgd water production on a year-round basis. Some flow equalization could be provided within existing tankage at the JWPCP.

The Sanitation Districts recently evaluated on-site options for flow equalization and identified the potential use of one secondary clarifier train at the JWPCP for flow equalization during low diurnal flow periods. One train (26 clarifiers) is estimated to provide about 10.3 million gallons (MG) of equalization capacity, which would be sufficient on all but 25 days out of the year based on hydraulic modeling. During these 25 days, a minimum daily volume of 2.1 MG would be required from another storage option. Because the AWT facility would be designed to allow flow attenuation through turndown of the unit processes or adequate break tank capacity to accommodate flow changes, no additional storage should be required[2]. To convert the train for storage, the Sanitation Districts would need to modify the return-activated sludge pump station discharge piping, automate the sluice gate in the clarifier channel,

[1] Sanitation Districts of Los Angeles County, 2016. *JWPCP Clarifier Storage for AWTF Makeup Flows Memorandum*. Whittier, CA. 2016.
[2] Ibid.

and install submersible pumps to fill the clarifier. Further analysis will be conducted during preliminary design to confirm the capacity and location of needed flow equalization.

JWPCP Secondary Effluent Characteristics

The JWPCP currently operates a high-purity oxygen-activated sludge system at a low solids retention time (SRT) to produce non-nitrified secondary treated wastewater. The median effluent concentrations for key constituents are presented in Table 5.1. These measurements were taken at bi-weekly intervals (at a minimum) over a period of 15 months during the pilot study between 2010 and 2012.

Table 5.1: JWPCP Secondary Effluent Characteristics

Parameter	Units	Median Concentration
Alkalinity	mg/L as $CaCO_3$	372
Ammonia	mg/L-N	37
Total Organic Nitrogen	mg/L-N	2.5
Total Kjeldahl Nitrogen (TKN)	mg/L-N	40
Nitrate + Nitrite	mg/L-N	< 0.1
pH	–	7.1
Total Dissolved Solids (TDS)	mg/L	1,400
Total Organic Carbon (TOC)	mg/L	16
Chemical Oxygen Demand (COD), Total	mg/L	54
Boron, Total	mg/L	0.88
Phosphate	mg/L-P	0.50
1,4-Dioxane	µg/L	8.9
Nitrosodimethylamine (NDMA)	ng/L	340 (1)

Sources: JWPCP NPDES Annual Monitoring Reports; "Joint Water Purification Pilot Program: Pilot Study of Advanced Treatment Processes to Recycle JWPCP Secondary Effluent – Final Report," Sanitation Districts and Metropolitan, 2012.

(1) The Sanitation Districts identified potential data quality issues involving low-level Gas Chromatograph–Mass Spectrometer analyses of NDMA and other nitrosamines as well as selected constituents of emerging concern (CECs) (i.e., galaxolide, tonalide, fipronil, and polybrominated diphenyl ethers). The Sanitation Districts notified regulatory agencies and took immediate action to remedy the issue, and new data will be provided prior to establishing the AWT design criteria.

The pilot study described in Section 5.1 and Chapter 7 did not report on the levels of biochemical oxygen demand (BOD), which are generally between 2 and 4 mg/L. Some low molecular weight fatty acids were detected in the secondary influent during a sampling event in July 2016, ranging from 68 to 117 mg/L. As they are readily biodegradable, no measurable amount of low molecular weight fatty acids is expected to exist in JWPCP's secondary effluent. Table 5.2 shows the concentrations of VOCs reported during the pilot study. The wide range of methyl tert-butyl ether (MTBE) in the secondary effluent is mostly likely due to variations in the plant influent water quality.

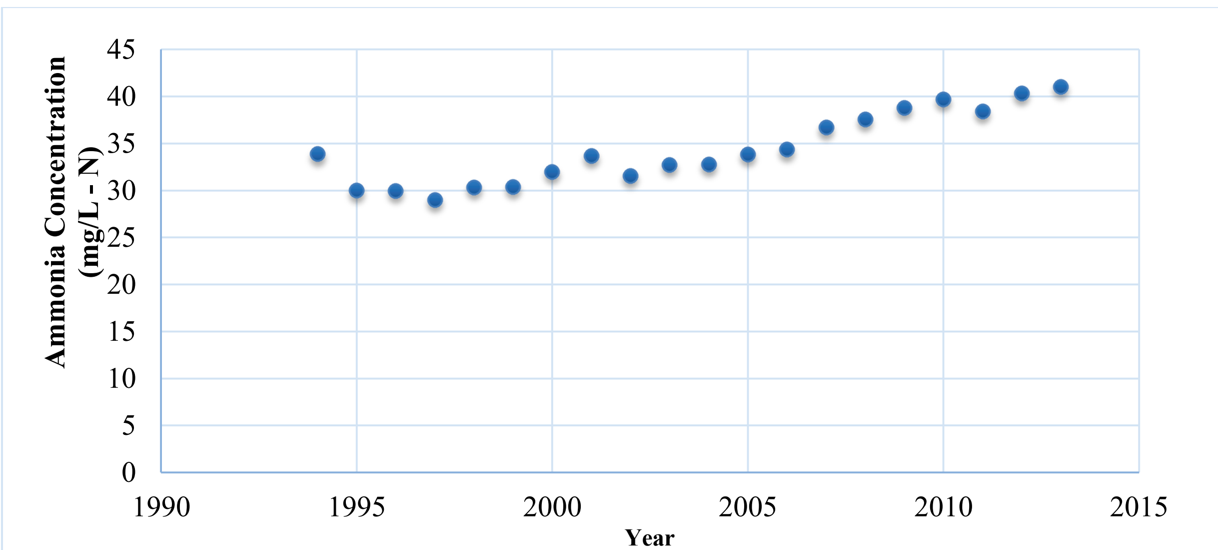
As shown in Table 5.1, the JWPCP secondary effluent has relatively high concentrations of ammonia and boron. The median ammonia concentration of 37 mg/L-N is due to low per-capita water use and the low SRT without nitrification in the secondary process. The median boron concentration of 0.88 mg/L may be attributable to industrial discharges within the JWPCP sewer-shed, which are currently being investigated by the Sanitation Districts.

Table 5.2: Volatile Organic Compounds in JWPCP Secondary Effluent

Constituent	Median (µg/L)	Range (µg/L)
Dibromomethane	0.67	0.58–0.71
Bromochloromethane	0.66	0.54–0.94
Dichloromethane	2.95	2.3–5.3
Chloroform	11	8.8–12
Total Trihalomethanes	11	8.8–13
MTBE	0.86	0.7–17

Figure 5.3 shows the historical levels of ammonia in the JWPCP secondary effluent. In general, ammonia concentrations have increased by approximately 25 percent over the last decade. A 10 percent increase of ammonia concentrations was also observed during the 2-year pilot study. The full-scale facility would be conservatively designed to account for a TKN concentration of up to 50 mg/L to allow for any future ammonia increases and a low concentration of dissolved organic nitrogen.

Figure 5.3: JWPCP Historical Annual Average Effluent Ammonia Concentrations



Although most key constituents listed will be removed through AWT processes, both nitrogen and boron will have a substantial impact on AWT design. Nitrogen removal will be necessary to achieve the basin recharge requirements. Although the RO process is expected to achieve some removal of boron, source control or further treatment prior to groundwater basin recharge may be required to achieve the Main San Gabriel Basin objective for boron. Section 5.4 further addresses nitrogen and boron management.

Source Control

The Sanitation Districts currently implement an extensive, well-established source control program upstream of each of their plants to maintain and enhance their wastewater treatment systems and ensure that the plants continue to protect public health and the environment. The program focuses on protecting the collection system and treatment plant and preserving downstream receiving waters. The program includes a comprehensive industrial pretreatment and source control program, public outreach and policy development, and a proactive source investigation and monitoring program.

While the industrial pretreatment program was formally approved by USEPA in 1985, it started well before that. In 1972, the Wastewater Ordinance was adopted, which gave the Sanitation Districts the strict legal authority to fully control industrial dischargers. The ordinance allows the Sanitation Districts to regulate for a broad spectrum of pollutants and is regularly evaluated to make sure it aligns with program objectives. The ordinance includes categorical and industry limits, which are specific to certain industry types, as well as local limits which are applied to all industrial and commercial dischargers.

The Sanitation Districts' program is one of the largest industrial waste programs in the country. It has an annual budget of more than $12 million and employs 67 staff, including 24 engineers, 29 inspectors, and 7 technicians. The Sanitation Districts permit more than 2,100 industries from a variety of different industrial categories. Due to the large number of industrial users and the diversity of the industrial base, the Sanitation Districts' pretreatment program has been enhanced through the use of computer-automated permitting, inspection, and compliance programs that allow for tracking, assessment, notification, and enforcement of applicable regulations.

Under the RRWP, the JWPCP will transition from functioning solely as an ocean discharge plant to a facility that provides water reclamation in addition to ocean discharge capabilities. As a source of recycled water to a groundwater recharge project, the Sanitation Districts will be responsible for administering a comprehensive source control program similar to that which takes place at its existing seven reclamation plants that are upstream of the JWPCP. Such a program for the RRWP will include the following: (1) an assessment of the fate of contaminants specified by the DDW and the RWQCB through the wastewater and recycled water systems; (2) provisions for contaminant source investigations and contaminant monitoring that focus on these contaminants; (3) an outreach program to industrial, commercial, and residential communities; and (4) an up-to-date inventory of contaminants. Because of the use of JWPCP secondary effluent as a source of water for IPR, the existing JWPCP source control strategies will be reviewed and assessed throughout the implementation of the RRWP to determine if modifications and enhancements are necessary to safeguard AWT processes and protect end-users.

Title 22 Articles 5.1 and 5.2 of the California Code of Regulations (22 CCR 5.1 and 5.2) provide wastewater source control requirements for groundwater replenishment projects using recycled water. The Sanitation Districts will comply with these source control requirements and will continue regular source monitoring and investigations that focus on chemicals and contaminants specified by the DDW and the RWQCBs. Furthermore, the Sanitation Districts will continue to take a proactive approach, tracking chemicals and contaminants resulting from new sources or changes to existing sources that may impact water quality. Because meeting the drinking water requirements is essential to this project, the Sanitation Districts will also routinely conduct source monitoring for drinking water constituents, both regulated and unregulated.

5.3 AWT Product Water Quality Goals

Water produced from the AWT facility would be used to recharge four groundwater basins in Los Angeles and Orange counties. The DDW has specific requirements for groundwater recharge by surface spreading or subsurface application. Based on these requirements, the AWT product water must meet drinking water Maximum Contaminant Levels (MCLs) and must comply with Notification Levels (NLs), as described in Chapter 7. The AWT processes must also achieve 12/10/10 log reduction for enteric virus, *Cryptosporidium*, and *Giardia*, respectively. The DDW specifies total nitrogen (TN) concentrations equal to or less than 10 mg/L-N; however, the nitrate requirements for some of the basins (rather than the DDW's TN requirements) would govern the design. The AWT facility would be required to achieve 0.5-log reduction of 1,4-dioxane, and NLs of 10 ng/L for nitrosodimethylamine (NDMA), nitrosodipropylamine (NDPA) and nitrosodiethylamine (NDEA). The requirements for TOC differ for surface spreading and subsurface injection. However, use of RO would ensure that the DDW's TOC requirements are always met, as RO would reduce TOC levels in the effluent to less than 0.5 mg/L.

In addition to the DDW's requirements, the RWQCBs have also established water quality goals for basin recharge. Table 5.3 shows the governing water quality requirements for key constituents and their corresponding basins. Chapter 7 provides further discussion of regulations applicable to IPR projects.

Table 5.3: Key Water Quality Requirements for AWT Product Water

Constituent	Limit	Basin
Boron	0.5 mg/L	Main San Gabriel
Chloride	100 mg/L	Main San Gabriel
Sulfate	100 mg/L	Main San Gabriel
TDS	450 mg/L	Main San Gabriel
Coliform, Bacteria	1.1/100 mL(1)	Orange County/Central/West Coast
Nitrate (as N)	3.4 mg/L(2)	Orange County(3)

Notes:
(1) Median over any 7-day period.
(2) Also shall not exceed 10 mg/L nitrogen as nitrate-N plus nitrite-N.
(3) Assimilative capacity for nitrate of 0.5 mg/L-N is available for the Orange County Basin and is not accounted for in the 3.4 mg/L-N goal. The full-scale AWT facility can be designed for a slightly lower product water quality goal, depending on the assimilative capacity available at the time of design.

Besides meeting regulatory requirements, the RRWP product water must also be chemically conditioned to prevent corrosion in the conveyance infrastructure, plugging of injection wells, or mobilizing undesirable constituents in the receiving aquifers. Chemical conditioning could be added to stabilize product water before it enters the conveyance system.

From a treatment standpoint, the product water quality requirements for nitrate and boron have a significant impact on project implementation options. Metropolitan's approach to boron and nitrogen management for the AWT facility is described in Section 5.4.

5.4 Advanced Treatment Approach

Achieving Log Reduction Credits with an MBR

Full advanced treatment (FAT), currently the industry standard treatment train for potable reuse, consists of membrane filtration (MF), followed by RO and UV/AOP. This treatment train has proven successful in facilities throughout the world and achieves the DDW's pathogen log reduction requirements. Notably, it is used at the largest potable reuse project in the world – the 100-mgd Groundwater Replenishment

System (GWRS) facility operated by the Orange County Water District (OCWD). Further expansion of this facility to 130 mgd is planned.

To meet the strict basin discharge requirements for nitrate, the non-nitrified secondary effluent feeding the AWT facility would need to be nitrified and possibly also denitrified prior to the FAT train. Use of a tertiary MBR system would achieve sufficient nitrogen reduction as well as pathogen log reduction, thereby eliminating the need for the MF in a typical FAT train. The MBR would be used directly upstream of the RO membranes. The effectiveness of the tertiary MBR system would be evaluated during the program's demonstration phase. If the MBR system achieves the necessary water quality standards and is accepted by the regulators, it could provide significant capital and O&M cost savings over the project's life. It would also provide significant benefits for water reuse development in California.

As the MBR process operates at a high SRT to allow complete oxidation of ammonia and biodegradable organic matter, membrane fouling in the downstream RO process can be minimized. Based on industry experience and current research efforts, the MBR process can achieve at least a 2.5 log reduction of *Cryptosporidium* and *Giardia*. However, actual credits to be granted to the MBR process would ultimately be determined by the regulators. In order for regulators to grant pathogen log reduction credits to the MBR process, regulators will likely require demonstration of membrane integrity through a pressure decay or other surrogate testing plus other monitoring protocols on the MBR membrane system.

Table 5.4 shows the expected pathogen reduction credits for the proposed base case AWT facility. It should be noted that all reduction credits presented in Table 5.4 are planned to be achieved on site. Retention time within the groundwater basin provides additional opportunity for virus reduction credit.

Table 5.4: Anticipated Log Reduction Credits for the Base Case AWT Facility

Unit Process	Log Reduction Credits (Virus / *Cryptosporidium* / *Giardia*)
MBR	0.0 / 2.5 / 2.5
RO	1.5 / 1.5 / 1.5
AOP	6.0 / 6.0 / 6.0
Free Chlorine*	6.0 / 0.0 / 0.0
Total	**13.5 / 10.0 / 10.0**

*Virus log reduction credit for free chlorine anticipated to be achieved at the AWT facility, based on experience at the City of Los Angeles Terminal Island Water Reclamation Plant.

Metropolitan and the Sanitation Districts meet regularly with regulators (the DDW and the Los Angeles and Santa Ana RWQCBs) to discuss program objectives and progress, particularly with respect to the proposed treatment approach and the intent to achieve a 2.5-log credit for reduction of *Cryptosporidium* and *Giardia* with the MBR to replace the use of MF. As described in Chapter 7, Metropolitan plans to collaborate with the DDW to develop the process monitoring and integrity testing protocols needed to obtain the pathogen log reduction credit for the MBR. In May 2016, Metropolitan presented to the regulators the process train planned for the demonstration plant, which includes a bypass around the MF process, and received positive feedback. The demonstration testing would have one area of focus on protocols for direct integrity testing of the MBR units. The DDW is currently involved in an ongoing research effort conducted at various treatment facilities throughout the United States to monitor MBR integrity and establish potential pathogen reduction credit for MBRs. Metropolitan's demonstration project plans to build on that work with the ultimate goal of gaining sufficient pathogen reduction credit for the MBR.

Nitrogen Management

Each groundwater basin that would receive the RRWP-purified water has a different nitrate discharge limit. The most stringent requirement is the Orange County Basin, with a nitrate limit of 3.4 mg/L-N. As mentioned earlier, a nitrogen removal process, such as MBR in combination with RO, would be required to treat non-nitrified JWPCP secondary effluent to comply with the basin objective.

Based on recent pilot-scale testing of sidestream treatment of the centrate stream from the dewatering centrifuge at the JWPCP, the total inorganic nitrogen (TIN) levels in the secondary effluent can be reduced by at least 20 percent (from 41.7 mg/L-N to 33.4 mg/L-N based on 2011–2015 data). Sidestream treatment could be an effective approach for minimizing the treatment cost by reducing the size of the mainstream nitrogen removal facilities[3]. A cost-benefit analysis will be performed during the conceptual design of the AWT facility.

For nitrogen management, the base case assumes sidestream de-ammonification at JWPCP, and complete nitrification and partial denitrification of the non-nitrified JWPCP secondary effluent with a tertiary MBR system at the AWT facility. Different degrees of denitrification would be tested during the demonstration phase to determine the optimum process parameters and carbon requirements for varying levels of nitrate concentrations in the MBR product water. Further nitrate removal would be achieved through the downstream RO process to meet the basin objectives. Reducing nitrate with ion exchange is not considered at the AWT site because treating the full flow with ion exchange would be cost-prohibitive.

Beyond the base case scenario presented above, a number of nitrogen treatment options at the JWPCP have been identified and evaluated. Opportunities include retrofitting the existing JWPCP secondary treatment with an MBR process, achieving only nitrification with the MBR, and removing nitrate through RO and a satellite ion exchange unit at the Orange County Basin (thus eliminating the need to denitrify the full flow at either the AWT facility or the JWPCP). Satellite ion exchange at the Orange County Basin would require a dedicated brine discharge line to either the Sanitation Districts or Orange County Sanitation District brine line facilities.

Retrofitting secondary treatment at the JWPCP would involve major changes and significant operational impacts. Metropolitan and the Sanitation Districts will continue to evaluate nitrogen management opportunities as the program progresses. It is important to note that any retrofit of the existing JWPCP secondary treatment facilities may affect the ability to provide flow equalization within existing tankage. Thus, additional flow equalization tanks would be needed upstream of the AWT processes.

Boron Management

To protect agricultural beneficial uses, particularly for citrus crops, the state boron NL is 1 mg/L and the Basin Plan limit is 0.5 mg/L for the Main San Gabriel Basin. The JWPCP median effluent boron concentration was 0.88 mg/L during the pilot study and has remained constant since then. Treatment

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[3] Sanitation Districts of Los Angeles County, 2016. *Evaluation of Technology Options for Nitrogen Treatment at the Joint Water Pollution Control Plant Progress Update Report*. Whittier, CA.

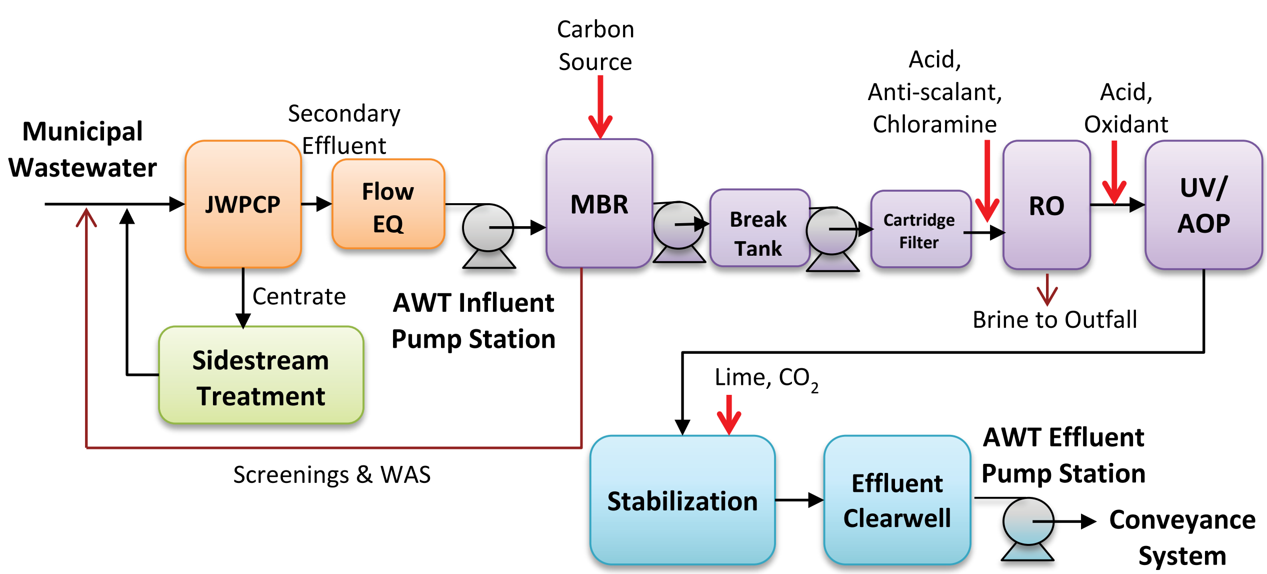
and/or source control measures must be taken to reduce boron levels prior to groundwater recharge at the Main San Gabriel Basin. The Sanitation Districts have identified a number of primary industrial sources that may contribute boron in the JWPCP's influent. Source control would be the most cost-effective and practical initial approach for boron management. The Sanitation Districts are currently monitoring the possible sources of boron in their service areas and identifying means for boron reduction before discharge into the JOS. The base case scenario assumes that boron removal would be achieved through source control and AWT's RO process to comply with water quality limits.

5.5 AWT Processes

Process Train

The base case scenario for the AWT facility includes a tertiary MBR followed by RO and UV/AOP. Using this train to achieve the necessary log reduction credits for potable reuse has not yet been demonstrated. The planned demonstration facility would include MF for RO pretreatment in the event that regulatory approval is not obtained for the required log credits by an MBR alone. However, based on industry experience in the testing and use of an MBR in potable reuse applications and initial positive feedback from the DDW, this study assumes that an MBR can successfully achieve sufficient pathogen log reduction credit during demonstration testing to eliminate the need for MF for the AWT facility. The process flow schematic for the base case AWT facility is presented in Figure 5.4.

Figure 5.4: Process Flow Schematic for the Base Case Full-Scale AWT Facility



Note: Base case assumes the demonstration facility will successfully demonstrate that MBR pretreatment achieves sufficient pathogen log reduction credit and that MF will not be needed in the full-scale AWT facility.

The screenings and waste-activated sludge streams generated from the AWT process would be returned to the JWPCP headworks. The brine waste streams would be directed into the JWPCP effluent system for eventual ocean discharge. The discharge, including the brine streams, needs to meet the ocean discharge standards specified in the California Ocean Plan. While the quantity and quality of the brine streams generated from the full-scale AWT facility can be estimated based on feed water quality and RO recovery, toxicity is best evaluated with toxicity testing. Brine streams from the demonstration facility will be tested to adequately determine the acceptability of the addition of the full-scale AWT brine stream to JWPCP discharges to the ocean. Metropolitan and the Sanitation Districts will coordinate with the RWQCB to establish the testing protocol for the brine evaluation, including toxicity. Additional studies would be needed for the disposal of full-scale brine streams, if any results from the demonstration facility monitoring indicate the inability to comply with the JWPCP's permit limits or any proposed separate permit limits for the brine discharge.

Membrane Bioreactor

The AWT facility proposes to use a tertiary MBR to achieve complete nitrification and partial denitrification of non-nitrified secondary effluent from the JWPCP. Additional nitrate removal would be achieved through the downstream RO process to meet the Orange County Basin objective for nitrate. Sampling of nitrogen and other key constituents was recently performed at the JWPCP. Metropolitan will use the results to establish the design criteria for the MBR process.

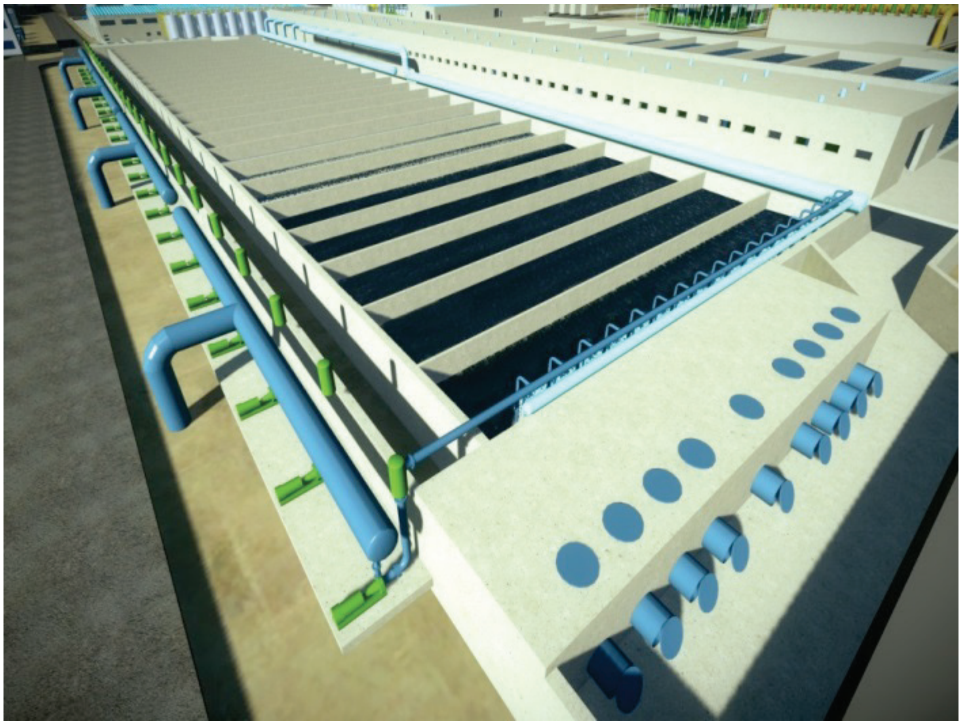
The tertiary MBR process is designed with aerobic and anoxic zones. Screened secondary effluent would be fed to the aerobic zone for nitrification and would flow by gravity to the anoxic tank and then to the membrane tank. Mixed liquor from the membrane tank would be pumped back to the aerobic tank to recycle solids back to the bioreactors and to achieve nitrate recycle from the aerobic to the anoxic zone. A three-dimensional model of the tertiary MBR system is presented in Figure 5.5.

The biological treatment portion of MBR would be designed with an SRT of 10 days to ensure complete nitrification. The anoxic tanks would be sized to achieve a product water nitrate concentration of less than 12 mg/L-N based on an influent TKN concentration of up to 50 mg/L-N. When combined with 80 percent removal of nitrate by RO, the target MBR product water nitrate concentration of less than 12 mg/L-N allows the AWT facility to achieve the target product water nitrate concentration of less than 3.4 mg/L-N with a reasonable safety factor. The biological portion of MBR is expected to remove any residual VOCs, low molecular weight acids, and alcohols.

Because the JWPCP secondary effluent does not have substantial residual COD (< 100 mg/L), an additional carbon source would be added to the anoxic tank to achieve the required level of denitrification. The anoxic basins would be designed with sufficient retention time to completely biodegrade the carbon added to the anoxic tank before it reaches the membranes in order to avoid any risks of fouling. Addition of carbon will be precisely controlled based on the nitrate concentration in the MBR effluent and the TOC concentration in the RO feed stream. Different degrees of denitrification would be tested during the demonstration phase to determine the optimum process parameters and carbon requirements for varying levels of nitrate concentrations in the MBR product water.

The MBR membranes will be cleaned with sodium hypochlorite once every 1 to 2 weeks.

Figure 5.5: Tertiary MBR Basins Modeled for the Full-Scale AWT Facility



Reverse Osmosis

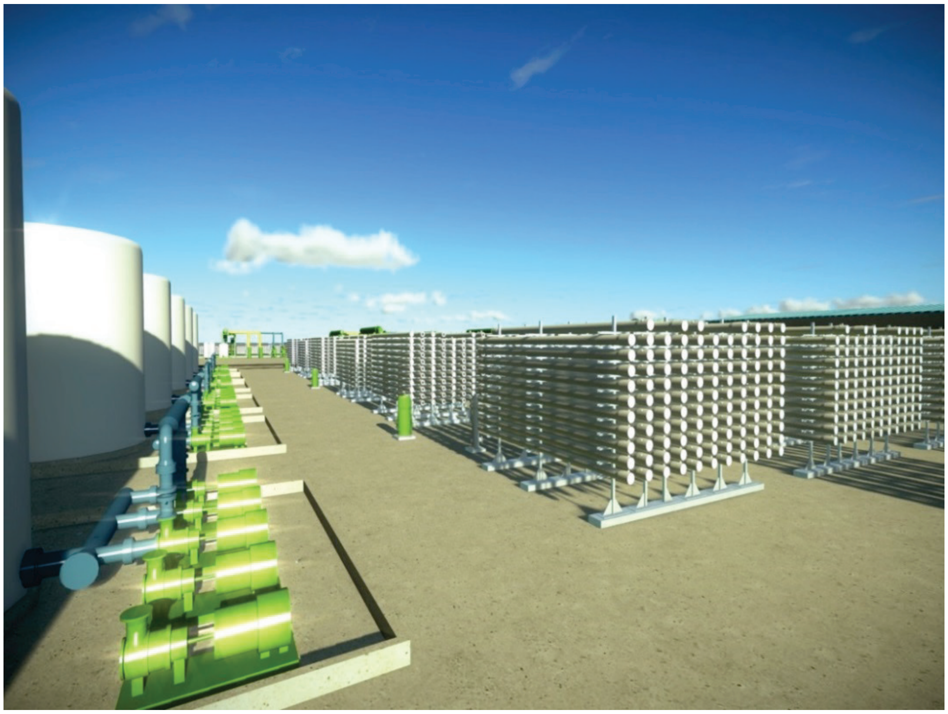
The RO system would remove a significant portion of the dissolved solids, organics, and pathogens that remain after MBR treatment. The RO system is expected to achieve a 1.5 log reduction of viruses, *Cryptosporidium*, and *Giardia*. A three-stage RO configuration is commonly used at water reuse facilities to achieve about 85 percent recovery while maintaining a reasonable flux at each stage. A two-stage RO configuration would require each stage to achieve higher recovery and is less common in reuse applications targeting 85 percent recovery.

Although the base case assumes the use of the more common three-stage RO configuration, both three-stage and two-stage configurations will be tested at the demonstration facility to quantify their operational and performance benefits. If the two-stage RO is successful in achieving the goals at the demonstration scale, it would become the preferred option due to its lower energy usage and fewer pressure vessels per system. Energy recovery devices would be considered for the AWT facility.

An RO feed tank would serve as an equalization tank between the MBR and the RO system. Filtrate from the MBR process would be pumped into the RO feed tank. RO feed pumps would deliver water from the RO feed tank through cartridge filters. Cartridge filters provide filtration for the RO feed as a safeguard against suspended particulates and colloids, which may damage the surface of the RO membranes. The filtrate exiting the cartridge filters would be pressurized by RO first-stage booster pumps. The RO flush system would be used to flush water from the RO trains before and after membrane clean-in-place (CIP) maintenance activities or during emergency system shutdowns. A combined chlorine residual would be maintained in the system to minimize biofouling by adding ammonium sulfate and sodium hypochlorite upstream of the RO membranes. Sulfuric acid and anti-scalant would also be added upstream of the cartridge filters to protect the RO membranes. Chemical-dosing systems are described later in this section.

A three-dimensional model of the RO system is presented in Figure 5.6.

Figure 5.6: Reverse Osmosis System Modeled for the Full-Scale AWT Facility



Note: Building enclosure for RO facilities not shown.

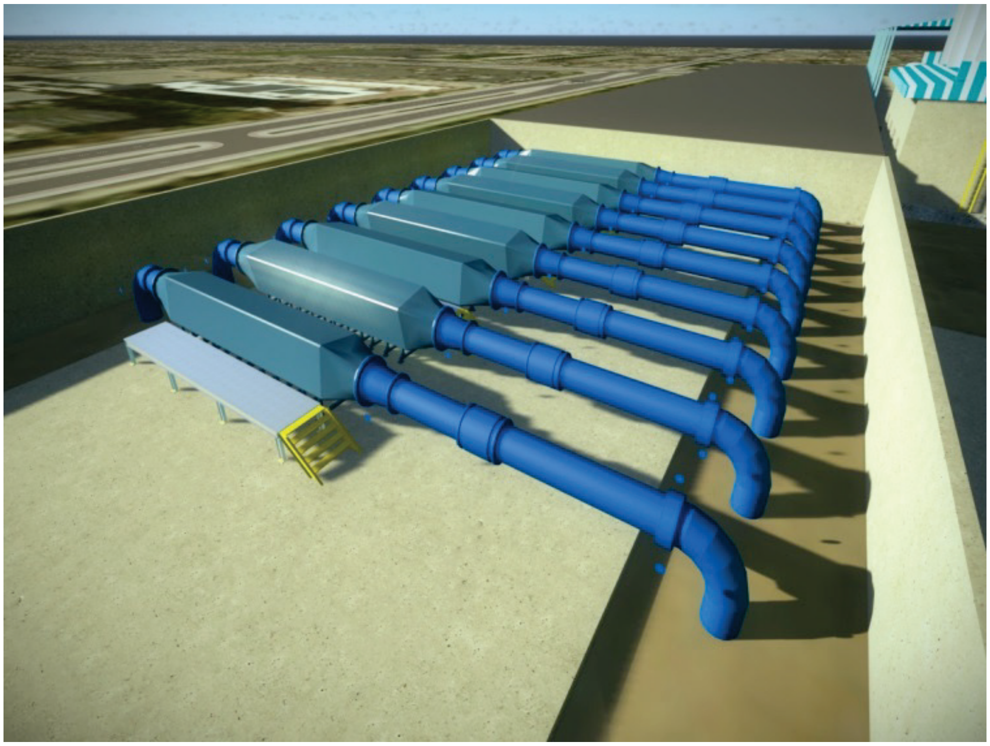
Advanced Oxidation

AOP involves generation of hydroxyl radicals to oxidize organic compounds at ambient temperature and pressure. Hydroxyl radicals react rapidly with organics, making AOP an effective strategy for reducing the concentration of trace organic compounds and recalcitrant compounds. Hydroxyl radicals are generated through photolysis of an oxidant by UV light, which helps degrade NDMA and other contaminants of concern. UV/AOP is also a highly efficient disinfection process that is capable of achieving at least a 6-log inactivation/reduction of viruses, *Cryptosporidium*, and *Giardia*, which is the maximum log reduction/inactivation disinfection credit that the DDW will allow for any single unit process. The primary water quality goals of the UV/AOP system are ≥ 0.5 log reduction of 1,4-dioxane, NDMA, NDEA, and NDPA reduction below the DDW NL of 10 ng/L, and a 6 log reduction of viruses, *Cryptosporidium*, and *Giardia*.

The base case assumes that chlorine (sodium hypochlorite) would be used as an oxidant to generate hydroxyl radicals, although both hydrogen peroxide and chlorine would be tested during the demonstration phase. While the use of hydrogen peroxide is more common, chlorine has the advantages of generating hydroxyl radicals with greater efficiency, thereby reducing the chemical requirement. Chlorine reduces the need to quench the oxidant while simultaneously providing chlorine residual to achieve additional disinfection credit in the product water pipeline leaving the AWT facility. The chlorine residual after UV/AOP is expected to range from 1 to 2 mg/L. The efficacy of an AOP system using chlorine as an oxidant decreases as pH increases, especially at a pH greater than 5.5. The pH adjustment would occur upstream of the UV/AOP. The pH of the UV/AOP influent is anticipated to be in the range from 5.0 to 6.5. An acid feed system would be needed at the UV/AOP influent to reduce pH as necessary.

A three-dimensional model of the UV/AOP system is presented in Figure 5.7.

Figure 5.7: UV/AOP System Modeled for the Full-Scale AWT Facility



Each UV/AOP system would include a UV reactor, a control panel, an oxidant dosing system, an acid feed system for pH adjustment, and associated instrumentation for monitoring, control, and performance validation. The base case assumes the use of low-pressure high-output (LPHO) UV technology. Historically, LPHO technology has been used in IPR projects in California, primarily because LPHO requires less energy than the medium-pressure high-output (MPHO) technology.

Chemical-Dosing Systems

Chemical storage would be designed to provide at least 7 days of on-site storage. Chemical storage tanks would be installed for those chemicals used in large quantities (sodium hypochlorite, carbon source, and sulfuric acid); all other chemicals used in lower quantities would be stored in totes.

Carbon Source. As currently configured in the base case, biological partial denitrification would require an external carbon source due to the absence of readily degradable carbon in the existing JWPCP secondary effluent. A variety of carbon sources are available for this purpose, including MicroC2000™, methanol, ethanol, acetic acid, and glycerol. In general, carbon sources are commercial chemical products, unrefined wastes, or processed wastes derived from industrial or agricultural sources and processes. For example, methanol is a commercial chemical product, MicroC2000 is derived from agricultural wastes, and glycerol is a byproduct of biodiesel generation. Waste-derived products can contain impurities that influence the effectiveness of denitrification and can lead to process upsets. Therefore, process control is important. These carbon sources are more sustainable with regard to their sourcing, but they would not have a significant advantage in terms of trucking volumes. Ultimately, the choice of the carbon source would depend on cost, safety considerations, environmental considerations, handling requirements, reaction kinetics (i.e., biological uptake), volume/hauling requirements, and relative sludge production.

The base case assumes the use of MicroC2000, although several alternatives would be evaluated at the demonstration facility. MicroC2000 is often favored as a carbon source because it has fewer safety issues than methanol. However, MicroC2000 has a lower COD value than methanol, meaning that greater quantities would be required to meet the same denitrification objectives. A three-dimensional model of the carbon storage tanks is presented in Figure 5.8.

Figure 5.8: MicroC2000 Storage Tanks Modeled for the Full-Scale AWT Facility

Chloramine. Chlorine residual is maintained in the system to control biological fouling of the membranes. Because RO membranes are typically incompatible with free chlorine, chloramines would be used by dosing both ammonium sulfate and sodium hypochlorite upstream of the RO system. However, due to the presence of precursors for formation of nitrosamines in the MBR effluent, NDMA formation during chloramination upstream of RO is likely. Because free chlorine starts to oxidize monochloramines above a chlorine-to-ammonia weight ratio of 5, lower chlorine-to-ammonia mass ratios are applied to ensure that excess ammonia will be present. The ammonia concentration upstream of the RO system is anticipated to be less than 2 mg/L-N. As such, with about 80 percent ammonia removal by RO, the AWT facility product water is anticipated to contain less than 0.5 mg/L-N ammonia.

Sulfuric Acid and Anti-scalant. Sulfuric acid and anti-scalant are used for RO pretreatment. These chemicals would be injected upstream of the cartridge filters to ensure that no particulate matter or impurities from the chemical system are present which could damage the RO membranes.

UV/AOP Oxidant. While the base case assumes that chlorine as sodium hypochlorite would be used as the oxidant for UV/AOP because it offers the best value and is commonly used in similar applications, both chlorine and peroxide will be tested at the demonstration facility. They would be injected upstream of each UV reactor.

CIP/Membrane-Cleaning Chemicals. Chemicals for the membrane-cleaning system include citric acid, sodium hydroxide (NaOH), sodium hypochlorite (NaOCl), and sodium bisulfite ($NaHSO_3$). Citric acid is used for low-pH cleanings; NaOH is used for high-pH cleaning; NaOCl would also be used for MBR membrane cleaning; and $NaHSO_3$ would be used to neutralize the CIP solution before discharge.

Stabilization

Stabilization is an important element of any potable reuse system that includes RO. Because RO permeate has very low TDS, hardness, and alkalinity, the water may be aggressive and chemically unstable. This could cause corrosion in the RRWP conveyance system, and mobilization of geochemical contaminants (e.g., arsenic) in groundwater basins that receive the purified water.

Three main stabilization processes are typically used for IPR:

1. Lime ($Ca[OH]_2$) addition and CO_2 addition/removal: $Ca(OH)_2$ dissolution with CO_2 in solution provides both carbonate alkalinity and calcium hardness. Both the target water quality (alkalinity, pH, and Langelier Saturation Index (LSI) and the RO operating conditions dictate whether CO_2 addition or removal is required before $Ca(OH)_2$ addition.

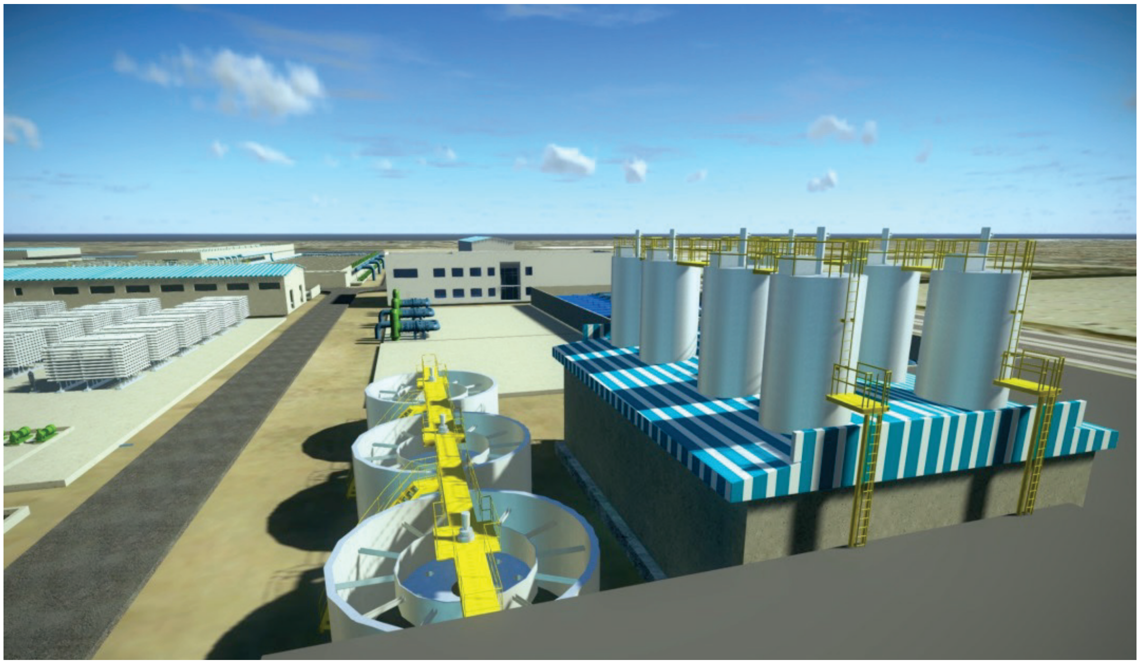
2. Calcite contactor + CO_2 addition: A limestone contactor uses natural limestone and CO_2, and adds calcium hardness and alkalinity to the UV/AOP product water. $Ca(OH)_2$ contactors are typically used outside the United States where calcium carbonate ($CaCO_3$) sources are readily available and other chemicals typically used for stabilization are expensive to import.

3. NaOH and calcium chloride ($CaCl_2$): NaOH provides hydroxide alkalinity and raises the pH, whereas $CaCl_2$ provides calcium hardness. Because NaOH and $CaCl_2$ are both expensive chemicals, this approach typically has high operating costs.

The base case assumes that $Ca(OH)_2$ and CO_2 addition would be used for post-RO stabilization because they offer the best value and are commonly used in the United States. However, these and other options would be tested at the demonstration facility to validate the water quality targets. The base case assumes that the RRWP product water would be stabilized to a pH of 7.5 to 8.5, with LSI just above zero. Sufficient alkalinity (> 50 mg/L as $CaCO_3$) would be added to ensure pH stability and corrosion control. These water quality targets are intended to condition the water such that it would not aggravate the conveyance system and would not clog the injection wells by depositing $CaCO_3$.

A three-dimensional model of the $Ca(OH)_2$ system for stabilization is presented in Figure 5.9.

Figure 5.9: Stabilization with Lime System Modeled for the Full-Scale AWT Facility



5.6 Site Issues and Facility Layout

The full-scale AWT facility would be located on the Sanitation Districts' former Fletcher Oil and Refinery Company (FORCO) property east of the JWPCP secondary treatment facilities. The entire 150-mgd facility fits within the FORCO property limits with available space for potential future expansion. The FORCO site is currently being remediated for soil contamination. The Sanitation Districts will be responsible for removing, disposing, and/or treating all pre-existing hazardous wastes and contamination and for remediating the site as needed to permit construction of the full-scale project. Relocation of three existing utilities would also be required, including a 72-inch-diameter sewer pipeline, a 10-foot by 12-foot concrete box storm drain, and a 10-inch high-pressure gas pipeline.

A conceptual site layout for the base case full-scale AWT facility is presented in Figure 5.10. Required facilities for the base case are shown in the site layout and include advanced treatment processes, below-grade RO feed tanks, inter-process pumps and storage tanks, post-treatment stabilization, chemical storage and feed systems, a new electrical substation, an operations building with a water quality laboratory and operations control center, a public education center (at the demonstration facility site), maintenance and shop facilities, access roads, and parking. If future wastewater flows make additional flow available for reuse, there will be sufficient space on site to accommodate expansion of the AWT facilities (areas shown in gray). The MF system is not included in the base case and is therefore not presented in the site layout. However, if the MF system is needed, it would be constructed on top of the below-grade RO feed tanks. Sufficient space is available on site for an MF system. The AWT effluent clearwell and pump station are described in Chapter 6 as part of the RRWP conveyance system.

Figure 5.10: Conceptual Site Layout for the Base Case Full-Scale AWT Facility (150 mgd)

5.7 Electrical Requirements

The AWT facility includes many energy-intensive processes. The overall power loads for the full-scale facility are estimated to be approximately 60 megawatts and will require a new dedicated electrical substation to be installed at the JWPCP specifically for this facility. During conceptual design of the AWT facility, Metropolitan and the Sanitation Districts will assess the overall energy consumption at the facility and consider energy recovery and alternative energy sources to minimize the carbon emissions. The major power-consuming equipment for each AWT process are described below:

1. ***MBR:*** rotary drum screen, influent pumps, aeration tank blowers, membrane blowers, membrane filtrate pumps, return-activated sludge pumps, and air compressors

2. ***RO:*** feed pumps, first- and third-stage booster pumps, flush pumps, and CIP pumps

3. ***UV/AOP:*** UV reactors

4. ***Miscellaneous:*** chemical feed systems, and building heating, ventilation, and cooling systems

Additional discussion on the embedded energy associated with the AWT facility is included in Chapter 2.

5.8 AWT Operational Considerations

Variations in AWT Production

As described in Chapter 4, the groundwater basins will be able to receive 150 mgd of RRWP water approximately 85 percent of the time. For the remaining 15 percent of the time, demand may be as low as 110 mgd. Therefore, the AWT facility must be capable of ramping down production during periods of low demand. Operational considerations to achieve this are presented below for each major process.

MBR. All trains for the MBR process would be kept in operation during demand reduction since it is not operationally feasible to drain the mixed liquor from the bioreactors and bring the basins back in service within a short time period due to acclimation time required for biomass. Instead, the MBR trains would be operated at lower flow rates. The biological process could handle a 30 percent turndown; the process blowers would be operated at a lower rate and the membranes would be operated at lower flux.

RO. Each RO skid produces approximately 3.5 mgd of permeate. Depending on the turndown required, a few RO skids could be taken out of production mode and membranes could be cleaned and preserved inside the membrane vessels until plant production resumes. To treat 110 mgd of product flow, approximately 11 out of 45 RO skids would be taken offline. The number of operating RO feed pumps would depend on the number of operating RO skids.

UV/AOP. Each UV/AOP reactor processes approximately 10 mgd of product water. Four reactors would be taken offline when only 110 mgd of product flow is required. The performance of the reactors is affected by the hydraulics inside the reactor; therefore, the reactor design will need to account for the range of flow each reactor would see in the event of the turndown. If the required turndown is less than a 10 mgd decrement, flow to the operational reactors could be reduced to a certain degree without affecting process performance.

Post-RO Stabilization. All three lime clarifiers would be kept in operation when producing 110 mgd of product flow. However, these clarifiers would be operating at a lower loading rate.

Critical Control Points and Monitoring Strategy

A testing and monitoring plan will be established during conceptual design to support regulatory approval and full-scale AWT design. Specifically, critical control points for each AWT process will be identified to provide early warning of key process deviations and to minimize risks to the final product water quality. The parameters to be monitored for each process, which may include indicator compounds for surrogates, will be closely coordinated with the regulators to ensure final acceptance of the program.

Operator Training

AWT is a sophisticated process that requires operators to have extensive experience operating similar facilities, with cross training from both water and wastewater system operations. Because Metropolitan is not a wastewater agency and currently does not operate an MBR system or any other reuse facilities, licensed operators would be retained and trained to operate the AWT facilities under all types of water quality and hydrologic conditions. Metropolitan will build up the internal skill base by involving its operations staff during the operation and maintenance of the demonstration facility.

Operation of the AWT facilities also needs to be closely coordinated with the JWPCP operators. There are a number of examples within California with regard to the operation and coordination between the wastewater treatment plant and the IPR facilities. A strategy will be developed during the conceptual design phase of the full-scale AWT facilities.

Chapter 6

Conveyance System

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6.0 CONVEYANCE SYSTEM

6.1 Overview

The RRWP conveyance system would consist of approximately 60 miles of pipeline and three pumping plants. The system would deliver up to 150 mgd of purified water as far east as the Orange County Spreading Basins in Anaheim and as far north as the Santa Fe Spreading Grounds in Irwindale. Delivery points, or RRWP water service connection locations with Metropolitan's member agencies along the pipeline alignments, would consist of either groundwater spreading basins or injection wells. Table 6.1 lists the proposed delivery locations and the approximate maximum design flows to be discharged at each location.

Table 6.1: Groundwater Recharge Locations and Flows

No.	Location	Type	Groundwater Agency/Operator	Maximum Design Discharge Flow (mgd)
1	West Coast Basin, Torrance	Injection Wells	Water Replenishment District of Southern California (WRD)	15
2	Central Basin, Long Beach	Injection Wells	WRD/City of Long Beach	4
3	Orange County Spreading Grounds, Anaheim	Recharge Basins	Orange County Water District	60
4	Central Basin, Montebello Forebay	Injection Wells	WRD	12
5	Santa Fe Spreading Grounds, Irwindale	Recharge Basins	Main San Gabriel Basin Watermaster/LA County Flood Control District	80

6.2 Pipeline Alignment

Numerous potential pipeline alignments could be selected to deliver purified water from the AWT facility to the various discharge locations. The pipeline alignment for the base case scenario has been developed to deliver up to 150 mgd based on a review of numerous potentially feasible routes, including a review of available record information, augmented by field visits. The alignment used for analysis was chosen from multiple identified alignments based on the route that appeared most economical to construct, while reasonably minimizing community and environmental impacts and complying with anticipated local municipal and other jurisdictional requirements. Initial communication was conducted with various municipalities and utilities (e.g., Southern California Edison, U.S. Army Corps of Engineers) regarding possible pipeline alignments and shared use of rights-of-way (ROWs). Extensive coordination will be conducted regarding the use of ROWs during preliminary design. The base case pipeline alignment is not intended to represent a preferred or final alignment as additional analysis and evaluation will be conducted in subsequent phases of the program, including environmental assessment and design activities.

Utility information was collected from municipalities and agencies along the base case alignment. The information has been compiled into geographical information systems (GIS) to allow the number and type of major utility crossings to be quantified and to sufficiently assess whether or not a wide enough corridor is likely to exist for the installation of a new pipeline to meet regulatory requirements and constructability needs. It is anticipated that more detailed mapping and utility exploration will be conducted in preliminary design.

Some of the major utility crossings assessed include:

- Storm drains/culverts greater than 30-inch diameter
- Gravity sewer mains/sewer force mains greater than 24-inch diameter
- Water transmission (potable/reclaimed) mains greater than 24-inch diameter
- Oil/gas transmission pipelines greater than 18-inch diameter

Smaller-sized utilities, including dry utilities, are expected to cross over the RRWP conveyance pipelines or have a negligible effect on construction risk. As is customary in the planning, design, and construction of utilities of this size and type, smaller-sized utilities will be avoided or relocated to accommodate the RRWP conveyance pipelines.

Figure 6.1 and Figure 6.2 present the proposed base case pipeline alignments in map and schematic format. For planning purposes, the pipeline alignment has been broken into five segments. Each segment consists of pipeline sections between pumping plants or between pumping plants and water delivery termination points. In preliminary/final design, it may be appropriate to break these five conveyance segments up into multiple smaller construction contract packages.

The following is a description of each pipeline segment:

- **Segment 1** – Segment 1 is approximately 13 miles long and starts at JWPCP Pump Station 1 (PS-1) and ends at PS-2 adjacent to the San Gabriel River in the City of Cerritos. From west to east, this segment passes through the city of Carson; a short stretch of unincorporated LA County; and the cities of Long Beach, Lakewood, and Cerritos. A majority of the alignment is within public street ROWs, with a short stretch along the San Gabriel River. This pipeline would convey up to 150 mgd, is anticipated to have an internal diameter of approximately 84 inches, and would be designed for a maximum internal head of 100 feet.
- **Segment 2** – Segment 2 is approximately 16 miles long and starts at PS-2 and ends at the Orange County Spreading Grounds at Anaheim Lakes in the City of Anaheim. From west to east, the alignment passes through the cities of Cerritos, La Palma, Buena Park, Fullerton, Placentia, and Anaheim. Approximately 6 miles of the alignment lie within the Southern California Edison (SCE) ROW while the remaining 10 miles falls within public street ROW. The pipeline would convey up to 60 mgd with a diameter of approximately 54 inches and would be designed for a maximum internal head of 360 feet.

- **Segment 3** – Segment 3 is approximately 15 miles long and begins at PS-2 and ends at PS-3 near Whittier Narrows Dam. From south to north, the alignment passes through the cities of Cerritos, Bellflower, Downey, and Pico Rivera. The majority of the alignment falls within SCE ROW paralleling the San Gabriel River. Due to the narrow SCE corridor, and some environmentally sensitive areas along the San Gabriel River, the pipeline may have to be placed within the confines of the river and public street ROW for a portion of the alignment. It is anticipated that the pipeline would convey up to 80 mgd with a diameter of approximately 60 inches and would be designed for a maximum internal head of 340 feet.

Figure 6.1: Conveyance System Map (Base Case Scenario Alignment)

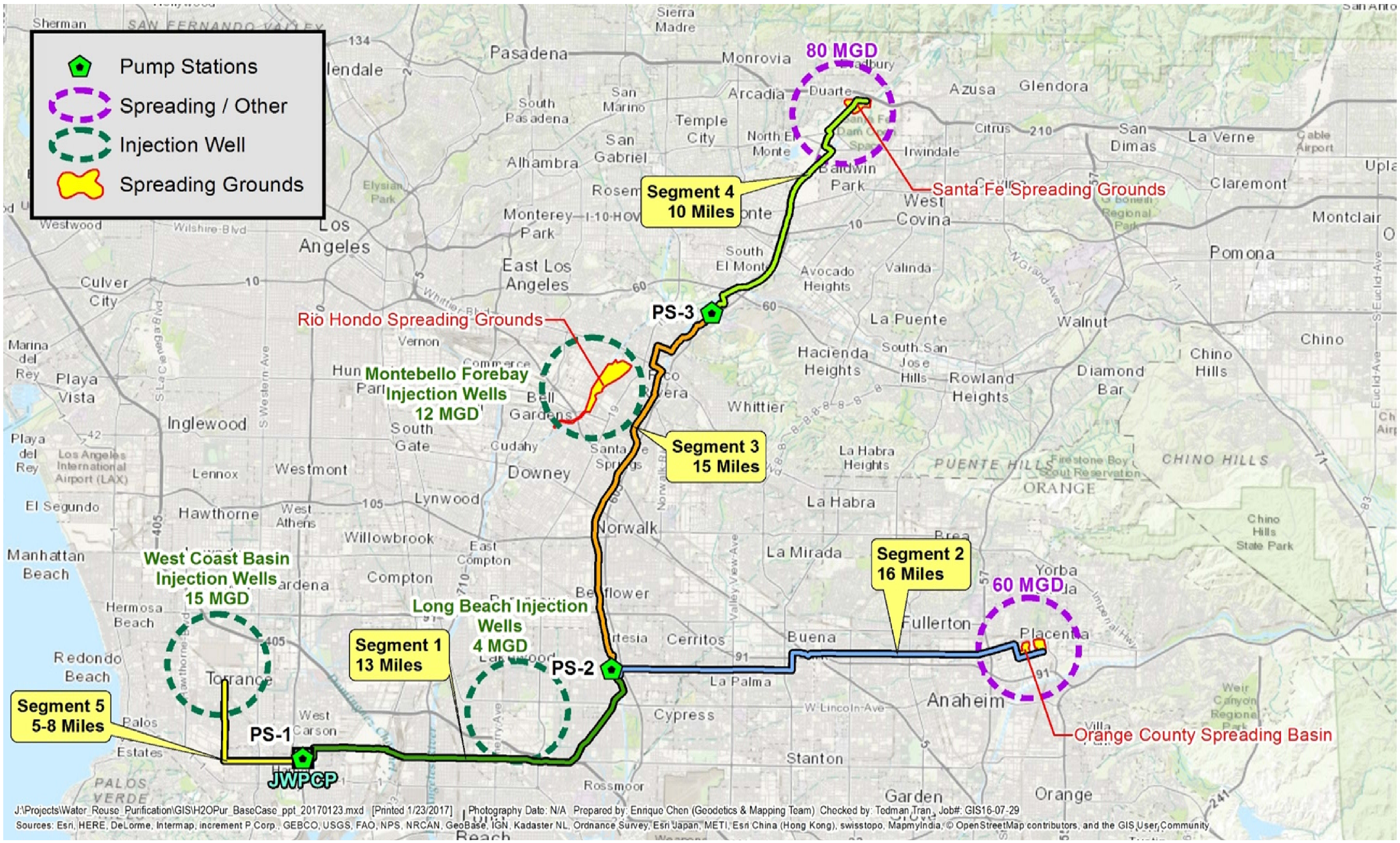
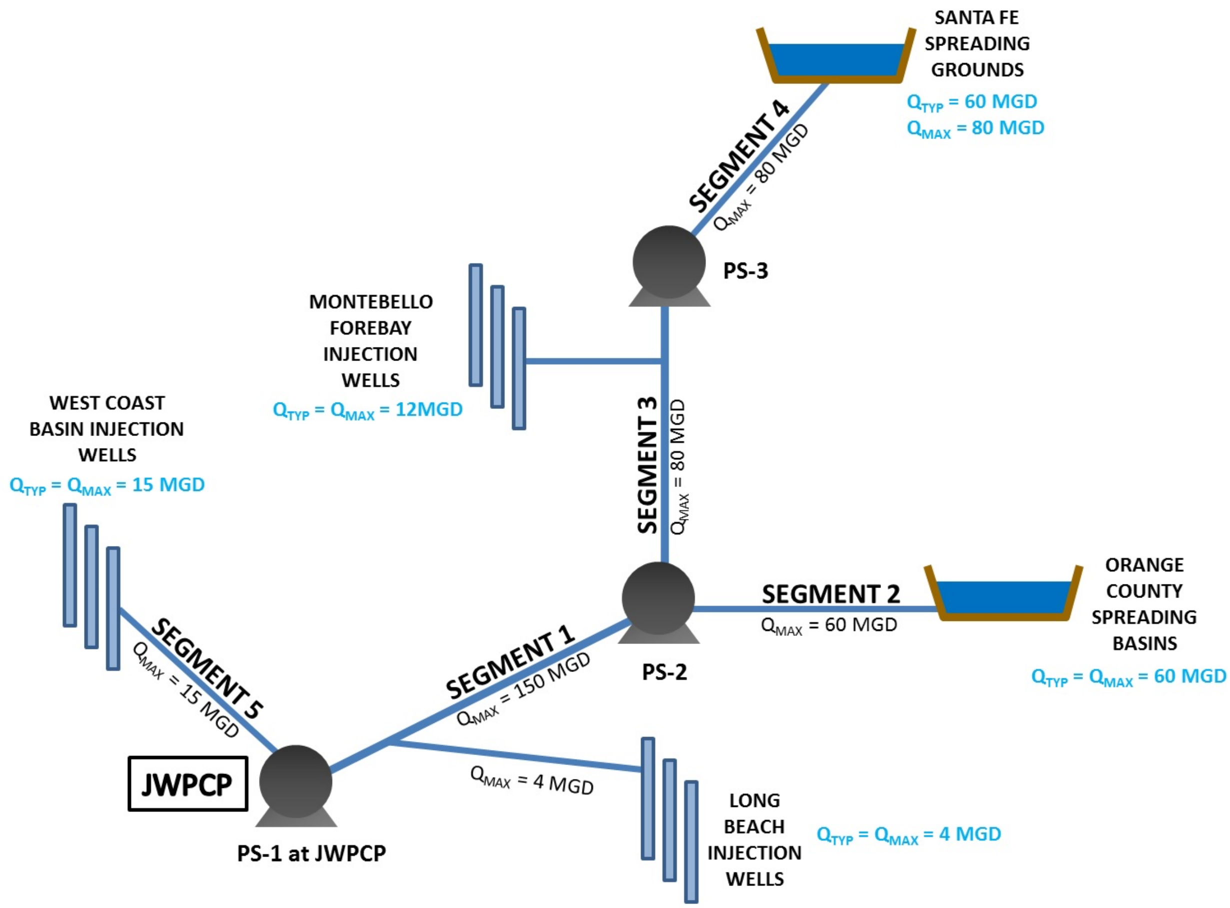


Figure 6.2: Conveyance System Schematic



- **Segment 4 –** Segment 4 is approximately 10 miles long and starts at PS-3 and ends at the Santa Fe Spreading Grounds in the City of Irwindale. A majority of the alignment falls within the SCE and Los Angeles County Flood Control District ROW, with a portion falling within public street ROW. It is anticipated that the pipeline would convey up to 80 mgd with a diameter of approximately 60 inches and would be designed for a maximum internal head of 390 feet.
- **Segment 5 –** Segment 5 is anticipated to be approximately 5 to 8 miles long. It would start at PS-1 and end at injection wells to be installed in the general area of Torrance to provide groundwater injection into the West Coast Basin. It is anticipated that the pipeline would convey up to 15 mgd with a diameter of approximately 30 inches and would be designed for a maximum internal head of 90 feet.

The methodology, criteria, and basis for developing the pipeline alignments took into consideration anticipated constructability, traffic impacts and access issues, utility impacts, and land use. Installation of pipe by means of open-cut trenching and backfill would be pursued in non-street corridors (e.g., SCE and Los Angeles County Flood Control District ROW) where sufficient width is available. In order to reduce impacts within public street ROW, typical pipe construction would use vertical shoring by way of a trench box. Pipe-jacking and/or tunneling would be implemented at key features, such as major street crossings, freeways, railroads, rivers, channels, etc.

Due to the number of substructures and utilities expected within street rights-of-way, pipeline construction costs within street corridors would likely be significantly higher than within a utility corridor like that held by SCE or a flood control corridor/channel like that held by LA County Flood Control District. Higher costs within these street corridors are anticipated due to the need for utility relocation/protection, traffic diversion/control, and possible business/resident relocations.

Excavation methods within streets would likely consist of vertical shoring, which is much slower to construct than sloped trenching. Sloped trenching outside of street ROWs can be completed at much longer distances, resulting in more rapid excavation and speeding up overall pipeline construction. Vertical shoring is more time consuming and can only be completed in much shorter segments, resulting in longer construction durations. In order to reduce negative impacts to vehicular movement, access to residences and businesses, and overall construction durations, Metropolitan would pursue the use of SCE and LA County Flood Control District ROWs.

Details of construction activities, including but not limited to construction sequencing, contractor access and storage area, and traffic control and road closures, would be assessed during the preliminary design phase if the RRWP goes forward.

6.3 Pump Stations

Three pump stations would be needed to convey purified water from the AWT facility to the various recharge locations listed in Table 6.2.

Table 6.2: Groundwater Recharge Location Elevations

Recharge Location	Approximate Elevation (ft.)
West Coast Basin Injection Wells	90
Central Basin, Long Beach Injection Wells	60
Orange County Spreading Grounds	223
Central Basin, Montebello Forebay Injection Wells	200
Santa Fe Spreading Grounds	500
Note: AWT facility elevation is 40 feet (above mean-sea-level).	

An initial study has been conducted to determine the appropriate number of pump stations for this system, taking into account hydraulic effects, likely pipeline elevation along the base case scenario alignment, required pipe diameters, pumping costs, and pump station construction and maintenance costs.

Table 6.3 describes the pump stations resulting from the preliminary analysis. Their general locations are shown on Figure 6.1. Specific pump station locations would be identified and evaluated in subsequent design and environmental assessment phases.

Table 6.3: Base Case Pump Stations

Pump Station	General Location	Preliminary Firm Capacity	Pumps To
PS-1	JWPCP, Carson	Pump Set A: 15 mgd at 90 feet (two 350 HP duty pumps + one standby) Pump Set B: 150 mgd at 100 feet (four 900 HP duty pumps + one standby)	• Pump Set A: West Coast Basin • Pump Set B: PS-2 Forebay
PS-2	Adjacent to San Gabriel River near Carson Street	Pump Set A: 60 mgd at 360 feet (three 1,750 HP duty pumps + one standby) Pump Set B: 80 mgd at 340 feet (three 2,500 HP duty pumps + one standby)	• Pump Set A: Orange County Spreading Grounds • Pump Set B: PS-3 Forebay
PS-3	Near Whittier Narrows, Pico Rivera	Pump Set A: 80 mgd at 390 feet (three 2,500 HP duty pumps + one standby)	• Santa Fe Spreading Grounds

PS-1 and PS-2 would have two separate delivery pipelines operating at different hydraulic grades. Therefore, in order to provide the most efficient system, two sets of pumps (Pump Set A and Pump Set B) would be provided at PS-1 and PS-2. PS-3 would have only one delivery location (Santa Fe Spreading Grounds), so only one set of pumps would be provided at PS-3. For the base case scenario, each pump set would have a total of three to five pumps to deliver the required flow to each recharge location. Each pump is equally sized to evenly share the total pump set capacity amongst the duty pumps; a spare pump would be provided for each pump set to keep the system running at full capacity while pumps are being maintained. Table 6.3 above lists preliminary pump motor sizes based on this sizing approach.

The initial recommended equipment for the project is vertical turbine pumps. These pumps have a smaller footprint than horizontal pumps, are familiar to Metropolitan staff, and offer efficient operation across the range of flows and heads that are being contemplated. It is proposed that the vertical turbine pumps be installed in cans/barrels within a pump station building location nearby, but separated from the facility water storage tank. In order to optimize efficiency and system control, it is anticipated that all pumps at each pump station would be equipped with variable frequency drives (VFDs). Pump sizing and selections would be optimized during the design phase. At this stage of concept development, it is envisioned that pumps would be installed outdoors at PS-1 and indoors at PS-2 and PS-3.

In addition to the pumping equipment, each pump station site would include the following ancillary facilities:

- **Water storage tank or forebay:** A water storage tank or forebay would provide suction storage at each pump station. These facilities would provide a hydraulic break between pump stations, which would improve system control and operational flexibility. For purposes of this study, the storage volume required at PS-1 (at the AWT facility) is estimated at 7.5 MG, PS-2 is estimated at 2.0 MG, and PS-3 is estimated at 1.5 MG. The storage tanks would be above grade at PS-1 and PS-3 and below grade at PS-2. The storage size assumes the controlled starting and stopping of the facilities would not exceed 20 minutes and that the flow imbalance between storage inlet and outlet flows would not exceed the capacity of the largest pump upstream or downstream of the facility. Final storage volumes and storage type would be determined in final design. An emergency overflow directed to the nearest drainage location would be provided for the storage facilities to prevent pressurization of the storage tank. Facilities would be provided to dechlorinate any overflow.

- **Surge Control Facilities:** It is anticipated that hydraulic surge (transient) control would be provided by pressurized hydro-pneumatic tanks located on the discharge side of each set of pumps. These tanks would be located outdoors and installed above grade. The tanks would also require air compressors and control equipment. Sizing of the surge control equipment would be provided during final design.
- **Valves and Meter:** Each pump station would be provided with valves and gates to isolate the entire station and individual pumps. Valving would also be provided to help fill and drain the pipeline during startup and testing operations. Flow meters would also be provided on each discharge pipeline.
- **Control Building:** PS-1, PS-2, and PS-3 would each have an enclosed building with a control room, electrical room, restroom, and storage room. This building would also contain the vertical turbine pumps; supporting controls; and heating, ventilation, and air conditioning (HVAC) at PS-2 and PS-3. It is assumed the pumps would be located outside PS-1 (at the AWT).
- **Control System:** It is envisioned that the entire conveyance system would be operated remotely from the AWT facility by Metropolitan staff. As such, sufficient instrumentation and controls would be included in the system to accomplish this objective.
- **Uninterruptible Power Supply (UPS):** A UPS system would be provided to power instrumentation and controls and lighting in the event of a power failure. Backup power to the medium-voltage pumping equipment would not be provided.

Electrical Requirements

The AWT will be located at one of the lowest points in the distribution system. Various sizes of pumps will be utilized to convey the purified water to the spreading basins and injection wells. The power consumption at each pump station is substantial and may require dedicated electrical substations. The estimated power requirements at each of the proposed pump stations is presented in Table 6.4.

Table 6.4: Electrical Requirements for Pump Stations

Pump Station	Pumping To	Horsepower (HP)	Megawatts (MW)	Power Consumption (kWhr/yr)
PS-1	PS-2	3,409	2.5	22,269,900
	West Coast Basin	298	0.2	1,946,577
PS-2	Orange County Spreading Basins	4,700	3.5	30,704,368
	PS-2	6,299	4.7	41,145,031
PS-3	Santa Fe Spreading Grounds	6,829	5.1	44,608,583
Total Pumping Electrical Loads (MW): 16.1 MW				

During conceptual design of the conveyance system, Metropolitan will assess the overall energy consumption for each pump station and consider energy recovery and alternative energy sources to minimize carbon emissions.

6.4 Pipelines

Pipelines would consist of cement mortar-lined welded steel pipe with diameters ranging from 30 to 84 inches. Pipe sizing was initially analyzed to optimize the pipe size based on hydraulic losses. To reduce/eliminate corrosion, the interior pipeline lining design would be determined by the expected water quality constituents of the conveyed water.

At this time, welded steel pipe with cement mortar lining is the most viable option, given the required capacity and internal pressure that the pipeline will have to withstand. Based on recent experience at other Southern California agencies with facilities similar to the RRWP, there is concern that the purified water could be aggressive to cement mortar lining. An assessment of pipeline material and lining will be conducted once the water quality from the demonstration plant is evaluated. If the water quality from the demonstration plant is shown to be corrosive, then a cost analysis will be conducted to evaluate either post-treatment options for the purified water, and/or alternative pipeline materials (e.g., plastic, fiberglass) and linings should be considered. Prior to delivering purified water to the conveyance system, it is intended that appropriate water quality targets would be established to condition the water to control pipeline corrosion, as well as minimize potential for scaling and impacts to conveyance or recharge facilities.

Cost optimization of the pipelines was not a primary consideration at this stage of the feasibility analysis. During the design phase of the program, a full system analysis would be completed in order to determine the most cost-effective diameters based on initial capital costs and annual energy consumption. For the purpose of the feasibility study, the conveyance system was evaluated for the base case condition only and does not account for future possible sources of water, such as other indirect or direct potable reuse projects or desalination projects. These potential sources of water could be evaluated in future phases of the RRWP, if directed by the Metropolitan board. Assumptions used for the pipeline hydraulic analysis include the following:

- Maximum flow of system = 150 mgd
- Steady state flow operating 24/7
- Sectionalizing butterfly valves approximately every 7 miles of pipeline
- Minor losses (transitions, horizontal/vertical bends) are 5 percent of pipeline friction loss
- Pipe mortar thickness = 0.5 inches
- Maximum design velocity in pipelines = 6 feet per second (fps)

6.5 Controls

Each pump station would be controlled via VFDs based on the wet-well working volume level. For the base case scenario, the working volume for each pump station was sized to accommodate 2 hours of storage at full system flow for that pump station. The storage capacity is recommended so pump speeds can respond slowly without distressing the pipeline network system. Storage volumes would be optimized in later stages of design. The pump station would slow down and turn off pumps as the working level in the tanks is reduced and would speed up and turn on pumps as the working level increases. The control system strategies would be defined and developed further during preliminary engineering and final design.

All equipment would be operated in local and/or remote control modes. In the local mode, the equipment is manually controlled at the equipment or from a nearby motor control center (MCC), switchgear, VFD, local control panel, valve actuator, or hand station. When equipment is in local mode, all remote-mode control of the equipment is disabled. In the remote mode, equipment is controlled through a programmable logic controller based on automatic control strategies, with commands issued from any authorized workstations at the Metropolitan Area Control Center through the supervisory control and data acquisition (SCADA) system.

Strategies to prevent hacking or other unintended access by third parties would be incorporated into the design to provide a secure system, but are not addressed in the base case analysis. Redundant communication pathways using telephone lines, radio or microwave signals, and other technologies would be considered. Reliability features, such as UPSs and backup computer systems, would also be considered.

6.6 Conveyance and Distribution System Operations

Unlike Metropolitan's existing untreated and treated potable water distribution system, the RRWP system is anticipated to operate consistently at 110 to 150 mgd and will have less storage to buffer operations and flow changes. Post-disinfection contact time and adequate chlorine feed capability could also provide additional disinfection to treat off-spec water (water that does not meet microbial water quality requirements) in the conveyance system in an emergency situation. Further, in an emergency situation, appropriate actions would be taken when necessary (including shutting off the treatment facility) to protect the public from exposure to inadequately treated water and provide an alternate source of water or remedial wellhead treatment.

Routine operations include startups, shutdowns, and flow changes between 110 and 150 mgd. Routine support activities would include the following: water quality monitoring and control; operations control and scheduling with the Sanitation Districts and the various agencies taking deliveries; power acquisition; preventative maintenance; and performance monitoring, especially of pumps and injection wells.

Various long-term, short-term, and real-time schedules would be coordinated between the Sanitation Districts, Metropolitan, flood control agencies, and groundwater agencies taking deliveries. These schedules would be used for long-term planning efforts, O&M planning, water quality sampling, and scheduling and outage coordination between the various agencies.

In general, forebay storage capacity at each pump station would be based on the expected ramp times for controlled starting and stopping of the facilities and the expected flow imbalance between storage inlet and outlet flows. In the event of major flow imbalances due to major control system malfunctions or operator error, an overflow path/drain would be needed. Facilities would be designed to address the need for surge mitigation equipment at each site.

The entire conveyance system would be operated remotely from the AWT facility by Metropolitan staff. The primary control system is anticipated to include coordinated flow set points for each station based on the flow being generated by the AWT facility. Detailed investigations during preliminary and final design will be conducted to plan for routine operation and maintenance.

6.7 Groundwater Recharge Discharge Points and Injection Wells

As shown in Table 6.2, purified water would be delivered for groundwater recharge to five locations. Depending on the specific location, groundwater recharge would be achieved either by percolation at a recharge basin or by injection into the ground by injection wells.

For the Santa Fe Spreading Grounds and the Orange County Spreading Grounds, the primary transmission pipeline terminates at these locations and would deliver purified water to spreading grounds at those locations. At Whittier Narrows, a turn-out off the primary transmission line will be provided. From this location, water would be conveyed to injection wells at the Montebello Forebay, and to a pump station with the capability to lift the water from Whittier Narrows to the Santa Fe Spreading Grounds.

To deliver purified water to the injection well locations, distribution laterals would be constructed to branch off from the main pipeline. The approximate locations for the injection wells and distribution laterals are depicted on Figure 6.1.

The number of injection wells for each location is dependent on a number of factors, including the maximum injection volume desired, the depth and spacing of the injection wells, and subsurface geological and hydrogeological conditions. The base case assumes that there is sufficient pressure in the distribution laterals to inject water directly at each well, eliminating the need for booster pumps. Table 6.5 provides a summary of preliminary parameters for each injection well field.

Table 6.5: Injection Well Parameters

Location	Maximum Injection Volume (mgd)	Number of Injection Wells	Minimum Injection Well Spacing (feet)	Injection Well Depth (feet below ground surface)	Distribution Piping Size (inches)
West Coast Basin	2	15	1,500	400–800	Varies (16–30)
Central Basin (Long Beach)	2	4 (existing)	1,500	400–800	Varies (12–20)
Central Basin (Montebello Forebay)	2	13	1,500	400–800	Varies (16–30)

The injection wells would be 18-inch-diameter wells with casings. Each injection well would be of stainless steel construction to mitigate corrosion and plugging issues and would be outfitted with the following equipment:

- Dedicated pumps
- Baski valve
- Motorized flow control valve
- Backwash piping
- Camera port/piezometer tube
- Air vent
- Flowmeter and transmitter
- Gravel feet tube
- Inlet isolation valve
- Discharge isolation valve
- Well screenings
- Hose quick cone connections
- Discharge to catch basin with grating, via air gap
- Pressure indicator and transmitters
- Local control panel for the Baski valve

Figure 6.3 and Figure 6.4 depict a typical injection well configuration. Each injection well site would require approximately 1,000 square feet of area. The exact location and size of these injection wells will be determined in subsequent design and environmental assessment phases of the program.

Figure 6.3: Typical Injection Well Plan View

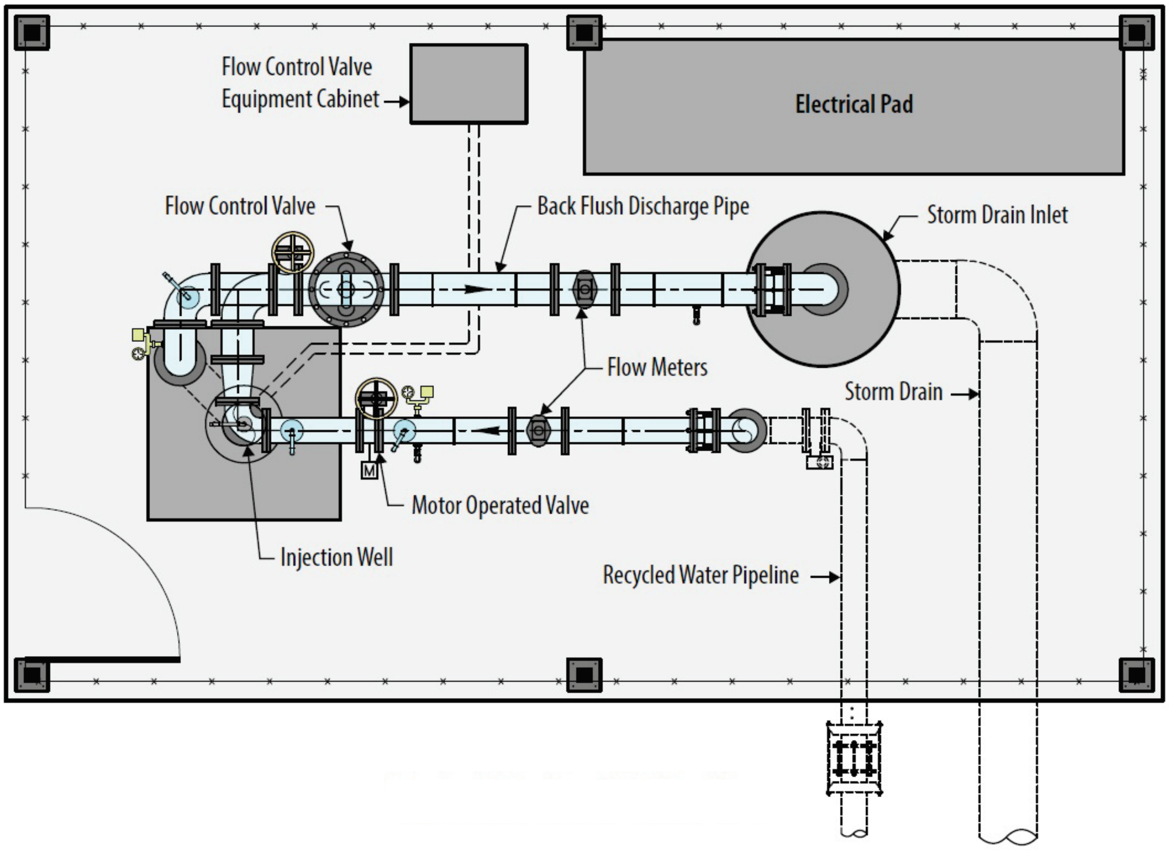
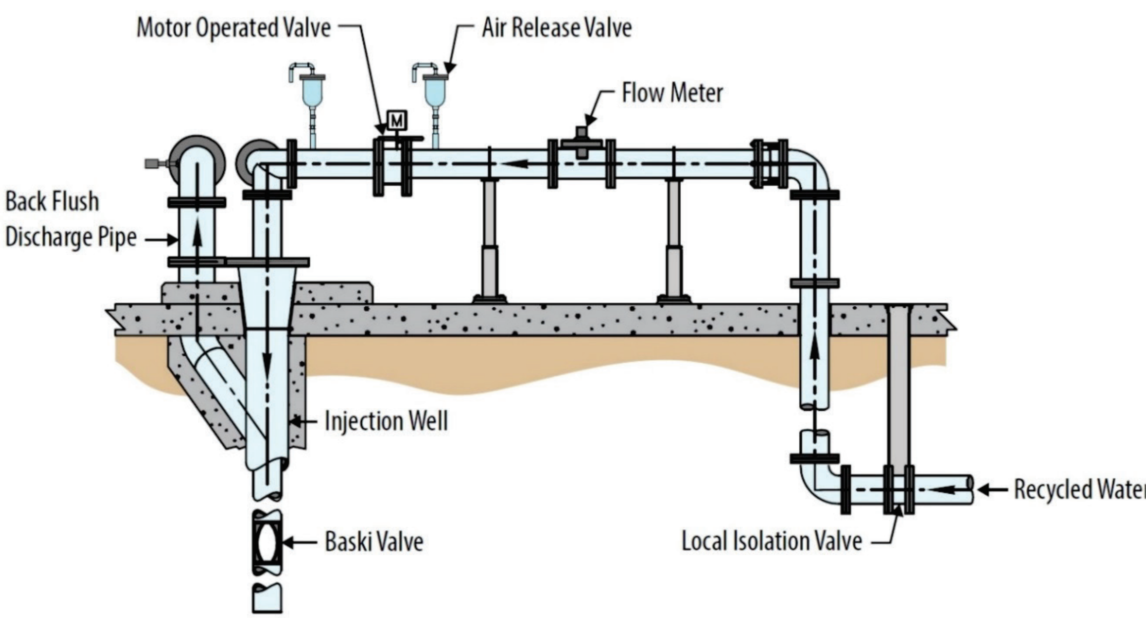


Figure 6.4: Typical Injection Well Elevation View



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Chapter 7

Regulatory Framework

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7.0 REGULATORY FRAMEWORK

7.1 Introduction

The use of recycled water for IPR is regulated in California to ensure protection of public health and water quality. IPR refers to the augmentation of groundwater or surface water with highly treated recycled water. IPR through groundwater replenishment, the focus of the potential RRWP, has been conducted for decades in California. The groundwater recharge regulations developed in the late 1970s allowed the use of recycled water, but proposed and existing groundwater recharge projects were evaluated on an individual basis. The draft criteria used to evaluate projects evolved over time. The final groundwater replenishment regulations were incorporated into Title 22 of the California Code of Regulations (22 CCR) in June 2014.

This chapter provides a general overview of regulations and policies associated with IPR through groundwater replenishment, the roles and responsibilities of the regulatory agencies that have oversight of water recycling, and the application of these regulations to the potential RRWP. This chapter also describes a potential permitting approach that Metropolitan would pursue in partnership with the Sanitation Districts and groundwater agencies.

Over the past year, Metropolitan has initiated discussions with the regulatory agencies on the RRWP and will continue to collaborate with these agencies. This chapter includes a summary of these discussions, along with a general timeline and associated milestones for securing a water recycling permit for the potential program. Finally, the current regulatory outlook in California for other forms of potable reuse, specifically IPR through surface water augmentation and DPR, is briefly described.

7.2 Regulation of Indirect Potable Reuse Projects

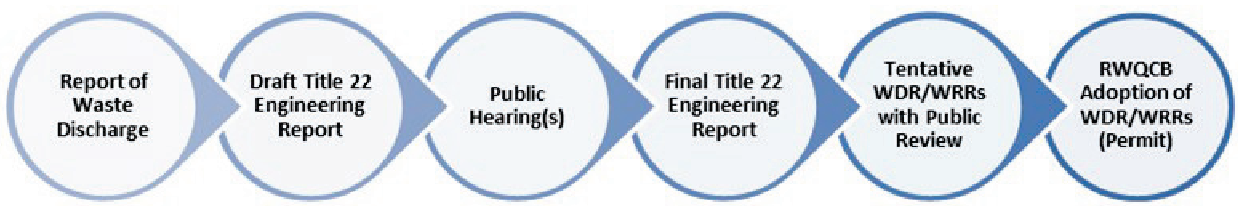
Regulatory Oversight of Water Reuse

Regulatory oversight of recycled water projects is carried out by the State Water Resources Control Board (SWRCB) through the Division of Drinking Water (DDW) and the individual Regional Water Quality Control Boards (RWQCBs). The DDW is statutorily directed to establish uniform statewide reclamation criteria for the various uses of recycled water that are set forth in 22 CCR §60301 to §60355. The RWQCBs have the exclusive authority to enforce water reclamation requirements through permit enforcement. The RWQCBs rely on the DDW's expertise to establish the permit conditions to protect public health.

Water Recycling Criteria have been established for the protection of public health and are codified in 22 CCR Division 4, Chapter 3, §60301 to §60355. These sections establish statutory authorities over water recycling and include specified approved uses of recycled water, numerical limitations and requirements, treatment requirements, reporting mechanisms, and performance standards. Use of recycled water is also regulated through the California Water Code (CWC) and the California Health and Safety Code. Recycled water is defined in CWC §13050 as *water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource.* Furthermore, CWC §60302 states that *the requirements in this chapter shall only apply to recycled water from sources that contain domestic waste, in whole or in part.*

The Water Recycling Criteria and Groundwater Replenishment Regulations (discussed later in this chapter) are implemented and enforced through water reclamation requirements (WRRs) and waste discharge requirements (WDRs) imposed by the RWQCBs. For projects involving surface water discharge, an NPDES permit is also required. MCLs established in 22 CCR are often used as a basis for effluent limitations in water recycling permits to protect municipal and domestic supply beneficial uses. CWC §13260 requires that a Report of Waste Discharge (ROWD) be filed with the RWQCB for any project proposing discharges that could affect the quality of waters of the State. The RWQCB prescribes WRRs and/or WDRs that reasonably protect all beneficial uses and implement relevant water quality control plans and policies. An entity proposing to recycle water would file a Title 22 Engineering Report with the DDW and the RWQCB on the proposed use. Following receipt of the Engineering Report, additional requests for information from the project sponsor, and consultation with the RWQCB, the DDW then holds a public hearing(s) along with the project sponsor. Following public hearing(s), the DDW provides recommendations to the RWQCB, which are then incorporated into WRRs and/or WDRs for the proposed use. Figure 7.1 summarizes the permit approval process for a water recycling project.

Figure 7.1: Water Recycling Permit Process



Title 22 CCR §60323 requires submission of the Engineering Report to the DDW and the RWQCB before recycled water projects are implemented. The purpose of the Engineering Report is to describe how a project will comply with 22 CCR §60301 through §60355 and protect public health. The report describes the design of the water reclamation system and clearly indicates the means for regulatory compliance. It also includes a contingency plan to ensure that no untreated or inadequately treated wastewater will be delivered to the area of use. In addition to Title 22 criteria, the Engineering Report includes a comprehensive hydrogeological assessment of the project area and addresses compliance with water quality standards and objectives in the applicable Water Quality Control Plan (Basin Plan).

The DDW has developed *Guidelines for the Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water*[1]. A typical Engineering Report for a groundwater replenishment project would provide sufficient details to address the following information:

Title 22 Engineering Report Contents	
1. Description of Project	8. Advanced Treated Water Quality
2. Project Participants and Regulations	9. Conveyance Systems
3. Description of Groundwater Basin(s)	10. Recharge Areas and Operations
4. Water Supply Uses of Basin(s)	11. Compliance Recharge Site Criteria
5. Groundwater Flow Evaluations	12. Monitoring and Reporting Programs
6. Source of Wastewater	13. Operation Optimization Plan
7. Treatment Process and Operating Criteria	14. Contingency Plan

[1] http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/recharge/ERGUIDE2001.pdf

Metropolitan would complete a Title 22 Engineering Report as part of the permitting process for the RRWP. The Engineering Report would follow the demonstration testing described later in this chapter, and would be accomplished in partnership with the Sanitation Districts and groundwater agencies. Engineering Reports must be amended prior to any modifications to a project and updated at least every 5 years with submittal to the DDW and the RWQCBs.

Groundwater Replenishment Regulations

The DDW and the RWQCBs regulate groundwater recharge projects under 22 CCR Division 4, Chapter 3. Final regulations for groundwater replenishment reuse projects using surface application (i.e., spreading) and subsurface application (i.e., injection) went into effect in June 2014. These Groundwater Replenishment Regulations address the protection of public health with respect to chemicals, microorganisms, and constituents of emerging concern (CECs). Groundwater replenishment projects must incorporate a multiple barrier strategy that protects public health by incorporating safeguards to ensure that a failure at any given treatment step will not compromise public health and will ensure long-term protection of the groundwater aquifer as a source of drinking water supply.

Table 7.1 summarizes the key requirements of the Groundwater Replenishment Regulations. Further information detailing Metropolitan's compliance requirements under these regulations is provided in the text that follows.

Source Control

Recycled water providers must administer a comprehensive source control program that includes the following: (1) assessment of the fate of DDW- and RWQCB-specified contaminants through the wastewater and recycled-water systems; (2) provisions for contaminant-source investigations and contaminant monitoring that focus on these contaminants; (3) an outreach program to industrial, commercial, and residential communities; and (4) an up-to-date inventory of contaminants. Some CECs for IPR projects may not fall under the authority of federal statutes addressing wastewater source control and must be addressed through proactive efforts. Industrial sources make up approximately 19 percent of the source water for the JWPCP and 30 percent of its organic load (lb/yr COD). The Sanitation Districts have a comprehensive source control program and are currently investigating opportunities to enhance current efforts within the JWPCP sewershed to safeguard the proposed AWT processes and protect end uses of the recycled water. Metropolitan will coordinate with the Sanitation Districts on this issue; improved source water quality will improve the safety, reliability, and cost-effectiveness of the advanced treated water delivered. Further details of the Sanitation Districts' source control program are described in Chapter 5, Section 5.2 of this feasibility study.

Advanced Water Treatment

The potential program will produce water treated by AWT for groundwater recharge. AWT can be defined as the treatment of an oxidized, filtered, and disinfected wastewater incorporating RO and an AOP that meets the performance criteria established in 22 CCR §60320.201. Metropolitan, in collaboration with the Sanitation Districts, may perform an occurrence study for the municipal wastewater to identify indicator compounds representative of various functional groups; removal of select indicator compounds must be demonstrated. As an alternative to conducting an occurrence study, Metropolitan would demonstrate at least a 0.5-log reduction of 1,4-dioxane through the AOP, with challenge tests conducted to confirm findings. Monitoring and reporting requirements are also established in the regulations to demonstrate the efficacy of the AOP.

Table 7.1: Groundwater Replenishment Regulations – Summary of Key Requirements

Constituent/ Parameter	Type of Recharge	
	Surface Application	Subsurface Application
Pathogenic Microorganisms		
Filtration	≤ 2 NTU	≤ 2 NTU
Disinfection	450 CT mg-min/L with 90 min. modal contact time or 5-log virus inactivation; and < 2.2 total coliform per 100 mL	450 CT mg-min/L with 90 min. modal contact time or 5-log virus inactivation; and < 2.2 total coliform per 100 mL
Pathogen Control	12-10-10 log reduction for enteric virus, *Cryptosporidium*, and *Giardia* reduction	12-10-10 log reduction for enteric virus, *Cryptosporidium*, and *Giardia* reduction
Response Retention time	≥ 2 months (depending on estimating method used)	≥ 2 months (depending on estimating method used)
Regulated Constituents		
Drinking Water Standards	Meet all drinking water MCLs in recycled water (or recharge water, as applicable); quarterly for primary MCLs; annually for secondary MCLs	Meet all drinking water MCLs in recycled water (or recharge water, as applicable); quarterly for primary MCLs; annually for secondary MCLs
Nitrogen Compounds	TN ≤ 10 mg/L in recycled or recharge water	TN ≤ 10 mg/L in recycled or recharge water
Unregulated Chemicals Control		
Total Organic Carbon	$\text{TOC} \leq 0.5\ \frac{\text{mg}}{\text{L}}$ Compliance point is in recycled water or in recycled water after soil aquifer treatment not impacted by dilution (no blending)	$\text{TOC} \leq 0.5\ \frac{\text{mg}}{\text{L}}$
Recycled Water Contribution		
RWC Definition	$\text{RWC} = \frac{\text{Vol of Recycled Water}}{\text{Vol of Recycled Water} + \text{Diluent Water}}$	
RWCmax Initial	Up to 20% without RO/AOP[a] Up to 100% with RO/AOP	Up to 100% (RO/AOP required for entire waste stream)
Increased RWCmax	≥ 20% subject to add'l requirements	Up to 100% subject to add'l requirements

[a]RO/AOP represents treatment using RO and an advanced oxidation process that meets requirements as outlined in the regulation.
CT = contact time. NTU = nephelometric turbidity unit. RWC = Recycled Municipal Wastewater Contribution.

Pathogen Control

At a minimum, recycled water quality for a groundwater replenishment reuse project must meet 22 CCR definitions for filtered wastewater (§60301.320) and disinfected tertiary recycled water (§60301.230). The treatment system must also achieve a 12-log enteric virus reduction, a 10-log *Giardia* cyst reduction, and a 10-log *Cryptosporidium* oocyst reduction using at least three treatment barriers (generally referred to as 12-10-10 pathogen log reduction). The log reduction represents the treatment that must be given to the wastewater during its conversion from raw municipal wastewater to the recycled water reaching a drinking water well. Each treatment barrier must achieve at least a 1.0-log reduction and no treatment process can be credited with more than a 6-log reduction. A project is also credited with a 1-log virus reduction for each month the recycled water is retained underground (up to a 6-log) based on a tracer test.

During the demonstration phase, Metropolitan will validate the log reduction credits for each treatment process by using challenge tests and/or submitting a report for DDW approval. Evidence must be provided to the DDW of the ability of the treatment process to reliably and consistently meet the log reduction requirements using DDW-approved monitoring procedures.

Nitrogen Control

The concentration of total nitrogen in recycled water must not exceed 10 mg/L. It should be noted that Basin Plan requirements for specific groundwater basins may employ more stringent nitrogen limits. Basin Plan requirements associated with the groundwater basins proposed for this program are described later in this chapter. Because the JWPCP secondary process does not remove nitrogen to a sufficient extent, meeting nitrogen limits for protection of the AWT system (nitrification to minimize membrane fouling) as well as the end use of the recycled water (meeting nitrate Basin Plan limits or antidegradation requirements) will be an important focus during the demonstration phase.

Regulated Chemicals Control

Recycled water must be monitored for regulated chemical constituents and must meet primary and secondary drinking water MCLs. Failure to meet MCLs requires follow-up sampling, notification to the DDW and the RWQCB, and/or discontinuation of recycled water use until the problem is corrected.

Constituents with Notification Levels

Notification Levels (NLs) represent the level of a contaminant in drinking water that DDW has determined does not pose a significant health risk but warrants notification to the public. NLs are non-regulatory, health-based advisory levels for constituents for which MCLs have not been established. Metropolitan will monitor the recycled water quarterly for NLs, with accelerated monitoring and notification to the DDW and the RWQCB if any results are greater than the NL.

Unregulated Chemicals Control

TOC is used as a surrogate for unregulated and unknown organic chemicals. Control of unregulated or emerging chemicals for all groundwater replenishment projects is accomplished through limits for TOC and treatment performance for indicator compounds. For surface applications (i.e., spreading), soil aquifer treatment (SAT) is assessed through monitoring TOC, along with other parameters approved by the DDW. The maximum TOC is 0.5 mg/L divided by the recycled water fraction of the total water applied. For subsurface application projects (i.e., injection), the entire recycled water flow must be treated using RO and an AOP. After treatment, TOC levels cannot exceed an average of 0.5 mg/L (with 100 percent recycled water contribution). Specific performance criteria for RO and AOP are included in the regulation.

Recycled Municipal Wastewater Contribution

Recycled Municipal Wastewater Contribution (RWC) is the fraction of the quantity of recycled water applied for a groundwater replenishment project divided by the total quantity of recycled water and credited diluent water (e.g., stormwater, imported water, subsurface underflow). Note that diluent water must be a DDW-approved drinking water source, or specific monitoring and a source water evaluation (i.e., watershed sanitary survey) must be conducted. The initial maximum RWC for surface application projects must not exceed 0.20 (or 20 percent), or an alternative initial RWC approved by the DDW. An alternative RWC up to 1.0 may be approved based on review of the Title 22 Engineering Report, information obtained through public hearings, and demonstration that treatment prior to surface application will reliably achieve TOC levels equal to or less than 0.5 mg/L divided by the proposed RWC.

For subsurface applications, the initial RWC may be assigned up to 1.0 based on the same criteria. Any increases in RWC during project operations must be approved by the DDW and the RWQCB. As discussed later in this chapter, a short ramp-up period to achieve an RWC of 1.0 is anticipated for the potential program.

Response Retention Time

The intent of the response retention time within a groundwater basin is to provide sufficient time to identify any treatment failures so that inadequately treated recycled water does not enter a potable water system. Sufficient time must elapse to allow for a response that would protect the public from exposure to inadequately treated water and provide an alternative source of water or remedial wellhead treatment, if necessary. The response retention time is the aggregate period for the following: (1) identification that the recycled water is out of compliance; (2) treatment verification samples or measurements; (3) analysis of the sample; (4) evaluation of results; (5) decisions regarding the appropriate response; (6) activation of a response; and (7) verification that the response is effective. The minimum response retention time is 2 months, but it must be justified by the project sponsors (i.e., Metropolitan and partnering groundwater agencies) and approved by the DDW. A tracer study can be conducted to establish the response retention time credited.

Monitoring Programs

Comprehensive monitoring programs are required for the recycled water and groundwater for regulated and unregulated constituents. If monitoring demonstrates failure to meet specific requirements, the project sponsor must notify the DDW and the RWQCB, investigate the cause and take corrective actions, and in some cases, discontinue the use of recycled water. Note that groundwater monitoring, taking into consideration seasonal variations, must be conducted within targeted basins prior to the operation of a groundwater replenishment project. Metropolitan and its partners would seek to use existing groundwater monitoring wells to the extent possible.

Operation Optimization Plan

Prior to operation of a groundwater replenishment project, Metropolitan, in conjunction with its project partners, would submit an operation optimization plan to the DDW and the RWQCB for review and approval. The intent of the plan is to ensure that facilities are operated to achieve compliance with the Groundwater Replenishment Regulations, achieve optimal reduction of contaminants (including achieving the credited pathogen log reductions), and identify how the project will be operated, maintained, and monitored. The operation optimization plan(s) would address both the AWT facilities and the groundwater injection/extraction systems. Considering the regional nature of the RRWP, coordination among Metropolitan, partnering groundwater agencies, and regulators will be necessary to determine whether separate plans will be completed to address each facility, or if a combined plan is appropriate. High levels of operator expertise along with specialized and ongoing training will be critical to the success of the potential program and must be described in the plan(s).

Drinking Water Well Locations

For each replenishment area, Metropolitan and partnering groundwater agencies must establish a "zone of controlled well construction," representing horizontal and vertical distances that reflect the underground retention times required for pathogen control and response retention time determination. Drinking water production wells cannot be located in this zone. Initial groundwater modeling has been conducted to represent zones of varying underground retention times and is described in Chapter 4. Note that project sponsors must also create a secondary boundary that represents a zone of potential controlled well construction—this may be beyond the zone of controlled well construction and would require additional study before a new drinking water well is sited.

Managerial and Technical Capability

Metropolitan must demonstrate to the DDW and the RWQCB that it possesses adequate managerial and technical capabilities to comply with all applicable regulations. The DDW developed a Technical Managerial and Financial Assessment form for public water systems to demonstrate its capability to provide a safe drinking water supply. Portions of this form can be used to demonstrate compliance with the managerial and technical capability requirements in the Groundwater Replenishment Regulations. Metropolitan, in partnership with the Sanitation Districts, would provide required information on project operational capabilities including information on certified operators, training, and emergency response.

Alternatives

Alternatives to any of the provisions in the Groundwater Replenishment Regulations are allowed if the project sponsor can demonstrate that: (1) the alternative provides the same level of public health protection; (2) the alternative has been approved by the DDW; and (3) an expert panel has reviewed the alternative unless otherwise authorized by the DDW. In addition, if required by the DDW and the RWQCB, a public hearing must be conducted on the proposed alternative. Further, prior to operation of the proposed project, Metropolitan and partnering groundwater agencies must have a DDW-approved plan that outlines the steps to provide an alternative source of water supply, or a wellhead treatment mechanism, that would ensure protection of public health in the event of the following: (1) an MCL violation; (2) degraded groundwater quality that is no longer a safe drinking water source; or (3) failure to meet pathogen reduction criteria.

Public Hearing

Metropolitan in conjunction with the DDW must hold one or more public hearings prior to the RWQCB issuing a tentative permit. In addition, a public hearing must be held when increases in the maximum RWC are proposed, if not addressed in a prior hearing. Relevant project information must be made accessible to the public for at least 30 days prior to the hearing.

Groundwater Plans and Policies

The RWQCB regulates groundwater replenishment projects under its Water Quality Control Plans (Basin Plans) and other applicable regulations and policies to protect water quality and the beneficial uses of surface water and groundwater. Key regulatory plans and policies associated with groundwater replenishment are described below.

Basin Plans

Basin Plans reflect applicable portions of a number of national and statewide water quality plans and policies, including the CWC and Clean Water Act. RWQCB permit requirements are based on the beneficial uses of surface waters and groundwater, and the applicable numeric or narrative water quality objectives. CWC defines water quality objectives as … *the limits or levels of water quality constituents or characteristics which are established for the reasonable protection of beneficial uses of water or the prevention of nuisance within a specific area* (CWC §13050(h)).

Four groundwater basins are being considered as part of the potential program. These basins are listed in Table 7.2 and are shown in Figure 7.2. Beneficial uses for these basins include municipal and domestic water supply (MUN), industrial service supply (IND), industrial process supply (PROC), and agricultural supply (AGR). As MUN is typically the most stringent standard, permit limits are often based on protection of this beneficial use. To protect the MUN beneficial use, Basin Plans include groundwater objectives based on primary and secondary MCLs, numeric objectives for coliforms, narrative objectives to prevent taste and odor issues, and basin-specific mineral objectives. Basin Plan water quality objectives that apply to the groundwater basins currently being considered for the program are shown in Table 7.3.

Table 7.2: Groundwater Basins Proposed for the Program

Basin	County	Basin Plan Region	Beneficial Uses
Central Basin	Los Angeles	Los Angeles (Region 4)[1]	MUN,IND,PROC,AGR
West Coast Basin	Los Angeles	Los Angeles (Region 4)	
Main San Gabriel Basin	Los Angeles	Los Angeles (Region 4)	
Orange County Basin	Orange County	Santa Ana (Region 8)[2]	

[1]http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/
[2]http://www.swrcb.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

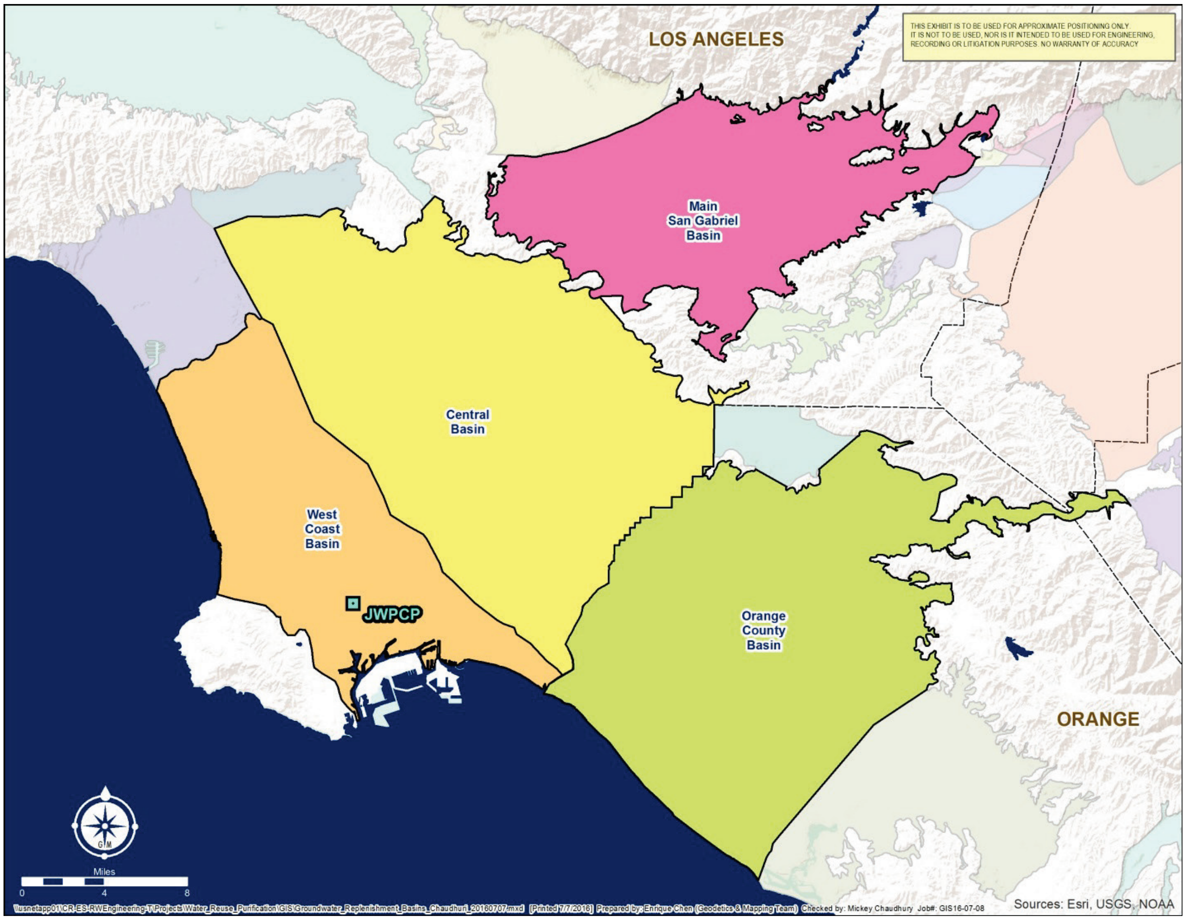
Table 7.3: Basin Plan Water Quality Objectives for Select Constituents

Constituent	Units	Central Basin	West Coast Basin	Main San Gabriel Basin	Orange County Basin
Aluminum	mg/L	1.0	1.0	1.0	NA[6]
Antimony	mg/L	0.006	0.006	0.006	NA[6]
Arsenic	mg/L	0.01	0.01	0.01	0.05
Bacteria, Coliform	1/100 mL[2]	1.1	1.1	1.1	2.2
Barium	mg/L	1.0	1.0	1.0	1.0
Boron	mg/L	1.0	1.5	0.5	0.75
Beryllium	mg/L	0.004	0.004	0.004	NA[6]
Cadmium	mg/L	0.005	0.005	0.005	0.01
Color	--	NA[6]	NA[6]	NA[6]	No adverse impact to beneficial uses
Copper	mg/L	NA[6]	NA[6]	NA[6]	1.0
Chloride	mg/L	150	250	100	500
Chromium	mg/L	0.05	0.05	0.05	0.05
Cobalt	mg/L	NA[6]	NA[6]	NA[6]	0.2
Cyanide	mg/L	0.15	0.15	0.15	0.2
Fluoride	mg/L	2.0	2.0	2.0	1.0
Gross Alpha	pCi/L	15	15	15	15
Gross Beta	pCi/L	50[7]	50[7]	50[7]	50[7]
Hardness	--	NA[6]	NA[6]	NA[6]	No adverse impact to beneficial uses

Constituent	Units	Central Basin	West Coast Basin	Main San Gabriel Basin	Orange County Basin
Iron	mg/L	NA[6]	NA[6]	NA[6]	0.3
Lead	mg/L	NA[6]	NA[6]	NA[6]	0.05
Manganese	mg/L	NA[6]	NA[6]	NA[6]	0.05
MBAS[3]	mg/L	NA[6]	NA[6]	NA[6]	0.05
Mercury	mg/L	0.002	0.002	0.002	0.002
Nickel	mg/L	0.1	0.1	0.1	NA[6]
Nitrate (as N)	mg/L	10[5]	10[5]	10[5]	3.4[4]
Oil and Grease	--	NA[6]	NA[6]	NA[6]	No adverse impact to beneficial uses
Perchlorate	mg/L	0.006	0.006	0.006	NA[6]
pH		NA[6]	NA[6]	NA[6]	Between 6 and 9
Radium-226 and Radium-228 (combined)	pCi/L	5	5	5	5
Selenium	mg/L	0.05	0.05	0.05	0.01
Silver	mg/L	NA[6]	NA[6]	NA[6]	0.05
Sodium	mg/L	NA[6]	NA[6]	NA[6]	180
Strontium-90	pCi/L	8	8	8	8
Sulfate	mg/L	250	250	100	500
Taste and Odor	--	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses	No adverse impact to beneficial uses
Thallium	mg/L	0.002	0.002	0.002	NA[6]
Total Dissolved Solids	mg/L	700	800	450, 600[1]	580[4]
Toxic Substances	--	NA[6]	NA[6]	NA[6]	No detrimental physiological responses in human, plant, animal, aquatic life
Tritium	pCi/L	20,000	20,000	20,000	20,000
Uranium	pCi/L	20	20	20	20

[1]Dependent on location in basin (Western Area, Eastern Area)
[2]Median over any 7-day period
[3]Methylene Blue-Activated Substances
[4]Based on assimilative capacity findings
[5]Also shall not exceed 10 mg/L nitrogen as nitrate-N plus nitrite-N
[6]Not specifically addressed in Basin Plan; would default to MCL where applicable
[7]4 millirem/year annual dose equivalent to the total body or any internal organ; pCi/L = picocuries per liter.

Figure 7.2: Groundwater Basin Map



Of particular note are the different nitrate limits for the individual groundwater basins. The Central, West Coast, and Main San Gabriel basins each have nitrate limits of 10 mg/L as N, matching the nitrate MCL. Due to basin-specific nitrate issues in the Orange County Basin, lower nitrate limits have been applied by the Santa Ana RWQCB. Due to a nitrate-N Basin Plan limit of 3.4 mg/L in the Orange County Basin, the Orange County Water District's permit for the Groundwater Replenishment System requires meeting a nitrate-N level of 3 mg/L. Basin Plan objectives will therefore help to dictate treatment technologies applied at the AWT facility proposed for the program. This issue is also discussed in Section 5.4.

Boron is another example of basin-specific limits. The state NL for boron is 1 mg/L; however, the Basin Plan limit for the Main San Gabriel Basin is 0.5 mg/L. Elevated boron levels affect the AGR beneficial use, particularly for use on citrus crops. The JWPCP pilot study conducted between 2010 and 2012 indicated boron levels exceeding 0.5 mg/L at times. Source control or treatment measures would be required to remove boron prior to groundwater replenishment. The Sanitation Districts are currently investigating potential boron sources within the JWPCP sewershed. This issue is also discussed in Chapter 5, Section 5.4. If source control efforts do not fully mitigate this issue, additional treatment or potential blending strategies could be employed for the portion of AWT flow directed to the Main San Gabriel Basin.

Recycled Water Policy

The SWRCB adopted a Recycled Water Policy in 2009, and amended it in 2013 to address monitoring requirements for CECs.[2] The purpose of the policy is to increase use of recycled water in a manner consistent with existing regulations. The Recycled Water Policy established a goal for California to increase the use of recycled water over 2002 levels by at least 1 million AFY by 2020, and by at least 2 million AFY by 2030.

A key element in this policy is the development of salt and nutrient management plans for every groundwater basin in California. These plans address basin-specific water quality issues associated with salts and nutrients, as well as other constituents found in recycled water that may impact groundwater basins. These include CECs, for which a monitoring strategy based on recommendations by an expert panel is required.[3]

The policy also provides guidance on conformance with the State's Antidegradation Policy (discussed in the following section) by allowing a project to use up to 10 percent of a groundwater basin assimilative capacity, or up to 20 percent for multiple projects, with an antidegradation analysis completed and submitted to the RWQCB for approval.

Finally, the Recycled Water Policy indicates the potential need for additional permit requirements based on the effect that a groundwater recharge project may have on the fate and transport of a contaminant plume in a specific groundwater basin. For example, there are areas of groundwater contamination in the San Gabriel Valley that are included on USEPA's National Priorities List, which must be considered for a groundwater recharge project in the Main San Gabriel Basin. The policy also requires evaluation of the effect that a groundwater replenishment project may have on the geochemistry of an aquifer that could cause dissolution of chemicals, such as arsenic, from the geologic formation into groundwater. These would be important issues for Metropolitan and groundwater agency partners to investigate and coordinate with regulators as part of the potential program.

Antidegradation Policy

Federal antidegradation regulations are identified in Code of Federal Regulations (CFR) Title 40 §131.12. The SWRCB has interpreted federal policy through adoption of Resolution No. 68-16, *Statement of Policy with Respect to Maintaining High Quality of Waters in California*,[4] which established antidegradation policy in California and included the following requirement:

> *Whenever the existing quality of water is better than the quality established in policies as of the date on which such policies become effective, such existing high quality will be maintained until it has been demonstrated to the State that any change will be consistent with maximum benefit to the people of the State, will not unreasonably affect present and anticipated beneficial uses of such water and will not result in water quality less than that prescribed in the policies.*

[2] http://www.swrcb.ca.gov/water_issues/programs/water_recycling_policy/docs/rwp_revtoc.pdf.
[3] http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/docs/cec_monitoring_rpt.pdf
[4] http://www.waterboards.ca.gov/board_decisions/adopted_orders/resolutions/1968/rs68_016.pdf

This policy applies to both surface water and groundwater in California. The SWRCB has also developed implementing guidelines (APU 90-004)[5] for its Antidegradation Policy. It should be noted that the Antidegradation Policy is not an absolute bar to reductions in water quality. The policy may allow lowering of water quality in surface water or groundwater if the change is consistent with providing a maximum benefit to the people of the State and does not unreasonably affect present and anticipated beneficial uses. However, depending on the level of assimilative capacity available for a particular constituent in a groundwater basin, some water recycling projects may have to meet levels below Basin Plan objectives and potentially current ambient groundwater constituent levels.

Salt and Nutrient Management Plans

Recognizing that some groundwater basins contain salts and nutrients that exceed or threaten to exceed water quality objectives established in the applicable Basin Plans, Salt and Nutrient Management Plans (SNMPs) have been mandated by the SWRCB. The Recycled Water Policy required that local water and wastewater entities, together with local stakeholders, develop an SNMP for each groundwater basin in California by May 2014. The purpose of the plans is to ensure preservation or attainment of Basin Plan water quality objectives. Several groundwater basins have received extensions for the submittal of their plans. SNMPs for the groundwater basins targeted for the potential program are complete and they are listed in Table 7.4 along with their regulatory approval status. Metropolitan will consider and ensure compliance with the SNMPs in the implementation of the potential program. Additional groundwater modeling and an assimilative capacity analysis may need to be conducted. Effects on a specific basin, considering the volume of recycled water recharged, for constituents such as TDS, chloride, and nitrate would be evaluated and incorporated into future updates of the SNMP.

Table 7.4: Salt and Nutrient Management Plans for Proposed Groundwater Basins

Salt and Nutrient Management Plan	Agency Lead	Regional Board Jurisdiction	Status
Central and West Coast Basins	WRD of Southern California	Los Angeles RWQCB	Complete; Basin Plan amendment in February 2015[1,2]
Main San Gabriel	Main San Gabriel Basin Watermaster	Los Angeles RWQCB	Draft SNMP under RWQCB review; Basin Plan amendment anticipated in January 2017
Santa Ana Region	Santa Ana Watershed Project Authority	Santa Ana RWQCB	Complete; Basin Plan amendments in January 2004 and April 2014[3]

[1]http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/RECUR/2015_06/FinalBasinPlanAmendmentCentralandWestCoastBasins'SNMP.pdf
[2]http://www.waterboards.ca.gov/losangeles/water_issues/programs/basin_plan/RECUR/2015_06/150212_FINALSaltNutrientMngtPlanforCentral&WestCoastBasins.pdf
[3]http://www.swrcb.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

[5] http://www.swrcb.ca.gov/water_issues/programs/npdes/docs/apu_90_004.pdf

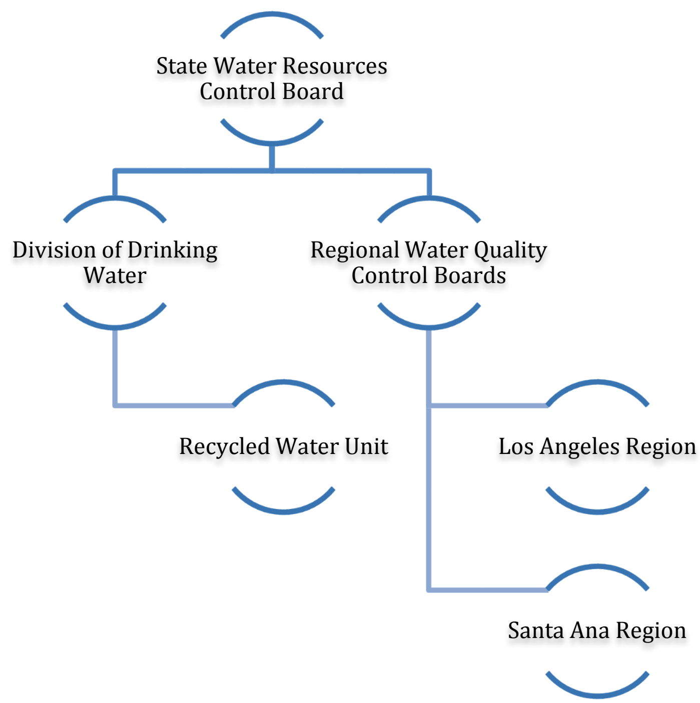
7.3 Regulatory Approach for Program

Regulatory Coordination

At every phase of the potential program, including the feasibility study, Metropolitan's close coordination and collaboration with regulators and partnering agencies is critical to ensure success. Although the eventual WRR/WDR permits are issued by the RWQCB, the DDW is the primary agency that will be involved in the technical review of program elements that have a potential to affect public health. Permits from both the Los Angeles and Santa Ana RWQCBs would be required, depending on the specific groundwater basins that will ultimately be pursued for recharge. A general overview of a permitting approach is discussed later in this section; further details on the specific approach would be developed in coordination with regulators and partnering groundwater agencies should the RRWP proceed.

Figure 7.3 identifies the regulating authorities associated with permitting of the potential RRWP, as well as their general organizational structure.

Figure 7.3: Regulatory Oversight of Program



Metropolitan and the Sanitation Districts have engaged in meetings with the regulators (the DDW and the Los Angeles and Santa Ana RWQCBs) since early 2016. Meetings have been well attended with 20 to 30 participants at each meeting. Along with other information presented at the meetings, following each meeting, a summary document of key discussions and feedback was distributed to all participants. As documents are generated or milestones reached, Metropolitan will continue to inform the regulators of program progress and direct them to Metropolitan's RRWP webpage for posted information.

The initial kickoff meeting in February 2016 introduced the regulators to the RRWP. Metropolitan and Sanitation Districts' staff presented information on the need for the program, overview of the JWPCP and source control efforts, previous AWT pilot studies, overview of the potential program elements, and a general approach for regulatory coordination and associated milestones. In addition to introducing the regulators to the program, a key objective of this meeting was to establish a high level of confidence with the regulatory authorities that Metropolitan and the Sanitation Districts are well suited to successfully implement a program of this magnitude.

The second meeting with the regulators was held in May 2016. This meeting focused primarily on the AWT process train for the demonstration facility, with other program updates including a recap of the first Advisory Panel workshop, public outreach planning approach, and regulatory milestones and anticipated timeline. Much of the discussion centered on the use of an MBR and the necessary process monitoring and integrity testing that would be needed to obtain pathogen log reduction credit. The DDW requested to collaborate with Metropolitan in developing these monitoring and testing protocols. It was recognized at the meeting that the use of MBRs for potable reuse applications could have significant benefits for water reuse development in California in terms of facility size requirements and cost. A follow-up meeting was held in August 2016 with the DDW to inform them of the demonstration facility rescaling from 1 mgd to 0.5 mgd, based on Metropolitan's value engineering assessment. With the continued use of full-scale cassettes for the MBRs, the DDW did not have any objection to rescaling the facility to meet the desired objectives of the demonstration project.

The third meeting with the regulators was held in September 2016. The primary objective of this meeting was to inform regulators on the results of groundwater basin analyses conducted on water demands and basin capacities, operational assessments of potential recharge facilities, and preliminary groundwater modeling associated with recharge and extraction for the potential program. The regulators were also updated on other program developments. This meeting served as Metropolitan's final meeting with the regulators in 2016.

Meetings in 2017 are anticipated to focus on testing and monitoring protocols for the demonstration facility, further discussion on an optimal permitting approach for the potential regional program, conceptual design of the full-scale AWT facility, and a field visit to the demonstration facility as it nears the end of construction. Table 7.5 summarizes the regulator meetings held to date and those planned for 2017.

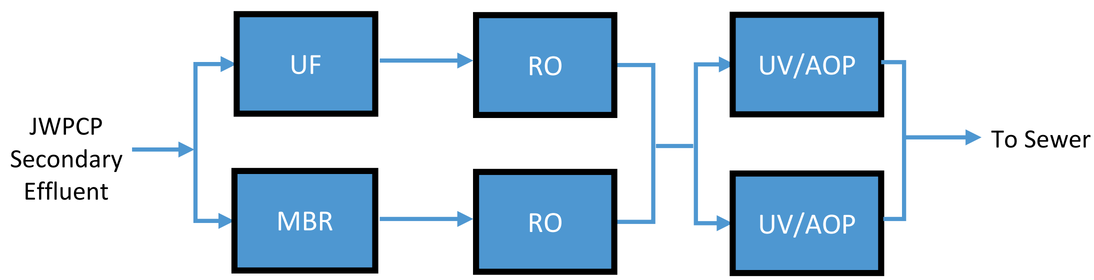
Table 7.5: Program Meetings with Regulators

Meeting Date	Meeting Focus/Objective
February 23, 2016	Kickoff meeting and overview of program
May 23, 2016	Demonstration plant process-train design
September 15, 2016	Groundwater modeling and basin assessments
2017 (projected)	Demonstration plant testing and monitoring protocols Regulatory/permitting approach Conceptual design of full-scale AWT facility JWPCP and demonstration plant site visit

Pilot Study

Prior to initiating a demonstration project, the Sanitation Districts and Metropolitan conducted a pilot-scale study between 2010 and 2012[6], using two 18-gpm facilities at the JWPCP. Receiving U.S. Bureau of Reclamation WaterSMART funding, the pilot study tested two AWT process trains to evaluate treatment of JWPCP effluent (Figure 7.4). The first train was the standard AWT process consisting of ultrafiltration (UF), RO, and UV/AOP with hydrogen peroxide. The second train used an MBR in lieu of the UF membrane. Key technical evaluations for the pilot study included assessing water quality performance of the two AWT trains, membrane process operations and performance, nitrification in an MBR, UV photolysis with and without hydrogen peroxide, and chemical additives to improve treatment. The pilot study demonstrated the ability of the tested AWT technologies to treat JWPCP effluent and meet regulations applicable at the time, identified the potential benefits of the MBR process in an AWT process train, and contributed to the process design for the demonstration facility. Overall, the study concluded that the JWPCP effluent is a viable source of new supply for IPR through groundwater recharge.

Figure 7.4: Schematic of Pilot Plant Process Train



Demonstration Project

A demonstration project is being pursued to provide the data necessary to present to regulating authorities and ultimately to secure a water recycling permit. The Metropolitan board authorized the design and operation of a demonstration facility in November 2015. The demonstration project would build on the work completed at the smaller pilot scale and would seek to demonstrate the ability to reliably and cost effectively treat JWPCP effluent at the larger scale, while meeting all regulatory requirements and operational objectives. In addition to supporting the regulatory approval process, the demonstration facility would help to develop and optimize full-scale design, establish capital and operational costs, facilitate operational coordination between Metropolitan and the Sanitation Districts, and serve as a vehicle for public outreach and acceptance. The demonstration facility would operate for 1 year to provide the necessary data to support the regulatory process and would likely operate beyond that time to support several of the other objectives noted above. Table 7.6 below identifies areas that will be focused on during the demonstration phase to ensure regulatory acceptability.

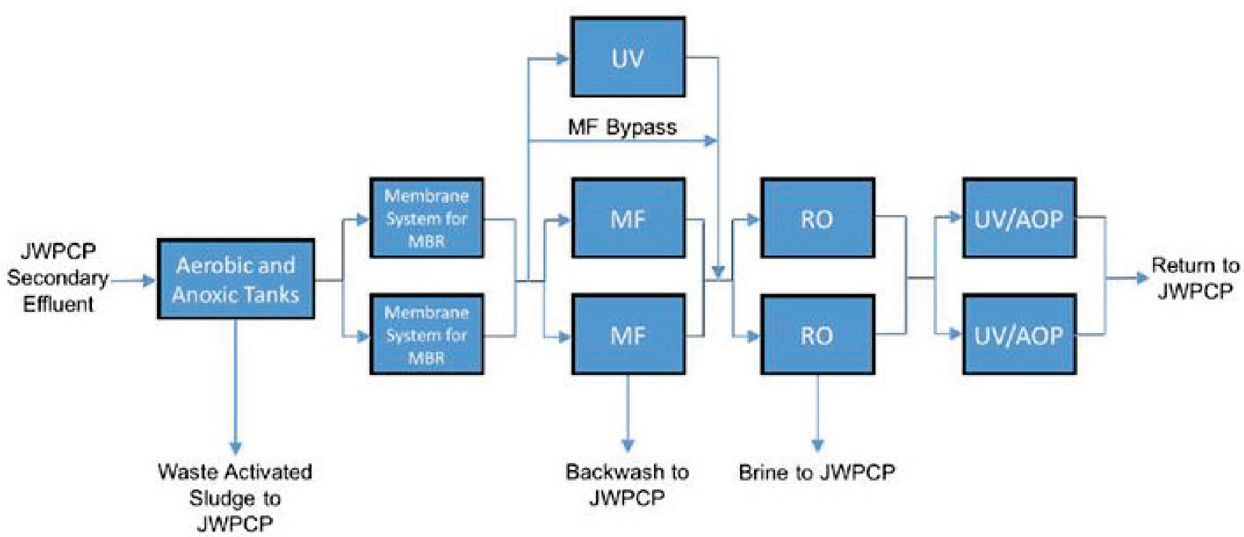
[6] http://www.mwdh2o.com/PDF_About_Your_Water/Pilot_Study.pdf

Table 7.6: Demonstration-Phase Focus Areas

Enhanced source control measures
Pilot study confirmation
Full-scale AWT process-train design
Pathogen control through 12-10-10 log reduction
Control of nitrogen compounds
TOC limits
Emerging constituents monitoring
Reliability and redundancy of treatment processes
Monitoring and response plan to address unanticipated operational issues
Technical and managerial capacity for AWT operation
Operational collaboration between Metropolitan and Sanitation Districts
Capital and operating cost estimates for full-scale project
Hydrogeologic assessments and groundwater modeling
Public education and outreach

Figure 7.5 illustrates the process train that was selected for the 0.5-mgd AWT demonstration plant. Secondary, non-nitrified effluent from the JWPCP will be delivered to the demonstration facility. The treatment train consists of an MBR, membrane filtration (MF) through either microfiltration or UF, and UV/AOP processes. The overall treatment process employs a "single-train, two-vendor" configuration. Two separate manufacturers/technologies at 0.25-mgd capacity each will be applied to each treatment process as shown, providing common feed water inflow into the subsequent unit process. Bypasses will also be included around certain treatment units. Effluent from the demonstration facility will be routed back to the head of the JWPCP. As indicated earlier, the demonstration process train was presented to the regulators in May 2016, with positive feedback received on the approach taken.

Figure 7.5: Schematic of Demonstration Plant Process Train



A unique aspect of this potable reuse demonstration facility is the use of an MBR. Because the JWPCP produces non-nitrified effluent, the MBR nitrification process will help reduce organics and minimize membrane fouling, and the denitrification process in combination with RO will help achieve nitrate levels that meet Water Quality Control Plan (Basin Plan) objectives for each specific groundwater basin. The treatment train will include a bypass of the MF process so that the MBR filtrate can be fed directly to the RO unit to determine its performance for *Cryptosporidium* and *Giardia* reduction. If sufficient log reduction credits can be granted by regulators for the MBR process, the MF treatment step could be removed, which could result in significant savings in capital and operating costs. A lower-dosage UV process will also be tested for *Cryptosporidium* and *Giardia* log reduction as a potential additional alternative to bypassing the MF process. Table 7.7 describes the pathogen log reduction credits that are currently granted for AWT processes by regulators, as well as the potential log reduction credits that could be granted to an AWT process using an MBR without the MF treatment step. A key focus area during the demonstration phase will be on protocols for direct integrity testing of the MBR units. Currently, the DDW has engaged with Santa Clara Valley Water District and Carollo Engineers on the issue of MBR integrity monitoring, and this demonstration project will build on that work. Note that the regulations allow up to a 1-month virus reduction for each month that the recycled water is retained underground.

Table 7.7: Approaches to Achieving Pathogen Log Reduction Credits

Unit Process	Currently Approved AWT Train			Alternate AWT Train Using MBR[1]		
	Virus	*Crypto*	*Giardia*	Virus	*Crypto*	*Giardia*
MBR	—	—	—	0	2.5[2]	2.5[2]
MF/UF	0	4	4	—	—	—
RO	1.5	1.5	1.5	1.5	1.5	1.5
UV/AOP	6	6	6	6	6	6
Free Cl_2	6	0	0	6	0	0
Total	**13.5**	**11.5**	**11.5**	**13.5**	**10**	**10**
Regulatory Requirement	*12*	*10*	*10*	*12*	*10*	*10*

[1]Pathogen log reduction credits currently not granted for MBRs by regulator.
[2]Requires demonstration and approval by regulator.
MF/UF = microfiltration/ultrafiltration

In addition to the demonstration-scale (0.5 mgd) testing, smaller scale bench- and/or pilot-testing will be conducted at the demonstration facility site to investigate additional treatment processes that may be considered as part of a full-scale facility. For example, ion exchange treatment will be tested at the smaller scale to assess boron and/or nitrate removal if necessary to meet Basin Plan objectives for individual groundwater basins. In addition, post-treatment stabilization processes and alternative biological treatment options for nitrogen removal will be tested at the smaller scale.

Design of the demonstration facility is underway and is expected to be complete in late 2016. Construction will begin in early 2017 pending the Metropolitan board's approval. Metropolitan will continue to closely coordinate with regulators throughout the development and operation of the demonstration facility. A testing and monitoring plan for the 1-year demonstration period will be developed with workshops planned in early 2017 with the DDW and the RWQCBs to allow input for the development of these protocols. Ultimately, the demonstration facility testing and monitoring plan will be submitted to the DDW for approval.

Because the JWPCP effluent has never been used for beneficial reuse, collecting data to demonstrate the AWT facility's ability to meet applicable regulatory criteria will be critical, especially because of the industrial nature of a portion of the sewershed. The demonstration phase will provide an opportunity for Metropolitan and the Sanitation Districts to cooperate on actions that may be necessary, through source control or additional treatment, to address constituents that may be problematic for the AWT facility or the end use of the water.

Information garnered from the demonstration phase will provide the information and water quality data necessary for Metropolitan and its partners to complete the Title 22 Engineering Report—a prerequisite for the WDRs/WRRs ultimately issued by the RWQCB. Operation of the facility will also demonstrate to regulators Metropolitan's capacity to reliably operate an AWT facility treating secondary wastewater effluent. The demonstration project will allow both Metropolitan and the Sanitation Districts to gain experience and collaborate on the operation of the wastewater and AWT systems, both of which play a critical role in ensuring that high-quality water is reliably produced and meets all regulatory requirements.

As noted in Chapter 2, an Advisory Panel has been established for the feasibility phase of the RRWP. It is anticipated that an Advisory Panel would continue to engage with Metropolitan and Sanitation Districts staff and provide critical input during the demonstration and full-scale phases of the program. This ongoing Advisory Panel for a full-scale program may have a similar makeup to the current panel, or additional/ alternative expertise may be desired. An ongoing external Advisory Panel is envisioned to provide guidance and technical review throughout the program and for all submittals to the regulating authorities.

Permitting Approach

Considering the regional nature of this program — spanning multiple groundwater basins, counties, and RWQCB jurisdictions — a number of permitting scenarios would be considered. Metropolitan will be producing advanced treated water at the JWPCP site and delivering it to various recharge sites across the region. This water will then be recharged into groundwater via spreading or injection facilities. Depending on the specific site, the recharge facilities could be owned and operated by Metropolitan, groundwater or flood control agency partners, or a combination thereof. Groundwater agencies would receive the water and extract it for municipal uses.

If the RRWP is approved, Metropolitan would engage in detailed discussions with its partners and the regulators on the permitting approach for the program. It is currently envisioned that individual permits (WDR/WRRs) will be required for each groundwater basin. When multiple recharge sites are proposed for a groundwater basin (e.g., recharge sites in the Montebello Forebay and Long Beach areas are proposed for Central Basin), both sites could be covered under a single permit. This approach is similar to the OCWD's Groundwater Replenishment System in which multiple spreading and injection sites are included in a single permit issued by the Santa Ana RWQCB. Also in line with other permits for groundwater recharge facilities in Southern California, it is anticipated that agency partners for the potential program may also be listed as co-permittees, where appropriate, based on their specific roles for the facility or project. Table 7.8 indicates key regulatory elements of a water recycling permit and some of the agencies that could play a role in those permitted activities. It should be noted that the basin managers are indicated in the table below because of their potential partnering role in the permitting process; however, activities such as groundwater extraction would be undertaken by individual pumpers within the groundwater basin and coordination would also be needed with these entities.

The unique nature of this regional program with multiple partners may require that creative permitting approaches are developed in collaboration with the regulators and project partners. In addition to the permits themselves, institutional arrangements would be necessary between Metropolitan and its partners to identify specific roles and responsibilities including those associated with program implementation, project operations, and permit compliance. In addition, the Sanitation Districts would need to work closely with the Los Angeles RWQCB to appropriately modify its NPDES permit to accommodate brine discharge.

Table 7.8: Key Coordinating Agencies on Program Permitting Elements

Permitting Element	Coordinating Agencies
Wastewater Treatment	Sanitation Districts of Los Angeles County
Advanced Water Treatment	Metropolitan Water District of Southern California
Spreading and/or Injection Site Operations	Metropolitan Water District of Southern California Los Angeles County Flood Control District Orange County Water District
Groundwater Extraction	Central Basin Municipal Water District West Basin Municipal Water District Orange County Water District Main San Gabriel Watermaster
Groundwater Monitoring	Water Replenishment District Central Basin Municipal Water District West Basin Municipal Water District Orange County Water District Main San Gabriel Basin Watermaster

The critical technical document that contributes to the permitting process is the Title 22 Engineering Report. Results and data generated from the 1-year testing period for the demonstration facility will be used to develop this report. Hydrogeological assessments and modeling for each groundwater basin will also be conducted as part of the Title 22 Engineering Report development. Because the regional nature of this program encompasses multiple groundwater basins and Regional Board jurisdictions, the structure and development of the program's Title 22 Engineering Report could be approached in a number of ways. Options would be further discussed with regulators and partners as the program progresses.

Because it is anticipated that results from the demonstration phase will provide regulators with the confidence that the full-scale program will be able to meet all applicable regulations and be fully protective of public health, Metropolitan will seek to achieve a 100 percent RWC as quickly as possible. As previous groundwater replenishment projects have experienced, a ramp-up period is expected to be required by the regulators to be assured that no unintended consequences arise as a result of recharging advanced treated water from the JWPCP site. At the current feasibility stage, a 3-year ramp-up period is assumed for groundwater basin areas that have not received recycled water. This ramp-up period may be 50 percent RWC during the first year, 75 percent RWC during the second year, and 100 percent RWC during the third year. For groundwater basins and recharge locations that have extensive history and data associated with groundwater replenishment (e.g., Orange County Basin), this ramp-up period could be accelerated. Source and quantities of diluent water available during a ramp-up period have been investigated and modeled as part of this feasibility study and described in Appendix C. A project RWC ramp-up period would have to be discussed with regulators during the demonstration and full-scale program development phases. It is anticipated that the timing to achieve 100 percent RWC may depend heavily on groundwater-basin-specific issues.

7.4 Program Regulatory Milestones and Timeline

Metropolitan would work closely with its partners and the regulating authorities to maintain an aggressive schedule for securing a water recycling permit. Key to the overall permitting timeline will be the construction of the demonstration facility and completion of the 1-year testing period. An ROWD, which essentially serves as a permit application, would be submitted to the RWQCBs in 2021. The Title 22 Engineering Report is the major milestone in the permitting process and it is anticipated that the draft report will be submitted to the DDW and the RWQCBs in 2022. Following a period of review and consultation with the regulating authorities on this report, the final version of the report is expected to be issued in 2024. Public hearings with the DDW will be conducted prior to its issuance. A tentative permit would then be issued and final adoption of the WDR/WRRs by the RWQCBs would be in 2025. This timing is intended to align with the development of the full-scale treatment and conveyance infrastructure, for which design should be complete in 2023 and 2024, respectively, and construction complete in 2028 and 2029, respectively.

Key milestones leading to the regulatory approvals by the DDW and the RWQCBs are shown in Figure 7.6. As indicated earlier, the projected timeline for permitting a full-scale AWT facility is contingent on the design and construction schedule for the demonstration facility.

7.5 Future Regulatory Outlook for California

Although regulations have been established for groundwater replenishment projects, to date limited criteria have been formally developed for other forms of potable reuse. In September 2010, Senate Bill 918 (SB 918) was signed into law. This bill required the DDW to adopt uniform water recycling criteria for IPR through groundwater replenishment, which was completed in June 2014. It also directed the DDW to develop regulatory criteria for surface water augmentation by December 2016. SB 918 further required the DDW to investigate the feasibility of developing regulatory criteria for DPR and to provide a final report to the Legislature by December 2016. The requirements of SB 918 were incorporated into the CWC §13350, CWC §13521, and Chapter 7.3. Although the potential RRWP is solely focused on IPR through groundwater recharge, it is relevant for this feasibility study to include a brief discussion on the regulatory outlook for other forms of potable reuse.

The type and size of environmental buffer can be used to categorize the potable reuse application. Figure 7.7, which was adapted from the SWRCB's DPR Advisory Group report addressing feasibility of developing water recycling criteria for DPR, illustrates the various forms of potable reuse on a "continuum." This continuum begins with *de facto* reuse that is ongoing nationwide as treated wastewater effluent is discharged into rivers and streams serving as sources of drinking water supply. As potable reuse classifications shift from groundwater replenishment to surface water augmentation, and ultimately to varying forms of DPR, the environmental buffer is reduced and the project would require additional barriers to ensure protection of public health. As illustrated in Figure 7.7, the regulatory certainty is also lessened as potable reuse enters into these newer areas along the continuum, specifically for surface water augmentation (another form of IPR) and DPR. The following sections provide an update on the status of California's regulatory development of surface water augmentation and DPR.

Figure 7.6: Key Regulatory Submittals and Estimated Timeline

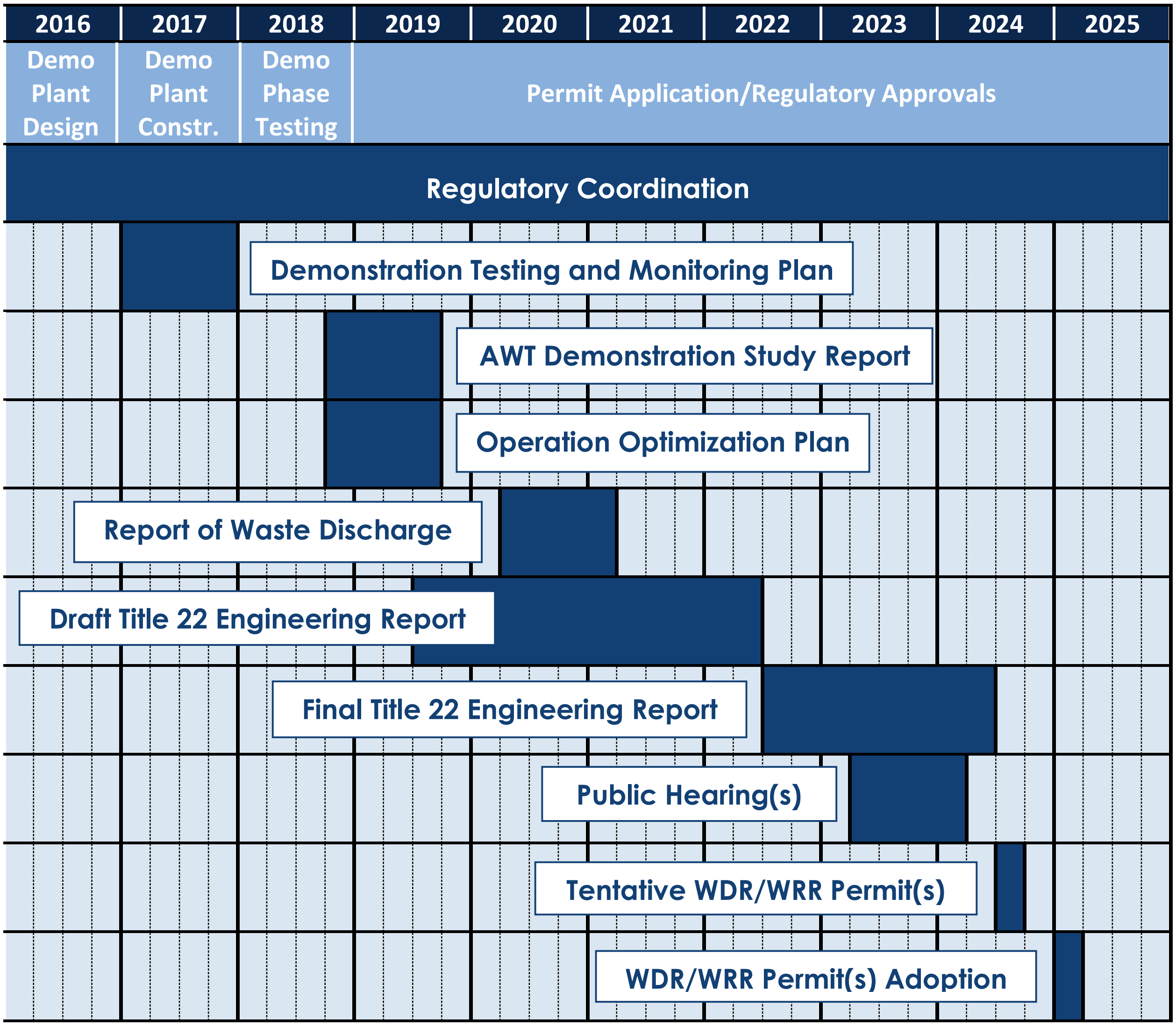
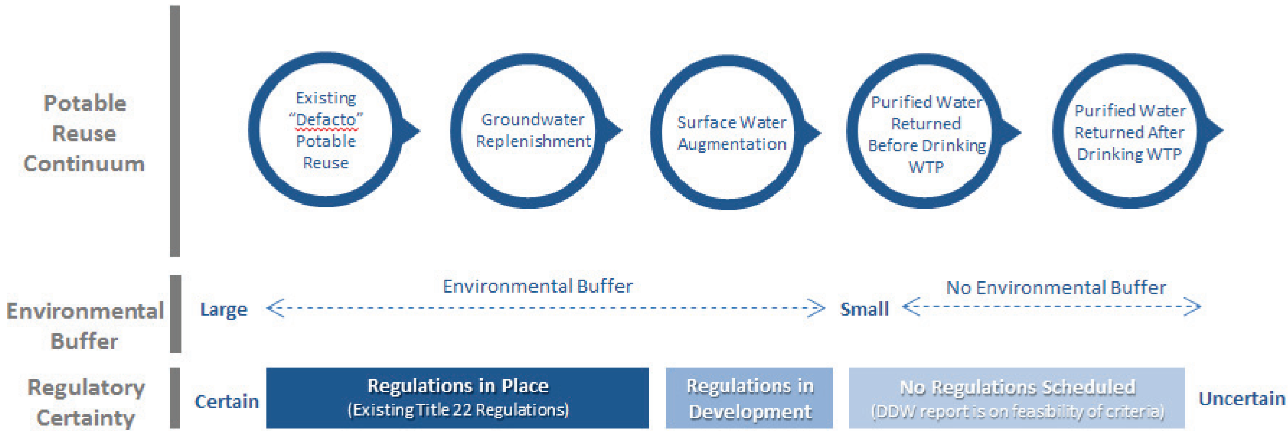


Figure 7.7: Potable Reuse Continuum[7]



Surface Water Augmentation

Surface water augmentation involves the process of adding advanced treated water to an existing surface water supply (e.g., river, lake, or reservoir) that would eventually be used for drinking water after further treatment. As noted above, the DDW has been charged to develop and adopt Water Recycling Criteria for surface water augmentation by December 2016. To facilitate that development, an expert panel has been convened to advise the DDW on public health issues, as well as on scientific and technical matters, regarding the development of surface water augmentation criteria.

The permitting process for a surface water augmentation project is anticipated to be significantly more complex than that for groundwater replenishment. As the project involves releases into a surface waterbody, a full NPDES permit would be required along with USEPA approval. In addition, the project sponsor must demonstrate that the reservoir provides a sufficient "environmental buffer" and that it provides the necessary blending of recycled water with sources of diluent water. The reservoir would have to provide sufficient retention that would allow for some contaminant degradation but with the primary purpose of enabling agencies to respond to an unexpected failure that may occur in the upstream treatment process. Nutrient management, as well as ensuring other reservoir operational and water supply objectives are being met, are additional considerations for a surface water augmentation project.

Direct Potable Reuse

No regulatory guidance is currently provided for DPR. In general, DPR refers to the direct augmentation of a water supply with advanced treated water without an intervening environmental or storage buffer. To date, a consistent, clear definition for DPR is lacking; the term has been applied to the entry of advanced treated water to a raw water supply and/or a drinking water treatment plant, or directly into a treated water distribution system (also termed "pipe-to-pipe" or "flange-to-flange"). The risks associated with each of those options can vary significantly. Primary concerns associated with DPR are the lack of currently available real-time monitoring capabilities in the absence of extended storage, as well as insufficient reaction times to potential system failures at the upstream treatment plants. In future regulatory development, additional treatment barriers will undoubtedly be necessary to compensate for the loss of an environmental buffer. Significant research is being conducted to investigate the feasibility of DPR.

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[7] *Adapted from* http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/rw_dpr_criteria/app_b_ag_rpt.pdf.

As indicated earlier, CWC §13563 requires that the DDW investigate and report to the Legislature by December 2016 on the feasibility of developing uniform water recycling criteria for DPR in California. An expert panel is also assisting the DDW in this effort by identifying additional research areas and an approach for accomplishing this research. An advisory group (consisting of regulators, water and wastewater agencies, environmental organizations, and the business community) was also convened to provide feedback to the expert panel on DPR criteria development. In September 2016, the DDW released its draft report investigating the feasibility of developing DPR regulatory criteria.[8] While acknowledging the technical feasibility of developing regulatory criteria, the DDW identified several research and knowledge gaps that remain. The DDW conducted public workshops in October 2016 to gain input into its final report to be presented to the Legislature by the end of 2016.

Although the feasibility of regulating DPR is under investigation, the adoption of regulations for DPR is likely to be many years off. At this time, with no regulatory guidance available, DPR is not a feasible approach for Metropolitan to consider for the RRWP. However, Metropolitan will continue to monitor and engage in research, technical assessments, and the regulatory development of DPR for consideration of its future application in Metropolitan's service area. It should be noted that the current program approach does not preclude the possibility of integrating DPR as an additional water supply in a future phase. Should DPR be a viable option for Metropolitan to consider in the future, there will still be the need to provide replenishment supplies to stabilize and rebuild the health of Southern California's groundwater basins. This need for replenishment will continue even with the advent of DPR.

[8]http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/rw_dpr_criteria/draft_report_to_legislature_dpr_public_review.pdf.

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Chapter 8

Public Acceptance and Environmental Planning

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8.0 PUBLIC ACCEPTANCE AND ENVIRONMENTAL PLANNING

Implementation of the RRWP will require public outreach on multiple levels beginning with the demonstration facility and continuing through project construction and operations. At the outset, the primary goal of this outreach will be to improve awareness of and achieve public acceptance for the new water supply and its associated treatment and conveyance infrastructure. This will require a coordinated, long-term effort that begins with the demonstration project. If the RRWP moves forward, outreach will continue during environmental review and permitting. Targeted outreach efforts will be needed during construction to inform and assist the neighborhoods and communities directly affected. In addition, local outreach will be needed to help inform the businesses and residential communities near the JWPCP about the construction and operation of the AWT facility. Once the project begins operating, outreach efforts will continue to help inform community leaders, elected officials, and the general public about the program and its benefits to the region. This long-term outreach approach must be developed and implemented collaboratively with the basin agencies, basin managers, and the Sanitation Districts using research results, local knowledge, and the outreach experience of the agencies involved.

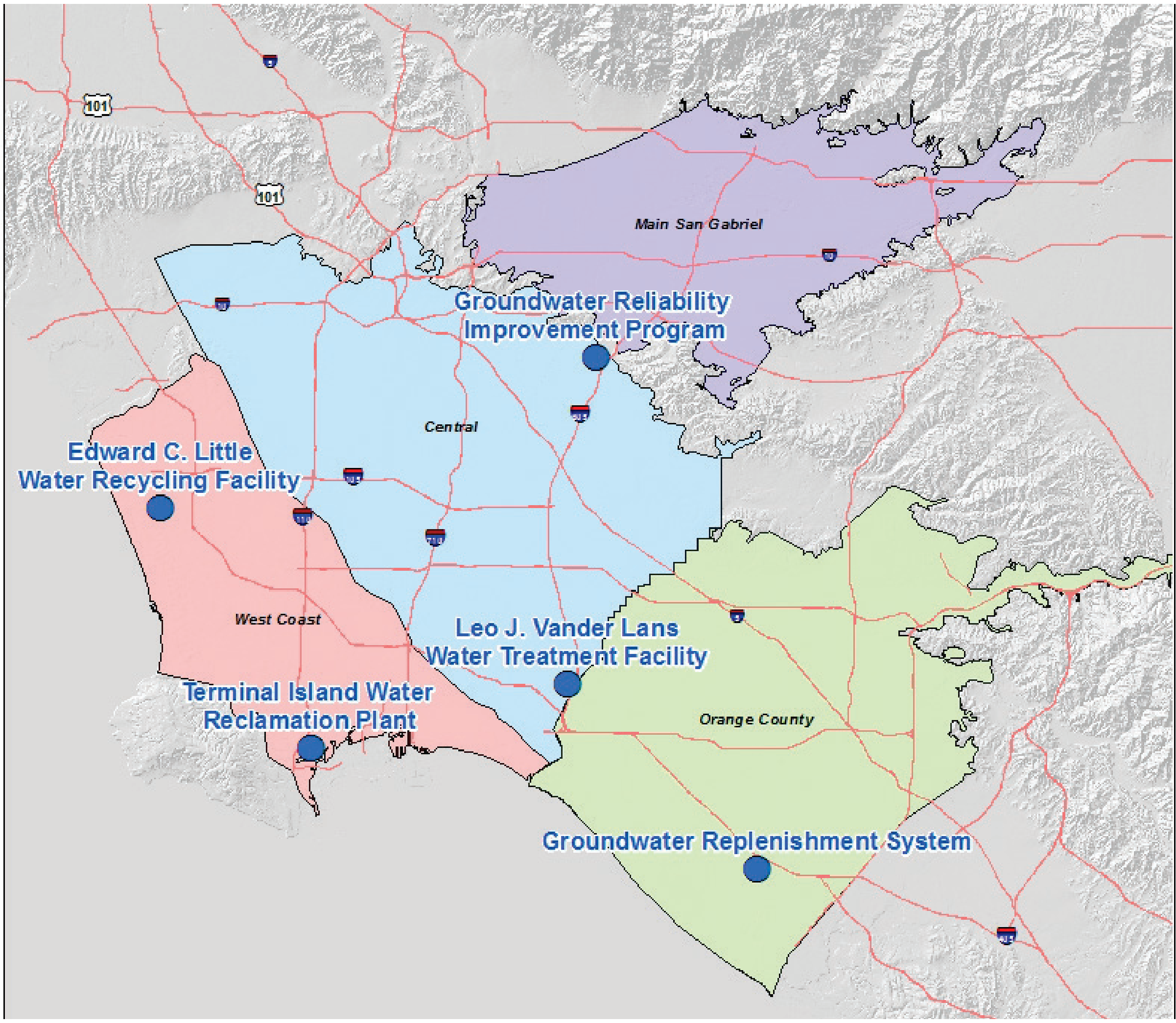
The outreach for the RRWP will have some complexity due to the geographic reach and the basins' varying experiences with using recycled water for groundwater recharge. Certain uses of recycled water are broadly accepted in Southern California, such as for irrigation and industrial uses. Some areas have successfully expanded the use of this resource and are now using advanced treated water for groundwater recharge and seawater barrier protection (see Figure 8.1). Notable projects within the program area include the GWRS for the Orange County Basin, the Edward C. Little Water Recycling Facility for the West Coast Groundwater Barrier, the Leo J. Vander Lans Advanced Water Treatment Facility for the Alamitos Barrier, the Terminal Island Water Reclamation Plant Advanced Water Purification Facility for the Central Basin, and the Groundwater Reliability Improvement Program for the Central Basin. Because the experience is different in the Main San Gabriel Basin where recycled water has not been used for recharge, different outreach strategies may be needed.

8.1 Gaining Public Acceptance

New Water Supply

Although considerable progress has been made in public awareness and acceptance of recycled water, there may be different perspectives on the RRWP within each basin. Metropolitan, the Sanitation Districts, the basin agencies, and basin managers must be prepared to address these perspectives. Using a project identity and key messages, outreach strategies and tools will be developed based on the demographics and interests of the communities that will ultimately have RRWP water as part of their groundwater supply. Effective communication channels will be developed through efforts that seek to build relationships with community and business leaders; environmental, educational, and faith-based organizations; trusted experts in public health and water resources; and the media. These relationships will be essential in situations where misinformation, project opposition, or even fear could influence public perceptions and attitudes. Metropolitan and the agencies involved with outreach will stay attuned to community concerns, as well as expressions of support, and coordinate in adapting the communications and outreach efforts.

Figure 8.1: Indirect Potable Reuse Projects within Proposed Groundwater Basins



Edward C. Little Water Recycling Facility: West Basin Municipal Water District
Groundwater Reliability Improvement Program: Water Replenishment District of Southern California
Groundwater Replenishment System: Orange County Water District
Leo J. Vander Lans Water Treatment Facility: Water Replenishment District of Southern California
Terminal Island Water Reclamation Plant: City of Los Angeles

New Conveyance System

The construction of a new conveyance system would require implementation of a strategic outreach effort that targets the local areas directly affected by construction. The construction-related impacts for the pipelines, pump stations, and injection wells will be significant, particularly in developed areas. The outreach will need to be focused street by street or neighborhood by neighborhood. Metropolitan has extensive experience with construction-related outreach. For the RRWP construction, Metropolitan would use similar processes and procedures to those developed over the years. Staff would collaborate with the member agencies, retail agencies, counties and cities, and residents and businesses along the selected pipeline alignments to identify and prepare for the following: traffic, noise, and dust impacts; temporary loss of access to driveways, sidewalks, and parking areas; and impacts to street trees and landscaping in medians and parkways.

Metropolitan and the agencies involved with outreach would work with the local agencies to provide community meetings and briefings for officials prior to construction. These meetings would be used to explain the purpose and need for the project, its schedule, and the expected impacts. Metropolitan would conduct direct outreach to residents and businesses affected by construction and assist them as needed for the duration of the construction activities. New digital communication tools that are geographically targeted could be used to help communicate project objectives and status with the local community and provide a means for residents and businesses to ask questions and request assistance from the outreach team.

New Facilities within the JWPCP Site

Focused outreach would be needed for the businesses and residential communities near the JWPCP. Although the AWT facility would be constructed within existing boundaries of the JWPCP, the full-scale RRWP would significantly increase the operations at the site. Metropolitan will work with the Sanitation Districts to address community concerns about construction and operational impacts, including traffic, noise, odors, and chemical storage. The Sanitation Districts meet with the local community on a regular basis; Metropolitan would participate in these meetings to provide information on the RRWP and assist with questions or concerns regarding the AWT facility.

8.2 Potential Public Acceptance Challenges

In 2013, Metropolitan co-sponsored a study with the Water Reuse Research Foundation (WRRF) on communications for potable reuse. The report, "Model Communication Plans for Increasing Awareness and Fostering Acceptance of Direct Potable Reuse" (2015, WRRF-13-02), noted the need for public outreach when planning and implementing a potable reuse project. General public acceptance cannot be assumed. Where opposition has been voiced, the top concerns are the "yuck" factor; perceived health and safety concerns related to CECs, pharmaceuticals and personal care products, and potential exposure to contagious diseases; cost to rate payers; environmental concerns; and general government distrust. Although public acceptance of recycled water has increased in recent years, some continue to negatively brand these projects, ignoring the multiple treatment processes used to purify the water before it enters the groundwater basins, the beneficial effects of groundwater percolation, and the treatment processes used before the water is served to customers. This challenge can be addressed through the support or involvement of health professionals and others to address public health concerns. Agencies can also create confusion by using inconsistent terminology for the same project. A key finding from the focus groups and telephone surveys in the WRRF study showed that after receiving additional information about potable reuse and the process used to make the water safe to drink, most participants became more comfortable with the idea of potable reuse.

Given the increased use of recycled water in Southern California and the successful implementation of several IPR projects in the RRWP area, concerns over the RRWP are expected to be manageable with a robust outreach program. However, it is not uncommon for opponents to conceal their real motives and concerns or to wait until late in the process to come forward. A previous effort to use recycled water for groundwater recharge in the Main San Gabriel Basin was not successful. A potential project is currently in the planning stages and does not appear to have opposition. Metropolitan and the agencies involved with outreach must learn from the extensive experience in the region and prepare for these types of issues by developing a coordinated, comprehensive, and strategic communication program that addresses the new water supply, construction, and increased operations at the JWPCP. The agencies must collaborate to build trust and increase local knowledge to help counter misinformation.

8.3 Outreach Goal and Objectives

The goal of public outreach for the RRWP is to educate and build public acceptance and support for the program, including the new water source, infrastructure construction for treatment and conveyance, and expanded operations at the JWPCP. The objectives are as follows:

- Collaborate with the member agencies, retail purveyors, basin managers, and the Sanitation Districts to develop and implement a strategic communication program for the demonstration facility, environmental review and permitting, construction of treatment and conveyance infrastructure, and operation of the system
- Consider the different perspectives and needs of the region's diverse multi-cultural, multi-lingual, and multi-generational population (see Figure 8.2 and Figure 8.3)
- Consider the different experiences of the basins with advanced treated municipal wastewater projects
- Ensure that the outreach plan and strategies are guided by what has been learned from other outreach efforts in the basins, other potable reuse projects in California, and new qualitative and quantitative research
- Consistently implement the outreach program across basins and over time to achieve the outreach goal; use effective approaches to listen and respond to community concerns
- Target outreach efforts to local communities for the specific construction impacts they may experience; keep communities, local agencies, and elected officials informed, beginning well in advance of the construction projects
- Work to develop trust and strong relationships with experts, leaders, and those living, working, and attending educational institutions in the communities
- Demonstrate the participating agencies' commitment to transparency, leadership, and sound public policy for this program
- Monitor and measure effectiveness, and adapt the communication plan and strategies as needed

8.4 Preparing for Outreach

Metropolitan would begin preparing for outreach for the RRWP through the following activities:

Collaboration with the Sanitation Districts, member agencies, retail agencies, and basin managers: Southern California has a history of successful collaboration on water and wastewater projects. For example, Metropolitan and its member agencies have extensive experience collaborating on regional outreach for water quality, conservation, and water infrastructure projects. In addition, Metropolitan regularly conducts outreach for major infrastructure projects with significant construction-related impacts. Metropolitan plans to convene a working group with the Sanitation Districts and the member agencies, retail agencies, and basin managers in the four basins. This group would collaborate on the development of a comprehensive outreach plan, a suite of strategies for different basins and stakeholder groups, and a toolbox of communication tools. Initial efforts would focus on learning about past and current outreach efforts and community perceptions in each basin. The group would identify research needs and begin working on the outreach plan for the demonstration facility, which is designed to facilitate public tours and provide information on the RRWP to the general public, community leaders, and stakeholder groups.

Figure 8.2: Population Density within Groundwater Basin Areas

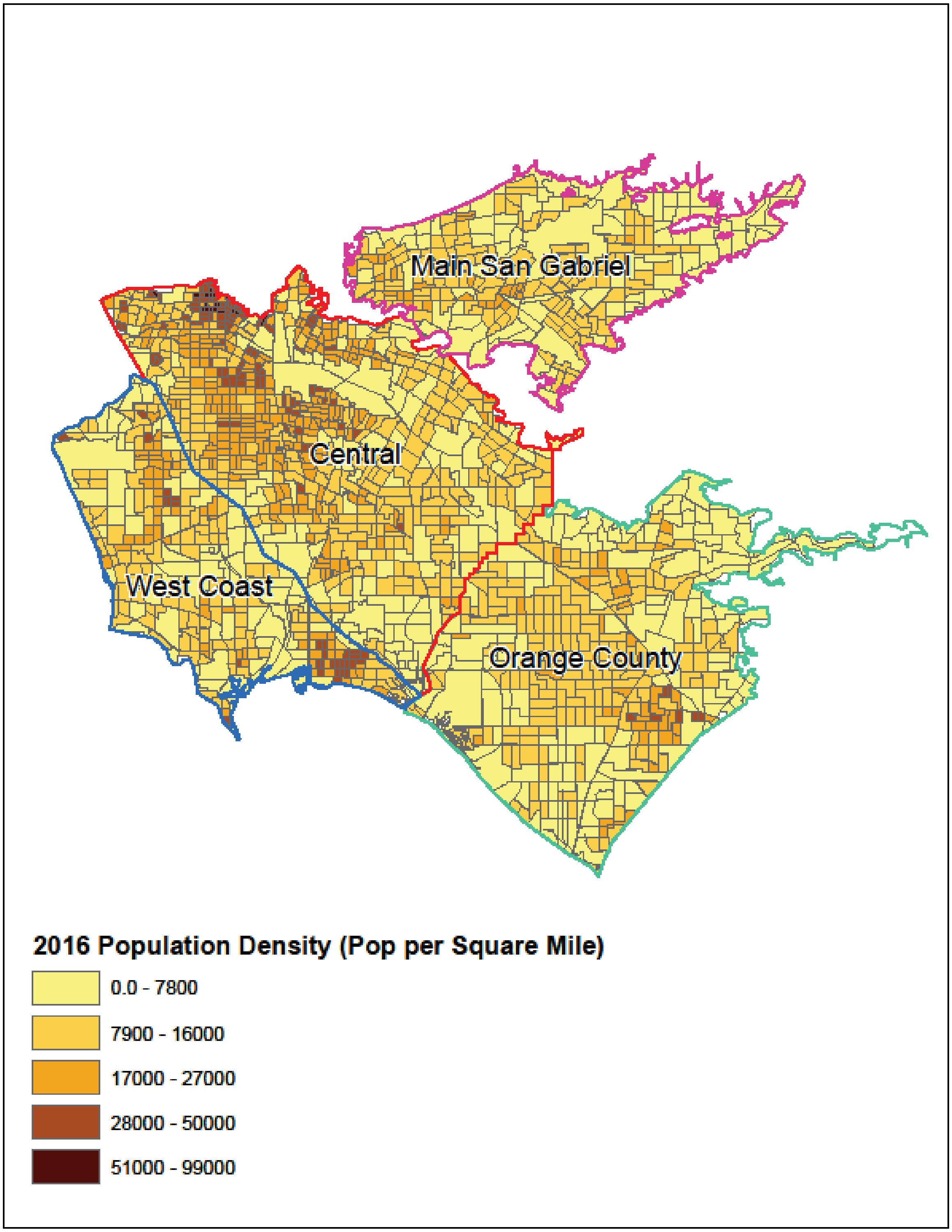
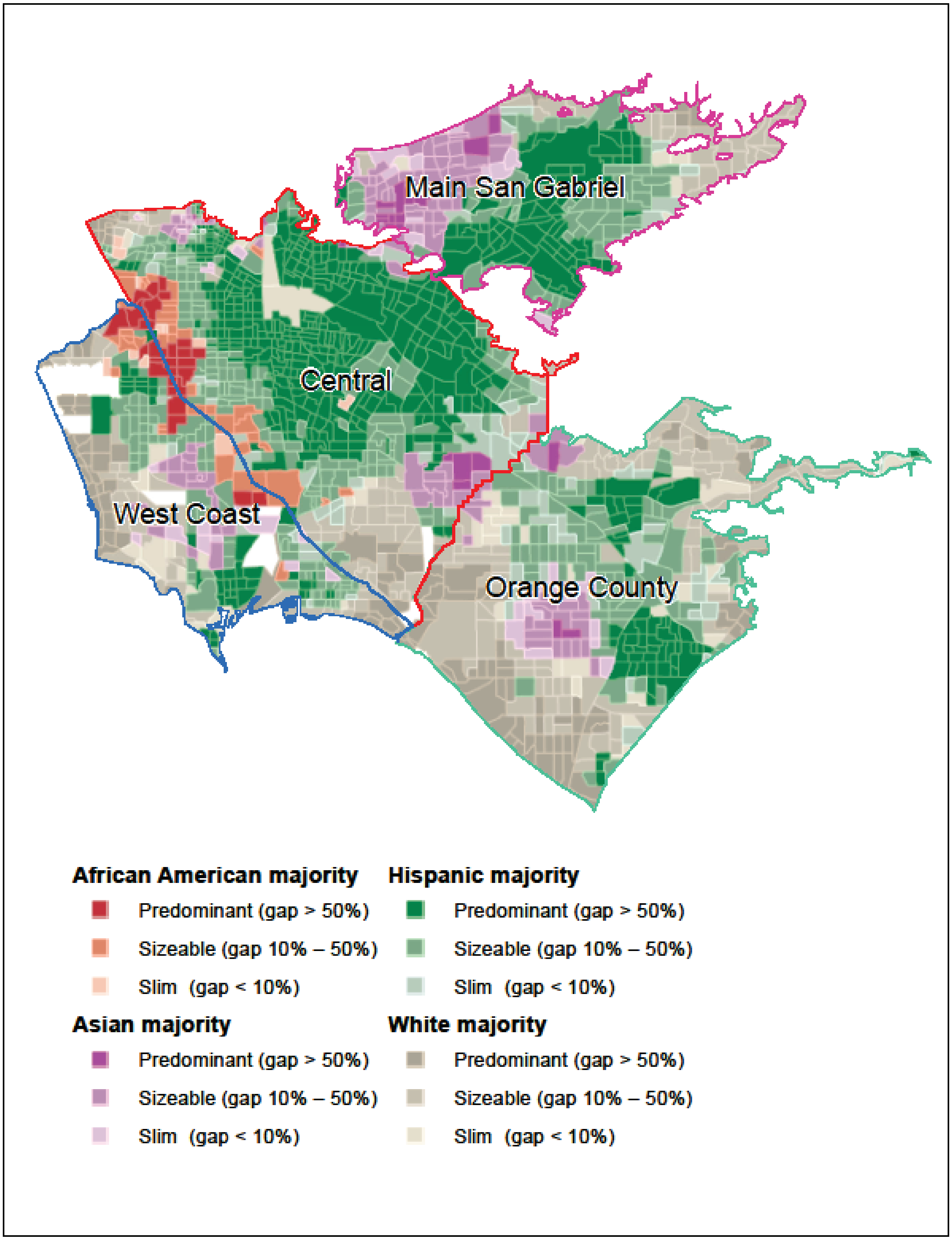


Figure 8.3: Race Diversity within Groundwater Basin Areas



The group would also consider how to use digital and social media for RRWP outreach. Metropolitan's comprehensive outreach and education programs include a growing presence on social media, with regular postings on Facebook, Twitter, Instagram, and YouTube. This communication channel can be used to expand the outreach for the RRWP and create opportunities for discussion and information-sharing across different groups and interests that may have a geographic reach beyond Southern California. Through coordination among the agencies, use of social media could be expanded to broaden the reach and impact of this outreach tool.

Research: The outreach plan and strategies for the RRWP must be informed and evaluated by research. Metropolitan plans to use existing and new regional surveys, as well as focus groups and other evaluation methods, to help assess public perceptions and acceptance. Research efforts would also help measure the effectiveness of different outreach strategies, tactics, and tools, as well as provide valuable feedback.

Learning from others: Several relatively new potable reuse projects are in various stages of development in California, including the Padre Dam Municipal Water District Advanced Water Purification Program; Pure Water San Diego; Pure Water Monterey; and the Silicon Valley Advanced Water Purification Center. Existing projects in the four-basin area include the GWRS for the Orange County Basin, the Edward C. Little Water Recycling Facility for the West Coast Groundwater Barrier, the Leo J. Vander Lans Advanced Water Treatment Facility for the Alamitos Barrier, the Terminal Island Water Reclamation Plant Advanced Water Purification Facility, and the Groundwater Reliability Improvement Program for the Central Basin. Other projects have experienced public opposition for a variety of reasons and have not moved forward. Metropolitan plans to learn from these projects to understand what does—and doesn't—make outreach efforts effective.

8.5 Environmental Planning

Implementation of the RRWP will require environmental review under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA), and possibly permitting under the Clean Water Act, California Fish and Game Code, and/or state and federal Endangered Species Acts. For the potential RRWP, Metropolitan is the lead agency under CEQA (California Public Resources Code [PRC] Section 21067) and is responsible for complying with the requirements of CEQA. The environmental documents for the program will do the following: (1) inform decision makers and the public about the potentially significant environmental effects of the proposed activities; (2) identify the ways that significant environmental effects can be avoided or reduced; (3) prevent significant, avoidable damage to the environment by requiring changes in the program through the use of alternatives or mitigation measures, to the extent that Metropolitan determines the changes to be feasible (CEQA Guidelines Section 15002; PRC Section 21002.1); and (4) identify compensatory mitigation measures to offset significant unavoidable impacts.

CEQA is a public process designed to create informed decision-making. If a project may cause significant adverse environmental impacts, the public agency must prepare an Environmental Impact Report (EIR). An EIR contains in-depth studies of potential impacts, measures to reduce or avoid those impacts, and an analysis of project alternatives. A key feature of the CEQA process is the opportunity for the public to review and provide input on the environmental document. At the current time, Metropolitan anticipates that a Programmatic EIR (PEIR) along with subsequent environmental documents for future phases of the overall program would be necessary.

Like CEQA, NEPA is a federal law that requires federal agencies to perform environmental analyses for any project that triggers a federal action, such as a permit, lease agreement, or grant funding and to determine the environmental consequences of their proposed actions before they act. The initial step of environmental review for projects subject to NEPA is generally the preparation of an environmental assessment, which may be prepared by Metropolitan in consultation with the federal lead agency. If the lead agency finds that the action could have a significant environmental effect, it will direct the preparation of an Environmental Impact Statement (EIS) in consultation with Metropolitan. The base case RRWP conveyance system alignment crosses federal property and is under federally-controlled structures (bridges, storm channels, dams); thus it is likely that Metropolitan must acquire federal permits, easements, or other approvals, which will trigger compliance with NEPA.

Both CEQA and NEPA require lead agencies to publish drafts of their EIR/EIS documents and to receive and consider public comments before making a final decision on the project. Metropolitan will coordinate the public review process and respond to comments, as outlined by the CEQA/NEPA process.

Metropolitan conducted preliminary, screening-level surveys of the potential alignments to identify and, where feasible, avoid environmental impacts from the program. The California Department of Fish and Wildlife's California Natural Diversity Database (CNDDB) and limited field site visits were used to identify species of concern. The California Department of Toxic Substances Control EnviroStor database was used to identify hazardous waste and Superfund sites. Leaking underground fuel tank data was obtained from the SWRCB. The California State Parks' Registry of Historic Resources and the Federal Registry of Historic Places were used to locate potentially affected cultural resources. Los Angeles and Orange County datasets were used to identify the presence of sensitive receptors (e.g., hospitals, schools, nursing homes), public parks, and other potentially affected public facilities.

Although all the environmental constraints listed above occur throughout the RRWP area, Metropolitan's environmental planning and design staff developed a base case scenario that avoids and reduces impacts to biological species, critical habitat, and other environmental resources to the extent feasible. Limited portions of the base case project footprint have the potential to impact federal and state Endangered Species Act–listed species or species of concern, including three listed bird species: Least Bell's vireo (*Vireo bellii pusillus*), Southwestern Willow flycatcher (*Empidonax traillii extimus*) and Coastal California gnatcatcher (*Polioptila californica californica*).

The projected base case project footprint may affect lands designated as state or federal wetlands or federal critical habitat for the coastal California gnatcatcher. One method to avoid or minimize impacts to these areas may be by using jack and boring or tunneling pipeline installation rather than trenching. The San Gabriel River alignment contains many bridges and other suitable roosting habitat for bats. Although the presence of bats can pose year-round constraints to construction, exclusionary devices can be installed to prevent bats from roosting, thus avoiding work delays.

A PEIR and a Programmatic Environmental Impact Statement (PEIS) are types of CEQA/NEPA documents designed to be used for large projects with multiple components that would require multiple agency approvals or multiple construction contracts. Based on preliminary environmental analysis, project schedule, and program constraints, Metropolitan recommends the preparation of a PEIR/PEIS for the overall program with additional tiered documents, which will support future phases of the program. The PEIR/PEIS will allow Metropolitan to consider broad policy alternatives and program-wide mitigation measures early in the design and will provide greater flexibility to consider design alternatives to avoid, minimize, and develop mitigation measures for impacts that are identified and to ensure adequate cumulative impact analysis.

The PEIR/PEIS will require the completion of detailed technical studies in numerous technical disciplines, which will commence upon board approval to proceed with CEQA/NEPA analysis. Technical studies will include biological surveys to identify species or habitat that could reasonably be impacted by the construction or operation of the RRWP's AWT or conveyance system. If sensitive biological resources are identified, Metropolitan will work with the appropriate federal and state natural resource agencies to develop strategies to avoid or reduce potential impacts or compensate for any unavoidable impacts likely to occur.

Metropolitan will also coordinate with federal and state agencies during the development of the PEIR/PEIS to ensure that these documents support any permits, approvals, or other actions from the California Department of Fish and Wildlife, United States Fish and Wildlife Service, California RWQCBs, and the United States Army Corps of Engineers.

Lastly, a new state law requires lead agencies to consult with Native American tribes on projects to determine if these projects have any effect on tribal cultural resources. Metropolitan will notify selected tribes of the program and then, if requested, consult with these tribes in good faith. The duration and timeline for this consultation process is not set in law and will be determined on a case-by-case basis.

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Chapter 9

Implementation Schedule and Cost Evaluation

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9.0 IMPLEMENTATION SCHEDULE AND COST EVALUATION

This chapter discusses the implementation schedule for the RRWP and the estimated capital and O&M costs for a full-scale program as defined in the base case scenario. It also includes a comparison of the unit cost of product water for similar potable reuse programs and facilities in California.

9.1 Project Implementation

A conceptual-level implementation schedule has been developed for the potential RRWP base case highlighting the major components and the key milestones (Figure 9.1). The schedule also shows the dependence between the various activities. Following Metropolitan board approval to commence the full-scale program, the overall timeline to design, construct, and start up/commission the entire program facilities composing the base case could take up to 11 years. A summary of the major components and key assumptions that led to the development of this implementation schedule is provided in this section. It is anticipated that the overall program schedule can be shortened once design activities (conceptual, preliminary, and final design) and opportunities for program optimization and enhancement are identified.

Demonstration Project

The Metropolitan board authorized a demonstration project in November 2015, which includes the design, construction, and operation of an AWT demonstration facility, and this study to assess the feasibility of implementing a regional recycled water program. In March 2016, the Board authorized award of a consultant agreement for design of the demonstration facility. Design for the demonstration facility is anticipated to take approximately 1 year (includes design and advertisement for construction bids). Construction and startup of the AWT demonstration facility would follow and is anticipated to take an additional year. The demonstration facility will then be operated for at least 1 year to compile information needed for the Title 22 Engineering Report, which would ultimately be submitted for regulatory approval.

Facility Planning/Engineering Studies

As described in Chapter 11, the recommended next steps include further studies and engineering tasks to answer key questions identified during this feasibility study. These studies would focus on opportunities to optimize the various program components, identify preferred pipeline alignment configurations for the conveyance system, and prepare all information needed to ensure a smooth transition into preliminary design and CEQA assessments. The facility planning/engineering studies are anticipated to take approximately 12 to 18 months.

Institutional and Financial Arrangements

Initial discussions on the willingness of agencies to enter into the financial and institutional arrangements necessary to integrate the purified water into the local resource portfolio have taken place during the process of this feasibility study. A summary of the potential arrangements is included in Chapter 4. However, specific terms and conditions of all these arrangements still need to be developed and finalized. Additional institutional arrangements to secure needed ROWs, as well as full use of the JWPCP facilities, to support the program are still needed. Coincident with starting the facility planning and engineering studies, Metropolitan staff would begin working with all of these various agencies to develop the institutional and financial arrangements beginning in early 2017. It is anticipated that all of these arrangements would be finalized prior to obtaining board approval for preliminary design and CEQA activities. These activities are planned to overlap with the facility planning and engineering studies that are discussed above.

Full-Scale Advanced Water Treatment Facility

Upon board approval to proceed with the full-scale program, the design of the AWT facility would commence. Preliminary design tasks and other engineering activities needed to support the program's CEQA and NEPA activities can commence while the demonstration facility testing is underway. During preliminary design and following the 1-year demonstration testing period, prequalification testing for potential equipment vendors for the full-scale processes will be conducted at the demonstration facility. Final design of the AWT facility is anticipated to take approximately 2 ½ years. It is assumed that the EIR/EIS documents will be complete and certified by the Metropolitan board prior to the completion of final design. Following the design and bid phase, construction is anticipated to last approximately 4 years, followed by 1 year of startup and testing. The total duration from preliminary design of the full-scale AWT facility through startup and testing is approximately 9 years. It is anticipated that the design, construction and startup of the AWT (including the time required to operate the demonstration plant) is not on the overall program's critical path.

Conveyance Facilities

Design and construction of the conveyance facilities is anticipated to be the most challenging aspect of the program due to the significant length of new pipelines being constructed within a highly urbanized area. Conceptual/preliminary design work to support CEQA and NEPA is anticipated to take approximately 2 years. Final design is anticipated to take an additional 3 ½ years to complete. Construction of the conveyance facilities would be divided into multiple contracts. It is assumed that some reaches of the alignment would be better defined earlier in the process, allowing for final design of those reaches to finish more quickly. Therefore, the timeline shows the first contract being advertised approximately 1 year following commencement of final design. Total duration for design and construction of the main conveyance facilities is 10 ½ years.

Well Field Facilities

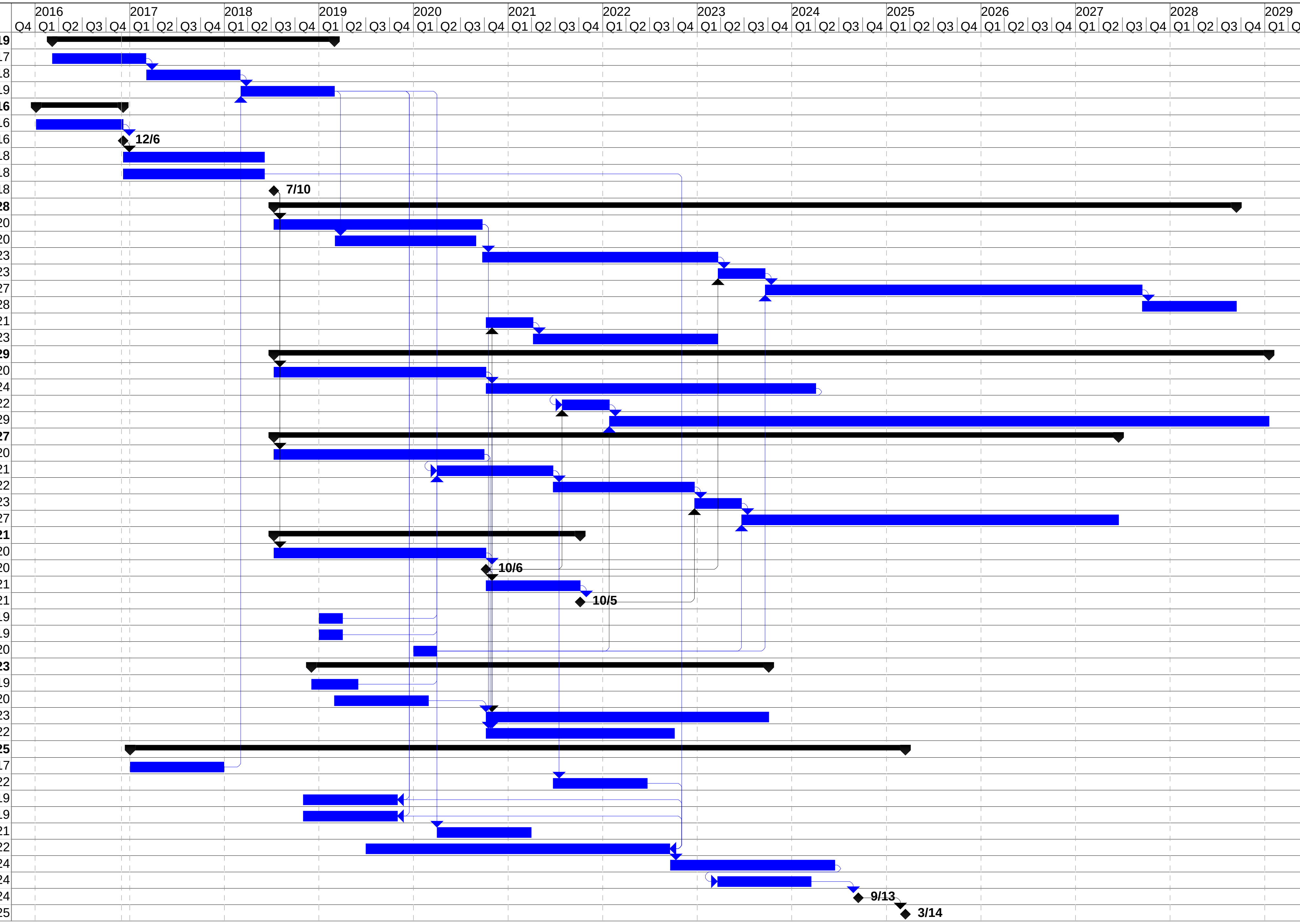
Conceptual/preliminary design work for the well field facilities is anticipated to take approximately 2 years. During this time, potential injection well locations would be identified, along with related monitoring well locations. Monitoring wells may also be needed for spreading basins. Following preliminary design, monitoring wells would be constructed in areas that do not have monitoring wells necessary to collect baseline water quality data. Baseline groundwater monitoring would last for 1 year. Final design and construction of the injection well facilities is anticipated to take approximately 4 years. Total duration for design and construction of well field facilities is anticipated to take approximately 9 years.

CEQA/NEPA/Permits

The expected timeline for development of the initial environmental documentation is contingent on the delivery of needed engineering and project data. Metropolitan expects the initial programmatic impact analysis to be completed in approximately 2 years. Permits must be obtained prior to the start of construction. The permit acquisition process would proceed in parallel with the design process. As necessary, subsequent environmental documentation would be completed as final design for each phase is completed.

Figure 9.1: Implementation Schedule

ID	Task Name	Duration	Start	Finish
1	**Demonstration Project**	**780 days**	**Mon 3/7/16**	**Fri 3/1/19**
2	Design	52 wks	Mon 3/7/16	Fri 3/3/17
3	Construction / Start-up	52 wks	Mon 3/6/17	Fri 3/2/18
4	Demonstration Testing	52 wks	Mon 3/5/18	Fri 3/1/19
5	**Program Feasibility Analysis**	**240 days**	**Tue 1/5/16**	**Tue 12/6/16**
6	Study	48 wks	Tue 1/5/16	Mon 12/5/16
7	Board Presentation - Feasibility Study Findings	0 days	Tue 12/6/16	Tue 12/6/16
8	**Facility Planning/Engineering Studies**	78 wks	Tue 12/6/16	Mon 6/4/18
9	**Develop Institutional and Financial Arrangements**	78 wks	Tue 12/6/16	Mon 6/4/18
10	**Board Award for Preliminary Design**	0 days	Tue 7/10/18	Tue 7/10/18
11	**Treatment**	**2655 days**	**Wed 7/11/18**	**Tue 9/12/28**
12	Preliminary Design	115 wks	Wed 7/11/18	Tue 9/22/20
13	Equipment Prequalification and Testing	78 wks	Mon 3/4/19	Fri 8/28/20
14	Final Design	130 wks	Wed 9/23/20	Tue 3/21/23
15	Advertise, Bid, Award AWT Construction	26 wks	Wed 3/22/23	Tue 9/19/23
16	Construction	208 wks	Wed 9/20/23	Tue 9/14/27
17	Start-up / Testing	52 wks	Wed 9/15/27	Tue 9/12/28
18	Advertise, Bid, Award Site Remediation / Preparation	26 wks	Wed 10/7/20	Tue 4/6/21
19	Site Remediation / Preparation	102 wks	Wed 4/7/21	Tue 3/21/23
20	**Conveyance**	**2745 days**	**Wed 7/11/18**	**Tue 1/16/29**
21	Preliminary Design	117 wks	Wed 7/11/18	Tue 10/6/20
22	Final Design	182 wks	Wed 10/7/20	Tue 4/2/24
23	Advertise, Bid, Award Initial Conveyance Contracts	26 wks	Wed 7/28/21	Tue 1/25/22
24	Construction	364 wks	Wed 1/26/22	Tue 1/16/29
25	**Well Field Facilities**	**2330 days**	**Wed 7/11/18**	**Tue 6/15/27**
26	Preliminary Design	116 wks	Wed 7/11/18	Tue 9/29/20
27	Monitoring Well Construction	64 wks	Wed 4/1/20	Tue 6/22/21
28	Baseline Groundwater Monitoring	78 wks	Wed 6/23/21	Tue 12/20/22
29	Advertise, Bid, Award Injection Well Construction	26 wks	Wed 12/21/22	Tue 6/20/23
30	Well Facility Final Design / Construction	208 wks	Wed 6/21/23	Tue 6/15/27
31	**CEQA/NEPA Coordination**	**845 days**	**Wed 7/11/18**	**Tue 10/5/21**
32	Programmatic Impact Analysis	117 wks	Wed 7/11/18	Tue 10/6/20
33	Board Approval Program EIR/EIS (Program ROD/NOD)	0 days	Tue 10/6/20	Tue 10/6/20
34	Tiered Environmental Documentation	52 wks	Wed 10/7/20	Tue 10/5/21
35	Board Approval Tiered Documents (Tiered ROD/NOD)	0 days	Tue 10/5/21	Tue 10/5/21
36	CEQA Early Clearance for Right of Way	13 wks	Tue 1/1/19	Mon 4/1/19
37	404 Permits	13 wks	Tue 1/1/19	Mon 4/1/19
38	Permitting	13 wks	Wed 1/1/20	Tue 3/31/20
39	**Right of Way**	**1262 days**	**Mon 12/3/18**	**Tue 10/3/23**
40	Entry Permits for GW Monitoring Wells	26 wks	Mon 12/3/18	Fri 5/31/19
41	ROW Studies	52 wks	Fri 3/1/19	Thu 2/27/20
42	Property Acquisition	156 wks	Wed 10/7/20	Tue 10/3/23
43	**Safety and Environmental Services Permitting**	104 wks	Wed 10/7/20	Tue 10/4/22
44	**Regulatory Coordination**	**2140 days**	**Mon 1/2/17**	**Fri 3/14/25**
45	Demonstration Testing and Monitoring Plan	52 wks	Mon 1/2/17	Fri 12/29/17
46	Compliance Groundwater Monitoring	52 wks	Wed 6/23/21	Tue 6/21/22
47	AWT Demonstration Study Report	52 wks	Thu 11/1/18	Wed 10/30/19
48	Operation Optimization Plan	52 wks	Thu 11/1/18	Wed 10/30/19
49	Report of Waste Discharge	52 wks	Wed 4/1/20	Tue 3/30/21
50	Draft Title 22 Engineering Report	168 wks	Mon 7/1/19	Fri 9/16/22
51	Final Title 22 Engineering Report	91 wks	Mon 9/19/22	Fri 6/14/24
52	Public Hearings	52 wks	Mon 3/20/23	Fri 3/15/24
53	Tentative WDR/WRR Permits Adoption	0 days	Fri 9/13/24	Fri 9/13/24
54	Final WDR/WRR Permits Adoption	0 days	Fri 3/14/25	Fri 3/14/25



Regional Recycled Water Program
Potential Implementation Schedule

Task · Split · Milestone · Summary · Project Summary · External Tasks · External Milestone · Inactive Milestone · Inactive Summary · Manual Task · Duration-only · Manual Summary Rollup · Manual Summary · Start-only · Finish-only · External Tasks · External Milestone · Progress · Deadline

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Right-of-Way

Initial studies for property acquisition would begin during the preliminary design phase and would take approximately 6 months. At the same time, Metropolitan would be working to gain entry permits for surveys and other geotechnical work that is needed. After sufficient information is gathered on the property needs for the project (generally during the final design phase), Metropolitan would begin appraisal studies. Multiple appraisers would be used to gather all appraisals needed. Approval by the Metropolitan board is required prior to property acquisition. Voluntary acquisition of property could begin prior to certification of the CEQA documentation. However, Metropolitan could not begin the process of property condemnation without CEQA approval. Property acquisition is anticipated to take approximately 18 to 24 months.

Regulatory Approval

Regulatory coordination for the program begins with the demonstration project and continues throughout design and construction. Regular meetings with the DDW and the Los Angeles and Santa Ana RWQCBs are anticipated throughout the design and construction of the full-scale program. More information on the regulatory schedule and key activities is provided in Chapter 7.

9.2 Estimated Program Costs

Cost considerations for the potential program include the capital costs associated with designing and constructing the required facilities to continuously treat and convey the purified water to local groundwater basins, and the costs associated with the O&M of the facilities. The key assumptions for development of the estimated capital and O&M costs for the program are explained in the following sections. The capital unit costs were developed based on Class 4 Opinion of Probable Construction Cost (OPCC) as defined by the American Association of Cost Engineers (AACE) International Recommended Practices, with a range of accuracy that varies from –20 percent on the low side to +40 percent on the high side.

Capital Costs

Advanced Water Treatment and JWPCP Modifications

Capital costs for the AWT facility assume a process train of MBR, RO, and UV/AOP sized for 150-mgd production of purified water, as discussed in Chapter 5, as well as the necessary appurtenances (e.g., chemical storage facility). Material and construction costs for the AWT facility were developed using a building information model (BIM) to assess material quantities, then adding allowances for various items such as contractor overhead, sales tax, and insurance. Included in the capital costs for the JWPCP modifications is the addition of sidestream treatment for reduction of nitrogen levels entering the AWT facility and modifications to existing JWPCP infrastructure for secondary effluent flow equalization. The Class 4 OPCC for the JWPCP modifications and the 150-mgd AWT facility is $681,600,000.

BIM

BIM was employed to model structures, process mechanical, civil yard piping, and roadways for the AWT site. Separate structural and process mechanical models were built, and a total of 18 area BIM models were produced. The structural models were developed based on existing geotechnical information from the JWPCP and nearby FORCO site and seismic requirements for this area. The assumptions used determined average thicknesses for foundations, slabs on grade, walls, and suspended slabs. Concrete quantities were extracted from the models using Bentley Structural. Reinforcement steel was estimated on average pounds per cubic yard of concrete. Buildings for various structures, such as the blower facility, RO facility, electrical buildings, and administration/operations/maintenance, are based on the square-foot area obtained from the models with an average cost per square foot based on a typical pre-engineered metal buildings.

Process mechanical models were produced with major process piping and equipment based on vendor supplied data sheets. These models were also placed on the site where interconnecting yard piping was installed. Piping systems were given unique line numbers and services based on standard specifications developed for Open Plant Modeler. Line lists were then generated and exported to spreadsheets for inclusion in the estimate.

The civil model was also used to calculate volumes for excavation and backfill using an average flat grade and keeping all process units in line with the hydraulic grade line as required. Backfill was based on a 1:1 side slope/excavation layback from the basic structure footprint. Roadway area was calculated, along with basic landscaping areas.

In summary, the BIM models utilizing 3D space, intelligent elements, and volumes provide a higher degree of accuracy when developing cost estimates for the treatment train. The first BIM model included the MBR-MF-RO-UV/AOP process train. A second version of the model was created to exclude the MF facility and associated equipment to calculate the capital and O&M cost estimates for the base case. Cost details for both versions are included in Appendix D.

Methodology, Assumptions, and Exclusions

Pricing reflects the estimator's opinion as to the probable costs that a "prudent" contractor would include in his tender to construct the defined facilities. The OPCC does not capture framework costs borne by the owner for pre-construction activities or for expenses related to the management and support of field construction activities. The OPCC is intended to be an indication of fair market value and is not necessarily a predictor of the lowest bid. Fair market value is assumed to be a mid-range tender of competitive bids. OPCC pricing is predicated on the contractor's compliance with all contract specifications and design parameters during field execution activities.

Direct costs representing the project's fixed physical scope are estimated against a work breakdown structure to organize the estimate details. Software functionality allows the direct cost detail to be decomposed to multiple sub-levels, which are referred to as item activities. All-in unit prices are applied against the line item quantities.

Indirect costs representing the contractor's time related to variable field management expenses or general conditions costs are factored in a top-down approach as a function of running direct costs.

Estimate add-ons representing the contractor's allowances for home office overhead expenses, sales taxes, insurance costs, risk provision, and fee are added to the cost estimate as a function of running direct costs.

Allowances are added to the OPCC to anticipate expenses for known but undefined scope items. Ten percent of the total OPCC (excluding construction allowances) is added to provide an allowance for estimation accuracy and unlisted items. No additional contingencies have been included for design or construction of the AWT as a contingency will be added to the overall program.

The following generic assumptions are incorporated into the OPCC:

- Competitive bid conditions will prevail at tender (e.g., +3 bidders)
- Standard industry commercial terms will attach to all procurements
- Stable market conditions will prevail without significant geopolitical events or economic disruptions
- An optimized contracting strategy will be employed to efficiently sequence and coordinate the work scope
- No trade discounts are considered
- Bulk material quantities are based on manual quantity takeoffs

The following specific assumptions are incorporated into the OPCC:

- Pricing basis is second quarter of 2016. Forward escalation to the mid-point of construction is not included.
- An allowance to provide underpinning or soil stabilization to the building foundation is not included.
- Perimeter fencing is not required.
- Specialized laboratory equipment is not included.
- Imported bedding and gravel materials will serve as pipe backfill and be placed to the top of the pipe.
- Non-rippable rock strata will not be encountered in trench excavations.
- Excess soils will be disposed of in the adjacent site.
- Significant groundwater will not be encountered in pipe trenches.
- Where force mains and sanitary sewers occupy the same trench, earthwork excavation costs will be assigned to the force main element.
- Over-excavation mitigation includes the fill areas behind the secondary clarifiers. The facilities impacted include the electrical substation, the influent pump station, and portions of the aeration basins.
- All known major utilities will be relocated and abandoned. An additional placeholder is included for undefined less significant utility lines.

The developed estimate excludes the following:

- Non-conventional environmental, heritage, and cultural mitigation measures.
- All owner soft costs.
- Removal of unforeseen underground obstructions.
- Hazardous material remediation or disposal.
- Electrical power, sanitary sewer service, and wastewater conveyance outside of project boundary limits.

- Utility costs for power connects or incoming transmission.
- Permits beyond those normally needed for the type of project.
- Facility O&M costs.
- New construction of bridges.
- All local duties, import fees, port charges, and local taxes.
- No allowance has been included for additional shift work or weekend work.
- Special inspections and testing.
- Furnishings, moving costs, artwork, furniture.
- Cost associated with loss of revenue or power production.
- No allowances have been included to account for potential impacts of minority business requirements.

The following bidding assumptions are considered in the development of this OPCC:

- Regional contractors will compete and tender bids for the project.
- Bidders will develop competitive proposals with regard to materials pricing and labor productivity and will not include allowances for changes, extra work, unforeseen conditions, or any other unplanned costs.
- The prime contractor will self-perform all work scope except the following:
    - Electrical/SCADA/PLC
    - Pre-engineered metal building
    - Concrete/rebar, etc.
- Builder's risk insurance will be available to the contractor.
- Contractors will structure their proposals to promote positive cash flow and to minimize operational finance.
- Additional costs may be incurred if the contracting strategy decomposes the work into too many overlapping construction packages or due to lack of competition for a single large project procurement.

Appendix D provides the detailed cost estimate for the AWT facility based on the assumptions discussed above.

Conveyance Facilities

Conveyance facility capital costs include costs for the main pipelines and pump stations for the base case alignments identified in Chapter 6. Cost estimates were developed for the various construction methods required to adapt to the various pipeline alignment conditions, such as shored, open-cut, or trenchless technology. Additional estimated costs for temporary and permanent easement and fee property were also included. A breakdown of costs for the major components of the conveyance system is provided in Table 9.1. The Class 4 OPCC for the conveyance system is $769,700,000.

Table 9.1: Conveyance System Construction Cost Summary

Facility	Total Cost (2016 million dollars)
Pipelines	617.7
Pump Station No. 1	27.0
Pump Station No. 2	28.3
Pump Station No. 3	17.6
Right-of-Way	79.1
OPCC for Conveyance	**769.7**

Pipelines

The cost estimate for the conveyance pipelines was generated by identifying four general construction setting types that will be encountered along the base case alignments. These four construction settings are as follows:

- Roadway (149,398 feet; 52 percent of alignment)
- Utility corridor (48,696 feet; 17 percent of alignment)
- Other non-road public ROWs (48,618 feet; 17 percent of alignment)
- Trenchless (39,517 feet; 14 percent of alignment)

From these four construction settings, standardized construction methods were determined, which include the following:

- Open-cut trenching with vertical shoring or use of trench boxes (typical within roadways or areas with limited ROW)
- Pipe jacking and auger boring (typical for trenchless sections 150 feet long or less)
- Micro-tunneling (typical for trenchless sections from 150 feet to 1,500 feet long)
- Traditional tunneling (use of tunnel boring machines for lengths in excess of 1,500 feet)

Roadway construction assumes the application of open vertical trenching to place pipe segments. This method assumes that trenches will be shored or will use trench boxes and that the work will take place within a 36-foot-wide construction zone.

Standardized unit costs were then developed for each of the four construction methods, representing the cost per linear foot to install the pipeline under a particular method and setting. The standardized unit costs were then multiplied by the length of the particular construction method to arrive at a cost to construct each segment. The standardized unit costs represent the total cost of construction for a complete project, including materials, equipment, and labor necessary to install and commission the facilities and restore ground to its prior condition.

To account for locations where the standardized construction methods do not strictly apply, a “cost adder” was applied for the additional construction costs associated with addressing special features, such as night work, major utility crossings, seismic hazards/fault zones, additional traffic control measures, dewatering, etc.

Direct costs for each segment were calculated by determining the applicable construction methods and cost adders. Total costs for each segment were then calculated to include the direct costs plus general requirements, general contractor overhead and profit, and bonds and insurance. Contingency for the conveyance system opinion of probable cost is included in the overall program contingency.

The calculated direct costs include construction costs only and do not include costs associated with design, project administration, construction management, or social and environmental impacts.

Roadway construction assumes the application of open vertical trenching to place pipe segments. This method assumes that the trenches will be shored and that the work will take place within a 36-foot-wide construction zone.

The costs included for roadway construction include the following:

- Demolition, such as pavement removal
- Site work, such as general traffic control and dust control
- Earthwork, such as excavation, shoring, bedding, and backfill
- Pipe material and installation
- Appurtenances, such as ancillary items like air release vacuum valves and cathodic protection
- Restoration, such as pavement replacement

Utility corridor construction for this project would take place within Southern California Edison easements, and assumes that SCE will grant Metropolitan permission to work within its easement. It is assumed that the method of construction within SCE easements would be vertical trenching within a 36-foot-wide construction zone.

The costs included for construction within SCE easements include the following:

- Demolition, such as clearing and grubbing
- Site work, such as temporary fencing
- Earthwork, such as excavation, shoring, bedding, and backfill
- Pipe material installation
- Appurtenances, such as ancillary items like air release vacuum valves and cathodic protection
- Site restoration

Other non-road construction public rights-of-way for this project are assumed within Los Angeles County Flood Control District (LACFCD) easements. Assuming there is sufficient room for pipeline installation, open-cut methods would be applied at the following LACFCD locations:

- **Adjacent to river:** Open-cut construction would be applied the top of the river bank.
- **Toe of levee:** Open-cut construction would be applied at the toe of the river levee.
- **Earthen channel:** Open-cut construction would be applied where a concrete encased pipe would be installed in an earthen river bottom.
- **Concrete-lined channel:** Open-cut construction would be applied where a concrete encased pipe would be installed in a concrete-lined river bottom.

The costs included for construction within LACFCD easements include the following:

- Demolition, such as concrete removal and clearing and grubbing
- Site work, such as temporary fencing
- Earthwork, such as excavation, shoring, bedding, and backfill
- Pipe material installation
- Appurtenances, such as ancillary items like air release vacuum valves and cathodic protection
- Concrete replacement and general site restoration

Trenchless construction includes the following three methods:

Jack & Bore: This method is used for trenchless lengths of 150 feet or less by means of a jacking system that pushes pipe casing with a simple cutting head to a receiving pit. A conveyor or muck car removes spoils from inside the casing pipe.

Micro-tunneling: This method is used for trenchless lengths between 150 and 1,500 feet by means of a jacking system that pushes pipe with a micro-tunnel boring machine (up to 5-6 feet in diameter) to a receiving pit.

Traditional tunneling: This method is used for trenchless lengths greater than 1,500 feet by means of a tunnel boring machine (generally larger than 6 feet in diameter) that places an initial pre-cast concrete segmental liner followed by pipe installation within the initial liner.

The costs included for jack & bore include the following:

- Demolition, site work, earthwork, and restoration for launching and receiving pits
- Jacking system
- Pipe casing
- Pipe material and installation

The costs included for micro-tunneling include the following:

- Demolition, site work, earthwork, and restoration for launching and receiving pits
- Jacking system and micro-tunnel boring machine equipment
- Pipe material and installation

The costs included for traditional tunneling include the following:

- Demolition, site work, earthwork, and restoration for launching and receiving pits
- Tunnel boring machine
- Pre-cast concrete liners
- Pipe material and installation

Appendix E provides the detailed cost estimate for the pipelines based on the assumptions discussed above.

Pump Stations

The base case for the conveyance system also includes three pump stations (PS-1, PS-2, and PS-3), as described in Chapter 6. The feasibility-level costs for the pump stations were developed by adjusting the OPCC developed for comparable pump station projects. Table 9.1 summarizes the construction costs for each pump station facility based on the pump station design criteria. The detailed cost breakdowns include the following construction cost-related prorates:

- General Conditions – 3 percent
- Design Contingency – 0 percent (included in overall program contingency)
- Escalation – 0 percent
- Mobilization – 2 percent
- Permits – 0.25 percent
- Bonds and Insurance – 1.5 percent
- Overhead and Profit – 10 percent

Appendix F provides the detailed cost estimate for the pump stations based on the assumptions discussed above.

Right-of-Way

To develop an estimate of ROW costs, a market data search was undertaken to identify property ownership, property values, and rental rates of properties along the base case alignment. These costs are based on the type of land uses impacted and include the following:

- Cost to acquire permanent easements for the placement of pipeline within each corridor segment
- Cost to acquire temporary construction easements for construction of pipeline within corridor segments
- Cost to temporarily relocate tenants during construction within each corridor segment
- Cost to temporarily relocate residences, within each street segment, for loss of access or construction related disturbances during pipeline construction adjacent to their property
- Cost to compensate businesses, within each street segment, for potential lost revenue during construction adjacent to their property

Wells

Capital costs for injection well fields include costs for new injection wells and the interconnecting pipeline network, monitoring wells, and relocated wells. Well siting was not conducted as part of this study. Therefore, a cost of $4 million for each new injection well and pipeline was assumed. A cost of $2 million was assumed to repurpose the wells in Long Beach. A cost of $1.5 million was assumed for each monitoring well and $4 million for each relocated well. No costs were developed for new spreading facilities as the base case assumes the use of existing facilities.

Use of the existing spreading facilities within the Montebello Forebay, Main San Gabriel Basin, and Orange County Basin was assumed in developing costs for the base case. Therefore, new injection wells were only assumed for the West Basin and Long Beach sites. Additionally, the cost for new monitoring wells was not included for the Montebello Forebay or Orange County sites. The base case assumes the use of the existing spreading facilities, which already spread recycled water, and the existing monitoring wells were assumed to be sufficient to meet monitoring needs. Table 9.2 shows the new well facilities assumed for the base case, as well as the associated costs. As shown in Table 9.2, the OPCC for well facilities is $155,000,000.

Table 9.2: OPCC for New Well Facilities

Facility	Number in Base Case Cost Estimate	Construction Cost (2016 million dollars)
New Injection Wells	15	60
Repurposed Injection Wells	4	8
Monitoring Wells	18	27
Relocated Wells	15	60
Total		**155**

Summary of Capital Costs

A summary of the OPCC for the base case scenario, including treatment, conveyance, and well facilities is provided in Table 9.3. A 25 percent additive for project management, engineering design, project administration, and construction management is provided in the estimated total capital costs. In addition, a 35 percent project scope contingency was added to encompass uncertainties within the base case scenario and the engineering analyses conducted to date. As shown in Table 9.3, the estimated total capital cost for the potential program is $2,710,700,000. The estimate provided is equivalent to a Class 4 OPCC as defined by the AACE and has an expected range of accuracy of –20 percent to +40 percent.

Table 9.3: Opinion of Probable Construction Cost

	Base Case 150 mgd Capacity (2016 dollars)*
Materials and Construction	
JWPCP Modifications	92,200,000
Advanced Water Treatment Plant	589,400,000
Conveyance Facilities (Pump Stations, Pipelines)	769,700,000
Well Facilities (Including Monitoring and Relocated Wells)	155,000,000
Subtotal Materials and Construction	**1,606,300,000**
Project Management and Engineering	
PM/CM/Design/Administration (25%)	401,600,000
Contingency (35%)	702,800,000
Total Capital (2016 Dollars)	**2,710,700,000**
*Class 4 cost estimate. Expected range of accuracy is –20% to +40%.	

PM = project management; CM = construction management

Operation and Maintenance Costs

Advanced Water Treatment

Operational costs for the AWT facility include the costs for power and chemicals associated with the treatment process (MBR, RO, and UV/AOP), operations staff labor, and replacement of unit process components that wear out over time (e.g., RO cartridge filters). Power costs were estimated based on the average annual operating condition for each major process equipment. Chemical costs were calculated using the average dose for major chemical feed systems during the course of normal operations over 1 year. Staff labor costs assume 55 staff assigned to the AWT facility. Replacement costs were calculated by prorating the amount of equipment that must be replaced within 1 year. For example, MBR elements have a replacement interval of 15 years. Therefore, the annual replacement cost is calculated by assuming approximately 7 percent of the MBR elements would be replaced in 1 year.

Maintenance costs include costs associated with replacement of parts during routine maintenance of process equipment, such as pumps, valves, and instrumentation, as well as the staff labor for performing the maintenance. Maintenance costs were calculated by multiplying the equipment capital cost estimates for each system by 2 percent.

The land use fee for siting the AWT on Sanitation Districts' property is included at $5,000 per acre per year for the lease of the property based on an initial term sheet that was developed between the two agencies in 2015. The land use fee is included in the AWT annual O&M costs and assumes that approximately 20 acres is appropriated for the AWT site. The estimated annual O&M cost for the AWT system is $99,700,000. Detailed O&M cost estimates for the AWT facility are provided in Appendix D.

Conveyance

O&M costs for the conveyance system include the power costs for energy used at the pump stations; labor costs for O&M of the pump stations, as well as pipeline maintenance; and material replacement costs for equipment within the conveyance system. Approximately 75 percent of the cost for conveyance O&M is attributed to the power costs for pumping the water to the various discharge locations. Table 9.4 provides the estimated annual power needs for the three pump stations for the base case scenario, which assumes a long-term average production of 147 mgd.

Table 9.4: Estimated Pump Station Annual Power Need and Cost for Base Case*

Pump Station	Pumping To	Annual Power Need (kWhr)	Annual Pumping Cost (2016 million dollars)**
PS1	PS2	21,825,000	3.3
	West Coast Basin	1,908,000	0.3
PS2	OC Spreading Grounds	30,090,000	4.5
	PS3	40,322,000	6.0
PS3	Santa Fe Spreading Grounds	43,716,000	6.6

*Estimated power need based on conveyance for 147 mgd average long-term production.
**Assumes $0.15/kWhr energy cost rounded to nearest $100,000.

An equivalent of 2.5 percent of the pump station capital cost and 1 percent of the pipeline capital cost were used to estimate the annual labor and material costs for the conveyance system. The estimated annual O&M for the conveyance system is $28,100,000.

Injection/Spreading Facilities

Operation costs for the wells include the power costs for backwashing the injection wells, labor costs for well maintenance, and materials costs for maintenance or replacement of equipment. An equivalent of 1 percent of the capital cost of the well facilities was assumed for the annual O&M labor and material costs. O&M costs for relocated wells are not included in the estimate because the cost would be handled by the well owner. Additionally, no O&M costs are included for the spreading facilities because the cost is assumed to be handled by the owner. The estimated annual total O&M cost for the well facilities is $1,200,000.

Summary of Operations and Maintenance Costs

The estimated annual O&M costs are summarized in Table 9.5. The O&M costs reflect the potential turn-down of the AWT production at certain times for a long-term annual average of 147 mgd. Reduced production at the AWT facility would lower costs associated with energy consumption for pumping and advanced treatment, as well as chemical usage and replacement of consumables at the AWT facility. Labor and maintenance costs would not be affected. The power consumption cost estimates are based on a combined load from the AWT facility (~60 megawatts [MW]) and the three pumping stations (~16.1 MW), thus the total potential power demand from the major program components is approximately 80 MW.

Table 9.5: Estimated Annual O&M Costs

	Base Case 150 mgd Capacity (2016 dollars)
Operations and Maintenance	
Advanced Water Treatment*	99,700,000
Conveyance (Pump Stations, Pipelines)*	28,100,000
Well Field and Spreading Facilities	1,200,000
Total Annual O&M Costs	**129,000,000**
*O&M costs shown reflect turndown of equipment during wet periods for long-term average production of 147 mgd.	

9.3 Comparison to Other Potable Reuse Projects

Using the estimated costs described above, the base case unit cost estimate for the project is $1,610 per AF[1], as presented in the following Chapter 10. This estimate includes the capital and operations costs of treatment at an advanced water treatment facility, as well as pumping and pipelines to convey the water to spreading grounds and injection wells. For comparison, Table 9.6 summarizes the unit cost for other potable reuse projects within California.

Unit costs are presented for illustrative purposes only and are not intended to be a true "apples-to-apples" comparison. Unit costs presented in Table 9.6 are based on the latest available information reported by or published by the lead entity for each project, all of which take into account unique assumptions, inclusions, and exclusions specific to the project (e.g., bond rate, financing terms, escalation, contingencies, insurance, subsidies, grants, third-party contributions, etc.). The level of accuracy and contingencies also vary depending on project phase (e.g., planning, construction, operational, etc.).

[1] The capital unit costs were developed based on Class 4 Opinion of Probable Construction Costs as defined by the AACE International Recommended Practices, with a range of accuracy that varies from –20 percent on the low side to +40 percent on the high side. The unit cost estimate is presented in Chapter 10 of this report.

Table 9.6: Unit Costs for Similar Advanced Treatment Facilities in California

Facility	Lead Entity	Advanced Processes	Source Water	Application	Status	Unit Cost \$/AF[1]
Potential Regional Recycled Water Program Advanced Water Treatment Facility	Metropolitan Water District of Southern California	MBR-RO-UV/AOP	Non-nitrified secondary effluent (high-purity oxygen-activated sludge w/ low solids retention time)	Groundwater replenishment	Planning	\$1,610[2]
Groundwater Replenishment System	Orange County Water District	MF/UF-RO-UV/AOP	Secondary effluent	Groundwater replenishment	Operational	\$850[3]
Edward C. Little Water Recycling Facility	West Basin Municipal Water District	O_3-MF-RO-UV/AOP	Secondary effluent (high-purity oxygen-activated sludge)	Groundwater replenishment and seawater barrier injection	Operational	\$1,848[4]
Groundwater Reliability Improvement Program Advanced Water Treatment Facility	Water Replenishment District of Southern California	MF/UF-RO-UV/AOP	Tertiary effluent	Groundwater replenishment	Construction	\$1,100[5]
Pure Water San Diego	City of San Diego	MF/UF-RO-UV/AOP	Tertiary effluent	Reservoir augmentation	Planning	\$1,700 – \$1,900[6]
Silicon Valley Advanced Water Purification Center	Santa Clara Valley Water District	MF-RO-UV/AOP	Secondary effluent	Groundwater replenishment	Operational	\$1,622[7]
East County Advanced Water Purification Program	Padre Dam Municipal Water District	MF-RO-UV/AOP	Secondary effluent	Surface water augmentation and groundwater replenishment	Planning	\$1,995[8]
Pure Water Monterey Groundwater Replenishment Project Advanced Water Purification Facility	Monterey Regional Water Pollution Control Agency	O_3-MF-RO-UV/AOP	Secondary effluent	Groundwater replenishment	Design	\$1,720[9]

Notes for Table 9.6:

(1) Unit costs are presented for illustrative purposes only and are not intended to be a true apples-to-apples comparison. Unit costs presented in this table are based on the latest available information reported by or published by the lead entity for each project, all of which take into account unique assumptions, inclusions, and exclusions specific to the project (e.g., bond rate, financing terms, escalation, contingencies, insurance, subsidies, grants, third-party contributions, etc.). Level of accuracy and contingencies also vary depending on project phase (e.g., planning, construction, operational, etc.).

(2) Estimated project unit cost; includes treatment, conveyance, and recharge facilities; not adjusted for grants and other subsidies; unit cost estimate developed in Chapter 10 of this report.

(3) Typical GWRS operating unit cost; includes treatment ($300–350/AF), conveyance ($30/AF), repair and replacement (R&R), and debt payback; not adjusted for grants and OCSD contributions; *Source: GWRS website and Mehul Patel/OCWD (Oct 2016).*

(4) FY 14/15 operating unit cost for barrier water; includes treatment, minimal conveyance, and R&R ($221/AF); not adjusted for subsidies and grants; *Source: WBMWD Finance Department and Shivaji Deshmukh/WBMWD (Oct 2016).*

(5) Estimated project unit cost; includes treatment and flow equalization; source water and discharge fees not included ($400/AF); potential subsidies and revenue from users not included; Source: *Esther Valle Rojas/WRD (Nov 2016).*

(6) Estimated project unit cost; includes treatment, conveyance, source control and public outreach; not adjusted for grants and other subsidies; *Source: Pure Water San Diego Fact Sheet (Oct 2016).*

(7) FY 14/15 operating unit cost; includes treatment and debt payback; not adjusted for outside funding for construction; product water blended with Title 22 water and serves South Bay Water Non-potable Recycling System in San Jose; *Source: Jim Fiedler/SCVWD (Nov 2016).*

(8) Estimated project unit cost for recommended alternative; program objective is less than $2,000/AF; includes treatment, conveyance, grants, and other subsidies; *Source: East County Advanced Water Purification Program Planning Study Final Report (Jan 2016) and Albert Lau/Padre Dam (Oct 2016).*

(9) Project unit cost guaranteed to California Public Utilities Commission; includes treatment, pond storage, debt payback ($634/AF), and insurance ($15/AF); conveyance provided by Marina Coast Water District through separate State Revolving Fund loan; *Source: Bob Holden/MRWPCA (Oct 2016).*

Acronyms:

GWRS – Groundwater Replenishment System
OCSD – Orange County Sanitation District
OCWD – Orange County Water District
WBMWD – West Basin Municipal Water District
WRD – Water Replenishment District of Southern California
SCVWD – Santa Clara Valley Water District
MRWPCA – Monterey Regional Water Pollution Control Agency

Chapter 10

Financial Evaluation

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10.0 FINANCIAL EVALUATION

10.1 Cost Summary

The cost impact of the potential RRWP has been estimated for the base case with low-cost, base case, and high-cost scenarios. A cost summary for each scenario is shown in Table 10.1. For the low-cost scenario, the capital cost contingency has been decreased to 25 percent without an O&M cost contingency. For the high-cost scenario, the capital cost contingency has been increased to 50 percent and a 25 percent O&M cost contingency added to reflect potential increases in power, labor, and material costs. The base case scenario is based on capital facilities sized for 150 mgd (168 TAF) and O&M costs based on an annual average flow of 147 mgd (165 TAF).

Table 10.1: Program Cost Summary in 2016 Million Dollars

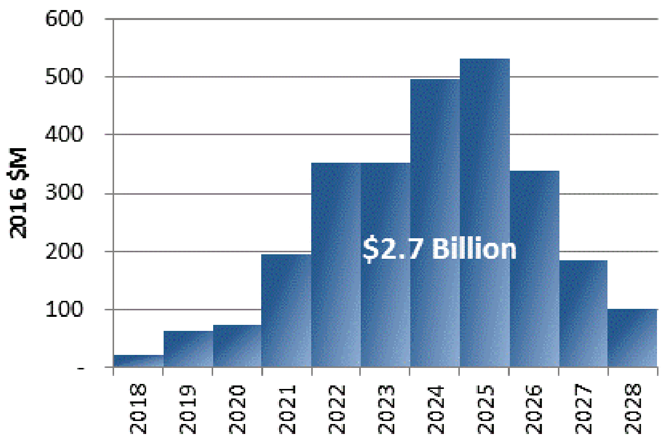
	Low	Base	High
Capital Cost			
Treatment Plant	same as Base	682	same as Base
Distribution		770	
Injection Wells/Spreading Basins		155	
Total Construction Costs		**1,606**	
Engineering Fees (25%)		402	
Total Construction Costs with Engineering Fees		**2,008**	
Contingency Rate	25%	35%	50%
Contingency	502	703	1,004
Total Capital Construction Cost with Engineering Fees and Contingency	**2,510**	**2,711**	**3,012**
Annual Operations and Maintenance Costs			
Treatment Plant	same as Base		same as Base
Power Costs		30.9	
Labor Costs		11.8	
Materials Cost		56.9	
Land Use		0.1	
Sub-total Treament Plant		**99.6**	
Distribution			
Power Costs		20.7	
Labor Costs		5.7	
Materials Cost		1.7	
Sub-total Distribution		**28.1**	
Injection Wells/Spreading Basins			
Power Costs		0.0	
Labor Costs		0.5	
Materials Cost		0.7	
Sub-total Injection Wells/Spreading Basins		**1.3**	
Total			
Power Costs		51.6	
Labor Costs		18.0	
Materials Cost		59.3	
Land Use		0.1	
Total Annual O&M Cost		**129.0**	
Contingency Rate	0%	0%	25%
Total Annual O&M Cost with Contingency	**$ 129.0**	**$ 129.0**	**$ 161.3**

Note: *May not total due to rounding*

Capital Costs Cash Flow

The estimated capital costs range from $2.5 billion to $3.0 billion with a base case projection of $2.7 billion in 2016 dollars. The projected capital costs cash flow for the base case is shown in Figure 10.1. For the purposes of this base case evaluation only, the capital costs cash flow is estimated to start in 2018, peak in 2025, and end in 2028 for an 11-year construction period.

Figure 10.1: Capital Costs Cash Flow – Base Case Scenario



10.2 Estimated Cost Impact

As described in the previous section, the low-cost, base case, and high-cost scenarios have differing assumptions on the capital and operational costs. In addition, as shown in Table 10.2, the low-cost scenario assumes $30 million in grant funding and an average cost of debt of 2.0 percent while the base and high-cost scenarios assume no grant funding and an average cost of debt of 4.0 percent for the base and 5.0 percent for the high case. All scenarios assume 100 percent of capital costs, less grant funds, are debt-financed annually, based on the capital cost cash flow required. However, as described in Section 10.4, some pay-as-you-go funding (PAYGO) might be needed to meet Metropolitan's revenue bond debt coverage and fixed-charge coverage targets.

Methodology

To evaluate the cost impact of the potential RRWP, Metropolitan's current projection of sales and costs was unchanged.

The analysis assumes the discount and escalation rate for both capital and O&M costs is 3 percent. Capital costs are debt-financed annually throughout the 11-year construction period with 30-year bonds structured to result in level debt-service payments. Issuing bonds annually over the 11-year construction period results in eleven 30-year cost streams.

The cost impact is based on when the project is complete and fully operational and debt-service and O&M costs are both incurred.

Cost Impact

A summary of the cost impact is shown in Table 10.2. At project completion, the potential RRWP is estimated to cost between $225 million and $331 million per year in 2016 dollars, resulting in an overall annual cost increase of between 14 and 21 percent. If these cost impacts were implemented over a 10-year period, beginning in the first year of project development, it would result in an annual average cost increase of 1.4 percent to 2.1 percent per year in addition to Metropolitan's projected 10-year financial forecast increases of 4.5 percent per year. The unit cost of the additional annual average flow of 147 mgd (165 TAF) produced by the RRWP ranges from $1,368 per AF to $2,013 per AF.[1] For the base case, the potential cost impact over Metropolitan's 1.70 MAF annual sales base is $156 per AF.

Table 10.2: Cost Impact Summary

	Low	Base	High	units
Capital Cost				
Contingency	25%	35%	50%	
Capital Cost	2.51	2.71	3.01	2016 $B
Financing Term	30	30	30	years
Financing Rate	2.00%	4.00%	5.00%	
Grants	30	-	-	2016 $M
Financing Cost	**96**	**136**	**170**	2016 $M/YR
Annual Operations and Maintenance Costs				
Contingency	0%	0%	25%	
Annual O&M	**129**	**129**	**161**	2016 $M/YR
Annual Costs				
Financing Costs (1)	96	136	170	2016 $M/YR
O&M Costs (2)	129	129	161	2016 $M/YR
Total Costs	**225**	**265**	**331**	2016 $M/YR
Unit Cost				
Average Yield	165	165	165	TAF
Capital Costs	584	827	1,033	2016 $/AF
O&M Cost	784	784	980	2016 $/AF
Total Unit Cost	**1,368**	**1,610**	**2,013**	2016 $/AF
Cost Impact (3)				
MWD Overall Cost Increase	**14%**	**17%**	**21%**	
annual cost increase over 10-years	1.4%	1.7%	2.1%	
Average Cost Increase	132	156	195	2016 $/AF

(1) Financing Costs when the project is complete
(2) O&M cost when fully operational
(3) Based on 2016/17 Budget of 1.70 MAF

[1] The RRWP would produce up to 150 mgd or 168,000 AF per year. Recognizing the need to potentially lower production to a minimum 110 mgd at certain times, the cost analysis uses an estimated long-term average yield of 147 mgd or 165,000 AF per year.

10.3 Cost Recovery Options

This chapter addresses potential funding sources for the RRWP, but does not address allocation of any costs to Metropolitan's rates and charges. This evaluation will be done in future studies. A survey of various methods that other California water agencies have used to recover the revenue requirements of projects with benefits similar to those of the potential RRWP is included in Appendix G.

10.4 Debt Policy and Coverage

Metropolitan is subject to limitations on additional revenue bonds. Resolution 8329 (the "Master Revenue Bond Resolution"), adopted by Metropolitan's Board in 1991 and subsequently supplemented and amended, provides for the issuance of Metropolitan's revenue bonds. This resolution limits the issuance of additional obligations payable from Net Operating Revenues, among other things, through the requirement that Metropolitan must meet an Additional Bonds Test, as defined in the resolution.

The Metropolitan Act also provides two additional limitations on indebtedness. It provides for a limit on general obligation bonds, water revenue bonds, and other indebtedness at 15 percent of the assessed value of all taxable property within Metropolitan's service area. As of June 1, 2016, outstanding general obligation bonds, water revenue bonds, and other evidences of indebtedness in the amount of $4.34 billion represented approximately 0.18 percent of the fiscal year (FY) 2015/16 taxable assessed valuation of $2,451 billion. The bonds issued for the RRWP would not cause Metropolitan's indebtedness to exceed the 15 percent assessed value limitation.

The second limitation under the Act specifies that no revenue bonds may be issued, except for the purpose of refunding, unless the amount of net assets of Metropolitan as shown on its balance sheet as of the end of the last FY prior to the issuance of the bonds equals at least 100 percent of the aggregate amount of revenue bonds outstanding following the issuance of the bonds. The net assets of Metropolitan as of June 30, 2015, were $6.9 billion. The aggregate amount of revenue bonds outstanding as of December 31, 2015, was $4.23 billion. The aggregate amount of total debt outstanding is forecasted to decrease to $3.6 billion over the 10-year period ending FY 2025/26 as bonds are paid down and capital projects are financed with operating revenues. Thus, there should be headroom between the value of net assets and outstanding revenue bonds to debt-finance the RRWP.

Metropolitan has also established its own policy regarding debt management. The purpose is to maintain a balance between current funding sources and debt financing to retain Metropolitan's financing flexibility. Flexibility allows Metropolitan to use a variety of revenue or debt-financing alternatives, including issuing low-cost variable rate and other revenue-supported obligations.

Metropolitan's debt management policy is to do the following:

- Maintain an annual revenue-bond debt coverage ratio of at least 2.0 times coverage;
- Maintain an annual fixed-charge coverage ratio of at least 1.2 times coverage;
- Limit debt-funded capital to no more than 40 percent of the total capital program over the 10-year planning period; and
- Limit variable-rate debt such that the net interest cost increase due to interest rate changes is no more than $5 million, and limit the maximum amount of variable rate bonds to 40 percent of

outstanding revenue bond debt (excluding variable-rate bonds associated with interest-rate swap agreements).

To comply with the debt management policy, Metropolitan has taken the following measures:

Revenue Bond Debt Coverage Ratio: This policy ensures that Metropolitan has sufficient annual operating revenues to pay its operating expenses and meet its debt-service obligations on its revenue bonds and other senior debt. The revenue bond debt coverage ratio is defined as Metropolitan's net operating revenue (current year's operating revenue less the current year's operating expenses) divided by the current year's debt service on all revenue bonds and other senior debt. The target is 2.0 times. Metropolitan's 10-year forecast projects the revenue bond coverage to achieve 2.0 times from FY 2021/22 forward.

Fixed-Charge Coverage Ratio: In addition to revenue bond debt service coverage, Metropolitan also measures total coverage of all fixed obligations after payment of operating expenditures. This additional measure is used to account for Metropolitan's recurring capital costs for the State Water Contract, which are funded after debt service on revenue bonds and other parity obligations. Rating agencies expect that a financially sound utility consistently demonstrates an ability to fund all recurring costs, whether they are operating expenditures, debt-service payments, or other contractual payments. Metropolitan's fixed-charge coverage ratio target is 1.2 times. Metropolitan's 10-year forecast projects the fixed-charge coverage exceeding 1.2 times in all years. These levels help maintain strong credit ratings and access to the capital markets at low cost.

Implications of the RRWP to Coverage Ratios

Issuing debt during the 11-year construction period of the RRWP may affect Metropolitan's revenue bond debt coverage and fixed-charge coverage ratios. The full effects of the additional debt-service payments on the coverage ratios cannot be determined at this time because most of the effects are beyond the timeframe of current long-term finance forecasts. One way to mitigate the impact of the additional debt service on the coverage ratios is to reduce the amount of revenue bonds issued by using operating revenues, or PAYGO. Use of operating revenues during construction would lower the cost impact when the project is complete as revenue bond debt service would be reduced. However, the tradeoff is that Metropolitan's rate increases during the construction period would need to be higher in order to generate the additional revenue.

10.5 Potential Grant and Loan Funding

Grant and loan funding opportunities are available from one or a combination of sources including the federal government, and state government, as well as potentially from non-profit research funds, public-private partnerships, and local agency partnering. Grant and loan funding is an attractive source of supplemental funding for the potential RRWP, but has various eligibility and reporting requirements. This overview will focus on grants and low-interest loans available from state and federal agencies. It should be noted that this feasibility study was not prepared to meet the criteria of federal and state funding programs. Additional analysis and information would be needed to prepare documentation for grant and loan programs that may be pursued in the future.

Federal funding for the potential RRWP is primarily available through the US Bureau of Reclamation (USBR). Funding from USEPA, the United States Department of Agriculture, or other federal sources may be available for the RRWP in the future. The SWRCB is the primary state agency that funds recycled water projects. The SWRCB's Division of Financial Assistance administers the Water Recycling Funding Program (WRFP), the State Clean Water and Drinking Water State Revolving Fund programs, and the Groundwater Grant Program. The Department of Water Resources (DWR) is the primary state agency for funding Integrated Regional Water Management projects. The following discussion provides an overview of the known funding sources available for the RRWP. Table 10.3 summarizes the programs described below.

Grant Funding Opportunities

WaterSMART Program

The WaterSMART (Sustain and Manage America's Resources Tomorrow) program was established in 2010 to implement the SECURE Water Act to secure water supplies for future generations, coordinate across agencies, integrate water and energy policies, and ensure the availability of science and information to support decisions on sustainable water supplies. WaterSMART contains several grant programs including the following: the WaterSMART Grants, Title XVI Water Reclamation and Reuse Program (Title XVI), Basin Studies, Watershed Management, Drought Response, and Water Conservation and Field Service Programs. The proposed 2017 WaterSMART Program budget requested $61 million. The USBR is the primary agency administering these WaterSMART programs. The two federal grant programs that may provide funding for the RRWP are the WaterSMART Grant program and Title XVI.

The WaterSMART Grant program includes approximately $23 million in FY 2017 for projects that offset potable water demand through conservation, watershed management, and innovative technologies. Reclamation is working on updating the program in 2017 to include additional grant categories for small implementation projects, water marketing, and revising the Water and Energy Efficiency Grant funding. Funding can be used for projects that conserve and use water more efficiently, improve energy efficiency, benefit endangered and threatened species, address climate-related impacts on water, or prevent any water-related crisis or conflict. WaterSMART Grant funding, typically announced in the fall, is a competitive grant program for up to $1 million that requires at least a 50 percent local-cost share and completion in 2 to 3 years. Metropolitan received a $334,208 grant in 2011 for the pilot project at the JWPCP and a $700,000 grant in 2014 to supplement the On-Site Recycled Water Retrofit Pilot program.

Title XVI Water Reclamation and Reuse Program

Title XVI, established through the Reclamation Wastewater and Groundwater Study and Facilities Act of 1992, provides grant funding for projects in the 17 western United States and Hawaii that reclaim and reuse municipal, industrial, domestic, or agricultural wastewater, and naturally impaired ground and surface waters. According to the USBR website, currently 53 Title XVI projects are authorized by Congress, 20 have been completed, and 37 have completed feasibility studies. The last project was authorized in 2011. Thirty-six Title XVI construction projects are located in California. Title XVI generally provides up to $20 million or 25 percent of project costs to selected congressionally authorized projects for construction. Project sponsors provide the remaining 75 percent of the funding necessary to carry out the projects. Title XVI provides funding of approximately $20 million a year (5 to 10 projects) for planning, design, or construction. Funding for a project is typically provided over 5 to 10 years in $3 million to $5 million increments. Approximately $629 million in federal funding has been leveraged with non-federal funding to implement approximately $2.4 billion in water reuse projects. Approximately $407 million in Title XVI grants has been provided to projects in Metropolitan's service area, including $50 million in the mid-1990's for the first phase of West Basin MWD's water recycling project. To be eligible for Title XVI funding, Metropolitan must submit a project feasibility study and receive congressional authorization for the project. Funding for feasibility studies is offered to projects that have not yet been authorized. Title XVI provided approximately $3 million in competitive funding for feasibility studies and new technology research in 2016. The proposed FY 2017 WaterSMART budget includes $22 million for Title XVI funding. The next Title XVI funding opportunity was announced in October 2016 with funding for entities with congressionally authorized water reclamation and reuse projects and funding for entities seeking to develop new water reuse feasibility studies. Legislation proposed by Senator Feinstein (S. 2533), if approved, would provide $200 million for new Title XVI projects and replace the congressional authorization requirement with a modern competitive grant program.

Proposition 1 – The Water Quality, Supply and Infrastructure Act of 2014

On November 4, 2014, California voters approved Proposition 1 (Assembly Bill 1471, Rendon) which authorized $7.545 billion in general obligation bonds for water projects including surface and groundwater storage, ecosystem and watershed protection and restoration, drinking water protection, groundwater sustainability, regional water management, and water recycling and desalination.

Proposition 1 – Water Recycling Funding Program (Prop. 1 – WRFP): Chapter 9 of Proposition 1 authorized $725 million for water recycling and desalination projects. $625 million will be administered through the SWRCB's WRFP for water recycling and treatment technology projects and $100 million through DWR for desalination projects. Of the $625 million, approximately $205 million was appropriated for FY 2015–2016. Another $320 million for water recycling was budgeted for FY 2016–2017. The funding will reportedly be split by the SWRCB with 50 percent grants and 50 percent loans. Both planning and construction projects are eligible for funding with up to $75,000 available for planning grants and $15 million for construction grants. Water recycling projects may receive grant funds up to 35 percent of actual eligible construction costs incurred with a maximum of $15 million. At least 50 percent local cost share match must be provided by the project sponsor. The applicant could satisfy the local match requirement through other sources, including its own revenues, other grants or loans, costs for studies, and other directly associated planning and design costs incurred prior to the grant award date. Local cost share may be provided by the SWRCB with Clean Water State Revolving Fund (CWSRF) financing. The remaining project cost above the $15 million cap could be funded through low-interest long-term loans from Proposition 1 or CWSRF. In future years, the $15 million maximum grant amount per project could be reduced if the repayment revenues cannot support the maximum grant benefit.

Applications for WRFP are continuously accepted by the SWRCB, and project proponents are encouraged to apply as soon as possible. Proponents are not required to have finalized documents before submitting an application. However, grants or loans will not be approved before submittal of the project's completed CEQA documents. If funding runs out during a fiscal year, the SWRCB will hold the application until sufficient funding is available. Because some funding may be through

CWSRF, which includes federal funding, CEQA evaluations should include federal NEPA cross-cutting items, which have been considered in the CEQA approach to this program. Projects are expected to be funded on a first-come and ready-to-proceed basis. Projects must meet at least 50 percent annual deliveries within 5 years of construction completion or demonstrate adequate future demands.

Proposition 1 – Groundwater Grant Program (Prop. 1 – GW): Chapter 10 of Proposition 1 authorized $900 million for grants and loans, for projects that prevent or clean up groundwater contamination that serves as a drinking water source. The SWRCB will administer $800 million of the funds. Approximately $80 million shall be available for treatment and remediation activities that prevent or reduce the contamination of groundwater that serves as a source of drinking water. Funding under this program is uncertain due to the focus on groundwater treatment. Additional research is necessary to establish funding likelihood for the RRWP.

Proposition 1 – Integrated Regional Water Management (Prop. 1 – IRWM): Chapter 7 of Proposition 1 authorized $510 million for grants to implement Integrated Regional Water Management (IRWM) plans. $98 million was allocated to the Los Angeles Region. The IRWM Grant Program is intended to improve regional water self-reliance and address changes on the water supply arising out of climate change. Proposed projects must be consistent with adopted IRWM Plans and priorities. Water reuse and recycling projects are generally eligible. Additional research is necessary to establish funding likelihood for the RRWP.

Loan Opportunities

Water Infrastructure Finance and Innovation Act (WIFIA) Program

The WIFIA program is a new 5-year pilot program authorized under the Water Resources Reform and Development Act (WRRDA) of 2014. The program is modeled after the successful Transportation Infrastructure Finance and Innovation Act (TIFIA) of 1998 to provide low-interest financing (secured loans or loan guarantees) for the construction of water and wastewater infrastructure including water recycling projects. WIFIA is similar to State Revolving Fund (SRF) programs, but is intended to provide subsidized financing for large-dollar-value projects. Eligible recipients include corporations, partnerships, municipal entities, and SRF programs. Eligible projects must be nationally or regionally significant and cost at least $20 million. The maximum amount of the loan is 49 percent of the eligible project costs. Currently, USEPA has only been appropriated $2.2 million to hire staff and develop the WIFIA pilot program. Implementation of the WIFIA program funding cannot occur until Congress appropriates funds for the program. The President's FY 2017 budget requests $15 million for USEPA to begin making loans.

Clean Water State Revolving Fund (CWSRF) Program

The CWSRF is a low-interest loan program administered by the SWRCB that provides funding to agencies to plan, design, and construct wastewater treatment, sewer collection, or water-recycling facilities, among other things. Applications are continuously accepted through the Financial Assistance Application Submittal Tool (FAAST) electronic application program by the SWRCB. Projects must submit applications including project description, financial information, and CEQA compliance before being considered for funding. The CWSRF is comprised of both federal and state monies. California receives annual capitalization grants from USEPA and provides a 20 percent match via state bonds and local funds. Because most of the CWSRF funding comes from USEPA, the CWSRF program requires applicants to provide additional environmental documents to comply with federal NEPA requirements.

The amount of the loan is dependent on the proponent's ability to repay the principal. Currently, CWSRF loans have payment terms up to 30 years at half the current general obligation bond rate. SWRCB data from 2014–2015 indicates that the average loan for the 40 projects was approximately $20 million. SWRCB staff verbally indicated that the RRWP is eligible for the CWSRF and recommended applicants file applications as soon as possible because funding for this program is almost fully subscribed and may require applicants to wait for sufficient funds to become available in the future.

Drinking Water State Revolving Fund (DWSRF) Program

The DWSRF is another low-interest loan program administered by the SWRCB that provides funding to agencies to plan, design, and construct drinking water infrastructure. DWSRF loans have payment terms up to 20 years at half the current general obligation bond rate. Projects must submit applications including project description, financial information, and CEQA compliance before being considered for funding. The amount of the loan is dependent on the agency's ability to repay the principal. SWRCB data from 2014–2015 indicates that the average loan amount for 24 projects was approximately $5 million. The DWSRF requires applicants to provide additional environmental documents to comply with federal NEPA requirements because the SWRCB receives approximately 80 percent of the DWSRF funding from USEPA. Additional research is necessary to confirm eligibility for the potential RRWP and establish the likelihood of funding. DWSRF funding would be a lower priority than the CWSRF funding because the loan term is shorter and the eligibility is less certain.

Proposition 1 – Water Recycling Funding Program Loan

As described above under the Grant Funding Opportunities, the Proposition 1 WRFP also has a low-interest loan component. The $625 million of Proposition 1 WRFP funding received by the SWRCB will reportedly be split in half with 50 percent for grants and 50 percent for loans. Loans would be available at half the general obligation bond rates (~1.7 percent) with repayment within 30 years. Repayment of loans is used to fund additional projects. Both planning and construction projects are eligible for funding. Proposition 1 funding (both grant and loans) cannot exceed 50 percent of the eligible project costs.

Potential Grant and Loan Funding Conclusions

Based on current information, an application for the full-scale RRWP should be submitted as soon as possible to the SWRCB to compete for remaining Proposition 1 WRFP funding. The maximum grant that Metropolitan is likely to receive is $15 million. In addition, Metropolitan will likely qualify for a low-interest loan through the CWSRF program for approximately 50 percent of the eligible project costs. Staff should be cautious of expecting more than 50 percent funding for the project due to high demands for the funding and competition from other projects. Support from other agencies and political leaders may facilitate receiving funding. An additional $20 million grant through Title XVI may be available in the future if Metropolitan gets congressional approval for the RRWP or the proposed legislation (S. 2533) referenced above is approved and revises current requirements. Staff recommends prioritizing funding requests first through the CWSRF low-interest loan program because the project eligibility is more in alignment with the proposed RRWP, the size of the loan is up to 50 percent of the project cost, the interest rate is half the general obligation bond rate (~1.7 percent), and repayment is up to 30 years.

Table 10.3: Summary of Grant and Loan Funding Programs

Program	Range of Possible Funding Amount			Likelihood	Comment	Terms
	Max	Average	Min			
Grants						
WaterSMART	$1M	$0.7M	$0.25M	Low	Water use efficiency focus	50% cost share
Title XVI	$20M or 25%	~$4M	$1M	Medium	Need congressional authorization	75% cost share; funding usually provided over 5–10 years
Prop 1- WRFP	$15M or 35% construction; $75,000 for planning	$5.5M	$1M	High	Submitted 7 planning grants	Competitive program, 50% cost share; Buy America, prevailing wage
Prop 1 – GW	Not specified	TBD	$0.5M	Low	Need to determine eligibility	50% cost share
Prop 1 – IRWM	Not specified	TBD	$0.5M	Low	Must be local priority; disadvantaged communities focus	50% cost share
Low-Interest Loan						
WIFIA	49% of eligible costs	TBD	TBD	Low	Only pilot program; need Congress to add funding; complete with other priority infrastructure	TBD; estimated loan rate at ~4%
CWSRF	No max	~$20M	Not specified	High	Good opportunity	30 years @ ½ GO bond
DWSRF	Not specified	~$5M	Not specified	Low	Need to determine eligibility	20 years @ ½ GO bond
Prop 1 – WRFP	Up to 50%	50%	Not specified	Medium	~1/2 Prop 1 WRFP funding for loans; need to determine if program is fully subscribed	30 years @ ~1.7% loan + grant up to 50% of cost

GO bond = general obligation bond

Chapter 11

Findings, Conclusions, and Recommendations

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11.0 FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

11.1 Primary Conclusions Regarding Feasibility

Investigations found that the 150 mgd RRWP, as described in the base case scenario, is technically feasible and can be accomplished under the specific assumptions used for the analysis. Primary challenges relate to the permitting and institutional arrangements that would be necessary to augment water supplies in multiple groundwater basins. The base case cost estimate for the project is approximately $1,610 per AF. This estimate includes the capital and O&M costs for the AWT facility, pump stations, pipelines, and injection wells to provide purified water in up to four groundwater basins. In answer to the key questions posed in the study methodology, *a priori* evaluations found the following:

1. No technical flaws or deficiencies were identified in the base case that would preempt or prevent its successful completion as described.
2. The RRWP can be implemented within current regulatory and environmental permitting frameworks, if supported by robust public outreach.
3. The RRWP's anticipated regional benefits and costs are consistent with the projections and targets established in Metropolitan's 2015 IRP Update.

Further investigations and studies are needed to confirm the assumptions and conditions associated with these findings regarding feasibility. These investigations and studies include the following:

1. Demonstration to regulators that the pathogen log reduction credits and membrane integrity monitoring associated with the MBR justify elimination of a membrane filtration treatment step prior to RO.
2. Completion of detailed analyses of water quality and water management requirements associated with each of the groundwater basins and recharge locations designated to receive product water.
3. Completion of additional technical investigations on the program's treatment and conveyance systems.
4. Negotiation, approval, and execution of final agreements with the Sanitation Districts associated with the roles, responsibilities, costs, and benefits provided by the RRWP.
5. Development of institutional arrangements that would ensure the ability to deliver agreed-upon amounts of recycled water on a near-continuous basis and ensure that the regional benefits defined in this report can be secured.

Additionally, given the scope of this investigation and its exclusive focus on program feasibility, no attempt has been made to optimize the concepts defined in the base case scenario. During the investigation, many promising ideas and concepts were identified for lowering costs, improving efficiency, and accelerating project delivery times. Those opportunities are believed to further strengthen the finding of overall program feasibility. Program optimization would be reviewed as part of the further required studies discussed above.

A discussion of the detailed findings that support the primary conclusions follows. For the purposes of this evaluation, the feasibility of program components has been ranked from highest to lowest using the following categorization:

1. **Feasible** – Found to have no fatal flaws or deficiencies, limited dependence on other parties, other existing examples of success, and some unknowns.
2. **Likely to be feasible** – Found to have no fatal flaws or deficiencies, significant dependence on other parties, limited comparable existing examples, and many unknowns.
3. **No apparent fatal flaws** – Found to have no apparent fatal flaws or deficiencies but in need of further investigation and studies.

None of the program elements were considered to be not feasible; none of the program elements had fatal flaws or deficiencies that cannot be reasonably mitigated.

The specific assumptions, risks, and risk mitigation used in this feasibility evaluation is provided in Chapter 3, Table 3.2 "Key Assumptions." These risks and their associated potential for mitigation led to the feasibility assessments that are described below.

11.2 Engineering, Constructability, and Operational Feasibility

Treatment Plant and Conveyance System

The base case scenario assumes the production of 150 mgd of purified water from the AWT facility located in Carson and the conveyance of purified water via approximately 60 miles of pipelines to five groundwater recharge locations.

Advanced Water Treatment Plant

Finding: *The feasibility studies indicate that the successful development of the AWT design, construction, and operations are considered to be feasible.*

Pilot studies conducted by Metropolitan and the Sanitation Districts from 2010 through 2011 determined that a robust treatment process can successfully treat the JWPCP's non-nitrified secondary effluent for IPR through groundwater recharge. Metropolitan's 0.5-mgd demonstration facility would be used to verify design criteria, optimize process features, and achieve regulatory approval for the treatment process which could be implemented in the full-scale program.

The feasibility study confirmed the need to use flow equalization to ensure constant production rates from the AWT facility due to the diurnal flow patterns that are experienced at the JWPCP.

Upcoming studies at the demonstration facility will be conducted to demonstrate that a tertiary MBR process can achieve the following goals: (1) minimize membrane fouling in the AWT process and meet nitrate objectives for the groundwater basins; and (2) achieve regulatory approval for necessary log reduction credits for *Cryptosporidium* and *Giardia* that would allow flow from the MBR process to go directly to RO. Nitrogen management has been identified as a crucial objective of the treatment portion of the program. The feasibility studies concluded that the program may rely on some nitrogen treatment being performed within the JWPCP (likely sidestream treatment), with the remainder of nitrogen treatment being performed within the AWT facility. Based on investigation efforts to date, it may be possible to reduce boron levels entering the JWPCP and the AWT facility, which may eliminate the need for ion exchange treatment to remove this constituent in the AWT facility, thereby saving treatment costs. Consequently, it appears that source control and nitrogen management will ensure that water quality goals for the groundwater basins can be met in regards to both constituents.

Conveyance System

Finding: *When assessed as a whole, and taking into account the wide variety of construction methodologies that would be considered for use, the investigation concluded the construction of the conveyance system for the RRWP within the schedule that has been identified in this report is considered likely to be feasible.*

The conveyance system will be constructed in an urban environment, thus significant effort was made to identify the feasibility criteria and methodology for constructing pipeline alignments and pump stations in congested locations. Among the factors considered in this feasibility study were the following: (1) anticipated constructability of various program components; (2) site access issues during construction and operations; and (3) utility, land use, and potential community impacts. At this initial feasibility level, no fatal flaws would prevent the factors above from being addressed, and consequently the construction of the conveyance system is considered likely to be feasible.

During the program's next phase, opportunities to reduce, mitigate, or eliminate construction or schedule impacts would be further investigated. Such work would include conducting a more thorough evaluation of the use of public and private ROWs, as well as a more thorough evaluation of the potential to repurpose existing Metropolitan pipelines to carry purified water from this program to various groundwater basins. Both alternatives hold the potential to reduce construction impacts and to shorten overall conveyance system construction durations. Close and consistent coordination and engagement with all local communities affected by the conveyance system construction will be required in all of the program's later phases.

Groundwater Basins, Storage, and Extraction

Finding: *Based on modeling and other analyses conducted for this report by both Metropolitan and groundwater basin managers, the groundwater basins were determined to be capable of using up to 150 mgd of purified water for groundwater recharge on a near-continuous basis, which is considered feasible.*

As configured in the base case scenario, the system would deliver and recharge up to 150 mgd for approximately 85 percent of the time on an annual basis. For the remainder of the time, the basins would accept at least 110 mgd of purified water. These assumptions are based on the following: (1) recent (2016) groundwater modeling that was conducted specifically for this feasibility report; (2) consultations with member agencies and groundwater basin managers that indicate a need and willingness to acquire water for recharge in quantities to support the program; (3) the assumption that the program would not acquire additional land for new spreading basins; and (4) injection wells would be used for replenishment purposes in some basins. Flexible delivery quantities to four groundwater basins would allow the overall system to continuously operate at or near an average annual production rate of 147 mgd, delivering all of this production for groundwater recharge. The base case scenario assumes that up to 150 mgd of production output from the AWT facility, with flexible water deliveries when needed, would be allocated among the four groundwater basins as follows:

- West Coast Groundwater Basin: 0–15 mgd (0–17 TAFY)
- Central Groundwater Basin: 0–15 mgd (0–17 TAFY)
- Main San Gabriel Basin: 62–77 mgd (70–85 TAFY)
- Orange County Groundwater Basin: 18–58 mgd (20–65 TAFY)

Metropolitan must work with the groundwater management agencies for each basin, as well as with the Los Angeles County Department of Public Works to infiltrate and store the water in the basins. The operation of the groundwater basins involved in the potential program is complex and a variety of issues could arise, although none of these issues are viewed as fatal flaws to the overall program. Potential risks for the future success of the base case include environmental, groundwater, legal, or logistical issues with delivering water to the groundwater basins.

With respect to groundwater quality, this report did not analyze the effects that the project may have on existing groundwater contamination plumes or groundwater remediation operable treatment units. The issue of groundwater quality would have the highest risk of potential impact to the project in the Main San Gabriel Basin. There is also a risk of water quality incompatibility between the delivered water and local groundwater, particularly in injection wells and/or recharge areas that have not recharged recycled water in the past. Impacts of incompatible water include biofouling, clogging, reduced injection and/or spreading rates, and aquifer leaching. All these risks appear to be manageable and do not represent insurmountable barriers to program implementation.

11.3 Environmental and Regulatory Feasibility

Finding: *The evaluation of regulatory and environmental permitting requirements for the potential RRWP elements did not reveal any challenges that would preempt or prevent approvals and permits needed from authorized regulatory agencies and thus the potential project is considered feasible in this regard.*

Several IPR projects have been successfully implemented in Southern California using surface spreading and subsurface injection. In some groundwater basins, this has been going on for decades and significant experience has been developed in assessing the public health impacts. In 2014, the DDW finalized its Groundwater Replenishment Regulations, which provide direct guidance regarding IPR projects for the protection of public health. Thus, the regulatory basis and framework, as well as precedent-setting models such as Orange County's GWRS, have been established for IPR groundwater replenishment projects. These factors make the reuse of JWPCP effluent a viable option from a regulatory perspective.

Implementing a groundwater recharge project will require close coordination with both the DDW and the RWQCBs. Metropolitan is initially proceeding with a demonstration facility, in partnership with the Sanitation Districts, to provide information necessary for regulatory approval of the program. The demonstration plant will validate the ability of the AWT facility to reliably produce advanced treated water that meets all regulatory requirements and ensures long-term protection of the groundwater basins proposed for the full-scale program. Completion of the Title 22 Engineering Report will be a major milestone to be met following conclusion of the demonstration testing and is a prerequisite of the water recycling permit ultimately issued by the RWQCBs. The permits issued are anticipated to be groundwater basin-specific. However, this will be further discussed with regulating authorities as the program proceeds. Metropolitan's partnership and close collaboration with the Sanitation Districts, regulators, groundwater basin managers, and end-users throughout the program's development would help to ensure the program's success in meeting all applicable regulations and protecting public health.

Implementation of the program will require environmental review under CEQA and NEPA, and possibly will require permitting under the Clean Water Act, California Fish and Game Code, and/or state and federal Endangered Species Acts. Metropolitan will coordinate with federal and state agencies during the environmental review process to ensure that the documents support any permits, approvals, or other actions from the California Department of Fish and Wildlife, United States Fish and Wildlife Service, California RWQCBs, and United States Army Corps of Engineers.

11.4 Feasibility of Essential Institutional Arrangements

Sanitation Districts

***Finding**: Based on the existing framework and ongoing collaboration with the Sanitation Districts on the demonstration facility and this feasibility study, the finalization, execution, and approval of agreements needed to proceed with the full-scale program are considered to be feasible.*

Throughout the program's development, the Sanitation Districts and Metropolitan have collaborated successfully on all program aspects and are proceeding to develop potential terms and conditions for a full-scale program consistent with the framework and the agreement approved and executed by the two agencies. Accomplishments to date include a pilot program, framework agreement, land lease, nitrogen management studies, and source control investigations. Metropolitan and the Sanitation Districts will work closely together on the construction and operations of the demonstration facility during the next several years.

Member Agencies, Groundwater Managers, and Los Angeles County Department of Public Works

***Finding:** Based on supporting documentation and direct discussions, development of the institutional arrangements needed for the delivery, storage, and extraction of RRWP water in groundwater basins on a near-continuous basis is considered to have no apparent fatal flaws.*

The potential program's overall ability to achieve regional benefits and meet the unit cost estimates in this report depends on the willingness of agencies to make appropriate arrangements for the delivery, storage, and extraction of delivered water produced by the RRWP. These arrangements could take many forms such as operational programs and adopted rates, contract commitments, project-specific partnerships, or other appropriate instruments. Preliminary discussions with primary parties needed to accomplish this requirement did not identify any insurmountable technical, legal, or institutional barriers. Establishing these arrangements is a necessary prerequisite to project implementation.

11.5 Economic Feasibility

Regional Benefits and Consistency with IRP

Finding: *The ability of the program to create significant regional benefits that are consistent with the projections and targets established in Metropolitan's 2015 IRP Update is considered to be feasible.*

Analysis of the base case scenario demonstrated specific regional benefits that would result from its implementation. The increase in regional groundwater basin storage levels provides the primary regional reliability benefit for all Southern California. Increased storage levels mean more reliability for all agencies in dry years. Increased storage levels also mean a reduction in the frequency and severity of Metropolitan water supply allocations, which have historically been tied to maintaining sufficient storage reserve levels. The program would help to ensure higher and more sustainable groundwater basin levels, minimizing the risk of reduced groundwater pumping in dry years. Such robust groundwater basin levels increase the likelihood of local agencies maintaining and potentially increasing stable groundwater pumping for meeting regional demands.

Another potential regional benefit resulting from the program is the impact on regional emergency storage reserves. The RRWP would positively affect the region's emergency storage preparedness in two ways. First, through the regular and continuous annual groundwater replenishment that the program provides, groundwater basins are more likely to be in a stable and sustainable condition on an ongoing basis. This means that groundwater, which is assumed to constitute most of the in-region local supplies available during an emergency outage of imported supplies, will more likely be able to continue at full production. Second, by providing a new supply source, total regional storage reserves would be higher than if the program was not in place. Higher total storage reserves provide an additional buffer of storage supplies on top of emergency storage reserves, and thus extend the length of time that the region can withstand an emergency outage of imported supplies.

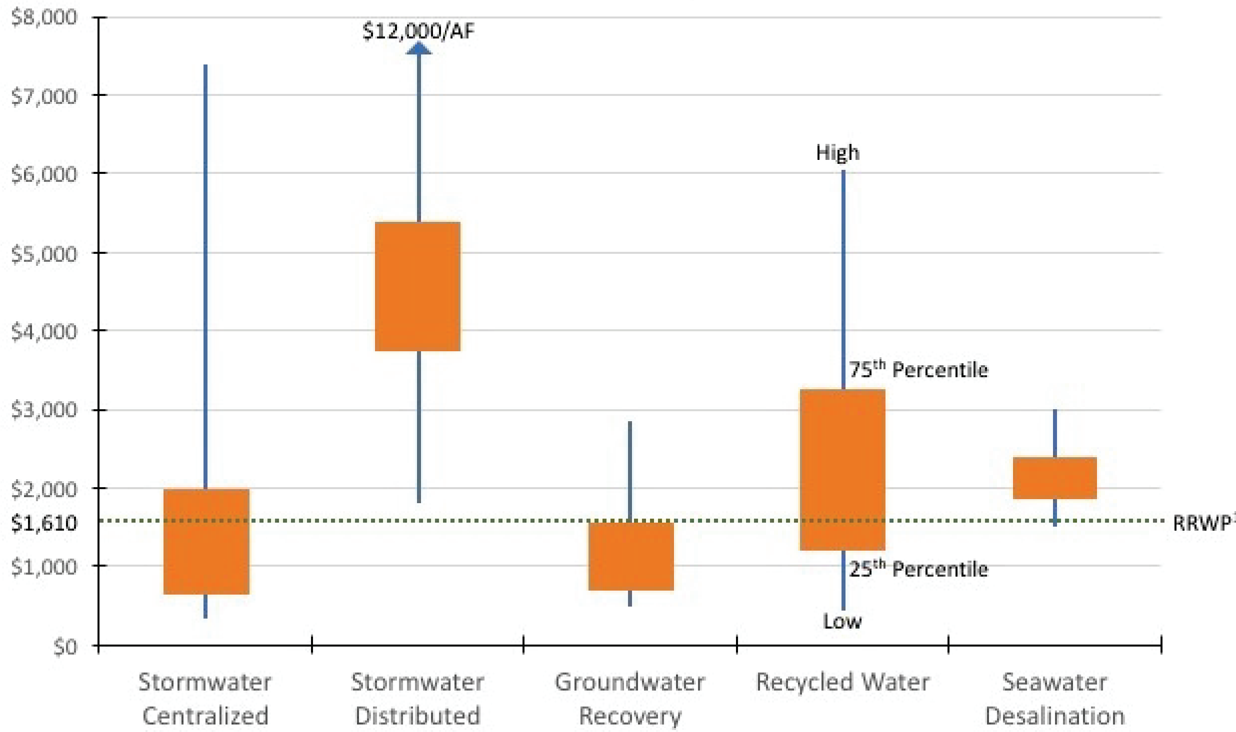
Additional benefits include but are not limited to the following: economies of scale; reduction in demands for imported water supplies, which decrease the burden on the Metropolitan's infrastructure and reduce system costs as well as free up conveyance capacity to the benefit of all system users; consistency with legislative mandate to Metropolitan to expand water recycling and groundwater storage and replenishment measures; improved water quality in the groundwater basins; and reduced vulnerability to climate change and environmental impacts.

Overall Estimated Program Costs

Finding: *The overall unit costs of the program (estimated to be approximately $1,610 per AF) fall within the projected future resource development costs for recycled water facilities developed in the 2015 IRP and are considered to be feasible.*

As indicated in Figure 11.1, the estimated unit costs for RRWP water delivered to groundwater basins fall within forecasted values for recycled water facilities shown in Metropolitan's 2015 IRP Update.

Figure 11.1: Future Resource Development Unit Costs ($/AF)



Source: Integrated Water Resources Plan 2015 Update

[1] Estimated unit cost is based on 4% interest rate financing and does not include additional outside funding or optimized design.

11.6 Public Acceptability

Finding: *If a robust outreach effort is implemented in conjunction with the RRWP, gaining public acceptance of a new purified water supply for replenishing groundwater basins, completing conveyance system construction, and addressing concerns of the communities near the JWPCP are considered to be feasible.*

Although considerable progress has been made in public awareness and acceptance of recycled water, there could be different perspectives on the RRWP within each basin. A robust outreach effort – planned and implemented in coordination with the member agencies, Sanitation Districts, basin managers, and basin agencies – is needed to address these perspectives. Outreach needs and strategies will differ among the four basins due to varying experience with potable reuse, cultures, and perspectives on environmental justice. Several AWT projects serve as examples of successful outreach in the four basins: the GWRS for the Orange County Basin; the Edward C. Little Water Recycling Facility for the West Coast Groundwater Barrier; the Leo J. Vander Lans Advanced Water Treatment Facility for the Alamitos Barrier; the Terminal Island Water Reclamation Plant Advanced Water Purification Facility for the Central Basin; and the Groundwater Reliability Improvement Program for the Central Basin. In the Main San Gabriel Basin, recycled water has so far not been used for recharge. Some projects in California have experienced public opposition for a variety of reasons and have not moved forward. The program may raise questions regarding the need for and public safety of introducing a new supply into the groundwater basin. Such concerns may originate from the amount of purified water that will be added to their local groundwater, or prior experiences with other environmental issues that have affected their local community. Metropolitan and the agencies involved with outreach need to learn from the extensive experience in the region and prepare for these types of issues by developing a coordinated, comprehensive, and strategic communication program that addresses the new water supply, construction, and increased operations at the JWPCP. The Sanitation Districts provide ongoing outreach to the businesses and residential communities near the JWPCP. Metropolitan would participate in this outreach to address concerns regarding the AWT facility.

11.7 Recommendations for Next Steps

The following recommendations regarding next steps are submitted for consideration, should the Metropolitan board accept the determination of this study that the potential 150-mgd RRWP is feasible and warrants further investigation. These efforts would be implemented over approximately the next 18 months.

1. **Construct and operate the demonstration facility:** The 0.5-mgd demonstration plant will provide critical information for multiple aspects of the full-scale program, including optimizing and refining the treatment processes, providing critical design criteria, refining capital and O&M costs, and providing a platform to secure regulatory approval for the overall treatment process. The planned work at the demonstration facility should occur prior to the commencement of final design of the full-scale AWT facility. Design of the demonstration facility will be completed by December 2016, and staff plans to bring a recommendation for the award of a construction contract to the Metropolitan board early in 2017. It is expected that operation of the demonstration plant will provide critical design information and regulatory approvals related to the proposed treatment processes needed for a full-scale project.

2. **Conduct facility planning/engineering to refine treatment, conveyance, and groundwater basin concepts**: Engineering work to date has consisted solely of investigations and analyses required to determine the feasibility of implementing the treatment and conveyance facilities required for the program. As mentioned above, the feasibility investigations have identified several potential opportunities to reduce the implementation schedule and/or reduce overall program costs, including a potential opportunity to repurpose all or portions of the Second Lower Feeder into a conveyance pipeline for the RRWP. Additional engineering efforts are now required to select specific project configurations and alignments, and to optimize program components by potentially taking advantage of these program opportunities. Staff should conduct facility planning and engineering efforts to accomplish these objectives. Also, additional groundwater modeling investigations focused on water quality issues and potential groundwater-level changes are needed to further facilities and operations planning within the groundwater basins.

3. **Develop agreements with the Sanitation Districts:** The Metropolitan board approved initial term sheets for both the demonstration facility and a potential full-scale recycled water program with the Sanitation Districts in November 2015. For the full-scale project, the initial set of terms and conditions were non-binding, however, they set forth key conditions anticipated to be in a future full-scale agreement. Building on these initial terms and subsequent discussions with the Sanitation Districts in 2016, staff should prepare for board approval a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale AWT project at the JWPCP site.

4. **Develop institutional and financial arrangements for the management and operations of the program:** The operations and management of the program would require a high degree of cooperation among Metropolitan, its member agencies, groundwater basin managers, and other affected parties to ensure the seamless integration of purified water to be stored in groundwater basins. The form and specific nature of these arrangements should be finalized before proceeding to the full-scale project. Metropolitan's IRP 2015 Update and related Metropolitan board discussions regarding the RRWP implementation, combined with concurrent discussions among potential program participants, will inform the development of such arrangements. These processes are expected to conclude with Metropolitan board direction and approval prior to moving forward, in order to ensure a viable and successful program.

5. **Develop the outreach plan for the demonstration facility:** The demonstration facility is a core element of the outreach effort to gain public acceptance of a new water supply for the region. It is designed to facilitate public presentations and tours, and provide a means to share information about the RRWP. To effectively use this facility for outreach, it will need a project identity, informational materials, signage, and other elements to enhance the visitor experience. The strategies and tools would be part of a comprehensive outreach plan for the demonstration facility that is developed in collaboration with the Sanitation Districts, member agencies, retail agencies, and basin managers. The outreach plan for the demonstration facility would create the foundation for future outreach for the full-scale program, should the RRWP move forward.

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Acronyms and Abbreviations

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ACRONYMS AND ABBREVIATIONS

AACE	American Association of Cost Engineers
AF	acre-feet
AFY	acre-feet per year
AGR	agricultural supply
AOP	advanced oxidation process
ASR	aquifer storage and recovery
AWT	advanced water treatment
BAF	biologically aerated filtration
BEA	Basin Equity Assessment
BIM	building information model
BOD	biochemical oxygen demand
BPP	Basin Pumping Percentage
$CaCl_2$	calcium chloride
$Ca(OH)_2$	lime
CCR	California Code of Regulations
CEC	constituent of emerging concern
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
CIP	clean in place
CM	construction management
CNDDB	California Natural Diversity Database
COD	chemical oxygen demand
CRA	Colorado River Aqueduct
CT	contact time
CWC	California Water Code
CWSRF	Clean Water State Revolving Fund
DDW	California Division of Drinking Water
DPR	direct potable reuse
DWR	Department of Water Resources
DWSRF	Drinking Water State Revolving Fund
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
FAAST	Financial Assistance Application Submittal Tool
FAT	full advanced treatment
fbgs	feet below ground surface
FORCO	Fletcher Oil and Refinery Company
fps	feet per second
FY	fiscal year
GIS	geographic information system
GPCD	gallons per capita per day
gpm	gallons per minute
GRIP	Groundwater Reliability Improvement Program
GWRS	Groundwater Replenishment System
HP	horsepower
HVAC	heating, ventilation, and air conditioning
IND	industrial service supply
IPR	indirect potable reuse
IRP	Integrated Water Resources Plan or Integrated Resources Plan

IRPSIM	Integrated Resources Planning Simulation Model
IRWM	Integrated Regional Water Management
JOS	Joint Outfall System
JWPCP	Joint Water Pollution Control Plant
kWhr	kilowatt hour
L	liter
LACDPW	County of Los Angeles Department of Public Works
LPHO	low pressure high output
LSI	Langelier Saturation Index
MAF	million acre-feet
MBR	membrane bioreactor
MCC	motor control center
MCL	Maximum Contaminant Level
Metropolitan	Metropolitan Water District of Southern California
MF	membrane filtration
MF/UF	microfiltration/ultrafiltration
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
mL	milliliter
MPHO	medium pressure high output
MRWPCA	Monterey Regional Water Pollution Control Agency
msl	mean sea level
MTBE	methyl tert-butyl ether
MUN	municipal and domestic water supply
MW	megawatt
MWD	Municipal Water District; Metropolitan Water District of Southern California
MWDOC	Municipal Water District of Orange County
$NaHSO_3$	sodium bisulfite
NaOCl	sodium hypochlorite
NaOH	sodium hydroxide
NDEA	nitrosodiethylamine
NDMA	nitrosodimethylamine
NDPA	nitrosodipropylamine
NEPA	National Environmental Policy Act
ng/L	nanograms per liter
NL	Notification Level
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity unit
O&M	operations and maintenance
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
OPCC	Opinion of Probable Construction Cost
PAYGO	pay-as-you-go funding
pCi/L	picocuries per liter
PEIR	Programmatic Environmental Impact Report
PEIS	Programmatic Environmental Impact Statement
PM	project management
PRC	California Public Resources Code
PROC	industrial process supply
PRP	potentially responsible party

PS	pump station
RA	Replenishment Assessment
RAS	return-activated sludge
RFP	Request for Proposals
RFQ	Request for Qualifications
RO	reverse osmosis
ROW	right-of-way
ROWD	Report of Waste Discharge
RRWP	Regional Recycled Water Program or program
RWC	Recycled Municipal Wastewater Contribution
RWQCB	Regional Water Quality Control Board
SAT	soil aquifer treatment
SCADA	supervisory control and data acquisition
SCE	Southern California Edison
SCVWD	Santa Clara Valley Water District
SDCWA	San Diego County Water Authority
SGVMWD	San Gabriel Valley Municipal Water District
SLF	Second Lower Feeder
SNMP	Salt and Nutrient Management Plan
SRF	State Revolving Fund
SRT	solids retention time
SWRCB	State Water Resources Control Board
SWP	State Water Project
TAFY	thousand acre-feet per year
TDS	total dissolved solids
TIFIA	Transportation Infrastructure Finance and Innovation Act
TIN	total inorganic nitrogen
Title XVI	Title XVI Water Reclamation and Reuse Program
TKN	total Kjeldahl nitrogen
TN	total nitrogen
TOC	total organic carbon
UF	ultrafiltration
UPS	uninterruptible power supply
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UV	ultraviolet
UV/AOP	ultraviolet/advanced oxidation process
VFD	variable frequency drive
VOC	volatile organic compound
WBMWD	West Basin Municipal Water District
WDR	waste discharge requirement
WIFIA	Water Infrastructure Finance and Innovation Act
WRD	Water Replenishment District; Water Replenishment District of Southern California
WRFP	Water Recycling Funding Program
WRP	water reclamation plant
WRR	water reclamation requirement
WRRDA	Water Resources Reform and Development Act
WRRF	Water Reuse Research Foundation

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APPENDIX A:

Reports from Advisory Panel Workshops

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THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

SANITATION DISTRICTS OF LOS ANGELES COUNTY

Advisory Panel

for the

Potential Regional Recycled Water Supply Program

Report No. 1: Demonstration Plant Design

June 30, 2016

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I. Executive Summary

The Metropolitan Water District of Southern California (Metropolitan) and the Sanitation Districts of Los Angeles County (Sanitation Districts) are considering development of a large-scale regional indirect potable reuse program for groundwater recharge in several groundwater basins. The potential Regional Recycled Water Supply Program (Program) would begin with a proposed 1 million gallon per day (mgd) advanced water treatment demonstration plant to be located at the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson. In early 2016, Metropolitan and the Sanitation Districts convened a panel of eight key subject matter experts to provide independent review and critical input on the scope and direction of the Program during its demonstration project phase. In this initial effort, the Panel will provide input into the development of the Program's feasibility and financial assessments, as well as the design of the demonstration plant. The Advisory Panel plans to meet periodically in a workshop format to provide input on overall program feasibility and work plans; design of the demonstration plant; groundwater basins and water delivery assessments; and ideas and approaches to program implementation.

At the first workshop on March 31 and April 1, 2016, the Advisory Panel reviewed the overall program and engaged the Project Technical Team in an in-depth discussion of the demonstration plant design. The Project Technical Team consists of Metropolitan staff, Sanitation Districts staff, and consultant staff. After the team presentation, the Panel met independently to consider the proposed treatment processes and related issues regarding nitrogen and boron management as well as the procurement process and selection of demonstration unit processes.

On the second day of the workshop, the Advisory Panel presented their recommendations and comments to the Project Technical Team. The Panel also raised other issues and ideas that need to be explored for full scale treatment plant design, maximizing recycled water use, public outreach, operator training, financing and institutional framework, which will be presented in future panel reports when those topics are covered. This report summarizes the first workshop and the Advisory Panel's guidance to the team on design of the demonstration plant. Future workshops are planned for the Advisory Panel to consider other elements of the Program.

II. Advisory Panel Members

The eight-member panel includes the following experts in advanced water treatment and recycled water programs:

- Richard Atwater, Co-Chair: Former Executive Director of Southern California Water Committee; expert on recycled water programs.
- Margie Nellor, Co-Chair: Nellor Environmental Associates, Inc.; expert on recycled water reuse programs, pretreatment and related regulatory issues.
- Shivaji Deshmukh: Assistant General Manager of West Basin Municipal Water District; expert on recycled water engineering and operation of advanced water treatment facilities.
- Thomas Harder: Thomas Harder and Associates (Hydrogeology); expert on Southern California's groundwater basins.

- David Jenkins: Professor Emeritus, University of California, Berkeley; expert on biological wastewater treatment processes, and water and wastewater chemistry.
- Edward Means: President, Means Consulting LLC; expert on water quality and water resources management.
- Joseph Reichenberger: Professor, Loyola Marymount University; expert on water, wastewater and recycled water systems and treatment.
- Paul Westerhoff: Professor, Arizona State University; expert on advanced water treatment processes.

III. Methodology

The Panel will meet periodically in a workshop format to review and discuss selected topics for the Program including:

- Overall program feasibility and work plans,
- Design of the demonstration plant,
- Groundwater basins and water delivery assessments, and
- Ideas and approaches to program implementation.

Prior to each workshop, the Panel will be provided resource material and a series of questions from the Project Technical Team to allow the panelists to prepare for the issues to be raised. After a morning briefing and facilitated discussion with the team, the Panel will work independently of the team to discuss the issues and develop recommendations. Upon completion of their discussions, the Panel will provide an "out-briefing" to the team and respond to clarifying questions regarding the Panel's comments and recommendations. The Panel will then prepare a report to Metropolitan and the Sanitation Districts documenting the issues discussed, recommendations, alternatives and other issues to be considered. The Panelists may not always reach consensus on the recommendations but will agree on the contents of each report. The Project Technical Team will consider the input received and provide written responses to the recommendations as appropriate.

IV. Workshop on Demonstration Plant Design

The Advisory Panel met on March 31 and April 1, 2016 to review the Potential Regional Recycled Water Supply Program proposed jointly by Metropolitan and the Sanitation Districts. The focus of this first workshop, held at Metropolitan's Headquarters, was the design of the demonstration plant. In addition to the Panel, the following members of the districts' management and Project Technical Team participated:

Paul Brown	Program Manager, Metropolitan
Michael Thomas	Facilitator, Metropolitan

Metropolitan: Debra Man, Gordon Johnson, John Bednarski, Gloria Lai-Blüml, Kimberly Wilson, Evelyn Ramos, Sun Liang (by phone), Carolyn Schaffer

Sanitation Districts: Grace Hyde, Robert Ferrante, Dave Snyder, Nikos Melitas, Rob Morton, Michael Liu, Martha Tremblay, Shannon Bishop, Phil Friess

Consulting Design Team: James Borchardt, Eric Mills, Zakir Hirani, Bill Vogel, Shane Trussell, Adam Zacheis, Debbie Burris, Michael Adelman

a. Project Understanding

The Advisory Panel understands that the proposed Program would involve the development of a large-scale (up to 150 mgd) regional indirect potable reuse program. The product water would be used for groundwater recharge in several groundwater basins that are managed through different institutional agreements and are subject to different regulatory requirements. The Program will need to:

- Identify locations to deliver an uninterrupted flow of product water at the flow rate supplied by the full scale treatment plant,
- Satisfy the public that the treated water is safe to use,
- Produce and deliver water that complies with all applicable regulations,
- Produce water that provides the reliability needs of customers and is at a cost that is marketable and competitive with other sources.

The Program would begin with a proposed 1 mgd advanced water treatment demonstration plant to be located at the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson. The demonstration plant would be used to test the effectiveness of various advanced water treatment processes.

b. Preparation for the Workshop

To prepare for the workshop the Advisory Panel reviewed the following documents:

- Potential Regional Recycled Water Supply Program, Historical Review and 2015 Update, Working Draft, Version 1.7,Metropolitan Water District.
- Proposal Design and Operation of Demonstration Plant for Potential Regional Recycled Water Supply Program, RFP-1116, December 2015, MWH.
- Metropolitan Board Authorization for $15 million, Potential Regional Recycled Water Supply Program, Agenda Item 8-3, 11/15/2015.
- PowerPoint Presentation to Metropolitan Board of Directors Potential Regional Recycled Water Supply Program, Supporting Agenda Item 8-3, 11/9/2015.
- Pilot Study of Advanced Treatment Processes to Recycle JWPCP Secondary Effluent – Final Report, Metropolitan and Sanitation Districts, September 28, 2012, including Appendices A – JWPCP Process Descriptions and Water Quality Data; Appendix B –Pilot Study Design Criteria, Operational Information, and Water Quality Data; Appendix C –Title 22+ Sampling Data; Appendix D -- JWPCP Background and NdN.
- Request for proposal, RFP-PL-1116, Design and Operation of Demonstration Facility for Potential Regional Recycled Water Supply Program, Metropolitan, including Attachments A through F.

The Panel was also provided a series of questions in advance of the meeting regarding design of the demonstration plant including:

1. Given the multiple uses expected for the demonstration plant (including process validation and optimization, vendor equipment testing, operator training, and public outreach), what are the most

important design considerations that should be addressed? Specific considerations should consider the following:

- What is the most effective approach for integrating the technical and regulatory-related elements of the design?
- What accommodations are needed to provide flexibility for various equipment vendor products?
- What is the Panels' experience regarding prequalification of equipment for testing?
- What features are needed to maximize the operator training objectives of the facility?
- What features are needed to maximize public outreach and educational aspects of the facility?

2. What specific design considerations should be included to increase the demonstration plant's value for process validation and optimization?
   - Are two complete parallel trains required? Can the trains be limited to test alternatives for biological treatment and microfiltration/ultrafiltration (MF/UF)?
   - Will the current approach evaluating various biological nitrification/denitrification (NdN) alternatives and ion exchange (IX) be sufficient to select the best overall strategy for nitrogen management?
   - Are the appropriate treatment processes being considered in the current design of the demonstration plant given the processes that are currently being utilized at the JWPCP?
   - Are there other concerns with the secondary effluent that should be addressed through the demonstration plant or process changes at the JWPCP?
   - Is the demonstration plant being configured appropriately to investigate the issue of log removal credit by various treatment processes in order to achieve regulatory approval?
   - Can the demonstration plant waste streams and brine discharges be used to evaluate full-scale impacts on JWPCP processes, secondary effluent quality, and brine management regulatory challenges?
   - How many equipment vendors or treatment processes should the demonstration plant be designed to evaluate?
   - What unit processes should be prequalified during operation of the demonstration plant?
   - Should the demonstration plant unit processes be selected based on their scalability to 150 mgd, especially the biological process?
   - Will the current approach comparing IX and reverse osmosis (RO), pH management be sufficient to select the best overall strategy for boron management?
   - What operational criteria should be considered in equipment evaluations?
   - Which existing demonstration projects implemented by other agencies serve as good examples for the proposed project?
   - How should make-up and variability of influent (JWPCP secondary effluent) to the demonstration plant be monitored and evaluated?
3. What considerations or design features should be incorporated in the demonstration plant in order to evaluate the benefits and cost-effectiveness of possible modifications at the JWPCP?
   - How can the demonstration plant be used to evaluate potential changes at JWPCP?

- Can alterations be made to the JWPCP to provide better quality feed water for the demonstration plant?
- Would additional source control be cost-effective in improving feed water quality?
- What are the best practices for integration of wastewater treatment and advanced water treatment facilities under the operation of the two agencies?
- How should training at the demonstration plant be developed to encourage cooperation, collaboration, and teamwork?

c. Background Presentation by Project Technical Team

To begin the workshop the Project Technical Team presented the proposed process train selection for the demonstration plant and the background behind that selection. Items of discussion included:

1. <u>Groundwater Quality Objectives:</u> Staff presented the groundwater quality objectives for the various groundwater basins where the recycled water potentially could be used for groundwater replenishment. Notwithstanding the Title 22 Criteria for groundwater replenishment, the boron objective of 0.5 milligrams/Liter (mg/L) in the Main San Gabriel Basin and the nitrate objective of 3.4 mg/L in the Orange County Basin may set the water quality requirements for the product water of a full-scale project. These would impact the selection of the treatment train.

2. <u>Secondary Effluent Water Quality:</u> Secondary effluent water quality at the JWPCP was compared to the secondary effluent water quality at the City of Los Angeles Hyperion Water Reclamation Plant (Hyperion) and Orange County Sanitation District (OCSD) Plant 1. Both Hyperion and OCSD facilities provide secondary effluent used as feed water for advanced treatment facilities that produce product water used for indirect potable reuse projects (groundwater replenishment via surface and subsurface application). Secondary effluent from Hyperion is feed water to the West Basin Municipal Water District's Edward C. Little Water Recycling Facility (ECLWRF) and is used for the West Coast Basin Seawater Intrusion Barrier. Secondary effluent from OCSD's Plant 1 is used as feed water to the Orange County Water District's (OCWD) Groundwater Replenishment System (GWRS).

3. <u>Nitrogen Removal:</u> The Sanitation Districts research team has considered three approaches to nitrogen removal based on literature review, process modeling, and some pilot testing:
   - Retrofit of the JWPCP activated sludge process – biological nitrogen reduction using either membrane bioreactor (MBR) or integrated fixed film activated sludge (IFAS).
   - Adding a tertiary process for nitrification and possibly denitrification – tertiary MBR (tMBR) or tertiary biological active filter (tBAF).
   - Side stream nitrification or deammonification treatment of ammonia-rich biosolids centrate.

   The Sanitation Districts nitrogen removal findings are as follows:
   - An activated sludge retrofit of the JWPCP would require significant operational changes.
   - Pilot testing of tBAF at JWPCP has been successful. The effect of tBAF on downstream membrane performance requires further study.
   - Pilot testing of side stream treatment of centrate demonstrated ammonia removal and robust operation. Side stream treatment may also provide bioaugmentation benefits to inducing nitrification in the main stream.

The mass balance calculations prepared by the design team suggest that nitrification alone on main stream or with 25% NdN on side stream treatment will not be enough to meet the lowest basin water quality objective for nitrogen in advanced treated product water, given typical nitrogen loadings and RO rejection.

4. Source Control Overview: The Sanitation Districts source control program has been approved by the U.S Environmental Protection Agency (USEPA) and is administered under a Wastewater Ordinance that includes permitting, monitoring, inspection, enforcement, and outreach. The program regulates 2,100 industries.

   The historical approach to management of the Sanitation Districts Joint Outfall System (consisting of six upstream water reclamation plants (WRPs) and the JWPCP) is to route higher salt and organic strength flows around the upstream WRPs for treatment at the JWPCP. This industrial contribution makes up about 19% of the JWPCP's influent dry weather flow.

5. Constituents of Concern: Constituents of concern identified in the pilot study that need further consideration for the demonstration plant include:
   - Boron – thought to be contributed from oil well fields
   - Nitrosamines – thought to be contributed as disinfection by-products (DBPs) or by industrial dischargers such as metal finishers
   - 1,4-dioxane – thought to be contributed via disposal of consumer products and by discharge from membrane manufacturers

   The Source Control Program will continue investigating sources of these constituents.

6. Pathogen Log Reduction: The requirements for log removals of virus, *Giardia*, and *Cryptosporidium* are 12/10/10 respectively based on the Title 22 Criteria pathogen log reduction requirements for groundwater replenishment. These requirements must be met by surface and subsurface application projects using at least three treatment processes. Full advanced treatment (FAT) facilities, as defined in the Title 22 Criteria must include (1) RO that meets sodium chloride rejection and TOC performance requirements and (2) advanced oxidation process (AOP) that meets either indicator compound or 1,4-dioxane performance requirements. The two AWT facilities, OCWD's GWRS and West Basin's ECLWRF, have been approved by the Division of Drinking Water (DDW) under the 2014 Title 22 Criteria and achieve greater log reduction.

7. Proposed Treatment Process: The proposed design being considered for the demonstration plant includes two parallel process trains, each with a capacity of 0.5 mgd:
   - Train #1: MBR tertiary treatment for nitrification and denitrification, followed by MF/UF, RO, AOP, and product water chemical stabilization. Side stream IX was proposed to remove additional nitrogen and boron.
   - Train #2: Similar to Train #1 except an alternative biological nitrification and denitrification system was proposed (e.g. tBAF) in place of MBR.

   The Project Technical Team is exploring options for virus removal that have not yet been approved by DDW. These options raise the following questions:

- When using MBR treatment is MF/UF required before RO? Log removals were estimated by the Design Team to be 14/10/10 with only MBR treatment prior to RO treatment.
- Can ultraviolet irradiation (UV) be substituted for MF/UF following MBR treatment? Log removals were estimated by the Design Team to be 14/12/12 with MBR and UV preceding RO.

Free chlorine and hydrogen peroxide will each be tested for the AOP.

There was significant discussion on the need for IX treatment for boron and nitrogen removal. In lieu of these treatment systems, could source control of significant industrial nitrogen and especially boron discharges be a more economical alternative?

The presentation by the Design Team included a discussion of data management and monitoring of critical control points.

The Design Team presented a “walk through” video of a hypothetical full scale, 150 mgd advanced treatment facility using the processes currently proposed for the demonstration plant. The facility occupies most of the land currently assigned to the water reclamation plant at the JWPCP.

It was clear from the presentation that schedule is a major driver for the Program. Design of the demonstration plant is proposed to be complete by the end of 2016; completion of demonstration plant construction and initial start-up is proposed by end of 2017.

d. Key Topics for Panel Discussion

With the information provided above as background, the Project Technical Team posed five questions to the Advisory Panel on the demonstration plant design:

1) Should UV-AOP and IX be tested on combined effluent from two trains?
2) Is the approach to nitrogen management appropriate?
3) Is the approach to boron management appropriate?
4) Is the equipment procurement strategy appropriate?
5) Should the demonstration plant unit processes be selected based on their scalability to 150 mgd?

e. Panel Discussions and Recommendations

Before addressing the specific questions on the demonstration plant design, the Advisory Panel stated the purpose of the demonstration plant is to ***demonstrate*** the treatment train on the JWPCP effluent rather than ***piloting*** new technologies. This is not a “pilot plant,” it is a “demonstration plant.” The Metropolitan Board direction in their approval letter of 11/10/2015 was that the “*demonstration project would serve as a proof of concept and would provide critical information needed for implementation of the potential regional recycled water supply program*.” The goal of the demonstration plant is to confirm source water quality; confirm treatment processes for regulatory approval and suitability for groundwater replenishment; and confirm quality of brine and waste streams. Where possible, the demonstration plant should focus on optimization of proven processes. Defining the critical control points is an important goal at demonstration scale. The Panel emphasized that although schedule is an important driver for the project, it should not be allowed to compromise the ability to garner critical data to secure public and regulatory acceptance.

The Project Technical Team must establish quantitative water quality targets entering and leaving the demonstration plant, recognizing that current requirements and treatment technologies will evolve over time. Direct potable reuse may be in the not-too-distant future and this should be considered in the layout and design of the demonstration plant. Above all, the entire Program is "customer driven." There must be a market for the product water and having a showcase demonstration project will assist in gaining and maintaining public acceptance.

The approach to some of the key questions, such as nitrogen management and boron removal, would best be implemented using a pilot study approach, (e.g., bench scale or small scale) rather than a "demonstration" approach. The Advisory Panel suggested that there could be, for example, one "demonstration" treatment train and one "exploratory" train for pilot-scale studies.

In the design of the demonstration plant, consideration should be made to provide connections for future, small-scale side stream treatment of alternative technologies. The Advisory Panel noted that piloting of alternative technologies could be done once the full scale facility was in operation.

The Advisory Panel strongly emphasized the value of a public outreach program as part of the overall Program, including the development of the demonstration plant and its operation. The Demonstration Plant is to be a showcase to build support from local agencies, regulators, political leaders and the general public. In that light, it must be odor free and noise free. All of its potentially odorous and noisy components should have sound attenuating enclosures and should not be located where the public has access to them. The Panel recommended that the demonstration plant continue to be available after the full scale plant is on-line for tours and testing alternative technologies in the future.

1. Testing UV-AOP and IX on combined effluent from two trains

The Advisory Panel does not recommend this. Combining the effluent produces an "artificial" water quality resulting in demonstrating something that will never exist. The AOP needs to be tested separately with water pretreated by the MBR-MF-RO or the BAF-MF-RO (if selected), because the water qualities from these pretreatment processes will be different.

The Advisory Panel recommendation is to use two 0.5 mgd UV-AOP systems, one for each train. If the budget cannot accommodate the parallel UV-AOP trains, then a single 0.5-mgd system would be satisfactory. In the latter case, it should be plumbed so that it could take effluent from one train or the other separately, and the balance of flow would bypass the AOP.

The Advisory Panel recommends small, side stream IX columns be plumbed to either treatment train.

In addition, bench-scale testing or small flow rates could be used to test the chemistry of post-stabilization and post-chlorination.

2. Approach to nitrogen management

Advanced treatment of the existing non-nitrified JWPCP secondary effluent, which would involve ammonia removal by RO, may not be desirable. West Basin's ECLWRF has had operational challenges with this approach; low flux rates and/or more frequent cleaning of the MF and RO systems were required. Direct treatment of non-nitrified secondary effluent also has other disadvantages. The Sanitation Districts' pilot plant showed that higher concentrations of TOC constituents, including chemicals of emerging concern, passed through the treatment plant because the current JWPCP biological treatment operates at a low solids retention time. The Advisory Panel recommends that RO not be relied on for ammonia removal.

The Advisory Panel discussed whether it would be possible for the JWPCP to be operated in an NdN mode. Sanitation Districts' staff evaluated this.

For a demonstration plant feed consisting of non-nitrified JWPCP effluent, the Project Technical Team's proposed approach is to size either the BAF or the MBR to achieve full NdN. Both systems could be operated in "nitrify only" mode or with carbon feed for partial or full denitrification. The advantage of testing BAF versus MBR is that the BAF footprint may be smaller than that of an MBR and the BAF operating cost may be lower than for an MBR. The BAF comes with some risk since, if the carbon dosing is not optimized and carefully paced for NdN, observations at El Paso have indicated that high levels of effluent colloidal solids can be produced that can lead to accelerated MF fouling. It is imperative to avoid process trains that might not work at demonstration scale.

The BAF could be made into a "conventional filter" by turning off the carbon feed so that it is not working in "biological" mode. There are both encouraging (San Diego) and discouraging (West Basin) examples of membrane treatment following tertiary filtration.

The Advisory Panel thought it might be appropriate to do pilot-scale BAF at the JWPCP during the design phase of the demonstration project and monitor fouling and AOC/BDOC (assimilable organic carbon/ biodegradable dissolved organic carbon) downstream of the BAF pilot system. To do this the Project Technical Team should coordinate with the Sanitation Districts to first verify that BAF is viable before taking it to demonstration scale. The demonstration plant design can always be changed or a process deleted or changed in the bid documents.

If, after collecting data from operating the existing BAF, it appears that the BAF is not an acceptable alternative, there could be two MBR trains. The MBR trains could use, respectively, technologies from the two major MBR manufacturers, with the possibility of one nitrifying only and the other operating in NdN mode.

Ideally, demonstration scale should focus on optimization rather than high-level process selection. Optimizing MBR for this application can be done readily using the proposed approach.

The total nitrogen load in the JWPCP secondary effluent and ultimately to the demonstration plant would be reduced if side stream centrate nitrogen removal was added at the JWPCP. This might result in lower costs for nitrification and nitrogen removal in the demonstration plant.

3. **<u>Approach to boron management</u>**

The boron water quality objective for the groundwater basins potentially being recharged through the Program ranges from 0.5 mg/L (Main San Gabriel Basin) to 1.5 mg/L (West Coast Basin). The DDW has set a Notification Level of 1.0 mg/L for boron. A preliminary assumption was made that the boron water quality objective for the Main San Gabriel Basin would be a driver for product water quality. The water quality objective for boron was set in the early 1970s based on maintaining existing groundwater water quality (non-degradation). Boron, in the concentrations noted above, has no known human health implication. The World Health Organization has relaxed their boron guideline and the USEPA has made a determination not to regulate boron with a national primary drinking water regulation (i.e., MCL) because it is not likely to occur at levels of concern in surface and ground water systems and, as such, does not present a meaningful opportunity for health risk reduction.

It is possible for Regional Water Quality Control Boards (RWQCBs) to establish site specific water quality objectives that could be less stringent than those adopted into Basin Plans. For example, the Santa Ana RWQCB adopted an amendment to its Basin Plan that allowed for higher objectives for total dissolved solids (TDS) and nitrate to promote water recycling. To be eligible for the higher objectives (maximum benefit objectives), wastewater dischargers were required to commit to implement specific projects and programs to reduce salts and nitrogen, (such as construction of brine lines and groundwater desalters, recharge of storm water and recycled water, etc.), otherwise the original, more stringent objectives applied. The use of recycled water is a benefit to the people of the State by reducing the need for imported water.

Legally a basin objective is not necessarily a hard limit on the concentration of the product water. RWQCBs have the authority to set discharge limits at the water quality objective if they believe it is necessary to protect groundwater quality and prevent degradation. However, the State Anti-degradation Policy (SWRCB Resolution 68-16) allows a lowering of water quality if the change is consistent with maximum benefit to the people of the State and will not unreasonably affect present and anticipated uses of water (including drinking) and will not result in water quality less than prescribed in policies. In addition, permit limits for groundwater replenishment projects are set to ensure that groundwater does not contain concentrations of chemicals in amounts that adversely affect beneficial uses or degrade water quality. The RWQCBs overseeing the affected groundwater basins would have to make regulatory accommodations for boron (whether via a change in the Basin Plan objective, the permit limit established taking into consideration available assimilative capacity in the groundwater, blending with recharge sources for surface application, or blending with native groundwater).

After further consideration of source control options for boron, it may be worth having a discussion with the State Board and affected RWQCBs to discuss this matter. Boron removal is very costly. Furthermore, IX for boron removal may cause additional operational and permit challenges at the JWPCP with product and brine management and ocean discharge (salt, pH, etc.).

The Project Technical Team should confirm that the 0.5 mg/L boron concentration is a real hurdle. The team should talk to the State Board, RWQCBs, DDW (drinking water and recycling staffs), and the groundwater basin managers to set water quality targets before eliminating boron removal from the demonstration plant scope. The basin managers will need to understand the cost and financing implications of any boron decision. If there is concurrence, the Advisory Panel recommends making boron a smaller point of emphasis in the demonstration plant work and, possibly, consider eliminating it from the scope. If boron is an issue, pretreatment, point-of-discharge treatment, and/or source control should be investigated first.

There are likely much less expensive ways of doing recharge in the Main San Gabriel Basin compared to large-scale IX for boron removal at the JWPCP. This should include discussions with the RWQCBs and DDW of the use of diluent water (as defined in the regulations) to reduce the boron concentration reaching the groundwater table. If required, point of discharge IX on a smaller flow might be more cost-effective for specific basins.

Any testing of boron IX should be done at a small scale, e.g. on a side stream. This is more "pilot scale" work than "demonstration" work and it could potentially be separate from the demonstration plant scope.

4. **Equipment procurement strategy**

Ideally the time allowed for prequalification testing for wastewater treatment should be one year to account for effects of seasonal water quality variation. However this is not possible considering the project schedule.

The Project Technical Team intends to "decouple" the demonstration study phase from the full-scale vendor prequalification phase. The demonstration study phase would demonstrate a given technology for each process; when it comes to procurement for full scale, an experience clause would be used for selection of the full-scale equipment supplier. It is important to not give the impression that equipment suppliers selected for the demonstration plant will be the only suppliers considered for full-scale.

If MF/UF is upstream of RO, suppliers should be comfortable doing qualification-based procurement for RO systems. The suppliers may not be comfortable going straight from MBR to RO. The Advisory Panel recommends that an area be set aside for vendor skids, installed and operated by the suppliers for short periods of time to validate their equipment. Appropriate turnouts should be designed into the demonstration plant to facilitate this. It could be specified that every supplier who wants to bid on the full-scale facility should be required to provide a skid and to validate their equipment.

The overall strategy should be to get as many vendors as possible to bid on the demonstration project and the full-scale plant. Transparency will be very important. Any process for selecting vendors should be clear and defensible. The process of procurement should be well documented and follow Metropolitan and Sanitation Districts procedures.

OCWD experience has shown that continuity of personnel is important for procurement. Having Metropolitan and Sanitation Districts staff involved throughout the process, from demonstration plant to full-scale construction, should be a priority. The procurement strategy selected must allow all qualified suppliers to bid and Metropolitan and the Sanitation Districts must carefully vet all of suppliers that ultimately end up furnishing equipment. The Advisory Panel recommends that an integrated procurement process for both the demonstration plant and full-scale plant be developed.

5. **Selecting demonstration plant unit processes based on scalability to 150 mgd**

The Advisory Panel reviewed the proposed demonstration plant processes and determined they would generally be scalable to a 150 mgd treatment plant as shown below:

Process	Scalability
Stabilization	Readily scalable even from bench-scale
UV-AOP (ultraviolet-advanced oxidation process)	Advisory Panel is not concerned about the risk of scaling from 1-mgd units to 10-mgd or larger units. There could be hydraulic changes that may affect the relationship between equipment sizing and dose, but this responsibility should be borne by the AOP suppliers. (As an aside, the Advisory Panel believes the extra equalization tank shown in the proposed process train at the demonstration plant will not be required.)
IX (ion exchange)	Readily scalable even from very small columns
RO (reverse osmosis)	Readily scalable from demonstration scale, as long as the appropriate elements are selected
MF/UF (microfiltration/ultrafiltration)	Readily scalable from demonstration scale
MBR (membrane bioreactor)	Readily scalable from demonstration scale
BAF (biologically active filter)	Scalability from demonstration to full-scale is unclear
Anammox (anaerobic ammonium oxidation)	There is no evidence on the scalability since this process has not been used at anything approaching 60 to 150 mgd. This would be a pilot project that is not ready for inclusion in the demonstration plant. Anammox may have applicability for side stream nitrogen removal from the centrate at the JWPCP. Reducing the overall nitrogen load to the AWT facility would be beneficial.

ACRONYMS

ANAMMOX	anaerobic ammonium oxidation
AOC	assimilable organic carbon
AOP	advanced oxidation process
AWT	Advanced Water Treatment
BAF	biologically active filter
BDOC	biodegradable dissolved organic carbon
BOD	biological oxygen demand
DBP	disinfection byproduct
DDW	Division of Drinking Water
ECLWRD	Edward C. Little Water Recycling Facility
FAT	Full Advanced Treatment
GWRS	Groundwater Replenishment System
IFAS	Integrated Fixed-Film Activated Sludge
IX	ion exchange
JWPCP	Joint Water Pollution Control Plant
MBR	membrane bioreactor
MCL	maximum contaminant level
MF	microfiltration
mg/L	milligrams per liter
MGD	million gallons per day
NdN	nitrification and denitrification
NF	nanofiltration
NPDES	National Pollutant Discharge Elimination System
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
O&M	operation and maintenance
PV	photovoltaic
RO	reverse osmosis
RRT	response retention time
RWQCB	Regional Water Quality Control Board
SWRCB	State Water Resources Control Board
tBAF	tertiary biologically aerated filter

tMBR	tertiary membrane bioreactor
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
UF	ultrafiltration
USEPA	United States Environmental Protection Agency
UV	ultraviolet (disinfection)
WRP	water reclamation plant

THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

SANITATION DISTRICTS OF LOS ANGELES COUNTY

Advisory Panel

for the

Potential Regional Recycled Water Program

Report No. 2:
Feasibility Methodology
Program and Infrastructure Review
Groundwater Basin Assumptions

September 18, 2016

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I. Executive Summary

The Metropolitan Water District of Southern California (Metropolitan) and the Sanitation Districts of Los Angeles County (Sanitation Districts) are considering development of a large-scale regional indirect potable reuse program for groundwater recharge in several groundwater basins. The potential Regional Recycled Water Program (Program) would begin with a proposed 0.5 million gallon per day (mgd) advanced water treatment (AWT) demonstration plant to be located at the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson. In early 2016, Metropolitan and the Sanitation Districts convened a panel of eight subject matter experts to provide independent review and critical input on the scope and direction of the Program for the demonstration project and development of the feasibility study for a full-scale AWT facility and conveyance system.

At the first workshop on March 31 and April 1, 2016, the Advisory Panel reviewed the overall program and engaged the Project Technical Team in an in-depth discussion of the demonstration plant design. The Project Technical Team consists of Metropolitan staff, Sanitation Districts staff, and consultant staff. The Advisory Panel's report is available on Metropolitan's website.

The second workshop was held July 27-28, 2016. The focus was on the approach to determining overall program feasibility, including methodology, infrastructure, and groundwater basin assumptions. The panel considered the approach and methodology for determining feasibility. This included a defined base case and assumptions for a 150 mgd AWT facility and conveyance system to deliver water for groundwater recharge to four groundwater basins within Metropolitan's service area. The Advisory Panel was asked to focus on two key questions raised in the feasibility analysis:

1) Is it technically and institutionally possible to implement a 150 mgd indirect potable reuse program using effluent from the JWPCP?
2) Are the costs and benefits of the program consistent with Metropolitan's 2015 Integrated Water Resources Plan (IRP) and other approaches for achieving a comparable amount of recycled water?

The Advisory Panel concurred with the overall approach to evaluating feasibility and stated that the proposed report outline and draft working documents were sound pending the incorporation of workshop input. The Advisory Panel encouraged the inclusion of all key assumptions and a description of associated risks and mitigation measures.

The Advisory Panel also considered the program infrastructure and whether the base case program adequately addressed all the critical requirements needed to evaluate program feasibility. The panel discussed the demonstration facility, full-scale AWT facility, and conveyance system. The panel generally concurred with the assumptions and approach, and provided recommendations for each of the program elements.

The Advisory Panel also considered the groundwater basin analysis and assumptions. The panel concurred that the use of calibrated groundwater flow models to assess potential changes in groundwater levels and flow that could result from the project is a reasonable initial investigation and should be followed up with additional studies. The three models currently being used to evaluate the project have been calibrated and documented and have previously been used to support basin management decisions. The model results of potential project operations in the Main San Gabriel Basin and the Central/West Coast Basins were not available at the time of the workshop and are, thus, still subject to review. However, the general approach Metropolitan has taken in using these modeling tools to evaluate potential project impacts is appropriate.

II. Workshop Objectives and Participants

The Advisory Panel met on July 27-28, 2016 to review the potential Regional Recycled Water Program proposed jointly by Metropolitan and the Sanitation Districts. The purpose of the workshop was to consider the approach to determining overall program feasibility, including methodology, infrastructure, and groundwater basin assumptions.

The following members of the Advisory Panel participated:

Richard Atwater (Co-chair)	Expert on recycled water programs
Shivaji Deshmukh	Assistant General Manager, West Basin Municipal Water District
Thomas Harder	Thomas Harder and Company (Hydrogeology)
David Jenkins	Professor Emeritus, University of California, Berkeley
Edward Means	President, Means Consulting LLC
Joseph Reichenberger	Professor, Loyola Marymount University
Paul Westerhoff	Professor, Arizona State University
Excused: Margaret Nellor (Co-chair)	Nellor Environmental Associates, Inc.

In addition to the panelists, the following members of the districts' management and Project Technical Team participated:

Paul Brown	Program Manager, Metropolitan
Renee Hoekstra	Facilitator, Metropolitan

Metropolitan: Debra Man, Gordon Johnson, Jim Green, John Bednarski, Brad Coffey, Gloria Lai-Blüml, Kimberly Wilson, Jay Arabshahi, Matt Hacker, Mickey Chaudhuri, Sun Liang, Carolyn Schaffer, June Skillman, Taylor Machado, Evelyn Ramos, Tom Hibner, Barbara Rogers

Sanitation Districts: Grace Hyde, Robert Ferrante, Rob Morton, Martha Tremblay, Shannon Bishop, Ann Heil, Phil Friess

Consulting Design Team: James Borchardt, Eric Mills, Zakir Hirani, Shane Trussell, Adam Zacheis, Gary Meyerhoffer, Hannah Ford, Michael Adelman

III. Preparation for the Workshop

Prior to the meeting, the Advisory Panel was provided with a series of working documents related to the following:

- Feasibility Approach and Methodology
- Full-Scale Advanced Water Treatment Facility
- Recycled Water Conveyance System
- Groundwater Basins Evaluation

The working documents were developed around a “base case” that is being used for the analysis and evaluation, defined as follows:

> *The base case is an implementable system of program elements, including facilities, infrastructure, institutional arrangements, and financing assumptions (each of which have quantifiable and acceptable levels of risk) that are necessary and sufficient for accomplishing the program objectives of indirect potable reuse. It is a hypothetical system model that has not yet been designed to achieve “optimized performance” but is deemed capable of accomplishing the program’s functional goals.*
>
> *The base case is not designed to handle peak flows to the JWPCP. The base case facilities are expected to periodically reduce deliveries to groundwater basins when conditions warrant.*
>
> *Finally, the base case system should not be considered as either the “best” or the “worst” case scenario with respect to implementation costs or timelines. It represents a realistic approach to achieving the program’s functional goals and is intended to demonstrate “feasibility” only.*

The base case is intended to provide delivery flexibility with a design flow of 150 mgd, average daily deliveries of 144 – 150 mgd and a minimum delivery of approximately 110 mgd.

IV. Panel Charge for the Workshop

The Advisory Panel was charged with the following series of questions for this workshop:

1) **Methodology for Establishing Feasibility**
   - Are the essential elements that must be considered for evaluating program “feasibility” being addressed?
   - Are there recommended improvements to the approach for assessing feasibility?
   - Is there additional information that should be provided?

2) Comprehensive Program and Infrastructure Review

- Has the base case program adequately addressed all the critical requirements needed to evaluate program feasibility?
- What aspects of the program present the greatest risk, uncertainty, and vulnerability?
- What can be done to improve overall program feasibility?

3) Groundwater Basin Assumptions

- Are there specific groundwater basin issues or concerns that should be acknowledged and/or addressed in the feasibility study?
- What are the advantages/disadvantages of providing a guaranteed annual replenishment supply for the regional groundwater basins?

Metropolitan updated the Advisory Panel on the status of the feasibility study and provided presentations on the key topics for the workshop. The panel presentations are included in the Appendix available on Metropolitan's website.

V. Methodology for Establishing Feasibility

The Advisory Panel was asked to provide comments on 1) whether the essential elements to determine feasibility, as described below, are appropriately considered; 2) recommended improvements to the approach; and 3) additional information that should be provided in the feasibility study.

The Advisory Panel focused on two key questions raised in the feasibility analysis:

1) Is it technically and institutionally possible to implement a 150 mgd indirect potable reuse program using effluent from the JWPCP?
2) Are the costs and benefits of the program consistent with Metropolitan's 2015 Integrated Water Resources Plan (IRP) and other approaches for achieving a comparable amount of recycled water?

To simplify the feasibility analysis, and to avoid analyzing and evaluating a myriad of possible program alternatives, a base case was developed that would meet the program goals. The base case includes a 150 mgd "demand-driven" AWT facility. This facility would be able to periodically ramp down production for delivery flexibility. It would not be designed to manage peak flows at the JWPCP. Based on the analysis, 110 mgd or more can be consistently delivered to the various spreading basins and injection wells, with 150 mgd delivered 85 percent of the time. No new spreading facilities are assumed to be needed.

The current wastewater flow at the JWPCP has dropped significantly due to water conservation. Although the JWPCP has a design capacity of 400 mgd, current (2015) average daily flow is 265 mgd. The daily minimum is 150 mgd; the daily peak is 350 mgd. With an estimated recovery of 85 percent, the AWT plant will need a minimum inflow of 180 mgd to produce 150 mgd of product water. Since the current minimum flow to the JWPCP is 150 mgd, flow equalization will be needed.

Advisory Panel Comments

The Advisory Panel concurred with the approach to evaluating feasibility and stated that the overall approach in the report outline and draft working documents is sound. The panel provided the following comments for consideration.

Direct Potable Reuse. The Advisory Panel discussed whether direct potable reuse (DPR) should be included in the base case, in addition to indirect potable reuse (IPR) through groundwater recharge. There is now a clearer regulatory path to future DPR, (e.g. the state has issued a draft feasibility study), and Metropolitan should be prepared for this eventuality. The panel acknowledged that DPR may not address the regional water supply reliability problem as effectively as storage in the groundwater basins. These basins provide a large share of the region's storage, and their availability is built into regional reliability assumptions. The demonstration plant data could help to evaluate the feasibility of future DPR even though regulations may still be ten years or more away. The report should describe how IPR projects would contribute to meeting future DPR standards and indicate how Metropolitan would be contributing to the development of this body of knowledge.

Program Implementation. The Advisory Panel stated that phasing the project to minimize the risk of stranded investments should be evaluated. In addition, planning should be coordinated with other projects to prevent overlapping planning for water demands and potential duplication of facilities. Development of other projects could impact demand for the program water.

Public outreach and environmental justice issues need to be considered and addressed. Panel members pointed out that the Orange County Water District (OCWD) has successfully addressed these issues through comprehensive outreach and education for the Groundwater Replenishment System (GWRS).

Stormwater capture is currently a major initiative throughout Southern California and has led to major ongoing and planned capital expenditures. Dovetailing with this initiative would provide additional regional-scale benefits.

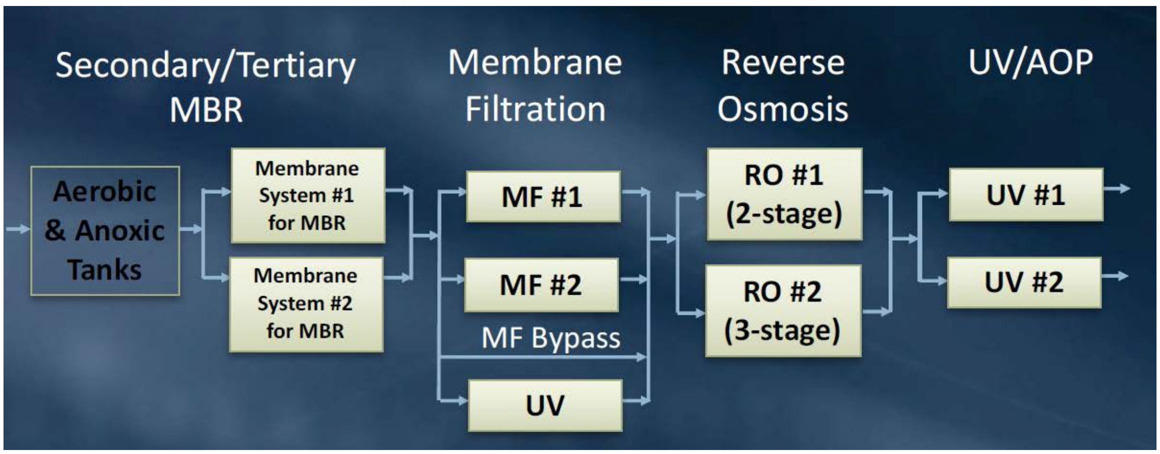
VI. Comprehensive Program and Infrastructure Review

The Advisory Panel was asked to provide comments on 1) whether the base case adequately addresses all the critical requirements needed to evaluate program feasibility; 2) aspects of the program that present the greatest risk, uncertainty, and vulnerability; and 3) recommendations to improve overall program feasibility.

Demonstration Facility

When the Advisory Panel met, work on the demonstration plant was at the 50 percent design stage. Preliminary cost estimates indicated that the original 1 mgd demonstration plant concept would not likely be constructed within the original program budget authorization of $15 million. To keep the program within budget and not compromise objectives, the demonstration plant was re-sized for 0.5 mgd. This change retained the full functionality for testing at a more reasonable cost.

An updated demonstration plant process train was presented to the Panel.



<u>Advisory Panel Comments.</u> The demonstration plant will use a two-pass RO system and a three-pass RO system in parallel for comparison. The panel agrees that the product water quality from either the two-pass RO system or the three-pass RO system will be similar.

The Advisory Panel questioned having two equipment vendors for each process when the trains are not separate. The Advisory Panel recommends that the Design Team confirm that the regulators are comfortable with there being more than one equipment vendor for each process.

The Advisory Panel suggests consideration of a short aerated zone upstream of the membranes to avoid anoxic water going directly to the membranes and creating risks of fouling.

The Advisory Panel agrees with the Design Team that the demonstration plant will be able to use several carbon sources (methanol and MicroC2000™). The treatment process should also include a phosphoric acid feed to prevent the biological process from being phosphorus limited.

The Advisory Panel recommends that the feasibility study include a discussion of how the demonstration facility fits into the program. It will confirm key assumptions and demonstrate the technology for the regulating agencies and the public. It will provide the design information for the first large-scale facility treating non-nitrified secondary effluent.

Advanced Water Treatment Facility

The base case includes a 150 mgd AWT facility located at the JWPCP. A conceptual site layout of the full-scale AWT facility was presented. There is space available for the facility within the existing JWPCP property with space for future expansion. Three dimensional renderings of major facilities in the AWT facility were presented.

The base case assumes that sidestream centrate treatment and flow equalization will be provided to improve the quality of the influent to the AWT plant and ensure a constant flow. The proposed treatment train for the AWT facility includes a membrane bioreactor, reverse osmosis, and advanced oxidation (MBR-RO-AOP) followed by stabilization with lime and carbon dioxide (CO_2), then finally chlorination, before the treated water is pumped into the conveyance system. This treatment train is expected to achieve more than the required 12 log virus/10 log *Giardia*/10 log *Cryptosporidium* removal/inactivation (12/10/10) without MF. This treatment approach assumes that the treatment processes used in the demonstration facility receive regulatory approval for use in the full-scale facility.

In the base case, the water quality goals for nitrogen will be met through sidestream centrate treatment at the JWPCP along with partial NdN, tertiary membrane bioreactor (tMBR) treatment following the existing secondary treatment at the AWT, and rejection of nitrate by RO. MicroC2000™ could be used as the carbon source for NdN. Satellite ion exchange (IX) or retrofit of JWPCP with NdN are alternative nitrogen management options. The Design Team is evaluating nitrogen management alternatives in coordination with the Sanitation Districts.

In the base case, boron loading will be reduced through source control with no additional treatment process at the AWT plant. If this is not achievable, satellite IX facilities or diluent water credit could be pursued with the groundwater basin managers and the regulatory agencies.

The AWT facility would be designed with spare/redundant equipment to achieve greater than 98 percent online time.

<u>Advisory Panel Comments.</u> The Advisory Panel recommends that operational water quality targets be established for the AWT source water. This includes influent and secondary effluent water quality, source control measures, boron, nitrogen, and water chemistry/blending. In this context, the panel asked if there had been any progress on boron source control. The Sanitation Districts responded that sampling is underway by their industrial waste staff. Sixty-five different possible dischargers had been identified. The panel asked if space should be allocated for ion exchange facilities (IX). The Design Team responded that it is anticipated that treating the full flow by IX would be cost-prohibitive, so satellite facilities treating only a small part of the flow would be used if needed. The Design Team stated that space would be set aside at the demonstration facility so that pilot-scale IX testing could be conducted on an as-needed basis.

The Advisory Panel thought it might be too optimistic to exclude MF/UF after the MBR in the base case and encouraged the Design Team's current plan to have the demonstration plant provide the data both with and without MF in the treatment train. The panel supports the decision to allocate space for future MF in the full-scale layout if needed. This could also provide for the addition of MF to meet future potential DPR requirements.

The Advisory Panel commented that it may be appropriate to divert denitrified water, prior to RO-treatment, for non-IPR use near the JWPCP.

The Advisory Panel asked about where the secondary effluent flow equalization basin would be located. The Sanitation Districts indicated that flow equalization is still being evaluated. Existing clarifiers that are not needed for current reduced flow could potentially be used. The Advisory Panel inquired whether tankage used for equalization could also be used to start the process of nitrification by adding fixed-film media, air, and return secondary solids. The Design Team responded that this would be considered in future studies.

The need for flow equalization in the future was discussed. Based on the flow rates experienced at JWPCP currently and as anticipated with ongoing conservation efforts, flow equalization may be needed to operate the plant at a constant flow rate of 150 mgd initially. However, as flows increase due to population growth, it is possible that flow equalization may not be needed at some point in the future. The Advisory Panel recommends that the trend of decreasing wastewater flows due to conservation be considered in planning the ultimate capacity of the AWT.

The Advisory Panel inquired about the acceptability of brine stream discharge from the full-scale AWT facility into the Sanitation Districts' permitted ocean discharge. The Sanitation Districts responded that they will assess this during the demonstration project and coordinate with the Regional Water Quality Control Board. Toxicity is critical because there may be constituents that could become an issue when concentrated in the brine discharge.

The Advisory Panel recommends that the planning process assess energy consumption and sources. AWT is an energy-intensive process and the issue of carbon emissions will arise.

Conveyance System

A schematic map of the conveyance system to deliver the water to the groundwater basins was presented. It included points of discharge to recharge basins in the Main San Gabriel Basin to the northeast and the Orange County Basin to the east. A range of flows to be conveyed to spreading grounds at Santa Fe, Rio Hondo, and Orange County, along with injection wells at West Coast Basin, Long Beach, and Central Basin were shown. The goal of the conveyance system analysis was to identify potential alignments using public rights-of-way to the extent possible and to minimize impacts on utility relocation, traffic, etc. Alignments were evaluated using a matrix based on environmental, constructability and real property criteria. The base case includes three pump stations and about 54 miles of new pipeline ranging from 60 to 84 inches in diameter.

Advisory Panel Comments. The Advisory Panel noted that two Metropolitan surface water treatment plants are relatively close to the conveyance lines as shown in the base case. The panel suggests that at some future time and, with DPR regulations permitting, connection to existing Metropolitan raw water pipelines and ultimately the treatment plants may be possible. This would enhance the operational flexibility when full spreading capacity may not be available.

The Advisory Panel commented that the base case conveyance system is proposing cement mortar-lined pipes, which have been a problem for OCWD. Even if the AWT facility is designed to produce stable water quality with post-conditioning, this is not always achieved in practice and a robust conveyance material is important. The panel suggested use of high density polyethylene pipe, but this material has size and pressure limitations. Fiberglass pipe, per AWWA C-950, may be suitable; it is available in large diameters and various pressure classes. The panel also noted that activated sludge effluent is aggressive and must be accounted for in the materials and budgeting. The panel recommends that a robust, non-corrosive pipeline material or lining *in lieu* of cement mortar lined steel be considered during design.

The Advisory Panel agrees with the assumption in the base case that new injection wells should be stainless steel to avoid issues with corrosion and plugging.

The Advisory Panel recommends that planning for the conveyance system should be flexible and account for future possible sources of water such as other reuse projects, desalination, DPR, etc. The conveyance system must be coordinated with existing water supply and recycled water facilities, other planned projects, and other possible sources, including the conveyance for the Water Replenishment District's Groundwater Reliability Improvement Project. Since these projects are likely to occupy the same space along the San Gabriel River levee, there may be a potential for joint ownership. Coordination with the Los Angeles County Flood Control District, Army Corps of Engineers, other utilities and cities will be needed during conveyance system planning.

VII. Groundwater Basin Assumptions

The Advisory Panel was asked to provide comments on 1) specific groundwater basin issues or concerns that should be acknowledged and/or addressed in the feasibility study, and 2) the advantages and disadvantages of providing a guaranteed annual replenishment supply for the regional groundwater basins.

The general approach to evaluating groundwater recharge feasibility in the base case includes:

- Demand Analysis – Is there sufficient demand for recharge water?
- Operational Assessment – Are there operational issues that may limit how much can be recharged?
- Groundwater Modeling – What are the impacts of recharge and extraction of project water?
- Facility Needs – Are additional facilities required?

Metropolitan has met with member agencies and basin managers to discuss the program. The agencies and basin managers provided data and information to assist with the evaluation. Metropolitan, in coordination with the basin managers and spreading basin operators, evaluated a range of groundwater recharge needs, demand, available spreading basin capacity and diluent water availability. Urban runoff and stormwater are percolated in the same spreading grounds during the rainy season. For the West Coast Basin, the water would be used for recharge through new injection wells as well as to meet refinery demands.

For the operational assessment, the base case assumes that spreading capacity at the recharge basins would be available at least 95 percent of the time. Metropolitan also assumed that diluent water (i.e. a blending water source) would be required in the initial three years of recycled water recharge.

Potential impacts from recharge and extraction of project water are being studied using groundwater flow models. Three pre-existing models are being utilized, each under the oversight of the respective basin managers: Central Basin under contract with Water Replenishment District (WRD); Main San Gabriel Basin under contract with Main San Gabriel Basin Watermaster; and Orange County Basin operated by the Orange County Water District. At the time of the workshop the Orange County Basin analysis had been completed with the analyses of the Central Basin and Main San Gabriel Basin underway and not available to the panel.

The normal operations assumed for the base case of 150 mgd are as follows: up to 62 mgd to Main San Gabriel Basin; up to 11 mgd to Central Basin at Montebello Forebay/Rio Hondo Spreading Grounds; up to 4 mgd to injection wells at Long Beach; up to 15 mgd to West Coast Basin through new injection wells; and 58 mgd to Orange County Basin. The deliveries during wet periods, with a minimum of 110 mgd, are as follows: up to 77 mgd to Main San Gabriel Basin; up to 18 mgd to Orange County Basin; and up to 15 mgd to West Coast Basin.

Advisory Panel Comments

<u>Groundwater Modeling.</u> The use of calibrated groundwater flow models to assess potential changes in groundwater levels and flow that could result from the project is reasonable and prudent. The three models currently being used to evaluate the project have been calibrated and documented and have previously been used to support basin management decisions. The model results of potential project operations in the Main San Gabriel Basin and the Central/West Coast Basins were not available at the time of the workshop and are, thus, still subject to review. However, the general approach Metropolitan has taken in using these modeling tools to evaluate potential project impacts is necessary and appropriate.

The Advisory Panel asked about the basis for the probabilities of recharging these flows and if wet/dry rotations of the basins were considered. Metropolitan stated that a detailed analysis was conducted using historic data from each basin. Wet and dry periods were included in the analysis.

The Advisory Panel asked whether diluent water from other sources was considered in the analysis of the proposed recharge sites. Metropolitan responded that this was taken into consideration in the analysis. The capacities at each basin are ultimate build-out capacities, and the modeling accounts for ramp-up using diluent water.

The Advisory Panel asked about the criteria for determining that 15 mgd could be delivered to the West Coast Basin. Metropolitan responded that the 15 mgd is based on unused capacity within the basin adjudication. The Advisory Panel commented that, in the West Coast Basin service area, taking imported water is easier and less costly than building wells. The base case assumes that pumpers in the West Coast Basin will increase production of their groundwater wells; however, assuming increased production is a potential risk. The location of the increased pumping could be affected by the location of the intruded sea water in the West Coast Basin and extraction and brackish water desalination may be required. The WRD is studying expanding brackish water desalination, and the injection of program water will need to be coordinated with WRD to optimize pumping in the West Coast Basin. Over time, pumping groundwater will likely cost less than direct deliveries of treated imported water. In the feasibility report, the planned flows should be described as ranges (e.g., 0-15 mgd) pending formalization of the flows with the basin managers.

Groundwater Contamination. The Advisory Panel commented that there are potential issues with recharging water in one place and producing from wells in other locations. The issues may arise from movement of a pollutant plume or mounding of groundwater around the injection site with depression around production wells, ("pumping hole"), depending on the ability to move water underground. A risk strategy needs to be considered for potential movement of Superfund and other contaminant plumes in the various basins.

The Advisory Panel noted the particle tracking work presented with the groundwater basin analysis. This was done to understand where the water goes when it is injected or spread into each basin, and to evaluate local issues (plume movement, potable water well impacts, etc.), that may result from replenishment. A six-month travel time from recharge to nearest production well is currently required by regulations. This travel time needs to be confirmed for injection into a confined aquifer. Additional analysis may be needed.

The Advisory Panel raised the issue of water losses in the basins. It was stated that basins have roughly a 3-6 percent loss on average. The panel agrees with Metropolitan's response that this issue is best addressed in the next/upcoming phases of the program via detailed groundwater modeling and documented along with other groundwater impacts.

The Advisory Panel noted that experience in Florida and elsewhere has shown that as a plume of low-TDS water enters the basin from IPR injection, it can mobilize naturally occurring geochemical constituents in the soil (e.g. arsenic). The Design Team indicated that some alkalinity addition as part of the post-stabilization step may be required to avoid mobilizing geochemical constituents in the soil during recharge. In addition, Metropolitan has been talking to groundwater basin managers about their experience with this in their basins.

Recharge Operations and Maintenance. Metropolitan is proposing to operate the AWT facility by ramping down to 110 mgd under wet weather conditions. This will allow the groundwater basins to recharge stormwater. The report should address wet weather operation of each groundwater basin since it is likely to vary from basin to basin.

Recharge in the Main San Gabriel Basin could eventually be limited by a maximum key well groundwater level above which replenishment with recycled water is not allowed (particularly in wet years like 1998 and 2004). This is an existing limit driven by agreements with the sand and gravel producers. The groundwater modeling for the Main San Gabriel Basin should account for this.

The Advisory Panel noted that there may be environmentally sensitive habitat issues associated with taking the basins offline for maintenance at some locations during certain times of the year. All basins need to be assessed for such habitat issues.

At existing locations where blended stormwater and AWT water will be recharged into the same basin, chemical effects that are difficult to predict may occur due to the blending of these water sources. Water quality modeling should look at stability and possible dissolution or precipitation. As water levels in the basins increase, nitrate leaching could be a greater issue than arsenic leaching.

Although reduction of infiltration has taken place in other locations due to swelling of clay minerals driven by ion exchange reactions, the existing recharge basins proposed for use in the program have not shown or documented this tendency.

Potential Regional Benefits. The Advisory Panel discussed the benefits of providing this water for groundwater recharge in the region. The program provides water that can be stored underground (i.e. in the aquifer) for supply during emergencies. In the event of an outage, earthquake, etc., this project is comparable in water supply significance to Diamond Valley Lake and provides a benefit in the form of avoided cost for building reservoir storage. Water quality improvement and salinity management for groundwater basins is an important benefit in counteracting salt accumulation. A firm supply of low-TDS water is a valuable regional asset.

Acronyms

AOP	advanced oxidation process
AWT	advanced water treatment
DPR	direct potable reuse
GWRS	Groundwater Replenishment System
IPR	indirect potable reuse
IRP	Integrated Water Resources Plan
IX	ion exchange
JWPCP	Joint Water Pollution Control Plant
MBR	membrane bioreactor
MF	microfiltration
mgd	million gallons per day
NdN	nitrification and denitrification
OCWD	Orange County Water District
RO	reverse osmosis
tMBR	tertiary membrane bioreactor
TDS	total dissolved solids
UF	ultrafiltration
UV	ultraviolet (disinfection)
WRD	Water Replenishment District

Appendix - Presentations*

- Demonstration Facility
- AWT Facility
- Conveyance System
- Groundwater Analysis Methodology

* The appendices are available on Metropolitan's website at the following link: http://mwdh2o.com/AboutYourWater/regional-recycled-water[mwdh2o.com]

APPENDIX B:

Regional Recycled Water Program Agreement between the Metropolitan Water District of Southern California and County Sanitation District No. 2 of Los Angeles County

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CSD C# 4940

REGIONAL RECYCLED WATER PROGRAM AGREEMENT

This REGIONAL RECYCLED WATER PROGRAM AGREEMENT ("**Agreement**") is between THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA ("**Metropolitan**") and COUNTY SANITATION DISTRICT NO. 2 OF LOS ANGELES COUNTY ("**Sanitation District**"), who may be referred to individually as "**Party**" or collectively as "**Parties.**"

The Sanitation District is the administrative district and agent for the Joint Outfall System[1] of the County Sanitation Districts of Los Angeles County, and in that capacity operates the Joint Water Pollution Control Plant ("**Joint Plant**") in Carson, California.

The Parties wish to develop a Regional Recycled Water Program ("**Program**") with the aim of producing up to 150 million gallons per day ("**MGD**") of advanced treated water ("**Purified Water**") from the Joint Plant for use within Metropolitan's service area.

The Program would benefit Metropolitan and its member agencies by diversifying regional supplies, improving storage and delivery capabilities, and providing a new source of high quality, reliable, and drought-resistant water.

The Program would benefit the Sanitation District by demonstrating the removal of salts and other constituents from the Joint Plant's secondary-treated effluent is feasible, allowing it to be reclaimed and reused in a beneficial manner.

THEREFORE, the Parties agree as follows:

1. **EFFECTIVE DATE:** The Agreement will be effective on the last date of execution by the Parties of the following: (a) this Agreement; (b) the Ground Lease Agreement specified in <u>Exhibit A</u>, Section A1.a; and (c) the Source Water Supply Agreement specified in <u>Exhibit A</u>, Section A2.a., except that Metropolitan's duties to indemnify the Sanitation District with respect to CEQA matters as set forth in Section 4 arise immediately upon Metropolitan's execution of this Agreement.

2. **TERM OF AGREEMENT:** The term of this Agreement will be twenty years from the Effective Date ("**Agreement Term**"), unless terminated earlier by agreement of the Parties.

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[1] The members of the Joint Outfall System are County Sanitation Districts Nos. 1, 2, 3, 5, 8, 15, 16, 17, 18, 19, 21, 22, 23, 28, 29, and 34 of Los Angeles County and South Bay Cities Sanitation District of Los Angeles County and are referred to as the "**Joint Outfall Districts**."

3. PROGRAM AND PROJECT INTENT

a. The goal of the Program is to produce up to 150 MGD of Purified Water from the Joint Plant that is suitable for groundwater recharge and other uses within Southern California.

b. The Program would consist of the following projects (collectively "**Projects**"):

i. Demonstration Project: Under the **Demonstration Project**, Metropolitan would design, construct, operate, and maintain a small-scale advanced water treatment facility on the Joint Plant property to treat secondary effluent from the Joint Plant with the aim of producing approximately 1 MGD of Purified Water. The principal purpose of the Demonstration Project is to assess the viability of and optimal parameters for proceeding with the Full-Scale Project described below.

ii. Full-Scale Project: If the Demonstration Project is successful, then the Parties may undertake a **Full-Scale Project**, subject to compliance with all laws. Under the Full-Scale Project, Metropolitan would design, construct, operate, and maintain large-scale advanced water treatment facilities on Sanitation District property to treat secondary effluent from the Joint Plant with the aim of producing up to 150 MGD of Purified Water. The Full-Scale Project may be constructed in multiple phases.

4. CALIFORNIA ENVIRONMENTAL QUALITY ACT

a. For purposes of the California Environmental Quality Act ("**CEQA**"), Metropolitan shall be the lead agency for the Demonstration Project and, if appropriate, for the Full-Scale Project. The Sanitation District shall provide in-kind staff assistance to Metropolitan in preparation of any CEQA documentation. Metropolitan shall be responsible for all other costs of CEQA compliance, and shall indemnify, defend, and hold harmless the Sanitation District and its directors, employees, and agents from any losses, claims, or legal actions of any nature arising out of or relating to the Program or projects' compliance with CEQA.

b. Project construction will not commence until the Parties have: (i) completed all necessary environmental reviews and public hearing processes; (ii) obtained all required permits, approvals and authorizations; and (iii) negotiated, executed, and delivered the Ground Lease Agreement and Source Water Supply Agreement described in Exhibit A.

5. PROJECT DESCRIPTIONS

a. Demonstration Project: This Agreement is binding only with respect to the Demonstration Project, the terms and conditions of which are set forth below and in Exhibit A ("**Demonstration Project Terms**").

b. Full-Scale Project:

i. The Agreement is not a binding commitment upon the Parties to proceed with the Full-Scale Project. Rather, the terms and conditions that are set forth in this Agreement and in Exhibit B with respect to the Full-Scale Project are proposed terms only ("**FSP Proposed Terms**").

ii. Either Party may decide, in its sole discretion, whether and on what terms to proceed with the Full-Scale Project following completion of the Demonstration Project and any environmental review required under CEQA.

iii. If the Parties decide to proceed with the Full-Scale Project, then the final terms and conditions applicable to that project ("**FSP Final Terms**") will be set forth in one or more separate agreements. It is the Parties' present intent that the FSP Final Terms be consistent with the FSP Proposed Terms. However, the FSP Final Terms may deviate from the FSP Proposed Terms. The Parties agree to negotiate in good faith regarding any changes to the FSP Proposed Terms, but each Party retains discretion to negotiate any changes it deems necessary or desirable.

6. NOTICES

a. Any notice under this Agreement must be in writing and addressed as follows:

The Metropolitan Water District of Southern California
Post Office Box 54153
Los Angeles, CA 90054-0153
Attention: John Bednarski, Section Manager
With a courtesy copy by email to: jbednarski@mwdh2o.com

County Sanitation District No. 2 of Los Angeles County
1955 Workman Mill Road
Whittier, CA 90601
Attn: Technical Services Department Head
With a courtesy copy by email to: pfriess@lacsd.org

b. A properly addressed notice will be effective on the day of delivery, if delivered directly by a Party or by a nationally recognized delivery service, or on the third day after mailing, if sent postage prepaid by U.S. Mail. The Parties shall transmit a courtesy copy of any notice to the other Party by email on the day the notice is sent.

c. Either Party may change the address listed in section 6.a above by providing five days notice to the other Party.

7. **AGREEMENT ADMINISTRATORS**:

a. The following persons are designated as the **Agreement Administrators**:

For Metropolitan Water District:
John Bednarski, Section Manager
Tel: 213-217-5526
Email: jbednarski@mwdh2o.com

For the Sanitation District:
Philip L. Friess, Department Head, Technical Services
Tel: 562-699-7411 x 2501
Email: pfriess@lacsd.org

b. A Party's Agreement Administrator will be the primary point of contact and authorized representative for that Party and shall be responsible for obtaining on that Party's behalf any approvals, authorizations or permits that may be necessary under this Agreement.

c. Each Party may designate a different person to serve as its Agreement Administrator by providing the other Party with five days notice of any such change.

8. **RECORDS RETENTION AND INSPECTION:** Each Party shall maintain, and shall cause its employees, agents, representatives, subcontractors and suppliers to maintain, all records, regardless of form or type, related to any activities undertaken or obligations performed pursuant to this Agreement, including any and all project-related documents, reports, data, analyses, plans, specifications, drawings, photographs and financial information ("**Records**"). Records must be maintained for a period of four years following the end of the Agreement Term or the conclusion of any litigation arising out of or related to this Agreement, whichever is later. Each Party may inspect, review, copy, transcribe and/or download the other Party's Records upon five days notice to that Party.

9. **WORKING COMMITTEE:** The Parties shall establish a working committee ("**Working Committee**") to oversee and manage, on a day-to-day basis, any work or activities conducted pursuant to this Agreement. The Working Committee should be comprised of appropriate managerial, technical, and support staff from each Party. However, each Party retains sole discretion to determine which of its staff to appoint to the Working Committee.

10. **DISPUTE RESOLUTION:** The Parties shall attempt to resolve any dispute, claim, controversy or disagreement arising from or relating to this Agreement ("**Dispute**") in a prompt, equitable, and amicable manner. Any Dispute will be submitted first to the Working Committee. If the Working Committee does not resolve the Dispute within fifteen days after submittal, then the Dispute will be referred to the Parties' Agreement Administrators. If the Agreement Administrators do not resolve the Dispute within thirty days after referral, then either Party may pursue any legal or equitable remedies it may

have with respect to that Dispute. The timeframes provided in this section may be extended by mutual agreement of the Parties.

11. **INDEMNITY:** Subject to the CEQA indemnity above and more specific indemnities set forth in any lease agreement or water supply contract, each Party will indemnify the other Party as set forth below.

a. The Sanitation District shall defend, indemnify and hold harmless Metropolitan and its Board of Directors, officers, agents, contractors, subcontractors of any tier, and employees ("**Metropolitan Parties**") from all suits, claims, causes of action or liability of any kind ("**Claims**") arising out of or in connection with (i) the acts or omissions of the Sanitation District and its Board of Directors, officers, agents, contractors, subcontractors or any tier, and employees ("**Sanitation District Parties**") under this Agreement; (ii) any work performed by the Sanitation District Parties pursuant to this Agreement; and (iii) the condition of the Joint Plant outside the leasehold areas. This duty to defend, indemnify, and hold harmless will not apply to any suits, claims, causes of action or liability resulting from the willful misconduct or active negligence of any Metropolitan Parties. The Sanitation District shall have any contractor it hires in connection with the Demonstration Project name Metropolitan and the Metropolitan Parties as additional insureds on any policies of insurance required of that contractor by the Sanitation District.

b. Metropolitan shall defend, indemnify and hold harmless the Sanitation District Parties from all Claims arising out of or in connection with: (i) the acts or omissions of the Metropolitan Parties under this Agreement; (ii) any work performed by the Metropolitan Parties pursuant to this Agreement; and (iii) Metropolitan's leasehold for the Demonstration Project Site. This duty to defend, indemnify, and hold harmless shall not apply to any suits, claims, causes of action or liability resulting from the willful misconduct or active negligence of the Sanitation District Parties. Metropolitan shall have any contractor working on the Demonstration Project name the Sanitation District and its affiliates, directors, officers, agents, and employees as additional insureds on any policies of insurance required of that contractor by Metropolitan.

12. **NO PARTNERSHIP; INDEPENDENT CONTRACTORS:** The Parties do not by this Agreement intend to create any partnership or joint power authority. In performing any work under this Agreement, Metropolitan and the Sanitation District are acting as independent contractors and all employees of each Party are solely the employees of that Party and not the agents or employees of the other Party.

13. **WAIVER:** No delay or failure by either Party to exercise or enforce at any time any right or provision of this Agreement will be considered a waiver of that right or provision, unless the waiver is made in writing signed by the Party granting the waiver, which need not be supported by consideration. No single waiver will constitute a continuing or subsequent waiver.

14. **SEVERABILITY:** If any provision of this Agreement is held illegal, invalid, or unenforceable, in whole or in part, then that provision will be modified to the minimum extent necessary to make it legal, valid, and enforceable, and the legality, validity, and enforceability of the remaining provisions shall not be affected.

15. **ASSIGNMENT:** Neither Party shall transfer or assign any of its rights or duties under this Agreement without the written consent of the other Party, which consent shall not be unreasonably withheld.

16. **JURISDICTION AND VENUE:** This Agreement is made and will be interpreted under the laws of the State of California. Venue for any action will be the Superior Court of Los Angeles County, California.

17. **ENTIRE AGREEMENT:** This Agreement and the attached Exhibits constitute the entire agreement of the Parties with respect to the Program. This Agreement may not be modified except by a writing signed by both Parties.

The Parties are signing this Agreement in duplicate originals.

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

By:______________________________
General Manager

APPROVED AS TO FORM:

By:______________________________
General Counsel

COUNTY SANITATION DISTRICT NO. 2 OF LOS ANGELES COUNTY

By:______________________________
Chairperson

NOV 16 2015

ATTEST:

By:______________________________
Secretary to the Board

APPROVED AS TO FORM:
Lewis Brisbois Bisgaard & Smith, LLP

By:______________________________
District Counsel

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EXHIBIT A

SPECIFIC TERMS AND CONDITIONS APPLICABLE TO THE DEMONSTRATION PROJECT

A1. Construction and Operation of Treatment Facility

a. Location: The Parties shall agree upon a suitable location within the boundaries of the Joint Plant for construction and operation of the Demonstration Project ("**Demonstration Project Site**"). The Demonstration Project Site will be leased to Metropolitan at no cost for the duration of the Agreement Term, subject to execution of a separate ground lease agreement ("**Ground Lease Agreement**") consistent with this Agreement.

b. Capacity: The Demonstration Project is anticipated to have the capacity to produce approximately 1 MGD of Purified Water. The exact design and configuration of this facility will be determined by Metropolitan in its sole discretion.

c. Construction:

i. Within two years after the Effective Date, Metropolitan shall complete all necessary permitting (including compliance with CEQA) and design and construct the Demonstration Project, which may include the following unit processes: ozone, biological granular activated carbon, microfiltration, membrane bioreactor, reverse osmosis, advanced oxidation processes (e.g., hydrogen peroxide, ultraviolet light), ion-exchange and nitrogen removal (e.g., nitrification and denitrification). Metropolitan shall design and construct any power feeds, raw water supply lines, waste stream lines, and other process lines required for the Demonstration Project ("**Ancillary Facilities**") from suitable tie-in locations at the Joint Plant. The Parties shall agree upon tie-in locations for the Ancillary Facilities prior to the commencement of **Final Design**, defined for the purposes of this agreement as 50% design completion, for the Demonstration Project. Metropolitan shall be responsible for the costs of these permitting, design and construction activities, except to the extent they are covered by other entities.

ii. Prior to the commencement of construction activities, Metropolitan shall make reasonable efforts to determine whether any hazardous wastes or materials ("**Hazardous Wastes**") or contaminated soil or groundwater ("**Contamination**") exists in, on, or under the Demonstration Project Site. If prior to or during construction of the Demonstration Project Metropolitan determines that any Hazardous Wastes or Contamination are present and will be impacted by construction, then Metropolitan shall notify the Sanitation District of the condition immediately after making its determination and shall cease activities as necessary to avoid further disturbing the site. The Parties shall meet and confer to develop an approach to mitigating the condition as cost-effectively as possible. However, unless the Parties agree otherwise, the Sanitation District shall be responsible for removing, disposing and/or treating all pre-existing Hazardous

Wastes and Contamination and for remediating the site as needed to permit construction of the Demonstration Project. Any delays caused by or resulting from these removal or remediation activities will not be considered a breach of this Agreement. Metropolitan shall be responsible for removal, disposal and/or treatment of all other wastes, deposited, produced, or generated during construction of the Demonstration Project.

d. Ownership and Operation:

   i. Metropolitan will be the owner of the Demonstration Project, including any Ancillary Facilities, and shall operate and maintain them for the duration of the Agreement Term. Except as provided otherwise, Metropolitan shall be responsible for all costs associated with operation and maintenance of the Demonstration Project including any Ancillary Facilities.

   ii. In the event that the Demonstration Project is not able to operate for any reason, Metropolitan shall divert untreated Source Water back into the Joint Plant for disposal. Metropolitan shall give the Sanitation District reasonable notice before taking any such action.

   iii. Either Party may utilize the Demonstration Project for public outreach purposes, which may include providing tours of the facility to members of the public. Neither Party shall deny or impose unreasonable restrictions on the use of and access to the Demonstration Project for such purposes.

e. Removal of Demonstration Project: At the conclusion of the Demonstration Project or this Agreement, whichever comes first, the Sanitation District may purchase the Demonstration Project and Ancillary Facilities for their salvage value, as determined by an independent appraisal. If the Sanitation District does not purchase these facilities, then within two years after notice from the Sanitation District, Metropolitan shall remove all facilities and improvements constructed by Metropolitan associated with the Demonstration Project, including any Ancillary Facilities, and return the Demonstration Project Site to its pre-project condition.

f. Permits and Authorizations: Metropolitan shall obtain any and all permits, authorizations, and approvals needed to construct and operate the Demonstration Project and Ancillary Facilities, and shall comply with any and all laws, rules and regulations applicable to the construction and operation of the Demonstration Project and Ancillary Facilities. The Sanitation District shall cooperate with Metropolitan in securing such permits, authorizations, and approvals.

g. Utilities: The Sanitation District shall be responsible for providing, at no cost to Metropolitan, any and all utility connections and services needed to construct and operate the Demonstration Project, including power, potable water, sewer, and solid waste collection services.

h. Right of Inspection: Upon reasonable notice, the Sanitation District may enter the Demonstration Project Site for the purpose of construction or operations.

A2. Provision of Source Water

a. General Obligation: The Sanitation District shall provide, at no cost to Metropolitan, secondary effluent from the Joint Plant ("**Source Water**") in an amount sufficient to meet the treatment capacity of the Demonstration Project as constructed. Prior to commencement of Final Design, the Parties shall agree upon the schedule and criteria for delivery of Source Water to the Demonstration Project. The provision of Source Water is subject to execution of a separate supply agreement ("**Source Water Supply Agreement**") consistent with this Agreement. Metropolitan acknowledges that circumstances beyond the control of the Sanitation District may adversely impact the quality or volume of Source Water available to the Demonstration Project. If any such circumstances occur, the Sanitation District's Chief Engineer may temporarily limit the amount of Source Water made available to the Demonstration Project.

b. Source Water Delivery Facilities:

   i. Construction: Within two years after the Effective Date, the Sanitation District shall complete any necessary permitting and design and construct all facilities necessary to deliver Source Water to the Demonstration Project ("**Source Water Delivery Facilities**"). In addition, the Sanitation District shall design and construct any other facilities necessary to provide the tie-ins at the Joint Plant ("**Tie-In Facilities**") for the Ancillary Facilities specified in Section A1.c.i. The Sanitation District shall be responsible for the costs of these permitting, design and construction activities, except to the extent they are covered by other entities.

   ii. Ownership and Operation: The Sanitation District shall be the sole owner of the Source Water Delivery and Tie-In Facilities and shall operate and maintain these facilities for the duration of the Agreement Term. The Sanitation District shall be responsible for all costs associated with operation and maintenance of the Source Water Delivery and Tie-In Facilities.

   iii. Permits and Authorizations: Sanitation District shall obtain any permits, authorizations needed to construct and operate the Source Water Delivery and Tie-In Facilities and shall comply with all laws, rules and regulations applicable to the construction and operation of such facilities. Metropolitan shall cooperate with Sanitation District in securing such permits, authorizations and approvals.

A3. Distribution and Use of Purified Water

a. Metropolitan shall convey all Purified Water produced by the Demonstration Project to a suitable location within the Joint Plant, as determined by the Sanitation District prior to commencement of Final Design for the project. The Sanitation District shall be responsible for any subsequent distribution, use or disposal of the Purified Water, and will be entitled to any revenues resulting from that distribution, use, or disposal. The Sanitation District shall obtain and maintain any permits necessary to distribute or use Purified Water from the Demonstration Project.

b. The Sanitation District is not obligated to use any Purified Water, and any Purified Water that is not utilized for non-potable reuse applications will be disposed at the Joint Plant at no cost to Metropolitan.

c. Metropolitan makes no representations, warranties or guarantees of any kind as to the quantity or quality of Purified Water produced by the Demonstration Project.

A4. Disposal of Treatment Residuals

a. The Sanitation District shall be responsible for disposal of any residuals generated by the treatment of Source Water at the Demonstration Project ("**Treatment Residuals**"), including membrane filtration backwash, reverse osmosis brine concentrate and other waste streams (such as acids, anti-scalants, dispersants, and membrane cleaning agents). Metropolitan shall return all Treatment Residuals to a suitable location at the Joint Plant, as determined by the Sanitation District prior to commencement of Final Design for the project.

b. Connection of the Demonstration Project to the Joint Plant for purposes of disposing of Treatment Residuals will not be considered a sewer connection. The Sanitation District shall not assess or collect from Metropolitan any charge or fee of any kind associated with the disposal of Treatment Residuals.

A5. Laboratory Analyses and Data Sharing

a. The Parties shall jointly conduct sampling and laboratory analyses as necessary to monitor and determine the treatment efficacy of the Demonstration Project. The Sanitation District shall be responsible for all sampling and laboratory analyses upstream of the Demonstration Project and Metropolitan shall be responsible for all sampling laboratory analyses within and downstream of the Demonstration Project. If potential cost savings and efficiencies would result from further collaboration on sampling or laboratory analyses, the Parties will meet and confer to determine if a revised division of responsibilities is warranted.

b. The Parties shall share all water quality and process data associated with operation of the Joint Plant and the Demonstration Project during the Agreement Term.

A6. Development of Full-Scale Project Requirements

a. Source Water Criteria: The Parties acknowledge the importance of establishing and maintaining Source Water flow and quality to ensure the long-term success of the Program. Accordingly, the Parties shall meet and confer to develop water quality and flow criteria for the Source Water that will ensure continuous and cost effective treatment at any Full-Scale Project facilities constructed during subsequent phases of the Program. The Parties also shall meet and confer to develop appropriate enhancements to the Sanitation District's industrial wastewater pretreatment program aimed at controlling the entry of contaminants into the Source Water.

b. Additional Studies and Evaluations: The Parties shall cooperate with each other in conducting and preparing any additional studies, evaluations and plans necessary to assess the economic and technical feasibility, financing needs, right-of-way and permitting requirements, environmental and regulatory compliance obligations, and engineering, construction and operational specifications for the Full-Scale Project ("**Additional Studies and Evaluations**"). Unless agreed otherwise, each Party shall be solely responsible for the costs of any Additional Studies and Evaluations it conducts or prepares.

A7. Pursuit of Grant and Loan Funding: The Parties shall jointly pursue grant and loan funding in support of the Demonstration Project. Any grant and loan funding received will be distributed based on the percentage of Demonstration Project facility design and construction costs contributed by each Party in support of the Demonstration Project, not including any fees waived or in-kind services provided by either Party.

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EXHIBIT B

PROPOSED TERMS AND CONDITIONS APPLICABLE TO THE FULL-SCALE PROJECT

B1. Construction and Operation of Treatment Facilities

a. Location: The Parties shall agree upon a suitable location within the boundaries of the Joint Plant for construction and operation of the Full-Scale Project ("**Full-Scale Project Site**") up to 35 acres. Subject to a separate Full-Scale Project ground lease agreement, the Full-Scale Project Site property will be leased to Metropolitan for the following rent: (i) First Year of Lease -- $5,000 per acre in 2015 dollars, adjusted using the Los Angeles-Riverside-Orange County Consumer Price Index for All Urban Consumers or the equivalent successor index ("**CPI**") to the effective date of the lease ("**Base Rent**"); (ii) Subsequent Years of Lease -- Base Rent adjusted annually for inflation using the CPI, but in no event will the adjustment ever be less than zero. The term of the Full-Scale Project ground lease will begin when the construction of the Full-Scale Project commences.

b. Capacity: The Full-Scale Project is anticipated to have the capacity to produce approximately 150 MGD of Purified Water at full build out. Prior to the commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree upon the maximum capacity for that phase. However, the exact design and configuration of each phase will be determined by Metropolitan in its sole discretion.

c. Construction:

i. Metropolitan shall design and construct the Full-Scale Project, which may include the following unit processes: ozone, biological granular activated carbon, microfiltration, membrane bioreactor, reverse osmosis, advanced oxidation processes (e.g., hydrogen peroxide, ultraviolet light), ion-exchange and nitrogen removal (e.g., nitrification and denitrification). Metropolitan shall design and construct any power feeds, raw water supply lines, waste stream lines, and other process lines required for the Full-Scale Project ("**Ancillary Facilities**") either from suitable tie-in locations at the Joint Plant (for Source Water and Treatment Residuals) or directly from utility providers (for potable water, power, and any other utilities). The Parties shall agree upon tie-in locations for the Ancillary Facilities prior to the commencement of Final Design. Metropolitan shall be responsible for the costs of these design and construction activities, except to the extent they are covered by other entities.

ii. The Parties acknowledge that the property potentially available for the Full-Scale Project Site has been undergoing remediation. Prior to the commencement of construction activities for the first phase of the Full-Scale Project, Metropolitan shall make reasonable efforts to determine the extent to which any hazardous wastes and material ("**Hazardous Wastes**") or contaminated soil or groundwater

("**Contamination**") will be impacted by construction. The Parties shall meet and confer to develop an approach to mitigating the condition as cost-effectively as possible. However, unless the Parties agree otherwise, the Sanitation District shall be responsible for removing, disposing and/or treating all pre-existing Hazardous Wastes and Contamination and for remediating the site as needed to permit construction of the Full-Scale Project. Any delays caused by or resulting from these removal or remediation activities will not be considered a breach of this Agreement. Metropolitan shall be responsible for removal, disposal and/or treatment of all other wastes, deposited, produced, or generated during construction of the Full-Scale Project.

d. Ownership and Operation:

   i. Metropolitan will be the owner of the Full-Scale Project, including any Ancillary Facilities, and shall operate and maintain them for the duration of the Program, which is anticipated to have minimum of duration of fifty years. Except as provided otherwise, Metropolitan shall be responsible for all costs associated with operation and maintenance of the Full-Scale Project and Ancillary Facilities.

   ii. In the event that the Full-Scale Project is not able to operate for any reason, Metropolitan shall divert untreated Source Water back into the Joint Plant for disposal. Metropolitan shall give the Sanitation District reasonable notice before taking any such action.

e. Removal of Full-Scale Project: At the conclusion of the Program, the Sanitation District may purchase the Full-Scale Project including any Ancillary Facilities for their salvage value, as determined by an independent appraisal. If the Sanitation District does not purchase these facilities, then within five years after notice from the Sanitation District, Metropolitan shall remove all facilities and improvements constructed by Metropolitan associated with the Full-Scale Project and Ancillary Facilities and return the Full-Scale Project Site to its pre-project condition.

f. Permits and Authorizations: Metropolitan shall obtain any and all permits, authorizations, and approvals needed to construct and operate the Full-Scale Project and Ancillary Facilities, and shall comply with any and all laws, rules and regulations applicable to the construction and operation of the Full-Scale Project and Ancillary Facilities. The Sanitation District shall cooperate with Metropolitan in securing such permits, authorizations, and approvals.

g. Utilities: Except for the provision of Source Water as set forth in Section B2, the disposal of treatment residuals as set forth in Section B4, and sewer services, Metropolitan shall be responsible for providing any and all utility connections and services needed to construct and operate the Full-Scale Project, including power, potable water, and solid waste collection services.

h. Right of Inspection: Upon reasonable notice, the Sanitation District may enter the Full-Scale Project Site for the purpose of inspecting construction or operations.

B2. Provision of Source Water

a. General Obligation: The Sanitation District shall provide, at no cost to Metropolitan, secondary effluent from the Joint Plant ("**Source Water**") in an amount sufficient to meet the treatment capacity for each phase of the Full-Scale Project as constructed. The provision of Source Water is subject to execution of a separate supply Full-Scale Project agreement ("**Source Water Supply Agreement**") consistent with this Agreement.

b. Source Water Criteria:

i. Prior to the commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree upon the water quality and flow criteria that will apply to any Source Water delivered to the project during that phase ("**Source Water Criteria**"). Once these Source Water Criteria are established, the Sanitation District shall not make any changes in the Joint Plant's facilities, operations or design that may significantly adversely affect the quality or quantity of Source Water, unless required to meet regulatory or other legal requirements. The Parties shall meet and confer in good faith to determine appropriate actions if changes are required. In addition, the Sanitation District shall not enter into any agreement to provide secondary-treated effluent from the Joint Plant to another entity or project that could significantly reduce the amount of Source Water available to the Full Scale Project without the consent of Metropolitan.

ii. Metropolitan acknowledges that circumstances beyond the control of the Sanitation District may adversely impact the quality or volume of Source Water available to the Full-Scale Project. If any such circumstances occur, the Sanitation District's Chief Engineer may temporarily limit the amount of Source Water made available to the Full-Scale Project. The Sanitation District shall use its best efforts, including modifying Joint Plant operations, to re-establish the availability of Source Water meeting the agreed-upon Source Water Criteria as soon as reasonably possible. In the event of a decrease in availability of Source Water, the Chief Engineer shall promptly notify Metropolitan.

iii. The Sanitation District will not be liable for any costs or damages incurred by Metropolitan arising out of or relating to any temporary interruption in service or limitation of availability of Source Water ("**Temporary Interruption**") due to either decreased influent flows, operation difficulties, or an inability of the Sanitation District to meet NPDES requirements. Metropolitan hereby releases and covenants not to sue the Sanitation District from or for any and all claims and actions arising out of a Temporary Interruption.

c. Source Water Facilities

i. Construction: The Sanitation District shall permit, design and construct all facilities necessary to provide the tie-ins at the Joint Plant ("**Tie-In Facilities**"), as specified in section B1.c.i. The Sanitation District shall be responsible for the costs of these permitting, design and construction activities, except to the extent they are covered by other entities.

ii. Ownership and Operation: The Sanitation District shall be the sole owner of the Tie-In Facilities and shall operate and maintain these facilities for the duration of the Program. The Sanitation District shall be responsible for all costs associated with operation and maintenance of the Tie-In Facilities.

iii. Permits and Authorizations: Sanitation District shall obtain any permits, authorizations and approvals needed to construct and operate the Tie-In Facilities and shall comply with all laws, rules and regulations applicable to the construction and operation of such facilities. Metropolitan shall cooperate with Sanitation District in securing such permits, authorizations and approvals.

d. Source Water Control Program: Prior to commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree on a program for controlling the entry of contaminants into the Source Water delivered to the Full-Scale Project during that phase.

e. Acceptance of Non-Specification Source Water: The Sanitation District shall immediately notify Metropolitan if for any reason the Sanitation District is, or anticipates that it will be, unable to meet the Source Water Criteria agreed to by the Parties pursuant to section B2.b above in the Source Water delivered to Metropolitan (**"Non-Specification Source Water"**). Metropolitan shall use reasonable efforts to accept Non-Specification Source Water for treatment at the Full-Scale Project. However, Metropolitan may reject any Non-Specification Source Water if Metropolitan determines based on its sole judgment that such Source Water may cause significant damage to the Full-Scale Project or cannot be treated to applicable standards in a cost-effective manner.

B3. Distribution and Use of Purified Water:

a. Metropolitan Rights and Responsibilities: Except as otherwise set forth in this Section B3, Metropolitan shall be responsible for and have discretion over any distribution, use or disposal of all Purified Water.

b. Sanitation District Allocation: Metropolitan shall provide Purified Water to the Sanitation District (**"District Allocation"**) at no cost based on the treatment capacity of the Full-Scale Project as follows:

i. 0 to 60 MGD: 600 acre-feet per year (AFY);

ii. 61 to 100 MGD: 1,200 AFY;

iii. 101 to 150 MGD: 1,800 AFY.

c. Delivery: Metropolitan shall deliver the District Allocation to groundwater basins within the Sanitation District's Joint Outfall service area where Metropolitan has facilities suitable for this purpose. The District Allocation will be delivered together with Metropolitan's distribution of Purified Water. The allocation between groundwater basins is at the Sanitation District's discretion. Any agreements for the replenishment use of the District's Allocation are the responsibility of the Sanitation District.

d. Participation within Sanitation District Service Area: [SUBJECT TO FURTHER NEGOTIATION]

e. Option: The Sanitation District has option to purchase up to 1 MGD of additional Purified Water at Metropolitan's cost of treatment for Joint Plant uses. Joint Plant uses include those uses identified and implemented during the Demonstration Project. Delivery and use of Purified Water under this option is the responsibility of the Sanitation District.

B4. Disposal of Treatment Residuals

a. The Sanitation District shall be responsible for disposal of any residuals generated by the treatment of Source Water at the Full-Scale Project, including membrane filtration backwash, reverse osmosis brine concentrate and other waste streams (such as acids, anti-scalants, dispersants, and membrane cleaning agents), in accordance with all applicable laws, rules and regulations.

b. Prior to the commencement of Final Design for each phase of the Full-Scale Project, the Parties shall agree to the quantity and quality of Treatment Residuals to be disposed at the Joint Plant during that phase. If the anticipated quantity and quality of Treatment Residuals would interfere with the Sanitation District's ability to discharge its Joint Plant waste streams in compliance with applicable laws, rules and regulations, the Parties shall agree to meet and confer to develop actions within their respective treatment operations to ensure such compliance.

c. Metropolitan shall return all Treatment Residuals to suitable locations at the Joint Plant, as determined by the Sanitation District prior to commencement of Final Design for the project.

d. As needed, Metropolitan will treat non-brine components of Treatment Residuals to standards generally applicable to current industrial waste dischargers to the Sanitation District's Joint Outfall System.

e. Connection of the Full-Scale Project to the Joint Plant for purposes of disposing of Treatment Residuals will not be considered a sewer connection. The Sanitation District shall not assess or collect from Metropolitan any charge or fee of any kind associated with the disposal of Treatment Residuals at the Joint Plant, subject to the meet and confer provisions in B4.b.

B5. Laboratory Analyses and Data Sharing

a. The Parties shall jointly conduct sampling and laboratory analyses as necessary to monitor and determine the treatment efficacy of the Full-Scale Project. The Sanitation District shall be responsible for all sampling and laboratory analyses upstream of the Full-Scale Project and Metropolitan shall be responsible for all sampling laboratory analyses within and downstream of the Full-Scale Project. If potential cost savings and efficiencies would result from further collaboration on sampling or laboratory analyses, the Parties shall meet and confer to determine if a revised division of responsibilities is warranted.

b. The Parties shall share all water quality and process data associated with operation of the Joint Plant and the Full-Scale Project during the term of the Program.

B6. Pursuit of Grant and Loan Funding: The Parties shall jointly pursue grant and loan funding in support of the Full Scale Project. Any grant and loan funding received will be distributed based on the percentage of Full Scale Project facility design and construction costs contributed by each Party in support of the Full Scale Project, not including any fees waived or in-kind services provided by either Party. Each Party may, upon 10 days notice, inspect the Program-related books and records of the other Party.

APPENDIX C:

Extended Writeup for Groundwater Basin Analysis

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FIGURES

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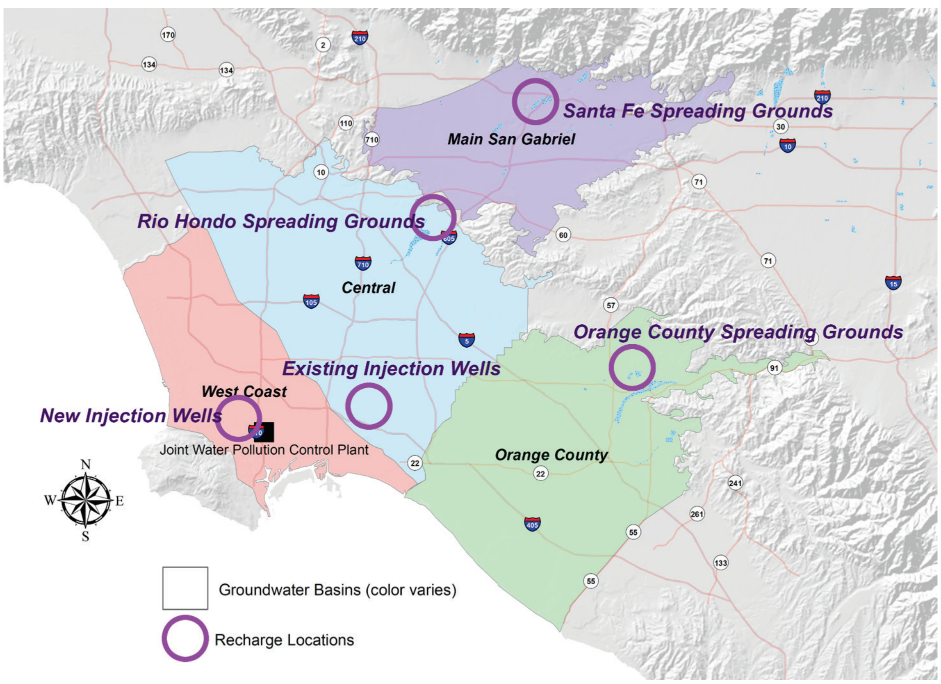
INTRODUCTION

This appendix provides a description of the base case pertaining to recharge and extraction in the groundwater basins. Topics in this appendix include a detailed description of the groundwater basins, demand analysis, groundwater modeling, and facility requirements in support of the 150-mgd (168,000 AFY) base case scenario. The scope of this analysis does not include water quality analyses at this time. Future work will include water quality analysis.

Figure C.1 shows the groundwater basins that are included in this study (i.e., Central Basin, West Coast Basin, Main San Gabriel Basin, and Orange County Basin). It also identifies proposed locations for recharge that will be discussed later in this chapter. These basins were selected based upon proximity to the Joint Water Pollution Control Plant and the ability of these basins to accommodate up to 150 mgd (168,000 AFY) of recharge. Other basins such as Chino Basin and Raymond Basin may be added to the program in the future.

Figure C.1: Groundwater Basins included in Analysis



BASINS BACKGROUND

General

The following section provides a description of the recharge facilities and groundwater basins that are proposed as part of this feasibility study. Topics include: description of the adjudications, hydrogeologic setting, and a brief description of issues within each basin.

Existing Recharge Facilities

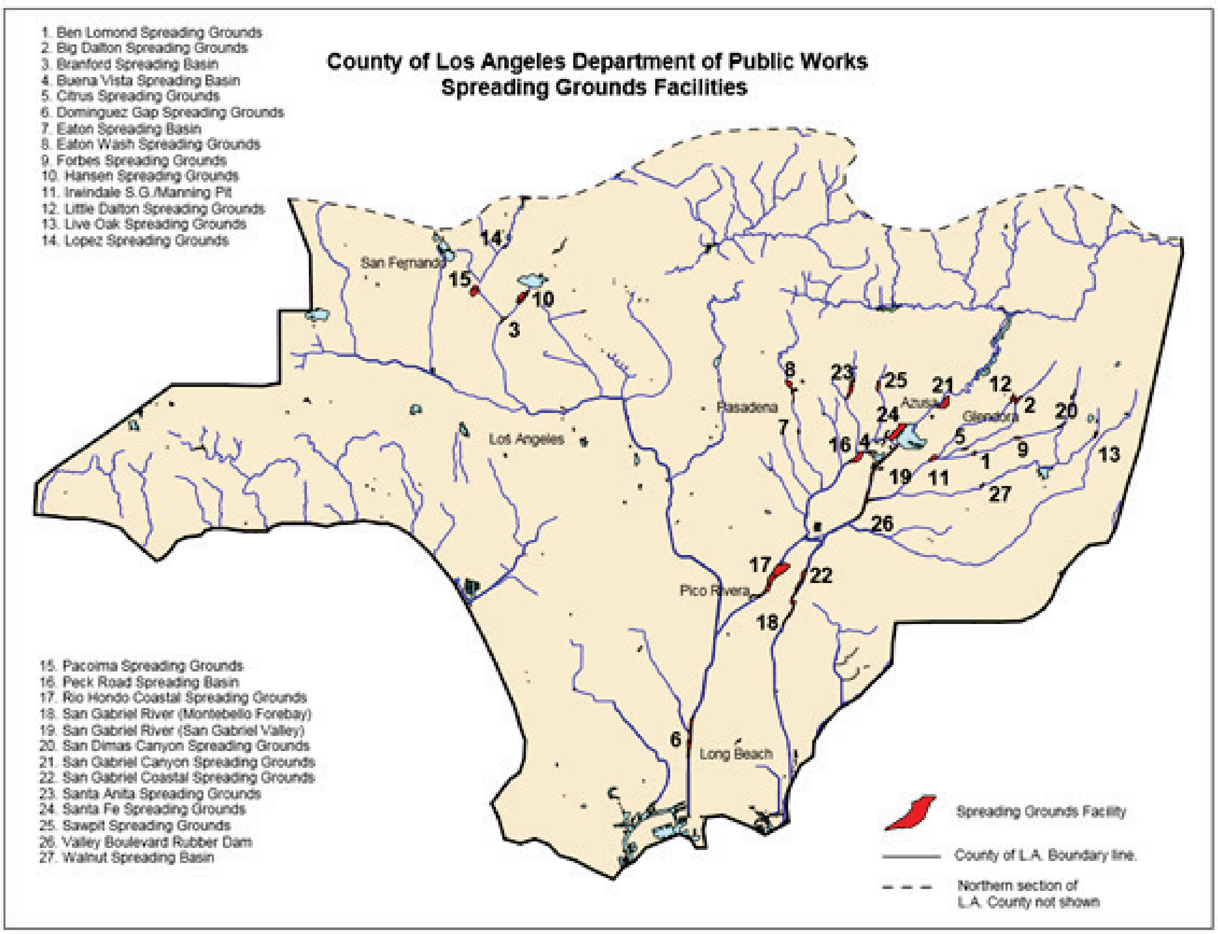
There are various existing networks of recharge facilities that collect and spread storm flows, imported water, and recycled water to replenish underlying groundwater basins. The study area encompasses facilities primarily operated by the County of Los Angeles Department of Public Works and the Orange County Water District.

County of Los Angeles Department of Public Works

The County of Los Angeles Department of Public Works (LACDPW) performs the duties of the Los Angeles County Flood Control District, which was formed to control and conserve flood, storms, and other waters.

LACDPW artificially recharges the groundwater supply aquifers underlying the Los Angeles County by spreading imported water, local runoff (including the water impounded by the upstream dams during storms), and recycled water at their 27 spreading facilities (**Figure C.2**). The spreading facilities are located throughout Los Angeles County along the main water courses and some of their tributaries. Imported and recycled water discharged into these channels and runoff resulting from storm events are diverted into the spreading facilities and allowed to percolate down to the water table. The water can then be pumped up to the surface for water supply purposes by the respective water supply agencies.

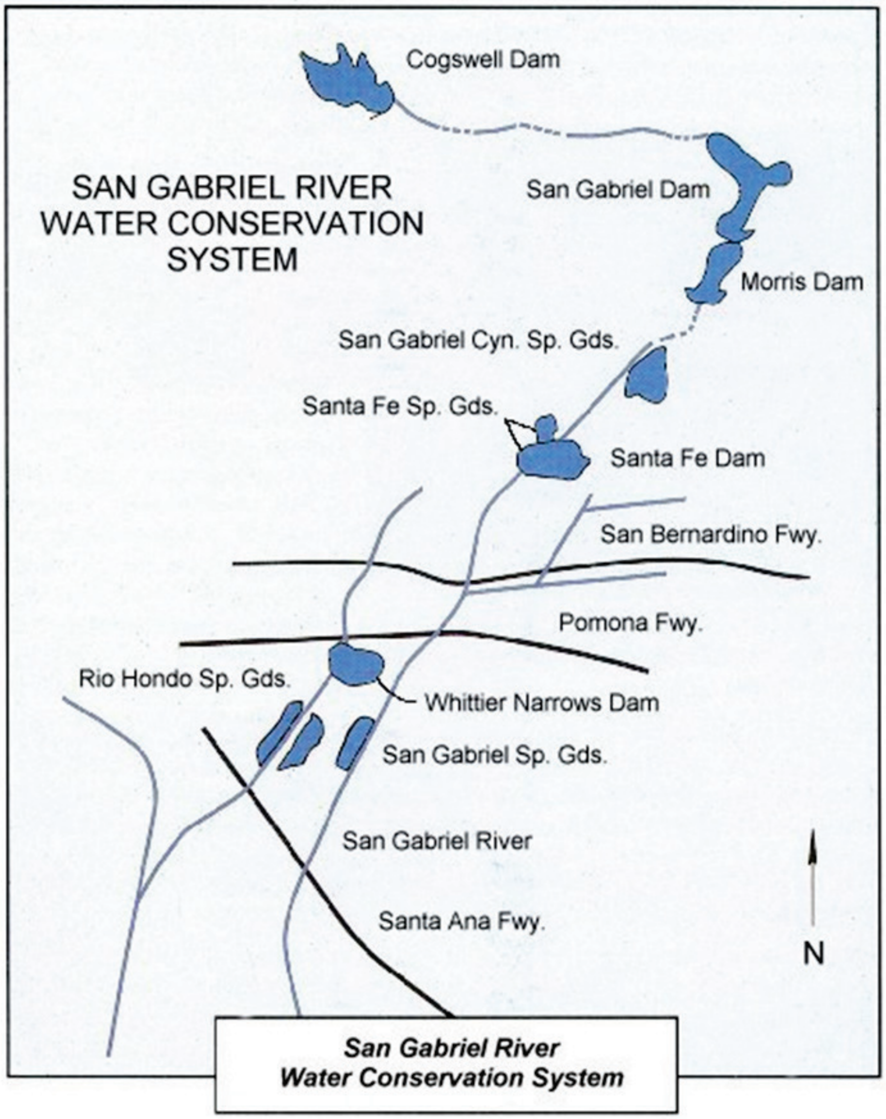
Figure C.2: LACDPW Spreading Basins



Source: LACDPW Website

The study area includes LACDPW's major spreading facilities located downstream of the San Gabriel Canyon and in the Montebello Forebay area. These facilities currently contribute the majority of water artificially recharged to the County's various aquifers. The major facilities in this system are shown in **Figure C.3**.

Figure C.3: San Gabriel River Water Conservation System



Source: LACDPW – The San Gabriel River and Montebello Forebay Water Conservation Study

The San Gabriel River and Montebello Forebay Water Recharge System

When San Gabriel River water is released from the canyon facilities (Cogswell Dam, San Gabriel Dam, Morris Dam, and the San Gabriel Canyon Spreading Grounds), it flows to the Santa Fe Dam, a compacted earth-fill dam owned by the U.S. Army Corps of Engineers (Corps). In the upper portion of the impoundment area above the dam is the Santa Fe Spreading Grounds. This spreading facility, which LACDPW operates under license from the Corps, which covers 168 wetted acres and 22 separate spreading basins, can percolate approximately 400 cubic feet per second continuously, has a storage capacity of 540 acre-feet, and currently recharges an annual average of 26,900 acre-feet to the Main San Gabriel Basin. The spillway area of the Santa Fe Dam and the San Gabriel River have additional, largely unused, capacity. A rubber dam is used to direct flows from the San Gabriel River into the Santa Fe Spreading Grounds. The San Gabriel River downstream of Santa Fe Dam was constructed as a soft bottom channel to promote infiltration of water released from the dam during large storms or for spreading.

A rubber dam, built in 1994, is located in the San Gabriel River near Valley Boulevard. This rubber dam creates a 76-acre, 495 acre-foot spreading facility within the San Gabriel River and Walnut Wash.

The Whittier Narrows Dam, also owned by the Corps, captures water flowing in the San Gabriel River and Rio Hondo Channel. Whenever the primary objective of flood control is not compromised, controlled released of water from Whittier Narrows Dam continue to LACDPW's Coastal Plain spreading grounds.

In addition to spreading stormwater, the spreading basins also recharges imported water from Metropolitan in cooperation with the Main San Gabriel Basin Watermaster and the Central and West Basin Municipal Water Districts. Another agency that provides imported State Water Project water for spreading is the San Gabriel Valley Municipal Water District, which has its own delivery pipeline. About 75,000 acre-feet of untreated imported water purchased by local water agencies are spread annually at this location.

A further aspect of the current ongoing water recharge program is spreading recycled water from facilities such as Whittier Narrows, San Jose Creek, and Pomona Water Reclamation Plants owned by the Sanitation Districts of Los Angeles County. Planned replenishment using recycled water has been practiced in the Montebello Forebay area since 1962. Currently, about 50,000 acre-feet of recycled water is spread each year on behalf of the Water Replenishment District of Southern California. Plans are under way to spread up to 10,000 acre-feet of recycled water in the San Gabriel River below Santa Fe Dam on behalf of the Upper and San Gabriel Valley Municipal Water Districts.

Montebello Forebay Facilities

Montebello Forebay, located just south of Whittier Narrows, is a valuable area for groundwater recharge due to its highly permeable soils which allow deep percolation of surface waters. Located within the Forebay are the:

- Rio Hondo Coastal Basin Spreading Grounds
- San Gabriel Coastal Basin Spreading Grounds
- Lower San Gabriel River spreading area

Current operations at these recharge facilities conserve an average of approximately 150,000 acre-feet of local, imported, and reclaimed water annually.

The Rio Hondo Coastal Basin Spreading Grounds, LACDPW's largest spreading facility, cover about 570 acres (430 acres wetted), percolates at around 400 cubic feet per second, has a storage capacity of about 3,700 acre-feet, and currently recharges an annual average of about 35,000 acre-feet to the Central Basin. Water is diverted from the Rio Hondo Channel by use of three large radial gates.

The San Gabriel River Coastal Basin Spreading Grounds, totaling 128 acres in size (96 acres wetted), has a percolation rate of 75 cubic feet per second, and storage capacity of about 550 acre-feet. Located at the headworks of the spreading grounds is an inflatable rubber dam used to divert flows to the grounds or regulate releases downstream.

The lower San Gabriel River, from Whittier Narrows Dam to Florence Avenue, also allows spreading by percolation (75 cubic feet per second) through its unlined bottom (153 acres wetted). Five inflatable rubber dams were installed in the 1980's to increase spreading capacity along this portion of the river (storage capacity of about 1,000 acre-feet). Combined, the San Gabriel River Coastal Basin Spreading Grounds and the Lower San Gabriel River Rubber Dams recharges an annual average of about 25,800 acre-feet to the Central Basin.[1]

Potential Future Facilities

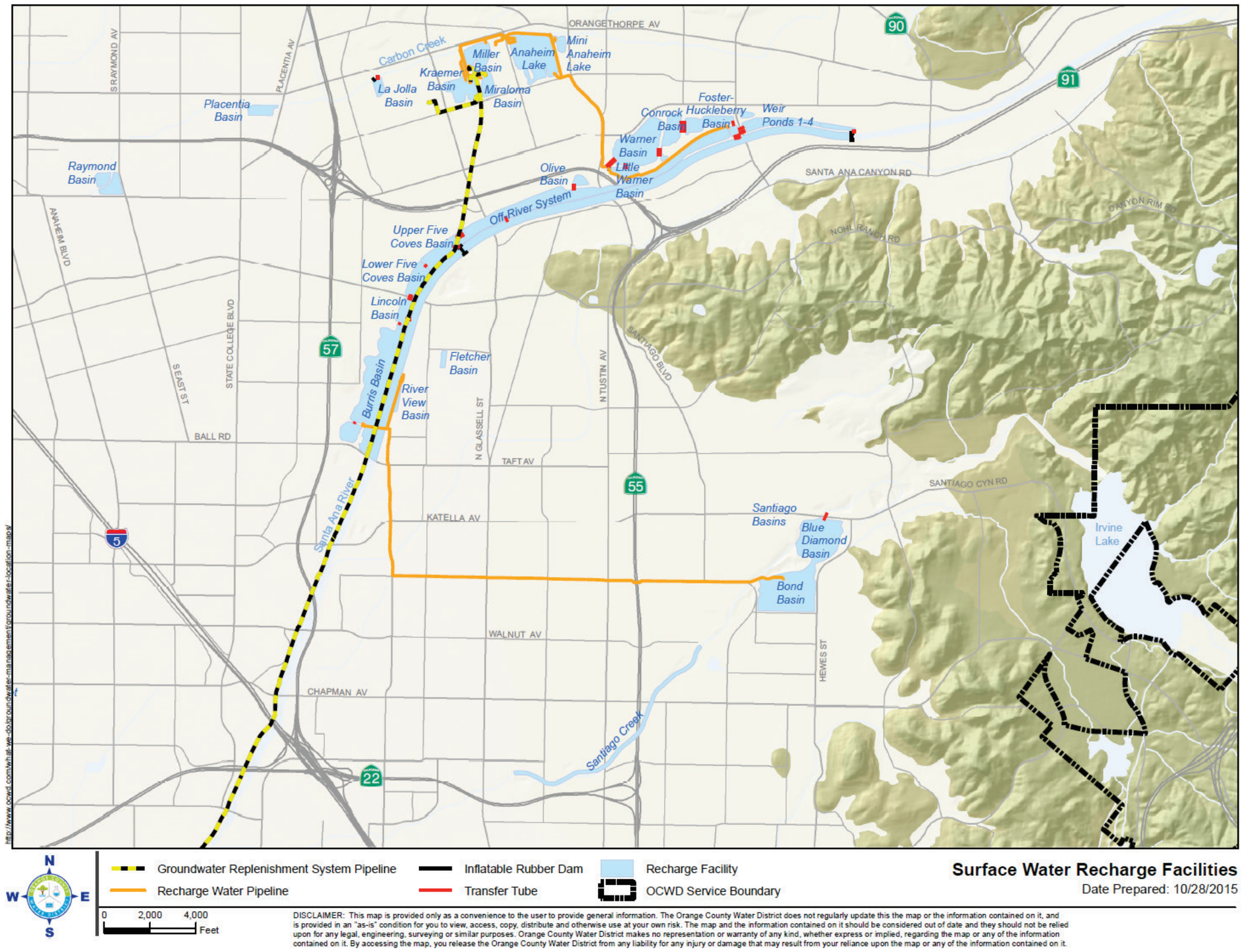
Additional storage or recharge opportunities include purchasing nearby properties, such as gravel pits, and installing additional rubber dams within the existing facilities to meet operational storage needs of the program.

Orange County Water District

Orange County Water District's (OCWD's) surface water recharge system is currently composed of 25 facilities covering over 1,000 wetted acres and a total storage capacity of approximately 26,000 acre-feet (**Figure C.4**). Total recharge capacity of these facilities is about 400 mgd. Sources of recharge include: Santa Ana River, recycled water from the GWRS facility, imported water, and precipitation. Total recharge to the Orange County Basin is an average of over 230,000 AFY. OCWD carefully tracks the amount of water being recharged in each facility on a daily basis.

[1] LACDPW San Gabriel River and Montebello Forebay Water Conservation Study

Figure C.4: Map of OCWD Recharge Facilities

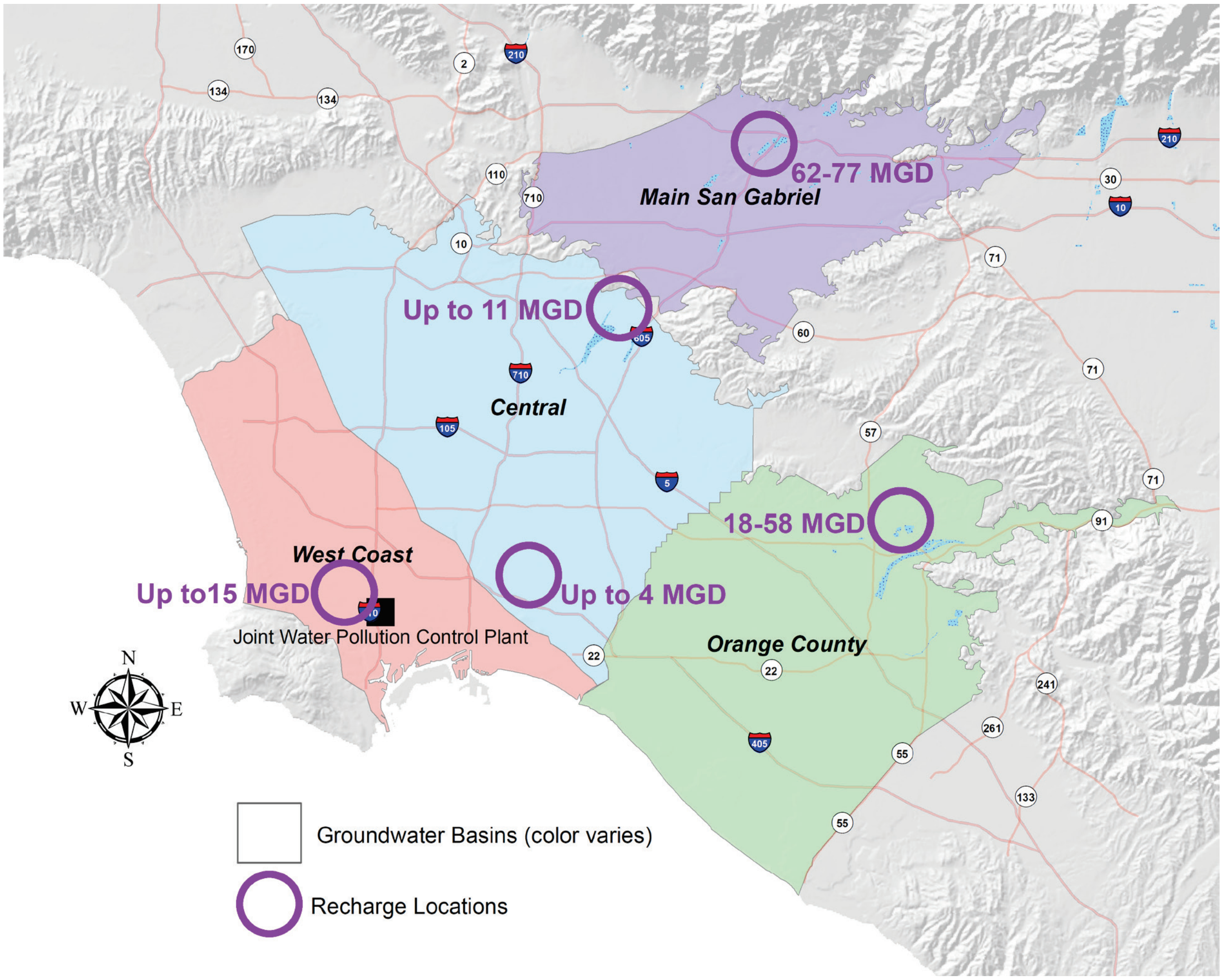


Source: OCWD Groundwater Management Plan, 2015.

Groundwater Basins

Figure C.5 shows the groundwater basins that are included in this study, which are Central Basin, West Coast Basin, Main San Gabriel Basin, and Orange County Basin

Figure C.5: Groundwater Basins included in Project



Central Basin

The Central Basin lies within central Los Angeles County, California. It underlies the service areas of Metropolitan member agencies Central Basin Municipal Water District (Central Basin MWD), West Basin Municipal Water District (West Basin MWD), the City of Compton, the City of Los Angeles, and the City of Long Beach. It includes the cities of Artesia, Bellflower, Cerritos, Compton, Downey, Huntington Park, Lakewood, Los Angeles, Long Beach, Montebello, Paramount, Pico Rivera, Norwalk, Santa Fe Springs, Signal Hill, South Gate, Vernon and Whittier. A map of the Central Basin is provided in **Figure C.5**

Hydrogeologic Setting

The Central Basin is bounded on the northeast and east by the Elysian, Repetto, Merced and Puente Hills. The southeast boundary is along Coyote Creek, which is used to separate it from the Orange County Basin, although no physical barrier between the two basins. The southwest boundary is formed by the Newport Inglewood fault system. The hydrogeologic parameters of the Central Basin are summarized in **Table C.1 and Figure C.6.**

Table C.1: Summary of Hydrogeologic Parameters of Central Basin

Parameter	Description
Structure	
Aquifer(s)	Forebay areas (unconfined) Pressure area (confined) Alluvium (Gaspur and Semi-perched aquifers) Lakewood Formation (Gardena and Gage aquifers) San Pedro Formation (Lynwood, Silverado, and Sunnyside aquifers)
Depth of groundwater basin	Forebay areas – up to 1,600 feet Pressure area – up to 2,200 feet
Thickness of water-bearing units	Alluvium (up to 180 feet) Lakewood Formation (up to 280 feet) San Pedro Formation (up to 800 feet)
Yield and Storage	
Natural safe yield	125,805 AFY
Allowable Pumping Allocation and Managed Safe Yield	217,367 AFY
Total Storage	13.8 million AF

Source: WRD, 2006a and WRD, 2006e

The depth of the Central Basin ranges from 1,600 to over 2,200 feet. The main potable production aquifers include the deeper aquifers of the San Pedro Formation (including from top to bottom, the Lynwood, Silverado and Sunnyside aquifers), which generally correlate with the Main and Lower San Pedro aquifers of Orange County. The shallower aquifers of the Alluvium and the Lakewood Formation (including aquifers Gaspur, Exposition, Gardena-Gage, Hollydale, and Jefferson) locally produce smaller volumes of potable water. In the northern portions of the Central Basin, referred to as the Forebay area, many of these aquifers are merged and allow for direct recharge into the deeper aquifers. In the area referred to as the Pressure Area, these aquifers are separated and create confined aquifer conditions. The underlying aquifers are protected from surface contamination by thick aquitards.

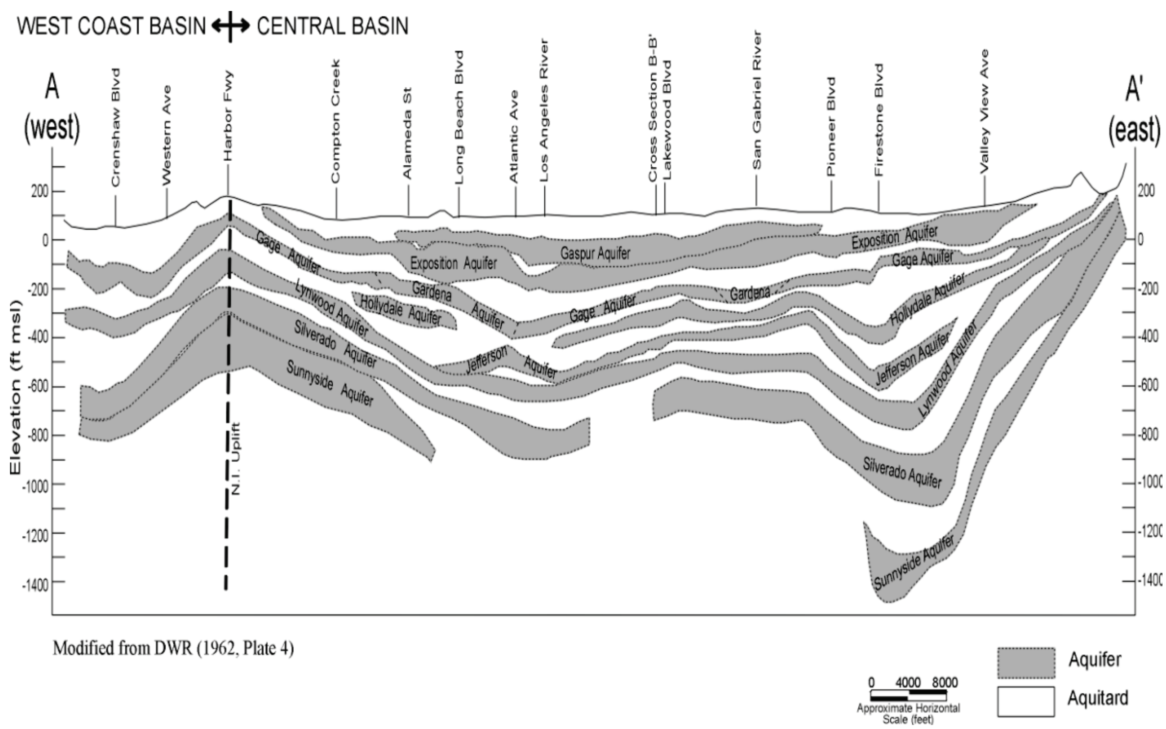
Central Basin receives inflow from the San Fernando Basin via the Los Angeles River (Los Angeles Forebay). The Los Angeles Forebay was historically a recharge area for the Los Angeles River. This forebay's recharge capacity has been substantially reduced since the river channel was lined. Recharge is now limited to deep percolation of precipitation, in-lieu when available, and subsurface inflow from the Montebello Forebay to the east, the Hollywood Basin and relatively small amounts from the San Fernando Valley through the Los Angeles Narrows.

The Montebello Forebay, located in the northeastern portion of the Central Basin, connects the Main San Gabriel Basin to the north with the Central Basin via the Whittier Narrows. The Rio Hondo and San Gabriel River spreading grounds in the forebay provide the vast majority of surface recharge to the Central Basin aquifers. Judgment in Case No. 722647 entered in September 1965 provides an adjudication of Upper and Lower Areas on the San Gabriel River. The San Gabriel River Watermaster prepares an annual Watermaster Report providing an accounting of water received, credits, and make-up water.

The Newport Inglewood Uplift separates the Central Basin from the West Coast Basin. Groundwater moves across the uplift, but its movement is slow and restricted because of low permeability sediments and offset of aquifers along the fault.

The boundary with Orange County Basin is not a barrier to flow. Therefore, water can flow between the two basins.

Figure C.6: Generalized Cross Section of Central Basin



Source: WRD, 2006

Total storage in the Central Basin is estimated to be approximately 13.8 million AF.

Existing Facilities and Locations

Wells

There are approximately 501 production wells in the Central Basin. Of the wells identified, 333 of these are active and 168 are inactive. Poor water quality is the primary reason for inactive wells (Central Basin Watermaster, 2015). In addition, there are currently four ASR wells owned by the City of Long Beach in Central Basin. The combined extraction capacity of the four wells is estimated to be at least 4,333 AFY. Injection capacity of the ASR wells is estimated to exceed 3,250 AFY.

Spreading Basins

There are currently three primary spreading areas, covering more than 1,000 acres within the Central Basin. The gross capacity of the spreading areas is nearly 550 cfs but is limited by mounding and other factors. LACDPW spreads imported water from Metropolitan and recycled water on behalf of WRD for recharge in the Central Basin. The Regional Board permit for recharge of recycled water limits recycled water spreading to no more than 45 percent of the total inflow to the forebay on a 10-year average.

Seawater Intrusion Barriers

The Alamitos Barrier Project consists of 43 wells with a combined injection capacity of 15 cfs and four extraction wells in the Alamitos Gap in Long Beach (DWR, 2005; WRD, 2006d). The barrier utilizes imported water purchased from the City of Long Beach or recycled water from WRD's Leo J. Vander Lans Advanced Water Treatment Facility that went on-line in 2006 and provided recycled water to the barrier project.

Governance Structure

The Central Basin is an adjudicated basin. It was adjudicated in October 1965 with adjudicated rights set at 267,900 AFY (WRD, 2006f). The amount of the adjudicated water rights that can be pumped each year (Allowable Pumping Allocation, or APA) is limited to approximately 80 percent of the total adjudicated amount (217,367 AFY).

Description of Adjudication

As discussed above, the Judgment APA is 217,367 AFY. However, natural recharge does not support this annual amount of pumping, and the APA exceeds the natural safe yield of the basin and is dependent upon artificial recharge of imported and reclaimed water. Each year WRD makes a determination of the amount of supplemental recharge that is needed based on an estimation of the ensuing year's groundwater production and an estimation of the annual change in storage based on groundwater levels collected throughout the basin.

In 2009, motions were filed in court to amend both basin Judgments to allow additional water Storage. The amendments include provisions that would allow implementation of water Augmentation projects whereby recharge and extraction volumes could be matched within an Established timeframe that would allow pumping beyond adjudicated rights, essentially increasing the recharge and extraction capacities of the basins. The Judgment amendment allows for increased optimization of the West Coast Basin and Central Basin operations and provides for a more reliable and cost-effective water supply for the region.

In December 2013, the Central Basin Judgment was amended, declaring water rights and providing provisions for the storage and extraction of stored water. The amendment enables large-scale changes in the management practices within the basin, which are expected to enhance opportunities to develop recycled water for recharge and improve the capability to utilize the basin's storage for conjunctive use. "Conjunctive use" refers to coordinating the management of surface water and groundwater to improve the overall reliability of water supply (Pacific Institute, 2011).

As a result of the Judgment amendment, the Watermaster is now comprised of three constituent entities: 1) Administrative Body, 2) Water Rights Panel, and 3) Storage Panel. WRD was designated as the Administrative Body is responsible for preparing the annual *Watermaster Service* reports and submitting them to the Water Rights Panel. The Water Rights Panel (comprised of water rights holders) is responsible for enforcement of water rights and for submitting the final *Watermaster Service* report to the Superior Court of the State of California for filing. The Storage Panel, comprised of the WRD Board of

Directors and the Water Rights Panel is responsible for reviewing and approving storage and augmentation projects that require the construction of new facilities.

West Coast Basin

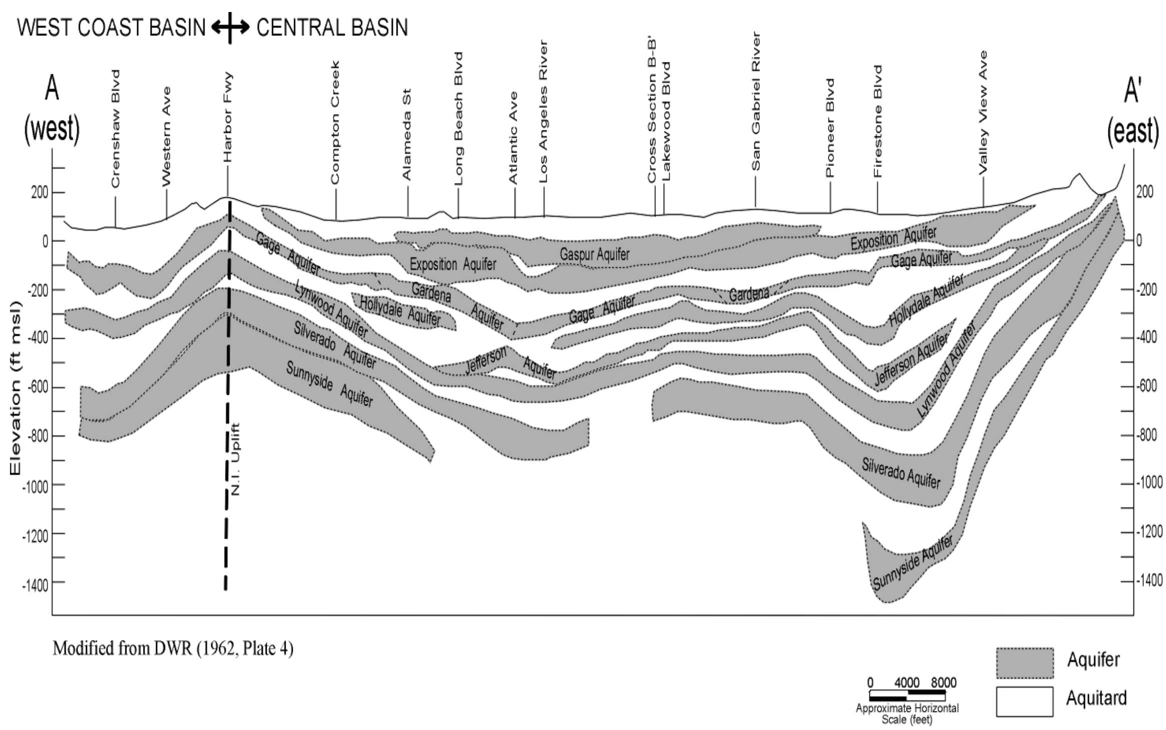
The West Coast Basin lies within western Los Angeles County, California along the coast. It overlies the service areas of Metropolitan member agencies: West Basin Municipal Water District (WBMWD), City of Los Angeles, City of Torrance, and the City of Long Beach. It includes the cities of El Segundo, Manhattan Beach, Hermosa Beach, Redondo Beach, Torrance, Inglewood, Hawthorne, Gardena, Lomita, Carson and Long Beach.

Hydrogeologic Setting

The West Coast Basin is bounded on the south and west by the Pacific Ocean, on the north by the Ballona Escarpment, on the east by the Newport-Inglewood Uplift, and on the south by the Palos Verdes Hills (DWR, 2005). Hydrogeologic parameters for the West Coast Basin are summarized in **Table C.2**.

Groundwater in the West Coast Basin is generally confined. The Silverado aquifer underlying most of West Coast Basin is the most productive aquifer in the basin. It ranges from 100 to 500 feet thick and yields 80 to 90 percent of the groundwater extracted annually (DWR, 2004). This aquifer generally correlates with the Main aquifer of Orange County. A generalized cross section is shown in **Figure C.7**. Minor yield also comes from the Gage, or "200-foot sand" aquifer and the Lynwood, or "400-foot gravel" aquifer, and from the Sunnyside, or Lower San Pedro aquifer.

Figure C.7: Generalized Hydrogeologic Cross Section of Central and West Coast Basins



Source: WRD, 2004

Table C.2: Summary of Hydrogeologic Parameters of West Coast Basin

Parameter	Description
Structure	
Aquifer(s)	Pressure area (confined) • Alluvium (Gaspur and Semi-perched aquifers) • Lakewood Formation (Gardena and Gage "200-foot sand" aquifers) • San Pedro Formation (Lynwood "400-foot gravel", Silverado, and Sunnyside aquifers)
Depth of groundwater basin	~800 to 2,000 feet
Thickness of water-bearing units	Alluvium (up to 180 feet) Lakewood Formation (up to 320 feet) San Pedro Formation (up to 1,050 feet)
Yield and Storage	
Natural safe yield	26,300 AFY (WRD, 2006e)
Adjudicated Rights	64,468.25 AFY
Total Storage	6.5 million AF

Source: WRD, 2006c and 2006e and DWR, 2004.

Total storage in the West Coast Basin is estimated to be approximately 6.5 million AF.

The Newport Inglewood Uplift is a major structural feature that acts as a partial barrier to groundwater flow between the Central and West Coast Basins. Discontinuities associated with Charnock and Overland faults in West Coast Basin also appear to affect groundwater flow (USGS, 2003). Approximately 7,100 AFY is estimated to enter the West Coast Basin from the ocean (WRD, 2006e; USGS, 2003). Most of this occurs on the seaward side of the barriers or in areas where production does not occur.

Existing Facilities and Locations

Wells

There are currently 111 municipal production wells in the West Coast Basin, 63 active wells and 48 inactive wells (DWR, 2005). There are also 761 other wells in the basin that include groundwater monitoring wells or seawater intrusion barrier wells.

Desalters

Two desalter projects are used to treat brackish groundwater trapped within the Silverado aquifer on the landward side of the West Coast Basin Barrier Project are operating within the City of Torrance: the Brewer Desalter and the Goldsworthy Desalter. An average of about 2,500 AFY has been treated by the two desalters since 2000. The Brewer Desalter was constructed by WBMWD in 1993 and is now operated by California Water Service Company. The capacity of the Brewer Desalter is 1.5 mgd. The Brewer Desalter was offline during 2004 and 2005 during the construction of a new desalter well.

WRD constructed and has operated the Goldsworthy Desalter since 2001. The Court ordered that the Goldsworthy may extract up to 3,300 AFY of saline water (greater than 1,000 ppm chlorides) without affecting adjudicated rights (DWR, 2005). When average chlorides do not exceed 1,000 ppm mechanisms are triggered that WRD must follow to meet the requirement. WRD has recently installed inflatable packers, which seal off lower chloride zones, in an attempt to increase the chloride concentration of the produced water from the desalter wells. An average of approximately 1,900 AFY has been treated since the desalter came online in 2001.

Seawater Intrusion Barriers

There are two seawater intrusion barriers in the West Coast Basin: the West Coast Basin Barrier Project and the Dominguez Gap Barrier Project. An average of about 24,400 AFY has been injected into these barriers since 1985.

The West Coast Basin Barrier Project began operation in 1953. The West Coast Basin Barrier Project is a line of 153 injection wells that parallels the coastline from Los Angeles International Airport to the Palos Verdes Hills. It is owned and operated by the Los Angeles County Department of Public Works. Since 1995, the West Coast Basin Barrier Project has injected an approximate 35 percent blend of imported water from Metropolitan and tertiary (including reverse osmosis) treated wastewater from the Hyperion Plant. It injects water into the "200-foot sand", Silverado and Lower San Pedro aquifers to impede seawater intrusion (LACDPW, 2006).

The Dominguez Gap Barrier Project began operation in 1971. The barrier currently comprises a line of 41 injection wells and 107 observation wells along the Dominguez Channel to the 110 Freeway in the City of Carson (LACDPW, 2006). Imported water from Metropolitan is currently injected into the "200-foot sand", "400-foot gravel" and Silverado aquifers in this area. WRD, LACDPW, and LADWP initiated delivery of recycled water to this barrier in 2006.

Governance Structure

The West Coast Basin is adjudicated. The West Coast Basin adjudication (Judgment) was finalized in 1961 and capped annual production at 64,468 AFY. The Water Replenishment District of Southern California (WRD), established in 1959, is the groundwater basin manager and has the statutory authority to replenish the groundwater basin and address water quality issues. The Los Angeles County Department of Public Works owns and operates the West Coast Barrier Project and the Dominguez Gap Barrier Project. WRD procures imported and recycled water to be recharged by the Public Works Department at these facilities.

Each year WRD makes a determination of the amount of supplemental recharge that is needed based on an estimation of the ensuing year's groundwater production and an estimation of the annual change in storage based on groundwater levels collected throughout the basin.

In December 2014, the West Coast Basin Judgment was amended, declaring water rights and providing provisions for the storage and extraction of stored water. The amendment enables large-scale changes in the management practices within the basin, which are expected to enhance opportunities to develop recycled water for recharge and improve the capability to utilize the basin's storage for conjunctive use. "Conjunctive use" refers to coordinating the management of surface water and groundwater to improve the overall reliability of water supply (Pacific Institute, 2011).

As a result of the Judgment amendment, the Watermaster in each basin is now comprised of three constituent entities: 1) Administrative Body, 2) Water Rights Panel, and 3) Storage Panel. WRD was designated as the Administrative Body for the basin and is responsible for preparing the annual *Watermaster Service* reports and submitting them to the Water Rights Panel. The Water Rights Panel (comprised of water rights holders) are responsible for enforcement of water rights and for submitting the final *Watermaster Service* reports to the Superior Court of the State of California for filing. The Storage Panel comprised of the WRD Board of Directors and the Water Rights Panel is responsible for reviewing and approving storage and augmentation projects that require the construction of new facilities.

Main San Gabriel Basin

The Main San Gabriel Basin lies in eastern Los Angeles County, California. The hydrologic basin or watershed coincides with a portion of the upper San Gabriel River watershed, and the aquifer or groundwater basin underlies most of the San Gabriel Valley. Metropolitan member agencies overlying the Main San Gabriel Basin (or Main Basin) include: Upper San Gabriel Municipal Water District (Upper District), Three Valleys Municipal Water District (Three Valleys) and the City of San Marino. The service areas of three member agencies (cities of Azusa, Alhambra and Monterey Park) of the State Water Project contractor, San Gabriel Valley Municipal Water District (SGVMWD), also overlie the Main San Gabriel Basin. Overlying communities include: Arcadia, Azusa, Baldwin Park, Bradbury, Covina, Duarte, El Monte, Glendora, Industry, Irwindale, La Puente, Monrovia, Rosemead, San Gabriel, San Marino, South El Monte, South Pasadena, Temple City, Walnut, and West Covina.

Hydrogeologic Setting

The Main San Gabriel Basin is bounded by the San Gabriel Mountains to the north, San Jose Hills to the east, Puente Hills to the south, and by a series of hills and the Raymond Fault to the west. The watershed is drained by the San Gabriel River and Rio Hondo, a tributary of the Los Angeles River.

The physical groundwater basin is divided into two main parts, the Main Basin and the Puente Basin. The Puente Basin, lying in the southeast portion of the map above, is tributary to the Main Basin and hydraulically connected to it, with no barriers to groundwater movement. Each basin is separately adjudicated and managed. **Table C.3** provides a summary of the hydrogeologic parameters of the Main San Gabriel Basin

Table C.3: Summary of Hydrogeologic Parameters of the Main San Gabriel Basin

Parameter	Main San Gabriel Basin
Structure	
Aquifer(s)	Unconfined
Depth of groundwater basin	800 to 1,600 feet MSL
Thickness of water-bearing units	300 to 2,000 feet
Yield and Storage	
Natural Safe Yield	152,700 AFY
Operating Yield	FY 2005/06: 240,000 AFY
Total Storage	8.6 million AF

Sources: Stetson, 2006 and Main San Gabriel Basin Watermaster, 2006

The Main San Gabriel Basin occupies most of the San Gabriel Valley and encompasses a surface area of more than 73,000 acres. Principal water-bearing formations of the Main Basin are unconsolidated and semi-consolidated unconfined alluvial sediments that range in size from coarse gravel to fine-grained sands. Total thickness of water-bearing sediments ranges from about 300 feet to more than 2,000 feet (Stetson, 2006).

The total amount of water in storage for the Main San Gabriel Basin is approximately 8.6 million AF (Main San Gabriel Watermaster, 2006b). Usable storage within the operating range is approximately 800,000 AF while the unused storage space is about 500,000 AF (Stetson, 2006).Supplemental imported water cannot be stored in the Main San Gabriel Basin when the groundwater elevation at the key well exceeds ~310 feet MSL.

Existing Facilities and Locations

Wells

In the Main San Gabriel Basin, there are 305 wells in the basin (250 active wells and 55 inactive wells).

Spreading Basins

There are currently 17 spreading basins, covering more than 1,100 acres, either operated by LACDPW or other agencies that are capable of capturing stormwater runoff from the adjacent canyons or imported water. LACDPW spreads imported water from Metropolitan and SGVMWD in the San Gabriel Valley on behalf of the SGVMWD, Upper San Gabriel Valley Municipal Water District, and the Three Valleys Municipal Water District. The spreading capacity of the existing facilities is more than 850 cfs.

Governance Structure

The Main San Gabriel Basin is an adjudicated basin. On January 4, 1973, after extensive negotiations, a stipulated Judgment in this case was entered (Main San Gabriel Basin Judgment) that created Watermaster, governing body and specified a program for management of water in the Main Basin. Since the Main San Gabriel Basin Judgment was originally entered, there have been subsequent amendments to it that extend and clarify Watermaster's role.

The Watermaster is a nine-person board appointed by the Los Angeles County Superior Court that administers and enforces the provisions of the Main San Gabriel Basin Judgment, which established water rights and responsibility for efficient management of the quantity and quality of the Basin's groundwater. The Watermaster manages and controls the withdrawal of groundwater/surface water and replenishment of imported water supplies in the Basin and determines the amount that can be safely extracted. The Watermaster coordinates imported water deliveries and recharge. Watermaster coordinates local involvement in efforts to preserve and restore the quality of groundwater in the Basin. The Watermaster assists and encourages regulatory agencies to enforce water quality regulations affecting the Basin; collects production, water quality, and other relevant data from producers; prepares an annual report of pumping and diversions; and a Five Year Plan to address water quality management.

The Main San Gabriel Basin Judgment allows a producer to pump or divert more water than its share, but the producer must pay for replenishment water for any amount produced above its water rights. Producers can carryover up to 100 percent of their water rights for only one year.

Any entity, public or private, desiring to spread and store Supplemental Water within the Basin for subsequent recovery and use for Watermaster credit must have a Cyclic Storage Agreement pursuant to Watermaster's Rules and Regulations. Cyclic storage agreements are for a term of five years and may extend for additional terms, not to exceed five years. The Cyclic Storage Agreement notes the maximum amount of supplemental water that may be stored at any point in time by a particular storing entity.

Orange County Basin

The Orange County Basin is located in north and central Orange County within the lower Santa Ana River watershed. Member agencies within the Orange County Basin include Anaheim, Fullerton, Santa Ana and the Municipal Water District of Orange County. It includes the communities of Anaheim, Buena Park, Costa Mesa, Cypress, Fountain Valley, Fullerton, Garden Grove, Huntington Beach, Irvine, La Palma, Los Alamitos, Newport Beach, Orange, Placentia, Santa Ana, Seal Beach, Stanton, Tustin, Villa Park, Westminster and Yorba Linda. The Orange County Basin has been divided into three subbasins: Yorba Linda, Main and Irvine.

Hydrogeologic Setting

The Orange County Basin is bounded by the Coyote and Chino Hills on the north, the Santa Ana Mountains on the northeast, the San Joaquin Hills on the south, and the Pacific Ocean and the Newport-Inglewood fault zone on the southwest (OCWD, 2004). The Orange County Basin is separated from the Central Basin along Coyote Creek and the County line, although there is no physical barrier between the two basins. The Newport-Inglewood fault zone acts as a complete barrier to flow from the ocean along most of its length in Orange County except at ancient river-crossing gaps, most notably the Alamitos Gap along the Los Angeles County line and the Talbert Gap in Huntington Beach and Costa Mesa. At these two locations, permeable river deposits cross the fault barrier providing the opportunity for seawater to flow into the Orange County Basin.

The Orange County Basin includes three subbasins: Yorba Linda, Main and Irvine. These subbasins are managed by OCWD as a whole and are described herein for informational purposes.

The Yorba Linda subbasin is located north of the Anaheim Forebay recharge area, within the cities of Yorba Linda and Placentia. It is part of the Basin, but currently has little groundwater pumping due to its low transmissivity and high TDS concentrations (Mills, 1987). Groundwater from the Yorba Linda subbasin flows southward into the Main Basin since the limited groundwater production is less than the natural replenishment from the adjacent Chino Hills.

The Irvine subbasin, bounded by the Santa Ana Mountains and the San Joaquin Hills, forms the southern-most portion of the basin. The Costa Mesa Freeway and Newport Boulevard approximate the subbasin's boundary with the Main Basin. Irvine-area aquifers are thinner and contain more clay and silt deposits than aquifers in the main portion of the basin. Groundwater typically flows out of the Irvine subbasin westerly into the Main Basin.

The hydrogeology of the Orange County Basin is characterized by a deep structural alluvial basin containing a thick accumulation of interbedded sand, silt and clay. **Table C.4** provides a summary of hydrogeologic parameters for the Orange County Basin. The Orange County Basin contains three defined aquifer units: the Upper, Principal (or Middle) and Lower aquifers. In the northern portions of the Orange

County Basin, referred to as the Forebay area, many of these aquifers are merged and allow for direct recharge into the deeper aquifers. In the area referred to as the Pressure Area, these aquifers are less hydraulically connected and create confined aquifer conditions. A conceptual geologic cross section across the Orange County Basin is provided in **Figure C.8**.

Table C.4: Summary of Hydrogeologic Parameters of the Orange County Basin

Parameter	Description
Structure	
Aquifer(s)	Forebay areas (unconfined) Pressure areas (confined) • Upper aquifer system • Principal aquifer system • Lower aquifer system
Depth of groundwater basin	> 2,000 feet
Depth of producing zones or screen intervals	200 to ~2,000 feet
Thickness of water-bearing units	Upper aquifer: Up to 300 feet (average ~200 feet) Principal aquifer: 500 to > 1,600 feet (average ~ 1,000 feet) Lower aquifer: ~300 to 1,000 feet
Yield and Storage	
Natural Safe Yield (Natural Incidental Recharge) [1]	70,500 AFY
Basin Production Percentage 2015/16	70 percent
Total Storage	Upper aquifer: 5 million AF Principal aquifer: 32.9 million AF Lower aquifer: 25.1 million AF Aquitards: 3 million AF 66 million AF

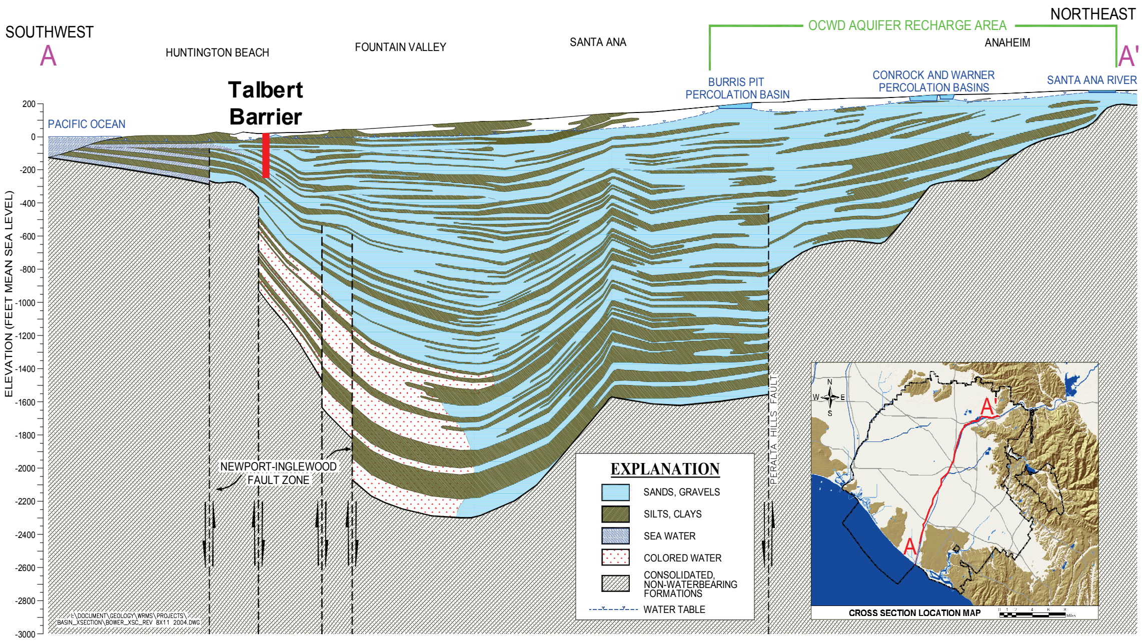
Source: DWR, 2004; OCWD, 2004

1 Natural safe yield includes infiltrated precipitation, irrigation, and other incidental recharge. Referred to as natural incidental recharge by OCWD.

2 Basin Production Percentage (BPP) is percentage of groundwater production out of the total water demand. BPP is set annually by OCWD. Historically, BPP has ranged from 64 to 80 percent.

3 Use of storage space is subject to approval by OCWD consistent with objectives for basin management

Figure C.8: Hydrogeologic Cross Section of the Orange County Basin



The Upper aquifer system, which averages approximately 200 feet in thickness, consists of alluvial sediments and includes the Talbert aquifer and Recent alluvium. The total storage of this aquifer system is estimated to be approximately five million AF (OCWD, 2004). However, only about 5 percent of the total basin production comes from this aquifer because of lower production rates and poorer water quality than the underlying aquifers.

The Principal aquifer system averages approximately 1,000 feet in thickness and is the primary source of production in the Orange County Basin. The principal aquifers are located approximately 200 to 1,200 feet below ground surface (fbgs). This aquifer is correlative with portions of the Lakewood Formation and the San Pedro Formation of the Central and West Coast Basins in Los Angeles County. Orange County Water District (OCWD) estimates the total storage in this aquifer system is approximately 32.9 million AF (OCWD, 2004).

Deeper aquifers below the principal aquifer system comprise the Lower aquifer system (DWR, 2004), with a thickness of about 300 to 1,000 feet. Few wells produce from this aquifer because of the increased depth and the potential presence of colored water.

The total estimated volume of fresh groundwater capable of being stored in the Orange County Basin when it is completely full is estimated to be approximately 66 MAF by OCWD (2004). . Based upon review of historical data, OCWD has established basin water contour levels, which represent a full basin. Volume in storage indicates how much storage space is available for use (defined as accumulated overdraft) within the Orange County Basin. OCWD estimates that between 400,000 and 500,000 AF of the total basin storage is actually usable (OCWD, 2004) in terms of emptying and filling operations. If groundwater levels are allowed to drop below the lower limit (i.e. >400,000 AF of accumulated overdraft) there is an increased potential for seawater intrusion, increased potential for colored water upwelling, and increased potential for subsidence. However, the basin can be operated on a short-term emergency basis with an accumulated overdraft up to approximately 500,000 AF without causing irreversible seawater intrusion or land subsidence (OCWD, 2004 and 2006).

Existing Facilities and Locations

Wells

Groundwater extraction from the Orange County Basin occurs from nearly 500 production wells. Approximately 97 percent of the production is municipal water supplied through approximately 200 large capacity wells.

Spreading Basins

The OCWD currently owns and operates more than 1,000 acres of ponds in and adjacent to the Santa Ana River and Santiago Creek. Over a few months, the bottom of the recharge basins can become clogged with fine silts, which greatly diminishes their spreading capacity. These facilities currently provide for the infiltration of approximately 250,000 AFY (OCWD, 2004). Water sources used for recharge include Santa Ana River baseflow and stormflow, Santiago Creek flows, imported water from Metropolitan and from the upper Santa Ana River Watershed, and previously treated water from OCWD's Water Factory 21 and now the Groundwater Replenishment System (GWRS).

Seawater Intrusion Barriers

To protect the fresh groundwater in the basin from seawater intrusion, OCWD injects water into the Talbert and Alamitos barriers.

Governance Structure

The Orange County Basin is a managed basin. OCWD has managed the Orange County Basin since 1933 pursuant to a special act of the State legislature (West's Annotated California Codes, Water Code Appendix Chapter 50 as amended and Deering's California Codes Annotated Water – Uncodified Acts. Act 5683). OCWD has managed the basin based upon the principal of seeking to increase supply rather than restricting access and to provide for uniformity of cost.

The basin groundwater pumping is not operated on a safe-yield basis each year. Rather, the goal is to maintain an approximate balance over a period of several years. The amount of production from the basin is governed through financial incentives based on establishing an annual Basin Production Percentage (BPP), which is the percentage of groundwater production out of the total water demand for the Orange County Basin. Pumping up to the BPP is charged a fee on a per AF basis, i.e., the Replenishment Assessment (RA). Groundwater production above the BPP is charged the RA plus the Basin Equity Assessment (BEA). The BEA is typically set so that the cost of groundwater production above the BPP is similar to the cost of purchasing alternative supplies. Pumping agencies do not accrue individual storage rights if they pump less than the BPP, which is a major difference compared to most adjudicated basins. Additionally agencies cannot transfer groundwater pumping rights.

The basin is managed to provide approximately three years of drought supplies for the region. The accumulated overdraft target of 100,000 AF was in part set to meet this goal. If Santa Ana River supplies decline and/or Metropolitan replenishment water is not available, OCWD can generally sustain high pumping rates by overdrafting the groundwater basin for a three year period down to an accumulated overdraft of 400,000 to 500,000 AF. The 100,000 AF target also provides sufficient storage space to capture excess water supplies that become available during very wet winters.

DEMAND AND OPERATIONAL ANALYSIS

To develop the base case assumptions for delivery of up to 150 mgd of purified water to groundwater basins, Metropolitan conducted a demand analysis to determine the projected need for the purified water in each of the groundwater basins to support future groundwater pumping. Existing groundwater models for each basin were used to aid in evaluating the ability of individual groundwater basins to receive the water and identify possible impacts that the recharge may have on the groundwater basins. The analysis of the groundwater basins was conducted to answer the following questions:

1. *Demand Analysis*: What is the demand for program water in each basin?
2. *Operational Assessment*: Do operational issues such as recharge capacity or extraction capability limit how much water can be recharged or extracted?
3. *Groundwater Modeling*: How does recharge and extraction of program water affect water levels and travel times to potentially impacted wells?
4. *Facility Needs*: Are additional new facilities required or is the existing infrastructure sufficient to support the program goals?

Assumptions and operational criteria for the demand analysis and groundwater modeling were developed through coordination with member agencies, basin managers, and the Los Angeles County Department of Public Works.

Assumptions and Operational Criteria

The assumptions and operational criteria were developed through coordination with member agencies, basin managers, and the LACDPW. Metropolitan staff met with each party on multiple occasions and attended a field trip of the LACDPW's spreading facilities.

Demand Analysis

The needs analysis provides the range of demand for the water for this project. Demand data are from Metropolitan's 2015 Integrated Resources Plan. Demand for the purified water may include: existing replenishment demand currently provided by imported water, consumptive demand that is currently served by imported water that could be converted to groundwater, or additional replenishment supplies above historical deliveries that will be needed for overdraft control or projected future demand.

Groundwater Pumping Capability

The groundwater pumping capability is an important part of the feasibility assessment. If an agency is unable to pump the stored water out, then the ability to take recycled water would be limited. The capacity data were collected from agency information. In the event that no data were available or when historical groundwater pumping does not reflect their full capacity (e.g. agencies prefer to take imported water over groundwater), a capacity of 3 cfs per well was assumed.

Spreading Capacity

The spreading capacity is also a key factor in determining feasibility. In the four basins under consideration, all the spreading basins are currently being used to capture a combination of imported water, recycled water, and stormwater. Stormwater flows are volatile and sometimes these flows exceed the capacity of the spreading grounds and must be diverted downstream.

Diluent Water Requirements

Diluent water may be required for this project to reduce the Recycled Municipal Wastewater Contribution (RWC), at least initially. Diluent water may include: imported water, stormwater, or subsurface groundwater. Sources for diluent water are discussed by groundwater basin in the remainder of the report.

The RWC means the fraction equal to the quantity of recycled municipal wastewater applied at the recharge site divided by the sum of the quantity of recycled municipal wastewater and credited diluent water. For this project, the goal is to reach 100% RWC as soon as possible. For this feasibility analysis, it is assumed that 100% RWC will be achieved with 3 years (50% RWC in the first year, 75% in the second year and 100% in the third year). The threshold for this analysis is to exceed 95 percent probability.

Diluent water and RWC assumptions for each basin are highlighted below.

<u>Central Basin – Montebello Forebay</u>

- Initial RWC for Metropolitan = 50%
- RWC for Existing/Tertiary GRIP = 45%
- RWC for AWT GRIP = 50%

<u>MSG Basin – Above Santa Fe</u>

- Initial RWC for Metropolitan = 50%
- RWC for Tertiary Upper District = 20% and 35%

<u>Orange County</u>

- Initial RWC for Metropolitan = 75%
- RWC for GWRS = 100%

West Coast and Long Beach injection not included in analysis. Treated water from Metropolitan will be required to meet any diluent water requirement in these areas.

Groundwater Modeling

Groundwater modeling is an important tool to evaluate the effects of recharge in the groundwater basins. The goal of the modeling is to make sure that water levels do not adversely impact producers in the basin and to identify any wells that would be impacted by the project. A description of the models for each basin and the results of the modeling are provided in subsequent sections of this report.

For the modeling effort, Metropolitan contracted with WRD for the Central Basin and West Coast Basin(worked performed by CH2M), Main San Gabriel Watermaster (work performed by Stetson Engineers), and the Orange County Water District to perform modeling.

For the modeling analysis, the Central Basin and West Coast Basin have been combined into one discussion. This is because they are collectively managed by the Water Replenishment District of Southern California (WRD), and both basins are incorporated into the same groundwater model.

Central Basin

Needs Analysis

The needs analysis provides the range of demand for the water in the Central Basin from this project. Projections are from Metropolitan's IRPSIM.

Projected Replenishment Needs

Replenishment needs within the Central Basin total about 35 TAFY as shown in **Table C.5**. Imported water currently delivered to the Montebello Forebay in the Central Basin for replenishment is about 21 thousand acre-feet per year (TAFY). The Groundwater Reliability Improvement Program (GRIP) proposed by the Water Replenishment District is anticipated to replace the current imported water deliveries with recycled water from the San Jose Creek Water Reclamation Plant. This project involves treating water from the San Jose Creek Water Reclamation Plant to advanced water treatment facilities and recharging in the groundwater basin. In addition, about 4 TAFY of imported water replenishment demand is anticipated in the Long Beach area and 10 TAFY of imported water replenishment demand is anticipated in the Los Angeles Forebay area due to projected pumping in these areas. In the event the Regional Recycled Water Program (RRWP) does not go forward, these demands would be met with imported water.

Table C.5: Projected Replenishment Needs in Central Basin

Project/Agency	Size (AFY)	Comments
GRIP	21,000	WRD project. Not included in demand projections.
Los Angeles	10,000	Increase in production due to Manhattan Wellfield Project
Long Beach	4,000	Existing Injection wells
Total	**35,000**	

Demand Assessment

Consumptive demand for imported water from Metropolitan for Central Basin MWD ranges from 40 to 80 TAFY as shown in **Figure C.9**. Of that, about 3 TAFY of the imported demand could be met with increased groundwater production from existing production wells. With additional facilities, up to 47 TAFY could be recharged in the Central Basin as shown in **Figure C.10**.

Figure C.9: Range of Consumptive Demand in Central Basin

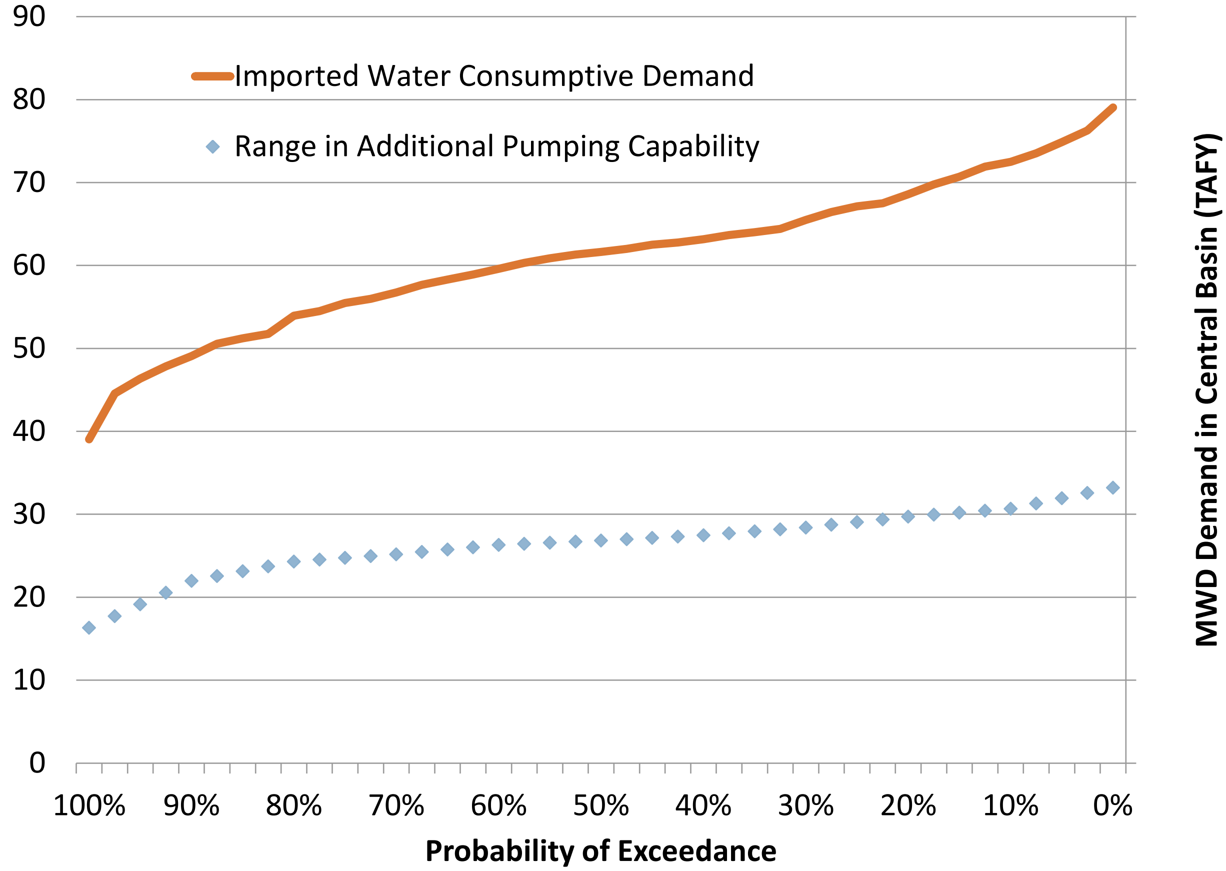
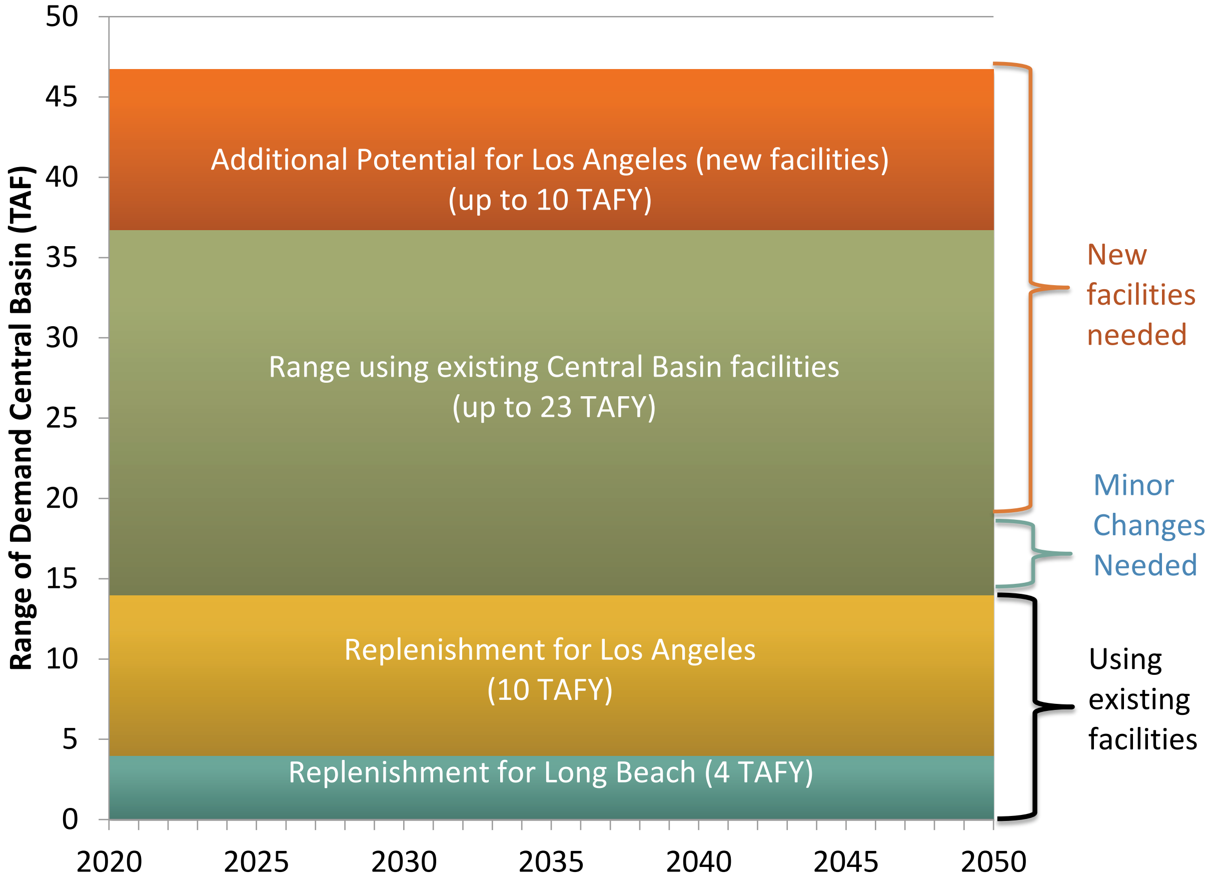


Figure C.10: Summary of Potential Projects in the Central Basin



Groundwater Pumping Capability

The estimated well capacity for agencies that could increase their groundwater production is about 100 mgd (112 TAFY).

Operational Assessment and Facility Needs

The Base Case assumptions for Central Basin (as shown in **Figure C.10**) include:

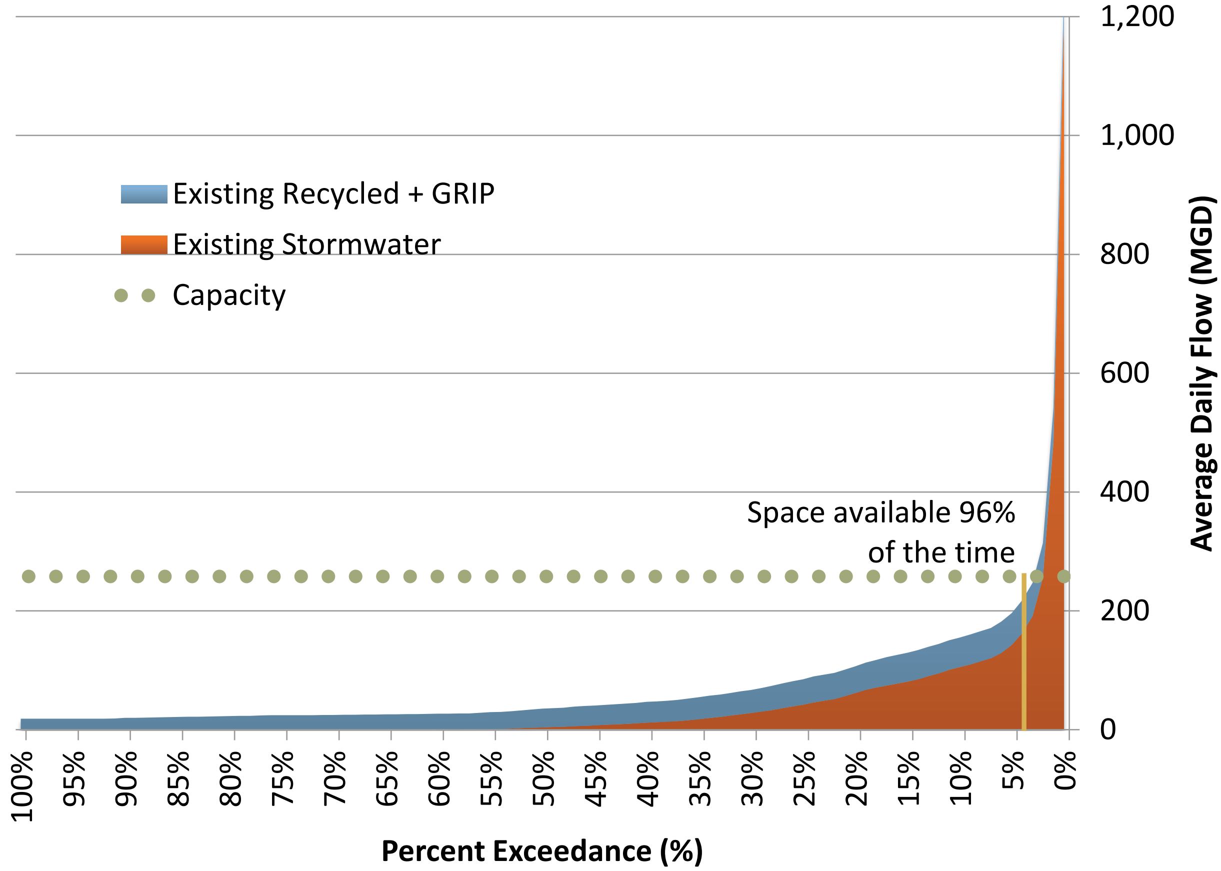
- City of Long Beach – 4 TAFY using existing injection wells
- City of Los Angeles – 10 TAFY of spreading at Montebello Forebay
- Central Basin MWD – 3 TAFY of spreading at Montebello Forebay

The Base Case assumes existing facilities with minor modifications could be used.

Spreading Basins

The capacity of the Montebello Forebay spreading grounds (Rio Hondo Spreading Grounds and San Gabriel Coastal Spreading Grounds) is about 550 cfs. There is available space for recharge 96 percent of the time as shown in **Figure C.11**.

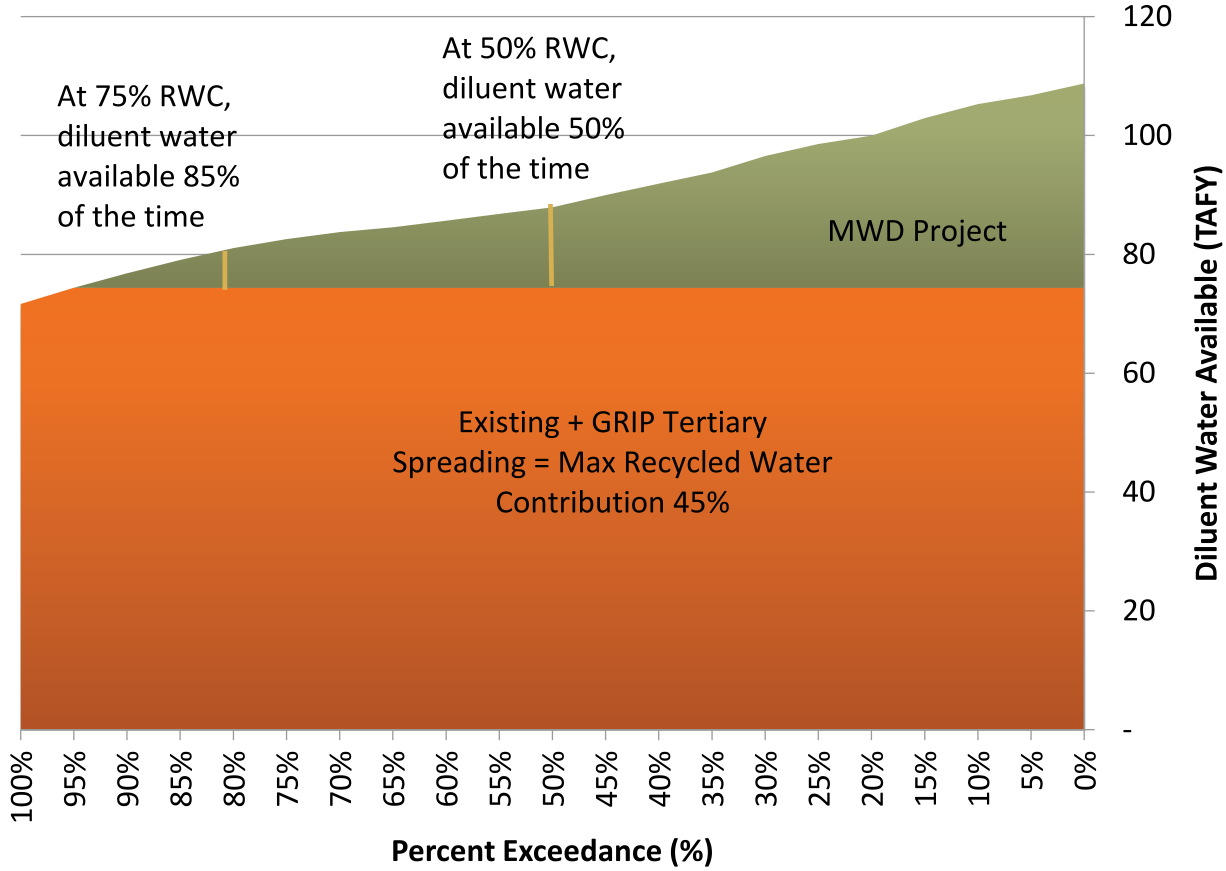
Figure C.11: Average Daily Flow in the Montebello Forebay



Availability of Diluent Water

Figure C.12 shows the availability of diluent water in the Montebello Forebay. The existing spreading and the proposed GRIP project would take the majority of the available blend water. At 50 percent RWC, sufficient diluent water would be available only 50 percent of the time. At 75 percent RWC, sufficient diluent water would be available 85 percent of the time.

Figure C.12: Diluent Water Availability – Central Basin



West Coast Basin

Needs Analysis

The needs analysis provides the range of demand for the water in the West Coast Basin from this project. Projections are based upon Metropolitan's IRPSIM.

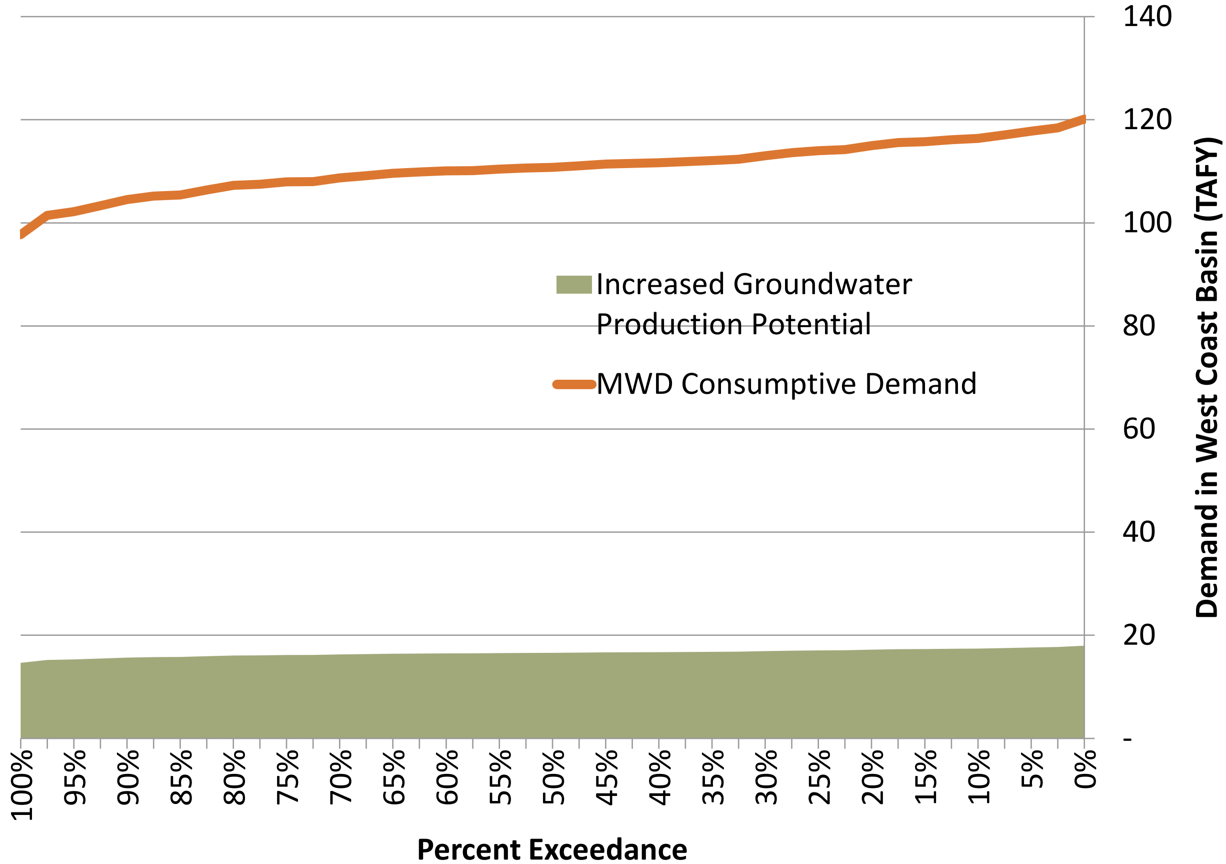
Projected Replenishment Needs

Replenishment for the West Coast Basin is largely from the seawater barriers. There is no additional replenishment demand in this basin.

Consumptive Demand Assessment

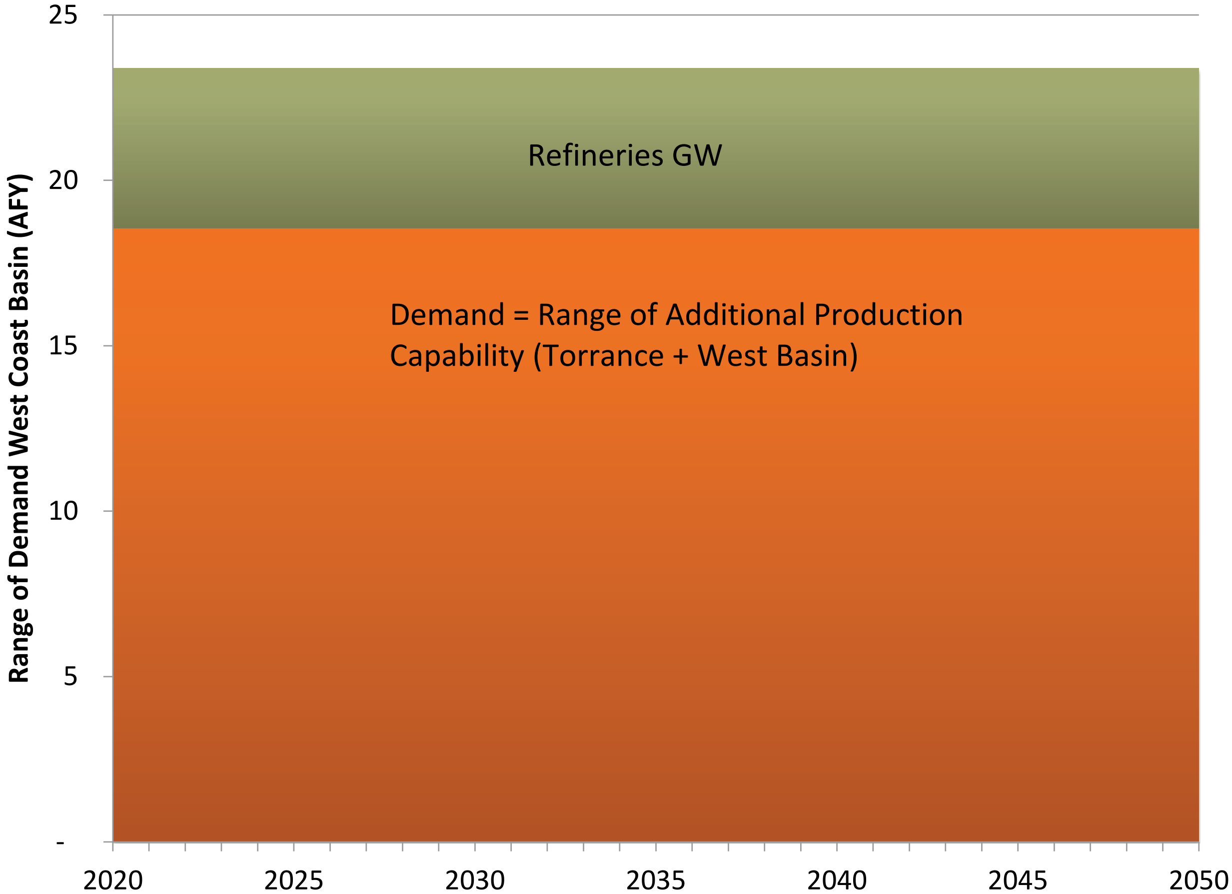
The Metropolitan consumptive demand for the City of Torrance and West Basin MWD ranges from 100-120 TAFY. Using existing well capacity, there is potential to increase groundwater production in the West Coast Basin about 18 TAFY. The producers within the West Coast Basin would need to increase their groundwater production above current levels and take less water from Metropolitan. This would require changes in how they operate their existing facilities. As shown in **Figure C.13 and Figure C.14**, there is potential to increase groundwater production in the West Coast Basin from 12-18 TAFY.

Figure C.13: Projected Demand in West Coast Basin



Refineries that pump groundwater in the West Coast Basin are also a potential demand that could be converted to recycled water. The refineries (Shell Oil, Phillips 66, Exxon Mobil, and Tesoro) pump an average of about 10 TAFY from the West Coast Basin. Due to variations in deliveries, these refineries could take about 5 TAFY on a continuous basis.

Figure C.14: Summary of Potential Projects in West Coast Basin



Groundwater Pumping Capability

In the Basin, there are 62 active extraction wells and 52 inactive extraction wells that have been reported to the Watermaster. An additional 12-18 TAFY could be pumped from the West Coast Basin with existing extraction facilities.

Operational Assessment and Facility Needs

The Base Case assumptions for the West Coast Basin include:

- City of Torrance and West Basin – 17 TAFY of injection in West Coast Basin

The Base Case assumes up to 15 new injection wells will be required. No new extraction wells will be required. It is assumed that the injection wells can be used during wet periods.

Availability of Diluent Water

Replenishment of groundwater in the Basin occurs primarily by underflow from the Central Basin, which bounds the West Coast Basin on the east. Water spread in the Central Basin percolates into aquifers there and eventually some groundwater crosses the Newport-Inglewood Uplift to replenish the groundwater in the West Coast Basin. Although the recharge water is not directly applied to the West Coast Basin, this recharge process returns large quantities of water to the Basin by substantially increasing the natural subsurface flow from the Central Basin to the West Coast Basin.

Groundwater Impacts

Groundwater Modeling

For the groundwater modeling analyses, the existing WRD model was used. The model uses the US Geological Survey (USGS) MODFLOW program (McDonald and Harbaugh, 1988; Harbaugh and Mc Donald, 1996), which was tailored to the Central and West Coast Basins by the USGS. The model includes separate layers for the four main aquifer systems of Central and West Coast Basins. The uniform finite-difference grid consists of 4,480 cells, each0.5 mi by 0.5 mi. The extent of the deeper aquifers is shown in **Figure C.15**.

Figure C.15: Model Configuration for the Central and West Coast Basins

Model Assumptions

From the results of the demand analysis and consultation with WRD and their consultant (CH2M), two modeling scenarios were developed:

- Baseline Scenario

- Base Case Scenario

The purpose of the Baseline Scenario was to simulate groundwater conditions within both basins (Central and West Coast) under existing hydrologic conditions with the inclusion of the existing Groundwater Reliability Improvement Program (GRIP). Results from this modeling scenario were used to simulate groundwater conditions without the potential Regional Recycled Water Program (RRWP).

Central Basin Assumptions

The baseline scenario simulated groundwater conditions within both basins (Central and West Coast) with existing levels of production and the inclusion of the WRD GRIP. Results from this modeling scenario were used to simulate groundwater conditions without the potential program.

The period 1970–2010 was selected for model period for the analysis. This provided for a long-term simulation for how the basin would respond to additional recharge, during both wet and dry periods.

The Base Case Scenario was used to evaluate the impacts of recharging in the Montebello Forebay. For the Base Case Scenario the following assumptions were used.

- Recharge Assumptions
  - Montebello Forebay – Although it is assumed that spreading capacity will be available for the RRWP, to evaluate the worst case scenario with respect to impacts, injection wells were assumed in the modeling for the Montebello Forebay. Thirteen new injection wells that targeted the deeper model layers (model layers 3 and 4) with a combined average rate of 13 TAFY were modeled. The injection wells were located between the existing Rio Hondo and San Gabriel Spreading Grounds.
- Long Beach area - Four existing injection wells with a combined average rate of 4 TAFY.
- Extraction Assumptions
  - Los Angeles Forebay area - 10,000 AFY from the LA Manhattan Wellfield.
  - Montebello Forebay area - 3,000 AFY near the Montebello Forebay area from Liberty Water Company, Golden State Water Company, and California Water Service wells.
  - Long Beach area - 4,000 AFY.

West Coast Basin Assumptions

The Base Case for the West Coast Basin West Coast Basin includes:

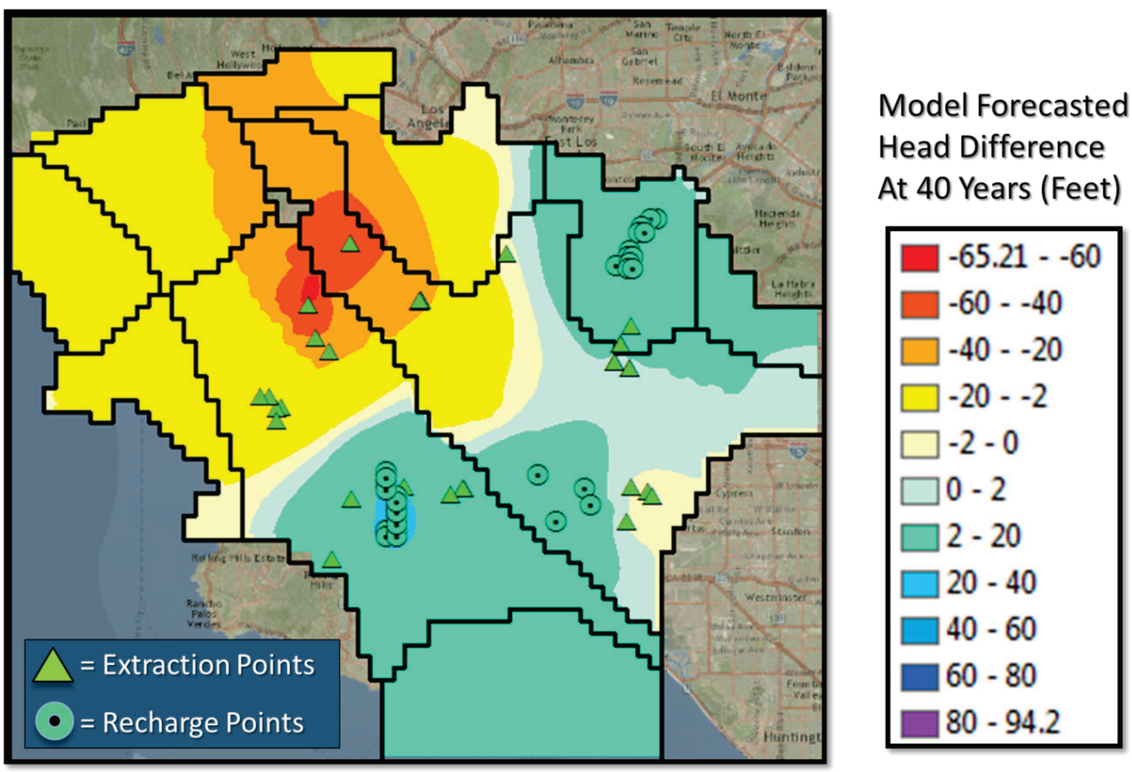
- Recharge Assumptions
- Up to fifteen new injection wells along the 110 corridor with a combined average rate of 15 TAFY
- Extraction Assumptions
- 9,800 AFY from Cal Water Services
- 300 AFY from Golden State Water
- 3,300 AFY from the City of Inglewood
- 200 AFY from the City of Lomita
- 1,000 AFY from the City of Manhattan Beach
- 400 AFY from the City of Torrance

Model Results

Output from the groundwater model was used to produce graphical representations of the modeling results. This includes groundwater contour maps; hydrographs of key locations; and particle tracking maps showing the 3 month, 6 month and 12 month travel times of the purified water along with nearby groundwater production wells. The Base Case Scenarios were also compared with the Baseline Scenario to evaluate changes to the groundwater basins attributed to the additional recharge.

Figure C.16 illustrates, that with the Base Case recharge and extraction scenario, there is a general increase in groundwater elevation in the eastern portion of the modeled area (shown as blue and green) and a general decrease in groundwater elevation in the western portion of the modeled area (shown as red and orange) when compared with the Baseline. The figure shows that the recharge from the Montebello Forebay does not reach the area of increased extraction in the LA Forebay, which creates a pumping hole. The pumping hole (areas of orange and red colors) is not created by the project, but rather by proposed production by the City of Los Angeles from their Manhattan wellfield that was not included in the baseline, but will happen without or without the project.

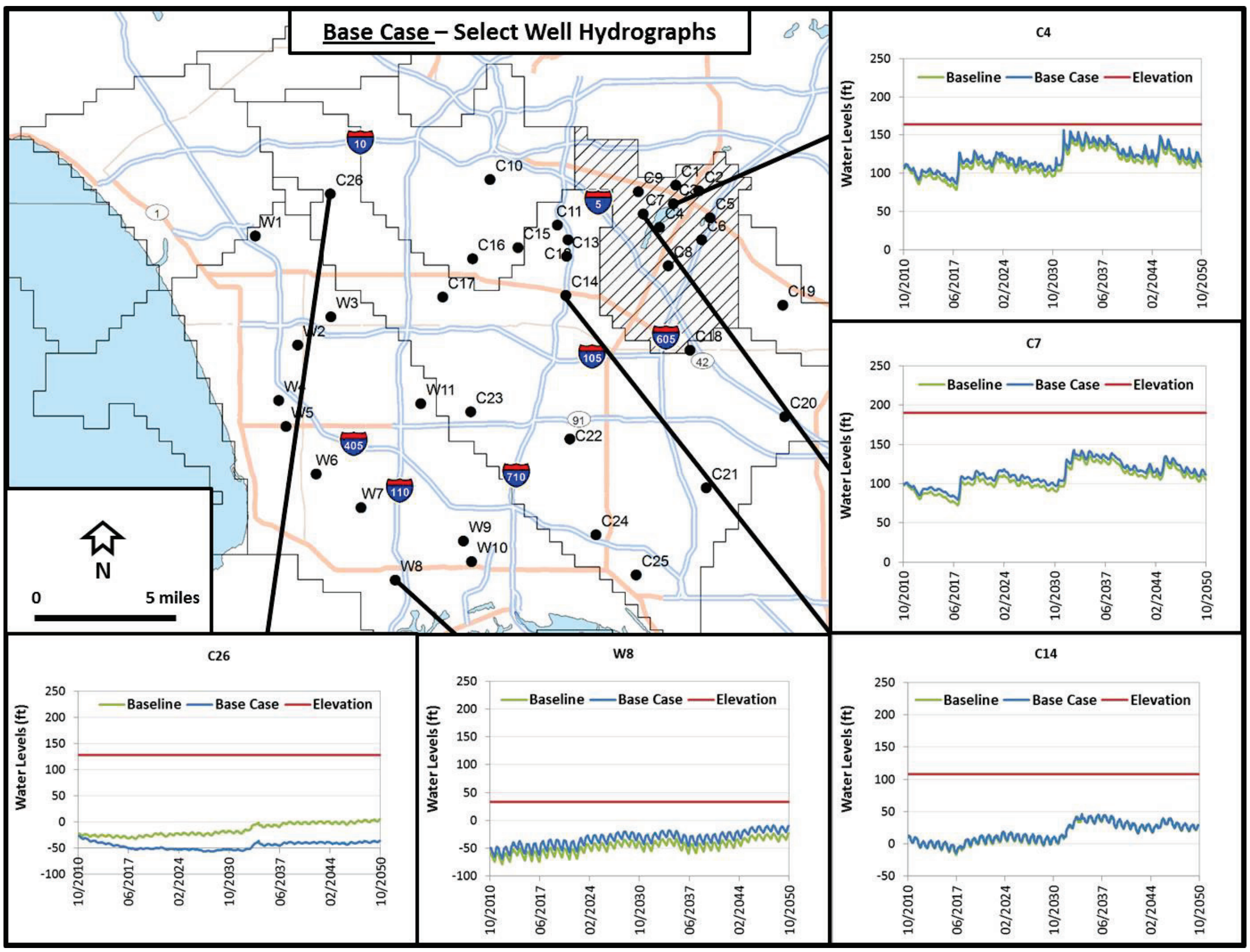
Figure C.16: Change in Groundwater Elevation from Baseline – Base Case



Output from the Base Case modeling scenario indicated that there is a net change in overall groundwater storage within the modeled area (Central and West Coast Basins) of about -2,400 AFY. The annual decrease in groundwater storage is attributed to localized changes in groundwater elevation (when compared to the baseline) that affects flow across the various model boundaries from adjacent basins.

Figure C.17 presents hydrographs for select wells. Each hydrograph shows the Baseline and Base Case water level trend for the entire 40 year modeled period. From the hydrographs it appears that groundwater elevations are well below the ground surface throughout most of the modelled area, with the exception of the Montebello Forebay. The hydrograph of Well C4 within the Montebello Forebay indicates that groundwater was a minimum of 10's of feet bgs for most of the 40 year modeled period. However, there does appear to be a couple brief periods where the groundwater elevation approached the ground surface. Recognition of the occasional occurrence of shallow groundwater is important for a couple of reasons: The shallow groundwater could temporarily reduce percolation of water from the spreading basins (if this option is considered) and the shallow groundwater could require the need to apply positive pressure at the injection well sites if injection wells are to be considered. In either case the occurrence of shallow groundwater appears to be relatively brief and occasional.

Figure C.17: Select Wells Hydrographs – Base Case



Travel Time Estimates

The next step in evaluating the model output was to determine the location and number of existing groundwater production wells that are within 3 month, 6 month and 12 month travel times from the application point of the purified water. This was necessary to plan for regulatory compliance issues and to determine the possible number of existing groundwater production wells that may need to be relocated as a result of the potential RRWP.

As shown in **Figure C.18**, up to 5 production wells may have to be relocated in the Montebello Forebay if injection wells are used for recharge due to their proximity to the 12-month travel time envelope. If the existing spreading basins can be used, there could be an opportunity to reduce the number of wells that will need to be replaced. No wells would have to be replaced in the Long Beach area or the West Coast Basin wellfield as shown in **Figure C.19**.

Figure C.18: Particle Tracking Map for Montebello Forebay Area – Base Case

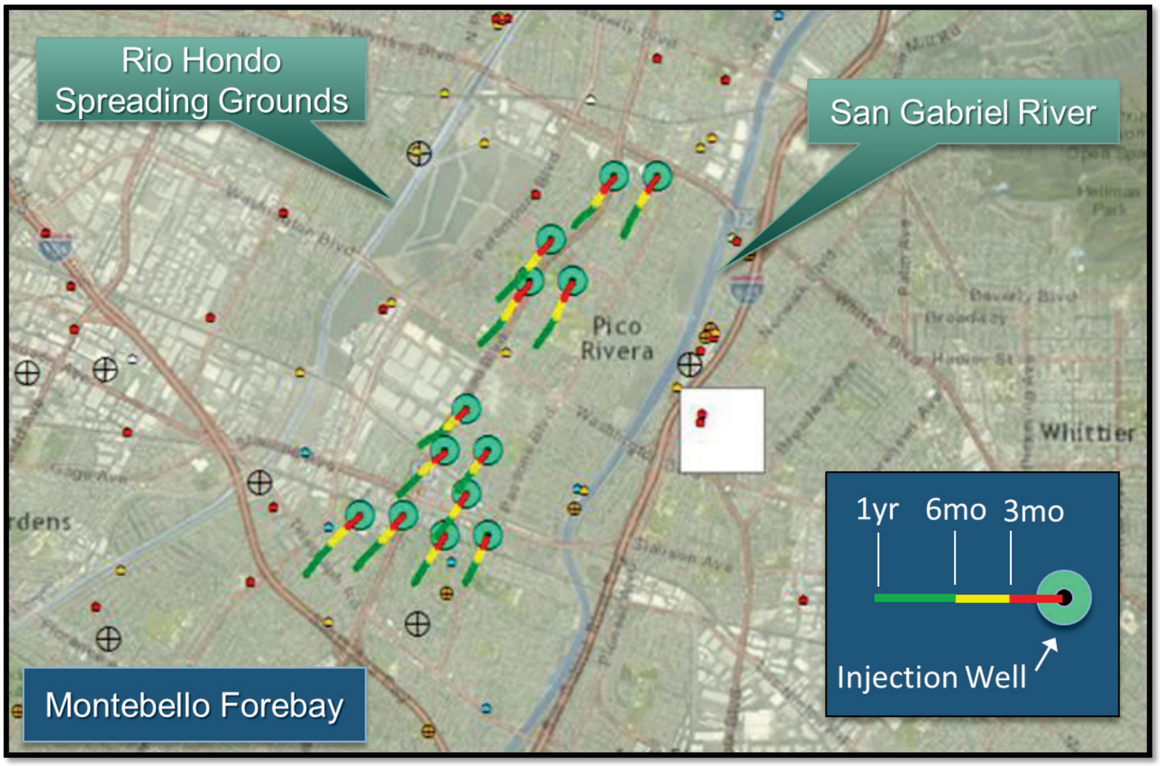
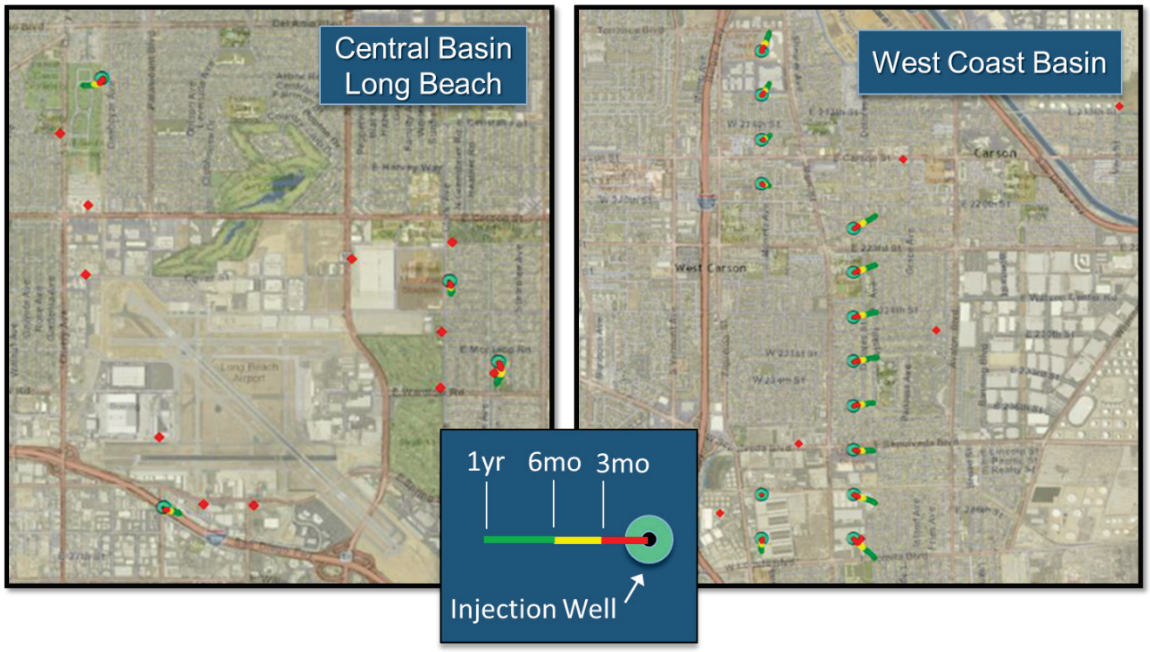


Figure C.19: Particle Tracking Map for City of Long Beach and West Coast Basin – Base Case



From the results of groundwater modeling for the Central and West Coast Groundwater Basins it appears that the basins are capable of receiving the full 30 mgd of RRWP purified water under the assumed conditions. It should be noted that conservative assumptions were used as input to the groundwater model and that the basin's capacity to receive and transmit the water could be further enhanced by making adjustments to some of these assumptions. Some of the variables affecting model output are the projected future basin demand and the locations and capacity of existing production wells to meet those demands. If demand is greater than the conservative assumption, particularly in the Montebello Forebay area, it would further enhance the basins ability to receive the additional water and the likelihood of shallow groundwater, attributed to the potential RRWP, near the Montebello Forebay would be reduced. With current model assumptions the occurrence of shallow ground water is only occasional and for brief periods of time.

Main San Gabriel Basin

Needs Analysis

The needs analysis provides the range of demand for the water in the Main San Gabriel Basin from this project. Projections are based upon Metropolitan's IRPSIM.

Projected Replenishment Needs

Current deliveries of imported water to the Main San Gabriel Basin for groundwater replenishment are about 45 TAFY. However, the basin continues to be in long-term decline. An additional 25 TAFY is anticipated to be required to maintain storage in the basin. Therefore, replenishment needs for the Main San Gabriel Basin are projected to be about 70 TAFY (62 mgd); 45 TAFY of existing demand and 25 TAFY of additional demand to maintain storage. In the event that the RRWP does not go forward, this demand will be fulfilled by imported water from Metropolitan as it does now.

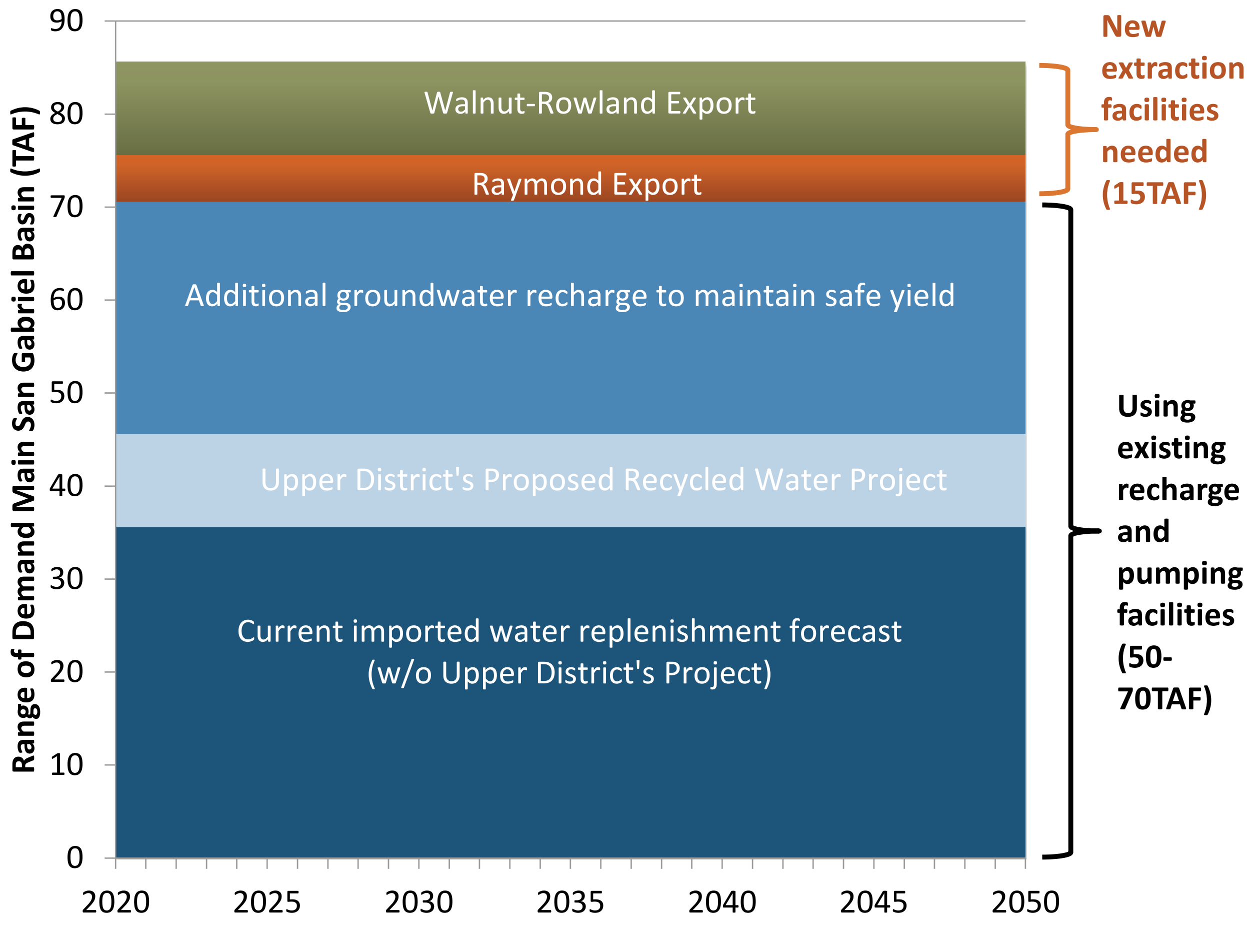
There could be up to 15 TAFY of additional demand if the water that was recharged into the Main San Gabriel Basin was exported to either the Raymond Basin via parties that have rights in both the Main San Gabriel Basin and the Raymond Basin. Similarly, water could be exported to the Puente Basin via Three Valleys MWD.

Figure C.20 shows the sum of the projects in the Main San Gabriel Basin.

Demand Assessment

The ability to convert consumptive imported water demand to groundwater is limited in the Main San Gabriel Basin. There is potential is other basins (e.g. Raymond Basin). Therefore, for purposes of this analysis, it is assumed that all demand in Main San Gabriel will be replenishment demand.

Figure C.20: Summary of Potential Projects in Main San Gabriel Basin



Groundwater Pumping Capability

Existing pumping capacity within the Main San Gabriel Basin is approximately 500 TAFY, which is significantly more than the annual demand.

Operational Assessment and Facility Needs

The Base Case assumptions for the Main San Gabriel Basin include:

- Three Valleys MWD, Upper District, and SGVMWD – 70TAFY of spreading
- During wet periods or periods of maintenance when recharge is not feasible in the Montebello Forebay, up to 15 TAFY would be diverted and spread in the Main San Gabriel Basin.

The Base Case assumes no new extraction wells will be required.

Upper District is also considering a 10 mgd recycled water project using water from the San Jose Creek Plant, which could impact the RRWP. The project is still in the early stages of development.

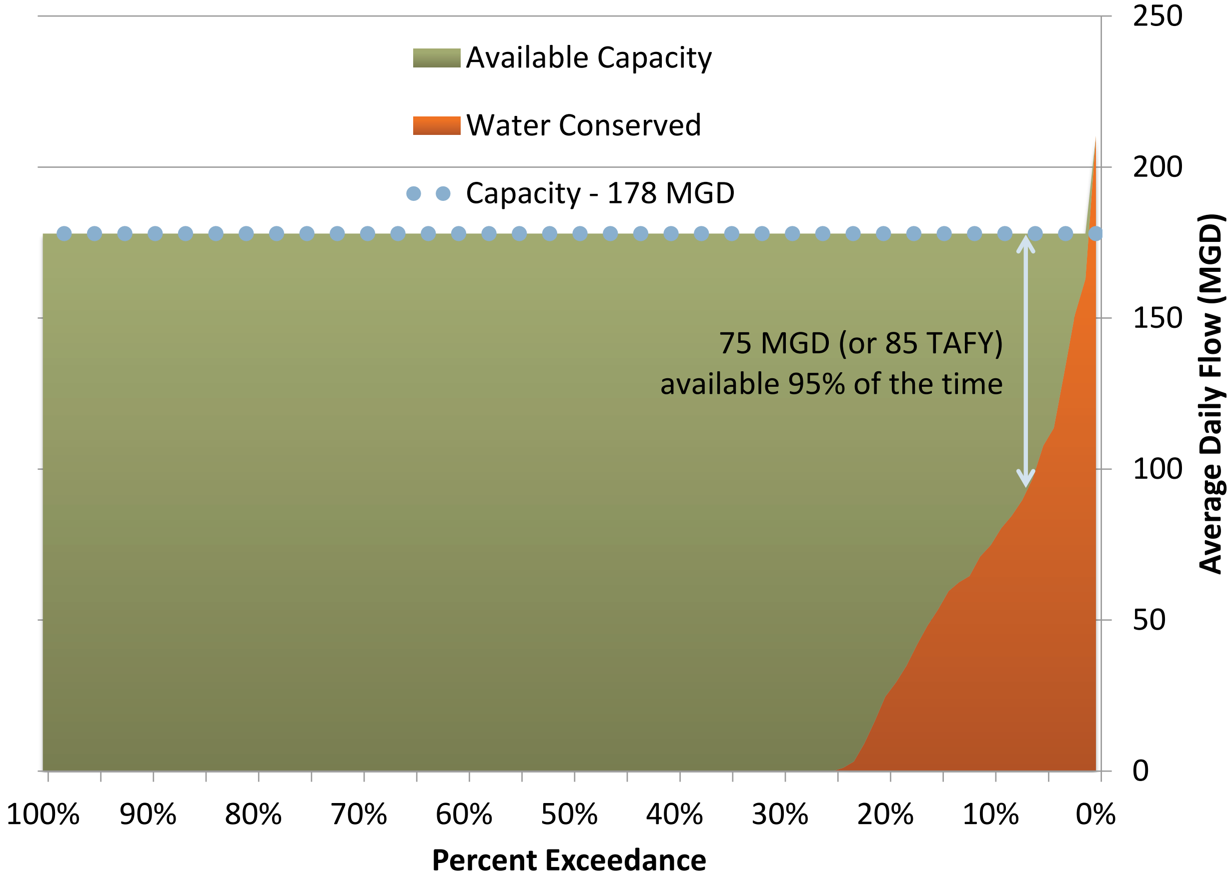
Spreading Basins

About 100 TAFY of stormwater and about 45 TAFY of imported water from Metropolitan are currently spread in the Main San Gabriel Basin. The base case assumption for the Main San Gabriel Basin is 70 TAFY (62 mgd) of spreading at the Santa Fe Spreading Grounds. The base case includes an additional 15 mgd (max total delivery of 77 mgd) to be delivered to the Main San Gabriel Basin for up to 3 months per year when other spreading basins may be unable to accept additional recharge. Upper District is also considering a 10 mgd (11 TAFY) recycled water project using water from the San Jose Creek Plant, which could impact the RRWP. The Upper District project is still in the early stages of development.

The Santa Fe Spreading Grounds has a long-term capacity of about 178 mgd (200 TAFY). Capacity is sufficient for spreading up to 77 mgd (86 TAFY) at Santa Fe at least 94 percent of the time as shown in **Figure C.21**. Unlike other basins under consideration, recycled water has never been recharged in the Main San Gabriel Basin before.

During the late 1970s and early 1980s, significant groundwater contamination associated with various VOCs was discovered in the Main San Gabriel Basin. The USEPA established operable units for areas within the basin that have been contaminated by VOCs and require groundwater cleanup. The operation of these operable units is key to the health of the basin. While water quality modeling is beyond the scope of this feasibility study, it is important to understand the potential impacts to the contaminant plumes, at least qualitatively.

Figure C.21: Capacity at the Santa Fe Spreading Grounds



Injection Wells Siting (if necessary)

Injection will not be needed. Sufficient spreading capacity exists to meet project objectives in the Main San Gabriel Basin.

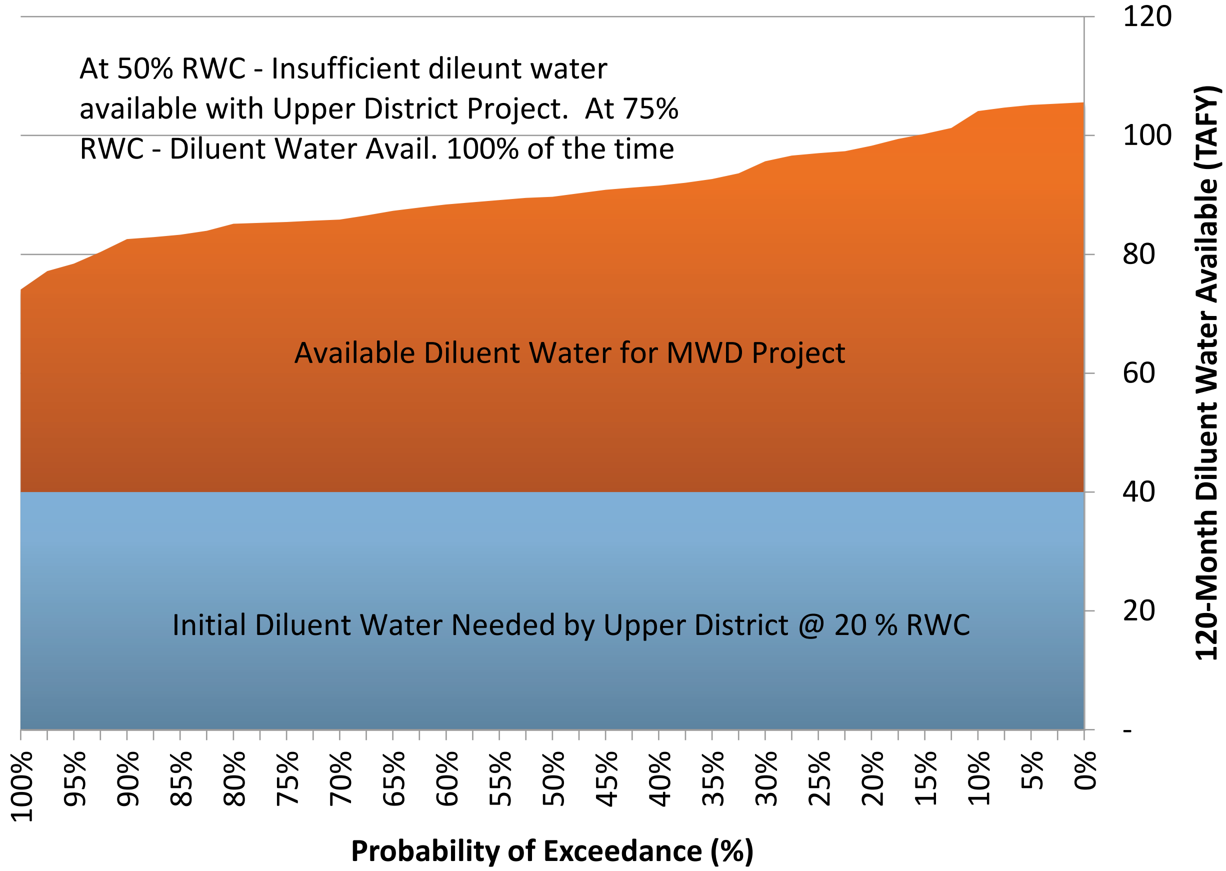
Diluent Water Availability

In general, there is sufficient diluent water available in the Main San Gabriel Basin to handle up to 85 TAFY of recycled water. However, if Upper District constructs their GRIP project (as tertiary treated only), there will be insufficient diluent water available for the full project size (as outlined in **Table C.6 and Figure C.22**).

Table C.6: Diluent Water Calculations Main San Gabriel

Project	50% RWC	75% RWC
With Upper District	Project size limited to 35 TAFY	Diluent water available 100% of the time
Without Upper District	Diluent water available 100% of the time	Diluent water available 100% of the time

Figure C.22: Diluent Water Availability in Main San Gabriel



Groundwater Impacts

Groundwater Modeling

Description of Model

For the modeling, the existing Main San Gabriel Watermaster model was used. The Watermaster's Groundwater Basin Flow Model was developed by Stetson in 1997 (Stetson, 1997). The model is a two-dimensional finite-difference model, which uses a modified version of the Prickett-Lonquist Aquifer Simulation Model code. The model has a 400 foot by 400 foot grid with sources (i.e., recharge facilities) and sinks (i.e., pumping wells) located at the nearest grid node. The model is 500 feet thick and is described in more detail in the documentation and user's manual (Stetson, 1997). For this analysis, the model was run in a steady-state mode to evaluate continuous recharge and recovery of various recharge rates

Model Assumptions

The model period for this analysis is fiscal years 1998-2015. This period represents a period that includes both wet and dry times, which will provide a good estimate of the long-term feasibility of storing water in the basin. The following model runs were performed for Main San Gabriel Basin.

- Baseline – This scenario is intended to evaluate the application of recharge water on a continuous basis at a rate equal to the long-term average imported replenishment demand.
- Base Case – The purpose was to evaluate the quantity of additional water that the groundwater basin could receive on a long-term continuous basis while maintaining groundwater elevations within a specific operational range.

The following assumptions were made for the two modeling scenarios:

- Projected future demand in the groundwater basin was the same as present demand. This is because under current demand conditions groundwater levels have shown a long-term decline and the purpose of the modeling was to evaluate the quantity of recharge required to stabilize groundwater levels and to evaluate the buffering capacity of the basin to receive a larger volume of recharge water for short periods of time. This approach would therefore provide a conservative estimate of the amount of additional water that the groundwater basin could accommodate under each of the modeling scenarios.
- The Santa Fe Spreading Grounds was modeled as the principal point of delivery for the purified water. An evaluation was made under each scenario regarding the capacity of the Santa Fe Spreading Grounds to receive the water, particularly during wet periods when LACDPW uses these facilities to capture and recharge storm flows from the San Gabriel River. If the capacity of the Santa Fe Spreading Grounds was exceeded, other spreading facilities would then be added to the model.

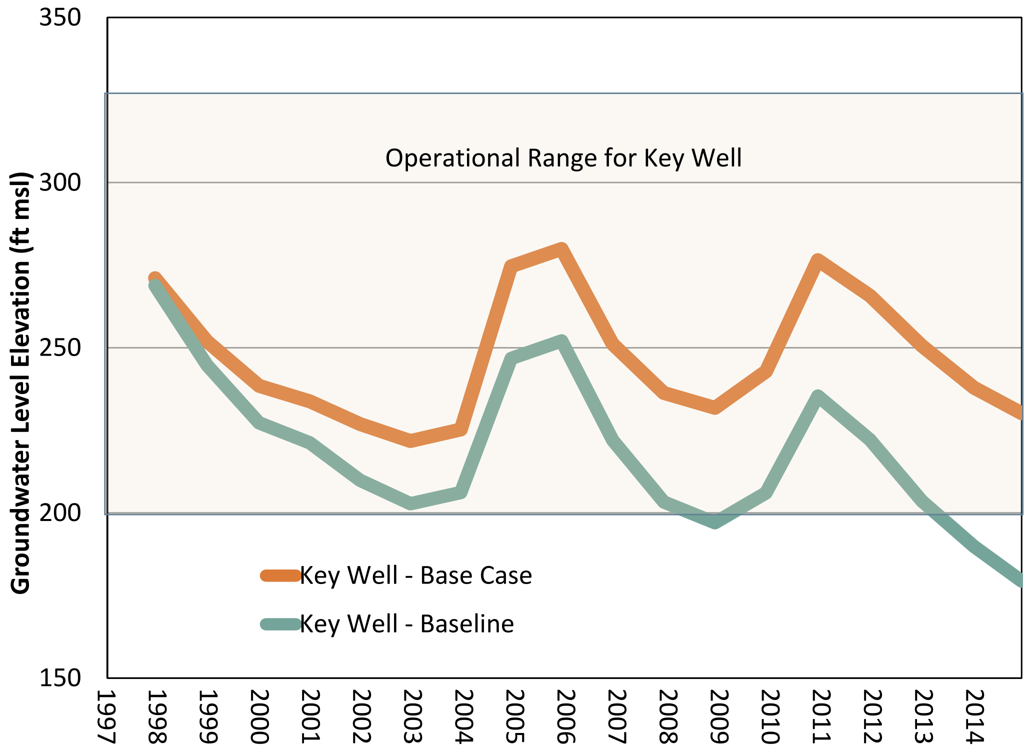
Model Results

From the results of groundwater modeling for the Main San Gabriel Basin it appears that the basin is capable of receiving the full 70 TAFY (62.5 mgd) of Metropolitan's recharge water with the occasional application of 86 TAFY (77 mgd) during wet periods or when other spreading areas are unable to recharge water. The changes in water level are within the range of water levels seen in the past. It is not anticipated to affect producers or the operable units in the basin. Future work will include further evaluation of the water quality effects of recharge to the operable units.

Water Levels

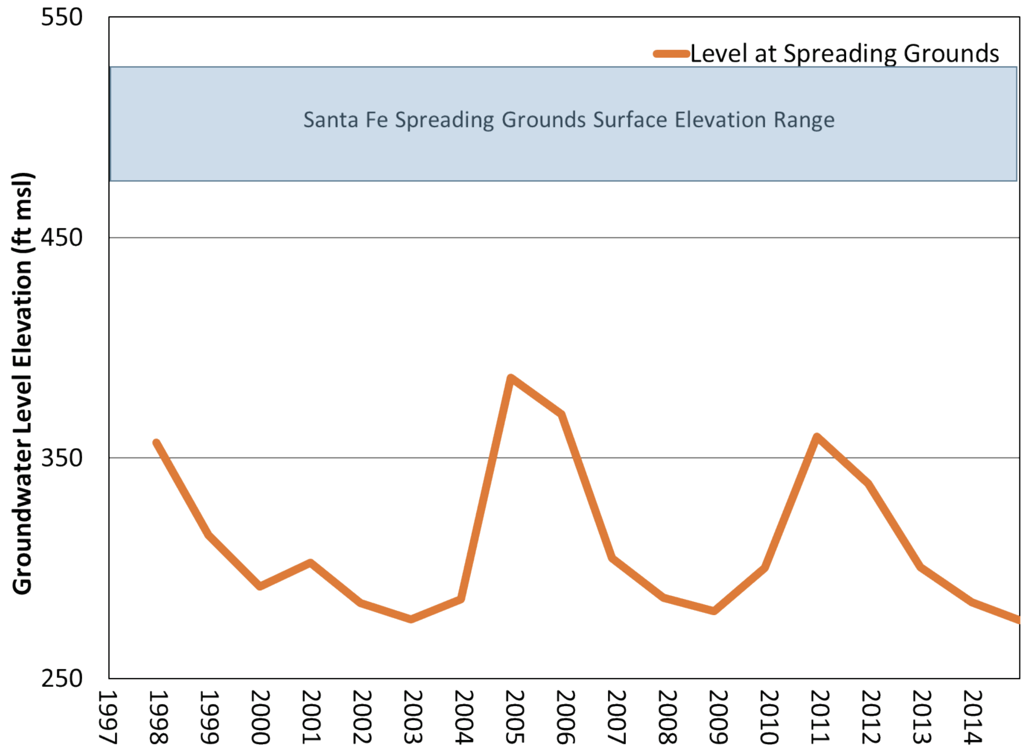
The longest continuous period for which the existing model was calibrated was from 1997-1998 through 2014-2015 fiscal years (18 years). The results are presented on **Figure C.23**.

Figure C.23: Main San Gabriel Basin Model Results Long-Term– Base Case



The long-term modeling results indicate that the groundwater basin can accommodate the recharge over the 18-year modeled period. The continuous recharge of 70 TAFY (62.5 mgd) could result in a cumulative increase in water level of about 50 feet, well within the operating range. It is important to note that even with the additional recharge, modeled water level at the key well at the end of the model period is still 40 feet below the starting point in the model run. In addition, water levels below the spreading grounds are not expected to be high enough to affect recharge as shown on **Figure C.24**.

Figure C.24: Model Results Base Case Level below Spreading Grounds

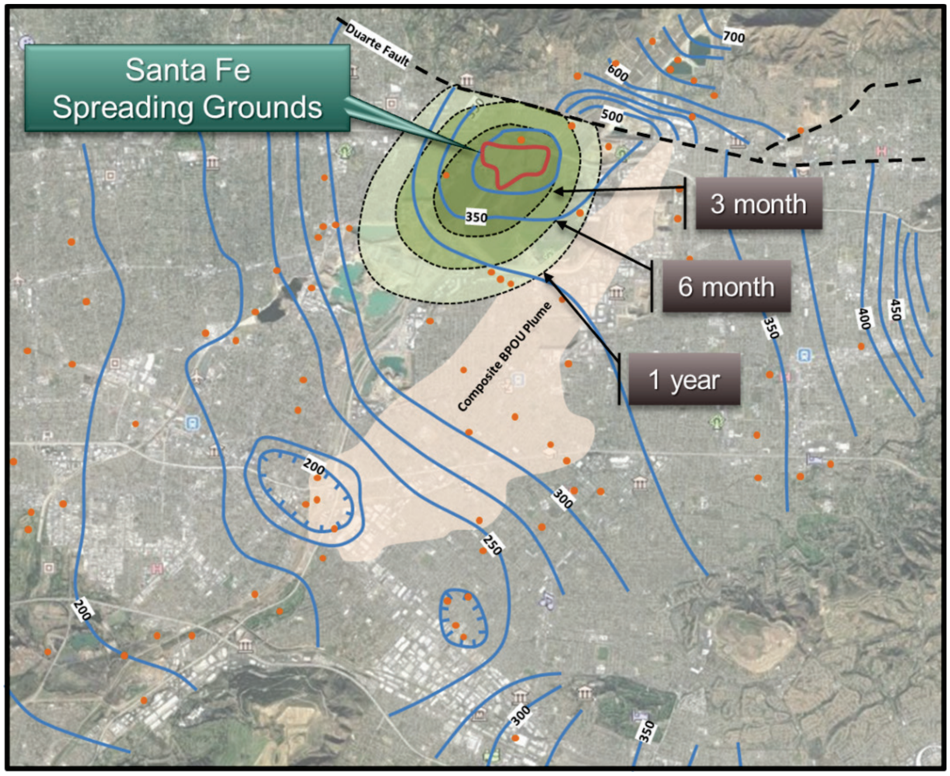


Travel Time Estimates

The travel time estimates are shown in **Figure C.25**. As many as seven wells may have to be relocated within the 12-month travel time envelope.

From the results of groundwater modeling for the Main San Gabriel Basin it appears that the basin is capable of receiving the full 70 TAFY (62.5 mgd) of Metropolitan's recharge water with the occasional application of 86 TAFY (77 mgd) during wet periods or when other spreading areas are unable to recharge water. The changes in water level are within the range of water levels seen in the past. It is not anticipated to affect producers or the operable units in the basin. Future work will include further evaluation of the water quality effects of recharge to the operable units.

Figure C.25 Travel Time Estimates – Base Case



Orange County Basin

Needs Analysis

The needs analysis provides the range of demand for the water in the Orange County Basin from this project. Projections are based upon Metropolitan's IRPSIM.

Projected Replenishment Needs

The current amount of imported water delivered for replenishment in the Orange County Basin is 65 TAFY. The RRWP would replace this demand with purified water from the JWPCP. If the RRWP did not move forward, imported water from Metropolitan would fulfill this demand, as it does today.

Demand Assessment

The Metropolitan consumptive demand for the Orange County Basin ranges from about 160 to 250 TAFY.

Groundwater Pumping Capability

According to estimates by MWDOC, the groundwater pumping capability in Orange County ranges from about 420 to 440 TAFY (Metropolitan, 2007).

Operational Assessment and Facility Needs

Spreading Basins

Currently, OCWD spreads about 37 TAFY of recycled water from its Groundwater Replenishment System (GWRS) facility and about 150 TAFY of stormwater from the Santa Ana River into the Orange County Basin. OCWD expects to purchase about 65 TAFY of imported water from Metropolitan going forward. Spreading basins owned by OCWD have the capacity to receive all of the 65 TAFY (58 mgd) of additional recharge during normal and dry periods, particularly during the summer months. However, during wet periods and some winter months the existing spreading basins (Mira Loma, Kraemer, Miller, and La Palma) may be limited to 22 TAFY (20 mgd) of additional recharge. For modeling purposes, it is assumed that Metropolitan would purchase land for a new spreading basin.

The available spreading capacity is shown in **Figure C.26**. To meet the goal of 65,000 AFY, an additional 30acres of spreading basins would be required. Without new spreading basins, wet period flow would be as low as 20 mgd.

Figure C.26: Available Capacity at GWRS Dedicated Basins

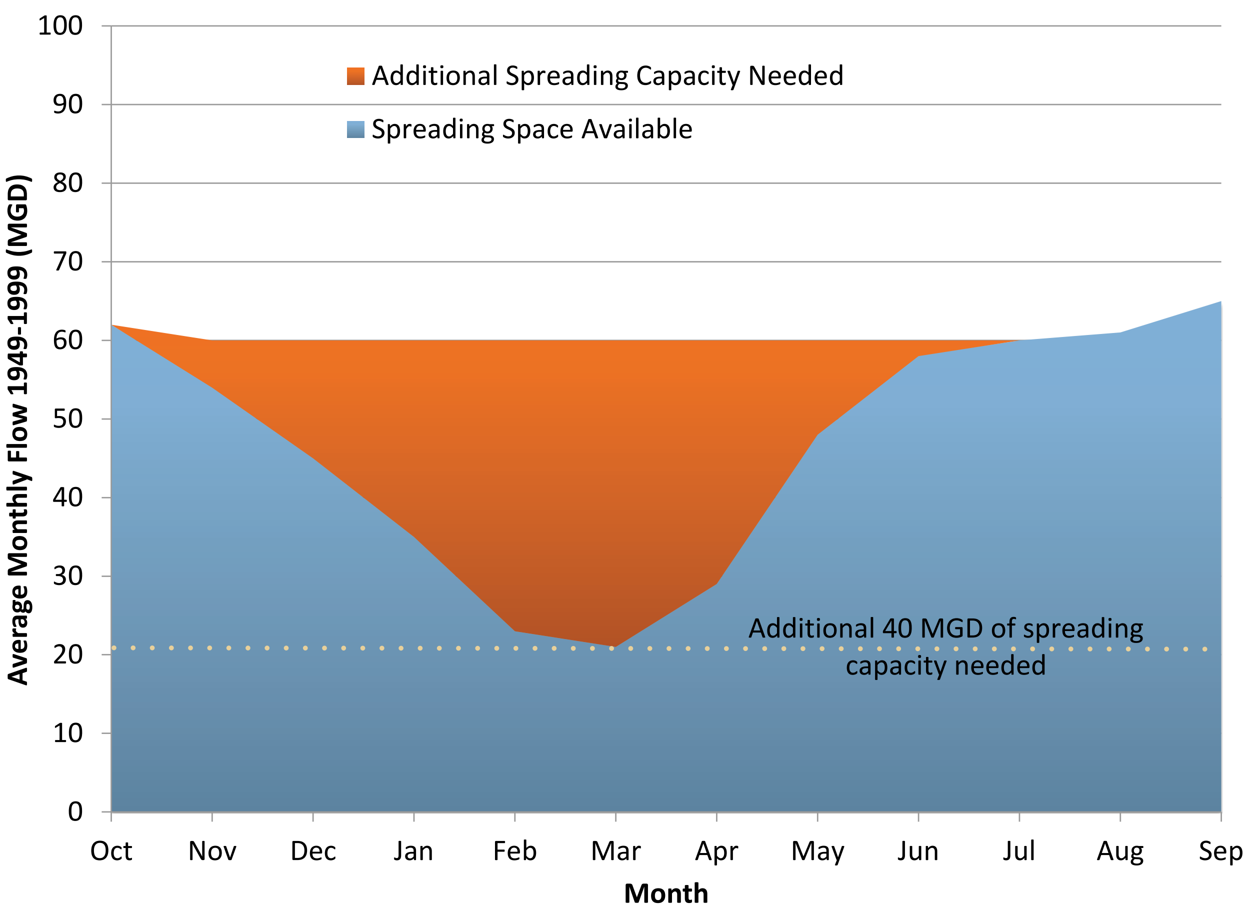
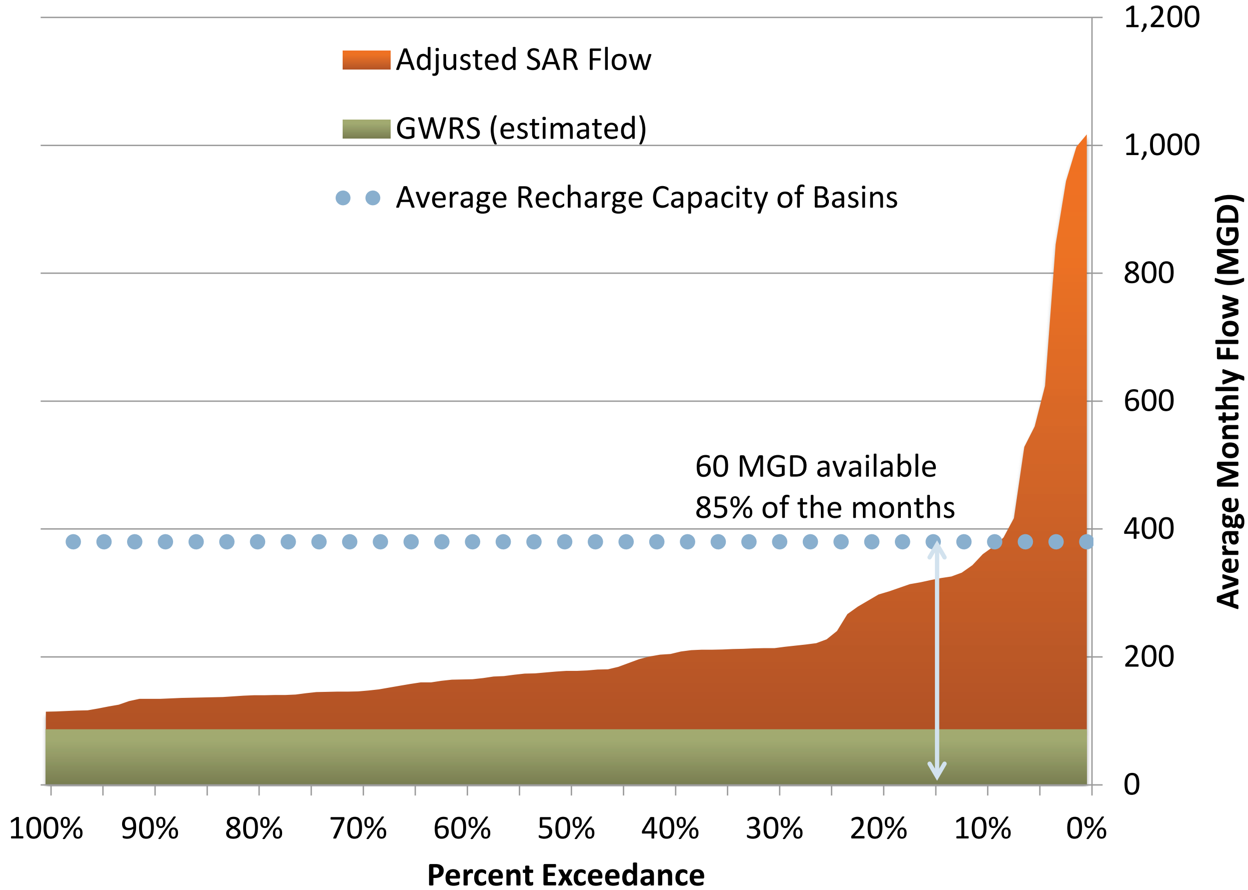


Figure C.27: Available Capacity in All Orange County Basins



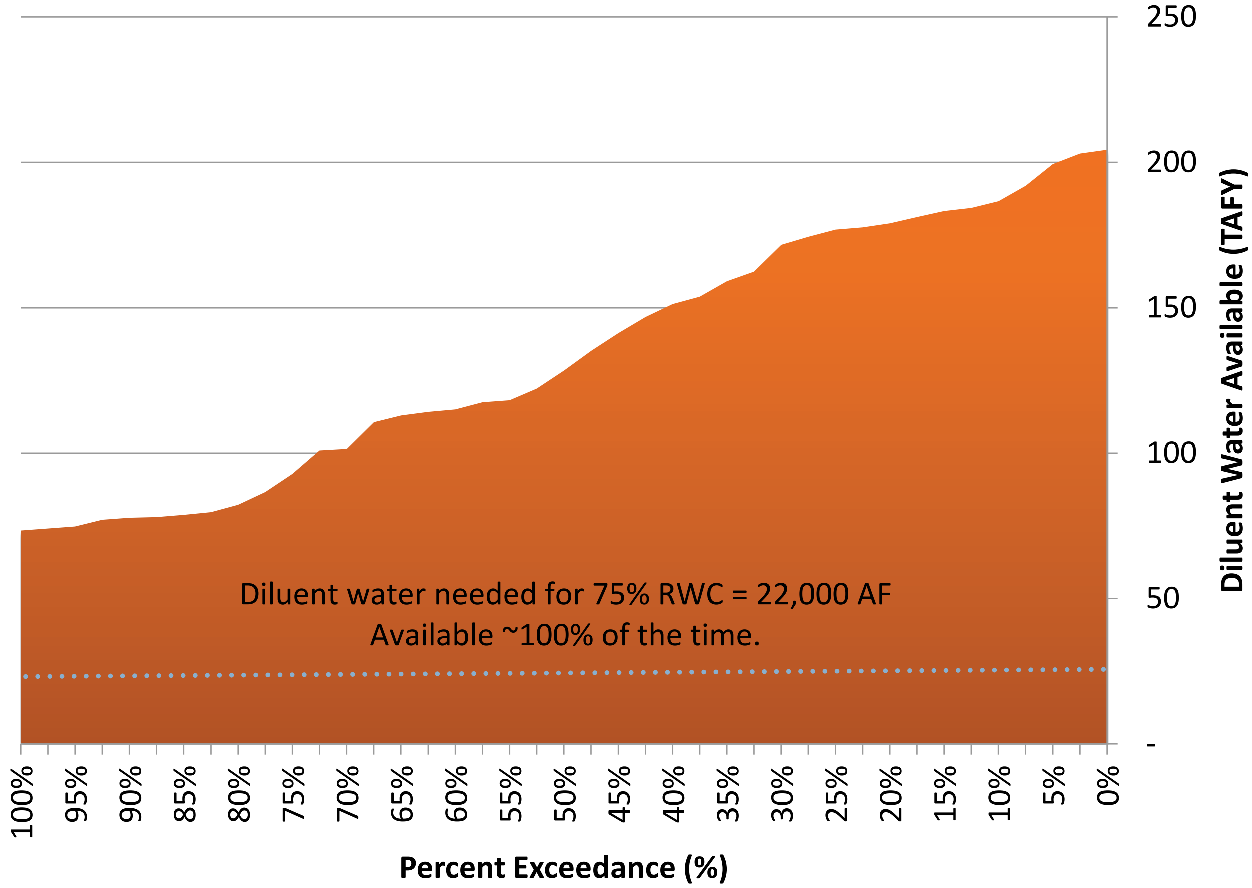
Results of the analysis are:

- If GWRS dedicated basins only are used (as shown in **Figure C.26**) :
  - Sufficient capacity available only 4 months out of year
  - 40 mgd of additional spreading capacity is needed (about 30 acres of new ponds)
- If all basins + SAR are used (as shown in **Figure C.27**):
  - Sufficient capacity available 85% of the time
  - Still need 40 mgd of additional spreading capacity to reach 90-95% availability

Diluent Water Availability

Assuming a 75 percent RWC, 22,000 AFY of diluent water would be needed. As shown in **Figure C.28**, sufficient diluent water is available 100 percent of the time.

Figure C.28: Diluent Water Availability in Orange County Basin



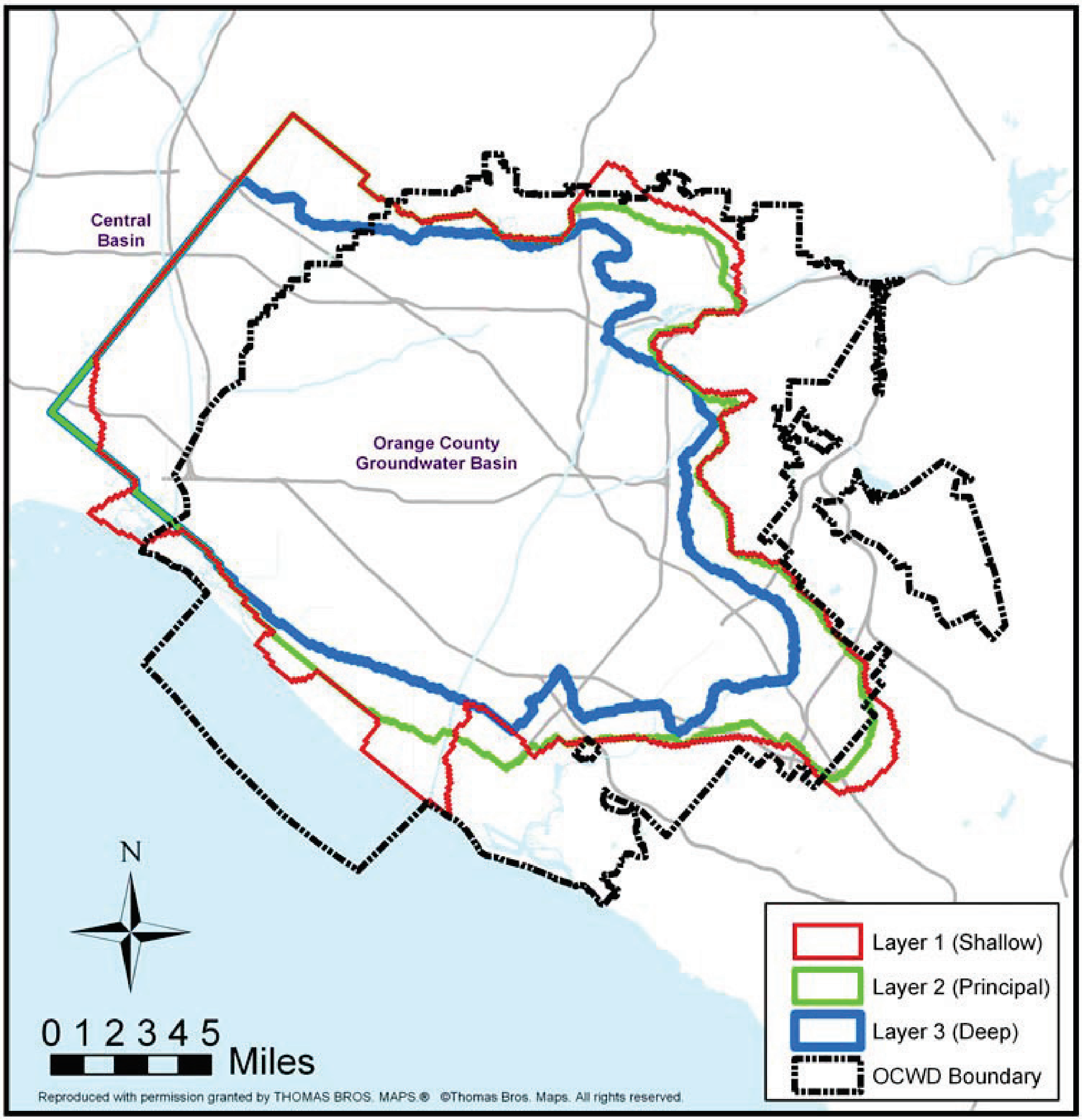
Groundwater Impacts

Groundwater Modeling

Description of Model

OCWD's Basin model encompasses the entire Basin and extends approximately five miles into the Central Basin in Los Angeles County to provide for more accurate model results than if the model boundary stopped at the county line (see **Figure C.29**). As noted previously in this chapter, the county line is not a hydrogeologic boundary, i.e., groundwater freely flows through aquifers that have been correlated across the county line. Coverage of the modeled area is accomplished with grid cells having horizontal dimensions of 500 feet by 500 feet (approximately 5.7 acres) and vertical dimensions ranging from approximately 50 to 1,800feet, depending on the thickness of each model layer at that grid cell location. Basin aquifers and aquitards were grouped into three composite model layers thought sufficient to describe the three distinguishable flow systems referred to as the shallow, principal, and deep aquifer systems. The three model layers comprise a network of over 90,000 grid cells.

Figure C.29: Extent of Orange County Model



The widely-accepted computer program, "MODFLOW," developed by the USGS, was used as the base modeling code for the mathematical model (McDonald and Harbaugh, 1988). Analogous to an off the-shelf spreadsheet program needing data to be functional, MODFLOW requires vast amounts of input data to define the hydrogeologic conditions in the conceptual model. The types of information that must be input in digital format (data files) for each grid cell in each model layer include the following: Aquifer top and bottom elevations; Aquifer lateral boundary conditions (ocean, faults, mountains); Aquifer hydraulic conductivity and storage coefficient/specific yield; Initial groundwater surface elevation contours; Natural and artificial recharge rates (runoff, precipitation, percolation, injection); Groundwater production rates for approximately 200 large system and 300small system wells These data originate from hand-drawn contour maps, spreadsheets, and the WRMS historical database. Because MODFLOW requires the input data files in a specific format, staff developed a customized database and geographic information system (GIS) program to automate data compilation and formatting functions.

Model Assumptions

Below is a list of the assumptions used for numerical input to the groundwater basin model.

- 10 year wet period (1990-2000) used to simulate conservative basin capacity to receive purified water
- Groundwater Basin Inflow
- OCWD to capture SAR flow in existing spreading basins
- SAR base flow of 52,000 AFY
- Calculated SAR storm flow from historical precipitation data
- Incidental recharge from model calibration
- Alamitos Barrier and other recharge of 2,000 AFY
- OCWD'S GWRS w/final expansion of 130,000 AFY
- Metropolitans potential RRWP of 65,000 AFY (58 mgd)
- Groundwater Basin Demand Variables
- Total Demand of 435,000 AFY
- Net Demand of 418,000 AFY
- BPP of 82 percent (this is near the maximum that existing pumpers can produce)
- Pumping outflow of 366,000 AFY

From this assessment several options were considered for the modeling effort:

- **Base Case.** Model 58 mgd of RRWP purified water in OCWD's existing spreading basins for 85% of the model period and 15-20 mgd during the remaining 15% of the model period. Under this option, 15% of the time 15-20 mgd of the purified water would be delivered to the existing Orange County spreading basins and the remaining 43 mgd would need to be delivered to an alternative location such as Main San Gabriel Basin, assuming the basin has the capacity to receive an additional 43 mgd of purified water.
- Model 15 mgd of purified water in OCWD's existing Kramer Basin with the remaining 43 mgd placed in a new spreading basin.
- Model 15 mgd of purified water in OCWD's existing Kramer Basin with the remaining 43 mgd being applied through injection wells.

To evaluate the worst case with respect to impacts to the basin, the model run for Orange County simulated 15 mgd of purified water in OCWD's existing spreading basins and to place the remaining 43 mgd of purified water in a new spreading basin. This model option will provide for maximum stress regarding the capacity of the groundwater basin to receive the additional recharge. When prescribing a location in the model for the new simulated spreading basin, a location was selected that was a minimum of ½ mile downgradient (west) of OCWD's existing spreading basins. The minimum ½ mile offset was intended to provide a reasonable distance among the multiple sources of recharge water in order to limit groundwater mounding within the shallow aquifer zone, while staying within the area that OCWD staff considers to have the greatest capacity to percolate water.

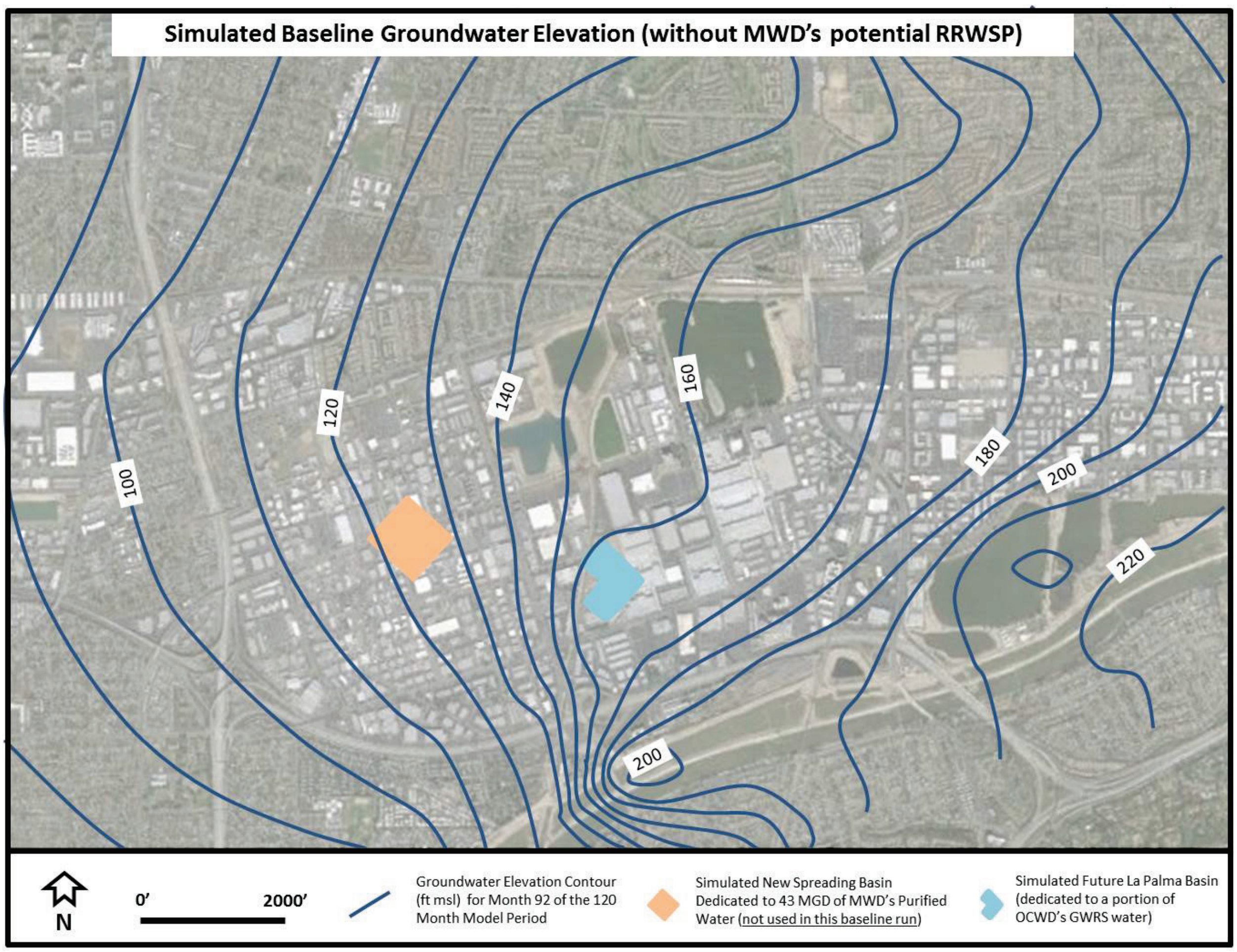
Model Results

Output from the groundwater model was used to produce graphical representations of the modeling results. This includes groundwater contour maps; hydrographs of key locations; and a particle tracking map showing the 3 month, 6 month and 12 month travel times of the recharge water along with nearby groundwater production wells.

Water Levels

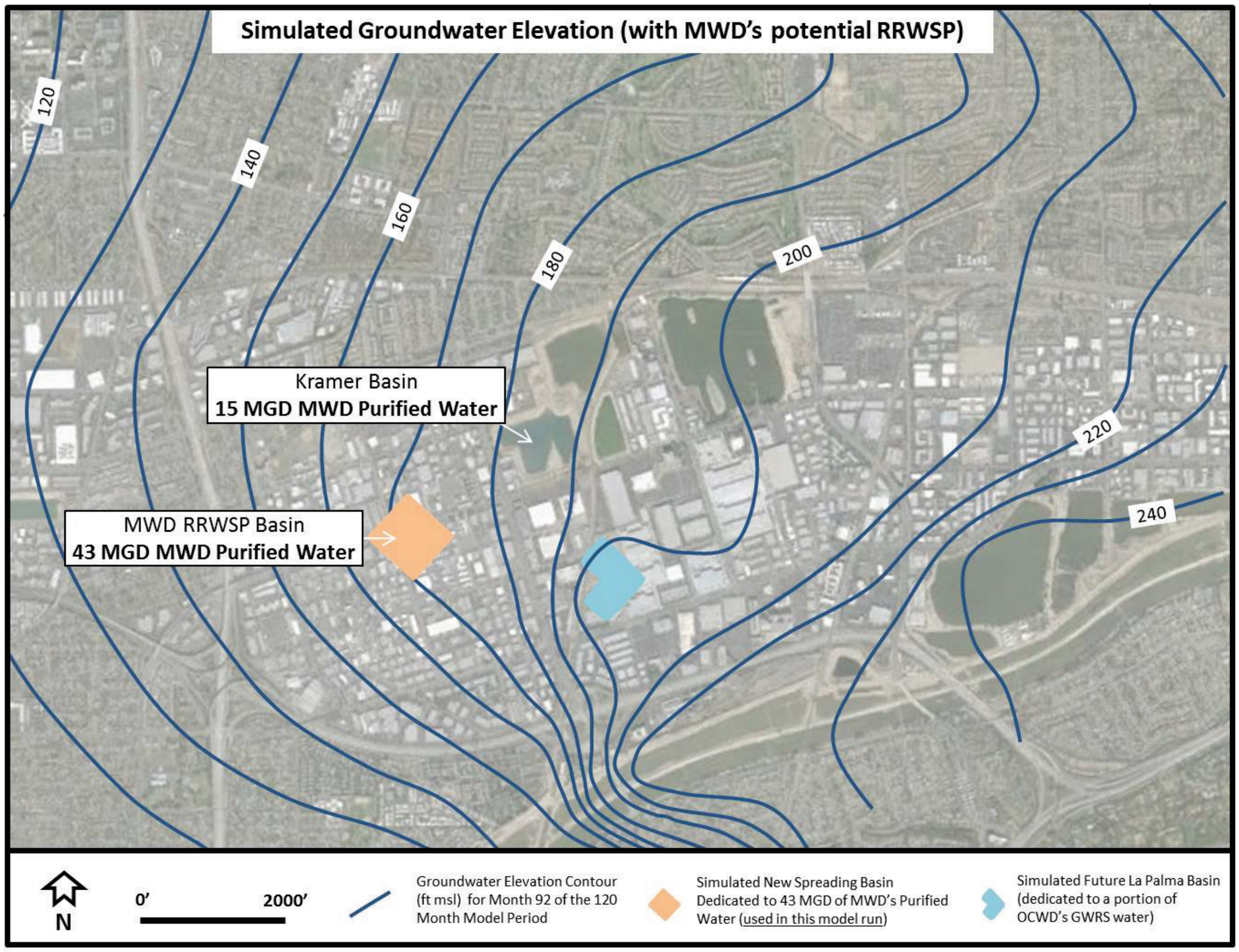
Figure C.30 to Figure C.33 collectively illustrate the effect that water from Metropolitan's potential RRWP would have on the local groundwater regime. **Figure C.30** shows the groundwater elevation without the potential RRWP, **Figure C.31** shows the groundwater elevation with the potential RRWP, **Figure C.32** shows the change in groundwater elevation (groundwater mound) attributed to the potential RRWP, and **Figure C.33** shows the depth to groundwater near the end of the 10 year model period.

Figure C.30: Simulated Baseline Groundwater Elevation Contours (without RRWP)



Note: Illustrates groundwater elevation contours at month 92 (highest water level elevation) of the 120 month model period.

Figure C.31: Simulated Groundwater Elevation Contours (with RRWP)



Note: Illustrates groundwater elevation contours at month 92 (highest water level elevation) of the 120 month model period.

Figure C.32: Change in Groundwater Elevation Contours Attributed to RRWP

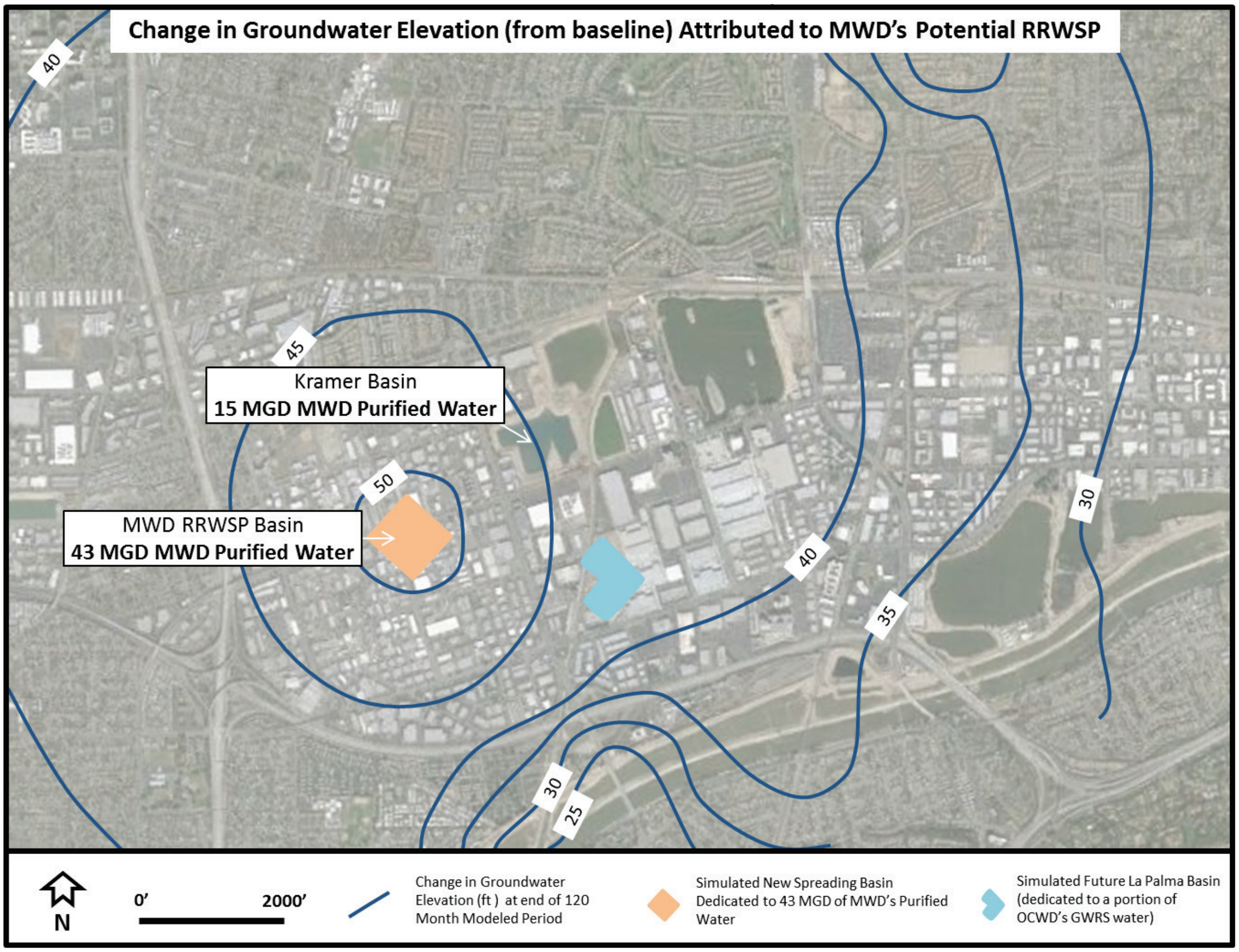
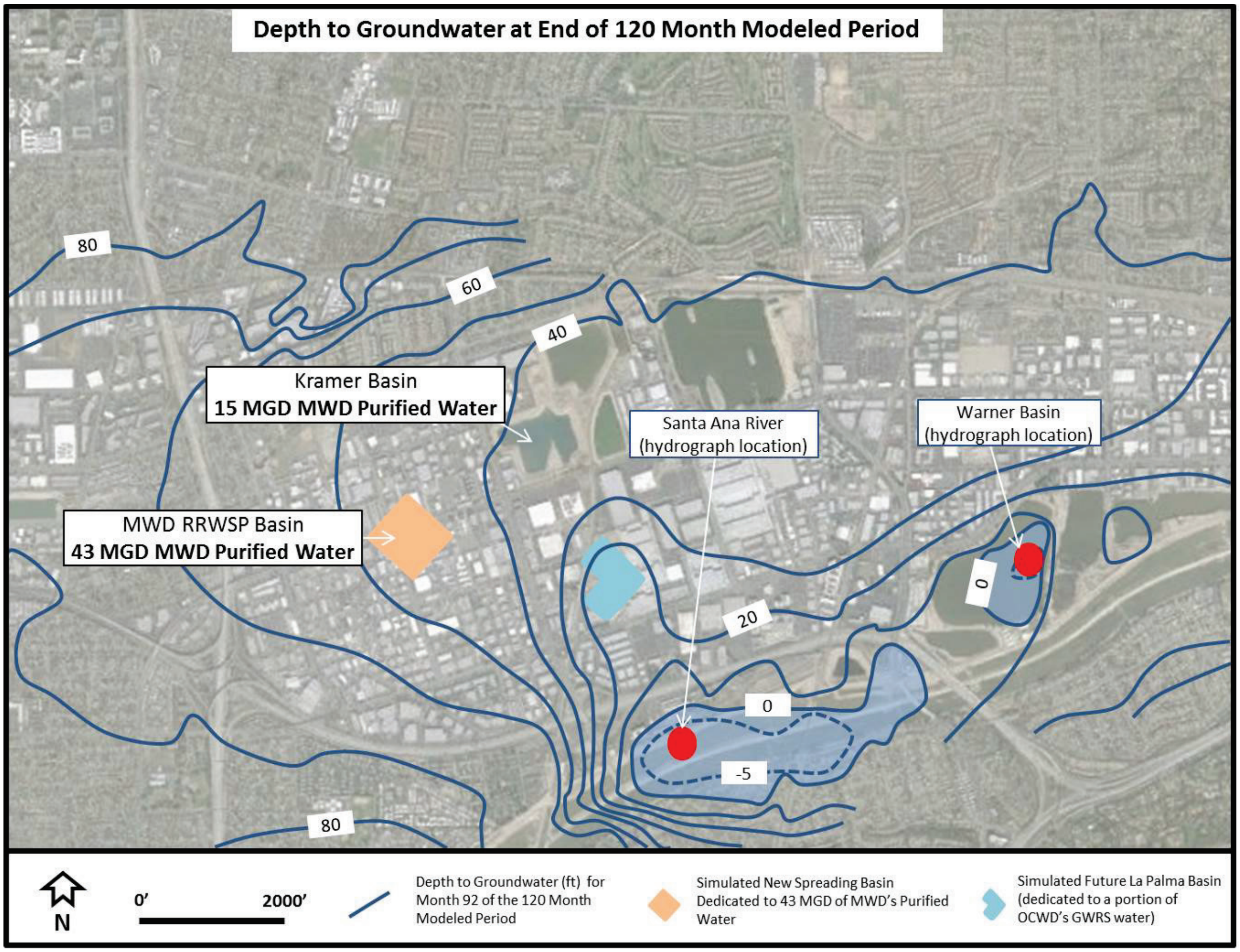


Figure C.33: Depth to Groundwater Contours (near end of modeled period)



From the figures above it appears that the groundwater mound attributed to the potential RRWP is approximately 50 ft. near the area of the simulated new spreading basin and is at an approximate depth of 55 ft. below the ground surface. However, the model results indicate that the elevation of the groundwater near the Santa Ana River is very shallow or at the ground surface for the time step shown on **Figure C.31.** This was the time step that showed the highest groundwater elevation. From these results OCWD produced a couple of groundwater hydrographs to illustrate the temporal nature of the shallow groundwater in the area of the Santa Ana River.

The hydrographs below (**Figure C.34 and Figure C.35**), shows the simulated groundwater elevations for two locations along the Santa River where the model indicated shallow groundwater as a result of Metropolitan's potential RRWP.

Figure C.34: Simulated Depth to Groundwater, Santa Ana River

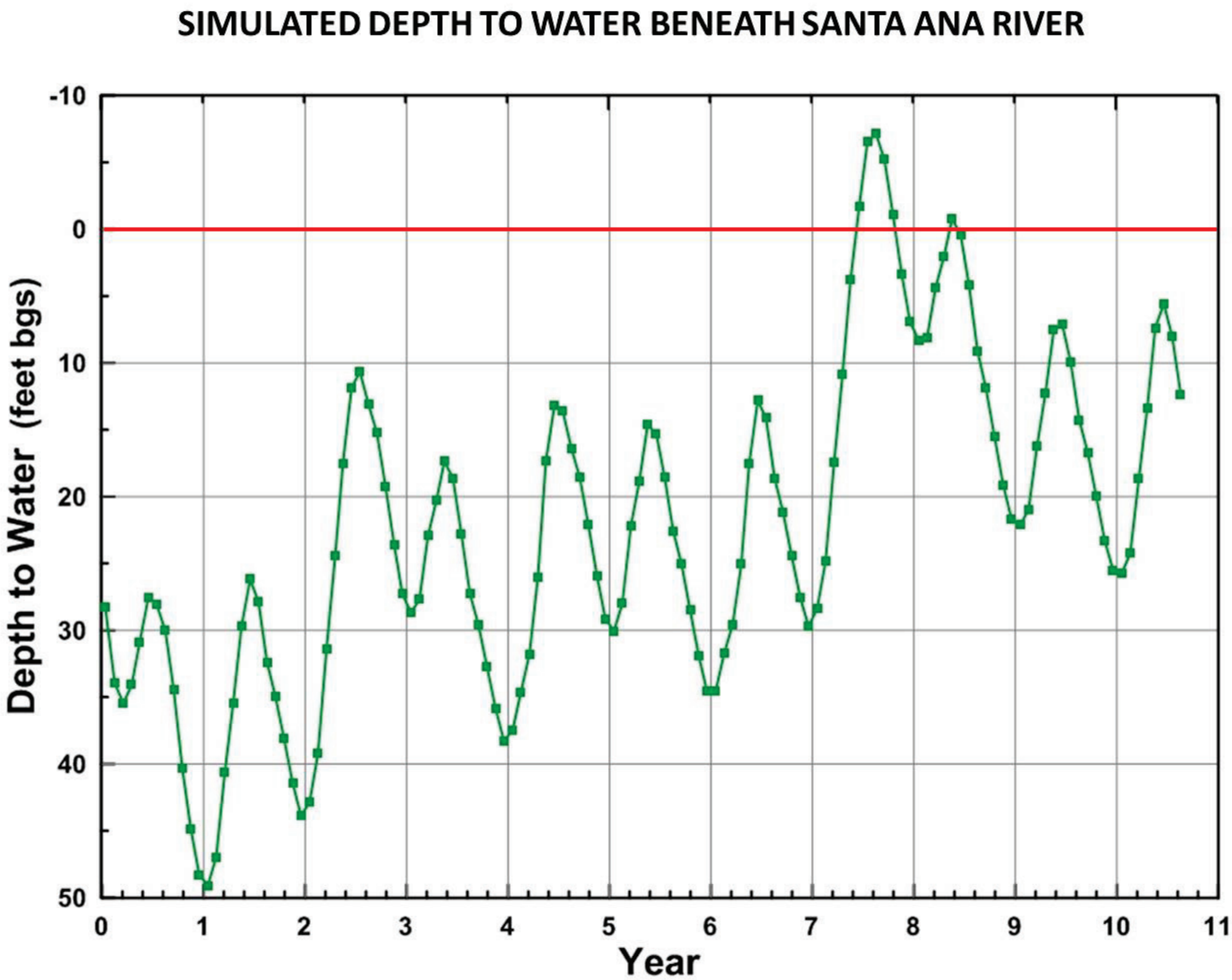
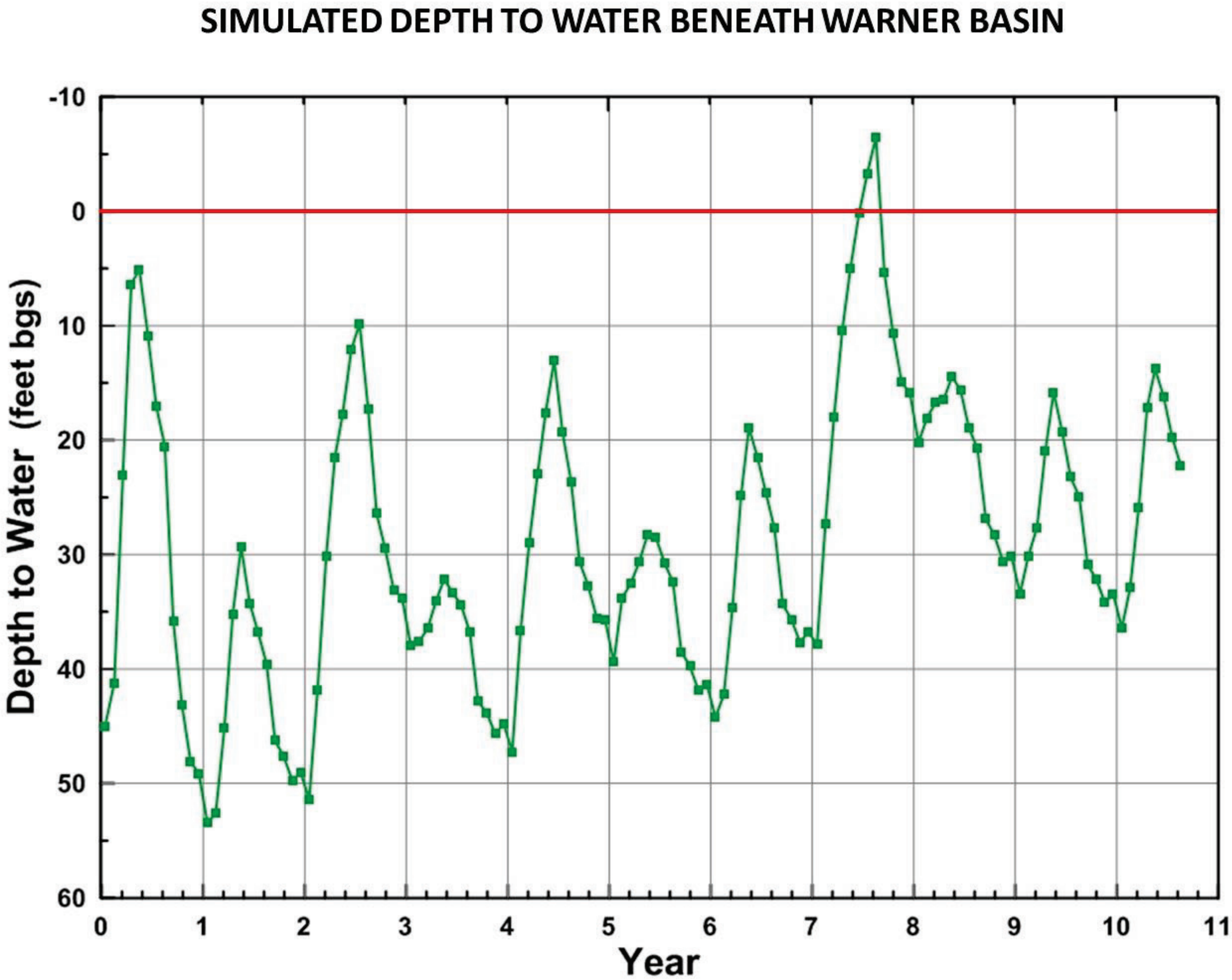


Figure C.35: Simulated Depth to Groundwater, Warner Basin (adjacent to Santa Ana River)

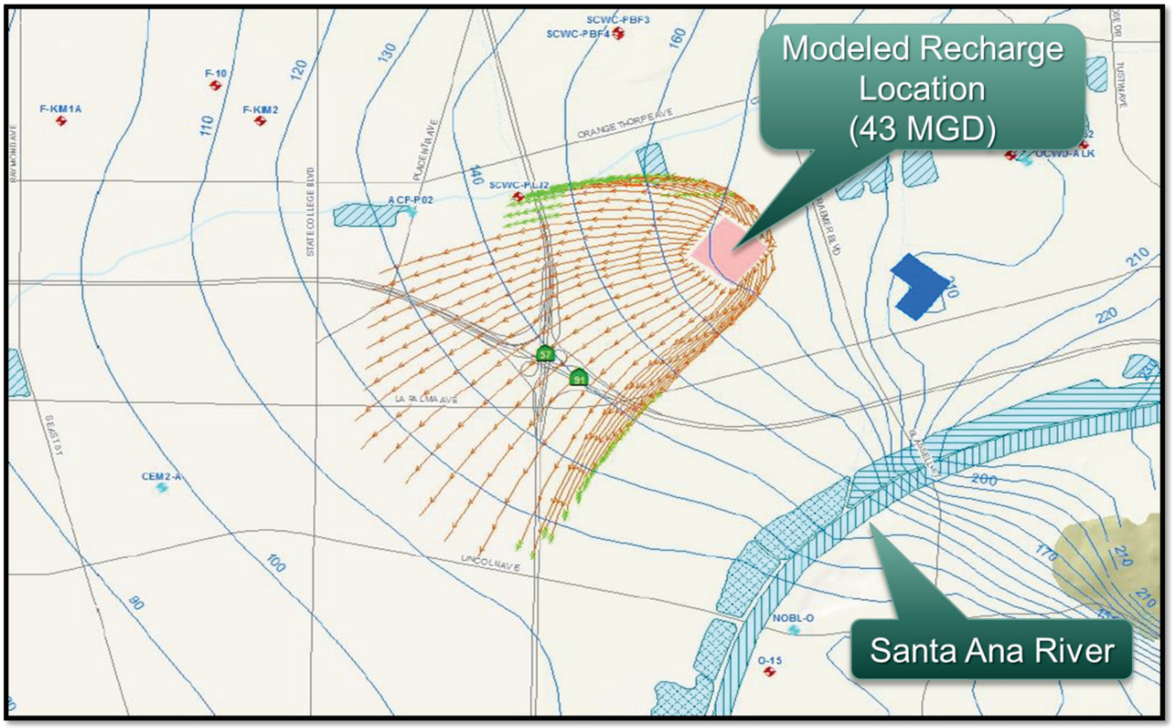


These figures indicate that very shallow groundwater occurs for only a few months of the entire 120 month modeled period and that this was during a very wet water year. It should be noted that the input variables to the model were very conservative and that less conservative assumptions (larger future water demand, greater BPP, fewer wet precipitation periods, etc.) would result in lower groundwater elevations.

Travel Time Estimates

The next step in evaluating the model output was to determine the location and number of existing groundwater production wells that are within 3 month, 6 month and 12 month travel times from the application point of the recharge water (**Figure C.36**). This was necessary in order to plan for regulatory compliance issues and to determine the possible number of existing groundwater production wells that may need to be relocated as a result of the potential RRWP.

Figure C.36: Travel Time Estimates



Note: Each arrow represents approximately 1 month of travel time

Impacted Wells and Water Quality

From the above figure it appears that there is only one groundwater production well within a travel time of up to 12 months from the simulated new spreading basin.

From the results of groundwater modeling for the Orange County Groundwater Basin it appears that the basin is capable of receiving the full 58 mgd of RRWP purified water under the assumed conditions. It should be noted that conservative assumptions were used as input to the groundwater model with respect to the basin's capacity to receive the additional recharge. Some of the variables affecting model output are the projected future basin demand and the operational aspect of the groundwater basin (i.e. the BPP). If demand is greater than the conservative assumption or the BPP is increased, it would further enhance the basins ability to receive the purified water and the risk of shallow groundwater near the Santa Ana River would be reduced.

Additionally, consideration could be given to only utilizing the existing spreading basins currently owned by the OCWD. This would allow for the full 58 mgd of purified water to be delivered up to approximately 85 percent of the time (from demand analysis section of feasibility report). The remaining 15 percent of the time 15 mgd of purified water could be delivered to OCWD's Kramer Basin and the remaining 43 mgd could be delivered to an alternative location and/or treatment plant output could be reduced. The value to this approach is that project costs would be reduced because an additional spreading basin or injection wells would not be required.

Summary

How much can be utilized in each basin?

The base case of up to 150 mgd (summarized in **Table C.7**) assumes constant output from the treatment plant was allocated among the four groundwater basins as shown below:

- West Coast Groundwater Basin — Up to 15 mgd (up to 17 TAFY)
- Central Groundwater Basin — Up to-15 mgd (up to 17 TAFY)
- Main San Gabriel Basin — 62-77 mgd (70-85 TAFY)
- Orange County Groundwater Basin — 18-58 mgd (20-65 TAFY)

When considering the delivery quantities shown above, Metropolitan recognized that there could be occasions when one or more of the groundwater basins might not be able to take its full allocation of purified water for short periods of time. The treatment plant could be operated in a range from 100-150 mgd. When the spreading basins are full, the lower flow could be used. To reach this goal for the treatment plant, it is important that the Main San Gabriel Basin be able to increase their flow to 78 mgd. This provides flexibility in other areas of the system.

Table C.7: Summary of Base Case

Groundwater Basin	Member Agency	Recharge Location	Amount85% of the time (TAFY)	Amount 15% of the time (TAFY)	Amount for Pipeline Size (mgd)	Notes
Central Basin	Central Basin MWD	Montebello Forebay	3.0	0.0	11.6	Delivered at Whittier Narrows Dam for spreading. Alternative to base case 13 new injection wells
	Los Angeles	Montebello Forebay	10.0			Alternatives to base case: up to 13 acres of new spreading basins/injection wells
	Long Beach	Existing Injection Wells	4.0	0.0	3.6	Existing injection wells
Main San Gabriel	Upper District & Three Valleys	Santa Fe	70.0	85.0	77.7	Upsized to handle Main San Gabriel + Central Basin recharge
Orange	MWDOC	GWRS Basins	65.0	20.0	58.0	Using all OCWD recharge basins
West Coast Basin	Torrance & West Basin	New Injection Wells	11.0	11.0	9.8	Will require up to15 new injection wells
	Los Angeles	Refineries	5.0	5.0	4.5	Alternative to base case: additional injection wells
Total			168.0	121.0	150.0	

What facilities are needed in each basin?

Central and West Coast

For this feasibility assessment, the conceptual base case assumption was to use injection wells as the sole method for recharging into the underlying aquifer(s) within the Central and West Coast Basins. This included:

- 13 new injection wells in the Montebello Forebay area, between the Rio Hondo and San Gabriel Spreading Grounds;
- existing wells in the Long Beach area; and
- 15 new injection wells in the West Coast Basin along the 110 corridor.

Each injection well was assumed to have a design injection capacity of 2 mgd with an average long term injection capacity of 1.0 mgd - 1.5 mgd. The difference between the maximum and long term average capacities is attributed to time-related decreases in well efficiency in between backflushing events, off-line periods for backflushing, well maintenance, etc. This base case feasibility scenario also assumed that the height of the water column in the well casing would provide enough head to drive the recharge water into the underlying aquifers without the need for additional positive pressure at the well head.

The depth and design of each injection well can be highly variable and is dependent upon many variables, including the local geology, hydrology, groundwater water quality, etc. For the purpose of this base case feasibility study it was assumed that each injection well would be constructed with 18-inch diameter stainless steel casing to 800 ft. depth with 400 ft. of well screen.

Periodic backflushing will likely be required in order to maintain well efficiency. Depending upon site-specific geology, individual well design, etc., backflushing events could be as frequent as weekly and about 1-2 hours in duration. Discharge from the backflushing will likely need to be directed into a wastewater line and placed in a nearby storm drain. This will need to be coordinated with the local regulating agencies. The base case also assumed that a dedicated pump would be installed in each well to facilitate the backflushing. It was envisioned that the pump-out capacity would be about 2000-3000 GPM in order to remove fine particles that accumulate around the well casing during injection activities.

Plumbing to and from each injection well will be a significant part of the capital costs associated with well construction, when compared to that of spreading basins. The base case assumed a main trunk-line terminating within an injection well-field with laterals going to each well. As mentioned above, a separate discharge line will also be needed for each well to accommodate the waste water during backflushing activities.

In order to limit the number of downgradient monitoring wells required for compliance monitoring, the base case assumed installing the injection wells within a well-field with wells spaced on approximate 1,500 ft. centers. This will likely provide adequate spacing to minimize mounding interference among injection wells while at the same time limiting the number of required downgradient monitoring wells. This is because the mound created by the collective influence of wells within the injection well-field will likely result in one large zone of influence as opposed to multiple smaller zones of influence if the wells were to be installed at significantly greater distances apart.

The base case assumes 6 downgradient compliance monitoring locations: 3 locations sited to meet the regulatory prescribed travel time requirements (one near the center of the groundwater mound, and one on either side of the groundwater mound), and 3 locations sited to meet the regulatory prescribed upgradient requirements for existing groundwater production wells. Additionally, multiple aquifer zones will likely need to be monitored at each monitoring location. This is attributed to the stratified nature of the aquifer(s) underlying the Central and West Coast Basins. The base case therefore assumes 2 monitored aquifer zones at each of the monitoring locations.

Main San Gabriel

For this feasibility assessment, the conceptual base case assumption utilized the existing Santa Fe Spreading Grounds for the delivery point of the purified water. The spreading grounds are currently maintained by the Los Angeles County Department of Public Works. Periodic clean-out of the spreading grounds will be required in order to maintain their high percolation capacity. For this base case it was assumed that each basin within the spreading grounds will need to be cleaned out at least once per year. Each clean-out event was assumed to take about 2 weeks.

The base case assumes 6 downgradient compliance monitoring locations: 3 locations sited to meet the regulatory prescribed travel time requirements (one near the center of the groundwater mound, and one on either side of the groundwater mound), and 3 locations sited to meet the regulatory prescribed upgradient requirements for existing groundwater production wells. Due to the nature of the aquifer near the spreading grounds, it is envisioned that only one monitoring zone will be needed at each monitoring location.

Orange County

For this feasibility assessment, the conceptual Base Case assumption was to use the existing spreading basins owned by the OCWD to deliver the purified water.

Periodic clean-out of the spreading basins will be required in order to maintain their high percolation capacity. For this Base Case it was assumed that each basin will need to be cleaned out about twice per year. Each clean-out event was assumed to take about two weeks to complete. These clean-out events can be coordinated with OCWD staff so that they occur during periods when OCWD's other basins have capacity to temporarily receive the water while the spreading basin is out of service.

The Base Case assumes three downgradient compliance monitoring locations: two locations sited to meet the regulatory prescribed travel time requirements, and one location sited to meet the regulatory prescribed upgradient requirements for existing groundwater production well (only one existing production well within 12 month travel time). Due to the nature of the aquifer near the spreading basins, it is envisioned that only one monitoring zone will be needed at each monitoring location.

POTENTIALLY IMPACTED FACILITIES

Central Basin

Potentially impacted facilities in the Central Basin under the Base Case include:

- Potential changes to the operation of the Rio Hondo Spreading Grounds
- Changes to the operation of the Long Beach wells
- Increased production from various entities in the basin
- Relocation of up to 5 wells

These impacts are minor and would not preclude the project from going forward.

West Coast Basin

Potentially impacted facilities in the West Coast Basin under the Base Case include:

- Increased production from various entities in the basin
- Potential system changes to pump new water
- No wells would need to be relocated

Main San Gabriel

Potentially impacted facilities in the Main San Gabriel Basin under the Base Case include:

- Potential changes to the operation of the Santa Fe Spreading Grounds
- Changes to how water is purchased
- Relocation of 6 wells will be required

Orange County

Southern California Water Company's PLJ2 well is projected to be impacted by the project.

Risk Analysis and Future Studies

The operation of the groundwater basins is quite complex and a variety of issues can arise. Risks for the future success of the base case include: environmental, groundwater, legal, or logistical issues with delivering water to the groundwater basins.

Groundwater

In this report, Metropolitan did not analyze the impacts to groundwater contamination plumes or operable units. This analysis will be done at the next stage of the project, if approved. It is recognized that there could be potential impacts to these operations. The risk would be the most in Main San Gabriel Basin and Orange County Basin, where the most water is being recharged.

There is also a risk of water quality incompatibility between the delivered water and local groundwater, particularly in injection wells and/or recharge areas that have not ever recharged recycled water. Impacts of incompatible waters include biofouling, clogging, reduced injection and/or spreading rates, and aquifer leaching. The AWT demonstration facility is planned to evaluate the water quality of the product water for the project. Once water quality data are available, studies on the compatibility of the two water sources can be evaluated. Evaluations may include, desktop modeling or field monitoring.

The amounts assumed that will be recharged to each basin are based upon groundwater production within adjudicated or managed rights. In order for the recharge to be feasible, the agencies must pump out the stored water. In West Coast Basin and within the City of Los Angeles' service area, adjudicated groundwater rights have not been pumped for years. There is a risk that the agencies that aren't pumping now, will not do so under the potential project.

Legal

If there are impacts to the groundwater basin in terms of yield, groundwater level, or water quality, Metropolitan could be subject to legal action. If contaminants are moved or changed, Metropolitan could become a potentially responsible party (PRP). This risk will be further evaluated in the next phase of this project, if approved.

Logistical

There are potential conflicts with other sources of water, especially in spreading basins where multiple sources of water are spread. In Central Basin and in Orange County Basin, imported water, stormwater, and recycled water are all currently spread. Coordination for cleaning, maintenance, and the management of stormwater flows is n part of the project. In the analysis of the previous sections, an assessment was made to determine how often these risks might occur and an approach to managing that risk. Main San Gabriel Basin and injection wells have the lowest risk. Unlike the Montebello Forebay, the Santa Fe Spreading Grounds are not operated as a stormwater first facility – water can be kept in the dams until needed. In the Montebello Forebay, stormwater capture is priority and on rainy days, all supplemental recharge operations are suspended, which creates a risk for Metropolitan.

The potential project is also hinged on the willingness of our partnering agencies to enter into a storage and extraction agreement. Given the uncertainties that our partnering agencies will potentially experience, it is important to recognize their stake in the project. The adjudicated basins are constrained on how much recharge water they are allowed to purchase, based upon production and storage in the basin. There will likely be times when Metropolitan will want to deliver water to the basins but the basins can't pay for it. Cyclic storage agreements (where water is delivered, but paid for later) may help the agencies pay for it when they need it – there is already a cyclic storage agreement in place in Main San Gabriel.

INSTITUTIONAL ARRANGEMENTS

Institutional arrangements for the storage, recharge, and extraction of RRWP water, as well as the acquisition of regulatory approvals and permits, are an important part of the proposed program. The arrangements can be complex and may involve multiple parties with multiple points of view. Therefore, engagement with these parties early on in the process is important. Institutional arrangements that may be required for each groundwater basin are outlined in **Table C.8.**

Table C.8: Summary of Institutional Arrangements

Basin	County	Agencies	Arrangements/Permits Needed
Central Basin	Los Angeles	WRD	Groundwater Modeling Agreement Coordination of Recharge
		Central Basin MWD	Institutional Arrangements
		California Water Service Golden State Water Company Liberty Water Company	Groundwater Pumping Arrangements
		City of Long Beach	Institutional Arrangements
		City of Los Angeles	Institutional Arrangements
		Los Angeles County Public Works	Operating Agreement
		Los Angeles RWQCB, Region 4	NPDES Permit Water Recycling Requirements/Permit
		DDW	Water Recycling Requirements/Permit
		Central Basin Watermaster	Approval of Storage and Extraction
West Coast Basin	Los Angeles	WRD	Groundwater Modeling Agreement Coordination of Recharge
		West Basin MWD	Institutional Arrangements
		California Water Service Golden State Water Company City of Inglewood City of Lomita City of Manhattan Beach	Groundwater Pumping Arrangements
		City of Torrance	Institutional Arrangements
		City of Los Angeles/Refineries	Institutional Arrangements
		Los Angeles RWQCB, Region 4	NPDES Permit Recycled Water Recharge Permit
		DDW	Recycled Water Recharge Permit
		West Coast Basin Watermaster	Approval of Storage and Extraction
Main San Gabriel Basin	Los Angeles	Main San Gabriel Watermaster	Approval of Storage and Extraction (a supplemental storage arrangement is required – could be part of cyclic storage) Groundwater Modeling Agreement
		Upper San Gabriel Valley MWD	Institutional Arrangements
		Three Valleys MWD	Institutional Arrangements
		SGVMWD	Institutional Arrangements
		Los Angeles County Public Works	Coordination of Recharge
		Los Angeles RWQCB, Region 4	NPDES Permit Recycled Water Recharge Permit
		DDW	Recycled Water Recharge Permit
Orange County Basin	Orange	OCWD	Approval of Storage and Extraction Groundwater Modeling Agreement
		Municipal Water District of Orange County	Institutional Arrangements
		Santa Ana RWQCB, Region 8	NPDES Permit Recycled Water Recharge Permit
		DDW	Recycled Water Recharge Permit

APPENDIX D:

Cost Estimate of the Base Case Full-Scale Advanced Water Treatment Facility for the Potential Regional Recycled Water Program

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Potential Regional Recycled Water Program

Task Order 20

Agreement No. 140025

Cost Estimate of the Base Case Full-Scale Advanced Water Treatment Facility for the Potential Regional Recycled Water Program

Draft Technical Memorandum | October 14, 2016

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1 Executive Summary

The Metropolitan Water District of Southern California (Metropolitan) and County Sanitation Districts of Los Angeles County (Sanitation Districts) are exploring the potential of a local water supply program by treating and reusing non-nitrified secondary effluent from the Joint Water Pollution Control Plant (JWPCP) in Carson, CA using advanced water treatment (AWT). The 150-mgd full-scale AWT facility would receive unchlorinated non-nitrified secondary effluent from the JWPCP. The full-scale AWT facility is intended to achieve nitrification and denitrification and advanced water treatment using a treatment train consisting of membrane bioreactor (MBR) - Reverse Osmosis (RO) – Ultraviolet/Advanced Oxidation Process (UV/AOP)). The MBR-RO-UV/AOP process train represents the base case as described in the program feasibility study concurrently prepared by Metropolitan.

MWH and its partners (Carollo and Trussell Technologies) were tasked to develop the design criteria for the full-scale AWT facility, develop a 3D model for the facility and determine the capital and operation and maintenance (O&M) cost estimates for the facility. After developing the design criteria, Building Information Model (BIM) software was used to develop the model and estimate capital and O&M costs. The cost estimates for the full-scale AWT facility are summarized in this Technical Memorandum (TM).

The Opinion of Probable Construction Cost (OPCC) for the MBR-RO-UV/AOP process train is estimated at $682 million, with MBR, RO and UV/AOP processes making up 25, 24 and 4% of the total OPCC, respectively (**Figure 1**). It should be noted that ten percent of the total OPCC (excluding construction allowances) is included to provide an allowance for estimation accuracy and unlisted items. No additional contingencies have been included for design or construction as these contingencies will be added separately. Typically, these contingencies will be in the order of 10-15% of the OPCC and should be added to any use of these OPCC beyond the context of this TM.

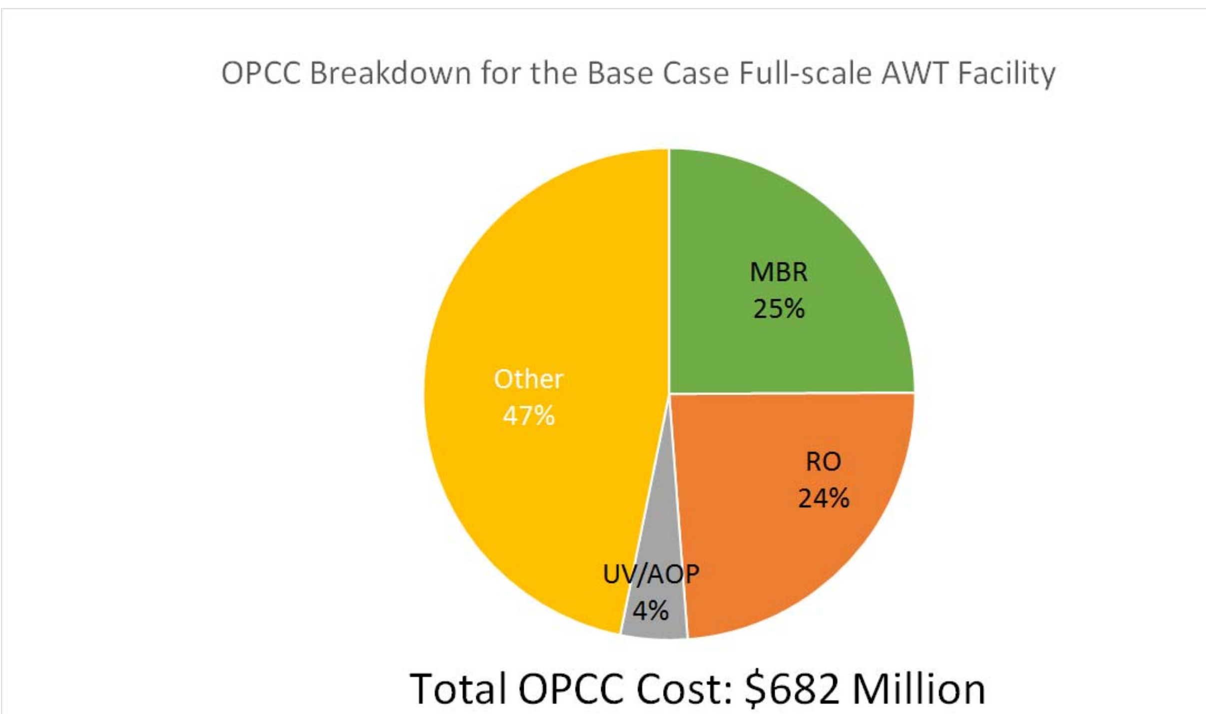

Figure 1: OPCC Breakdown for the Base Case Full-Scale AWT Facility

Figure 2 shows the breakdown of the O&M costs for the base case full-scale AWT facility. The chemicals and power cost make up 49 and 31% of the total O&M costs, respectively, with total annual O&M cost estimated at $101M.

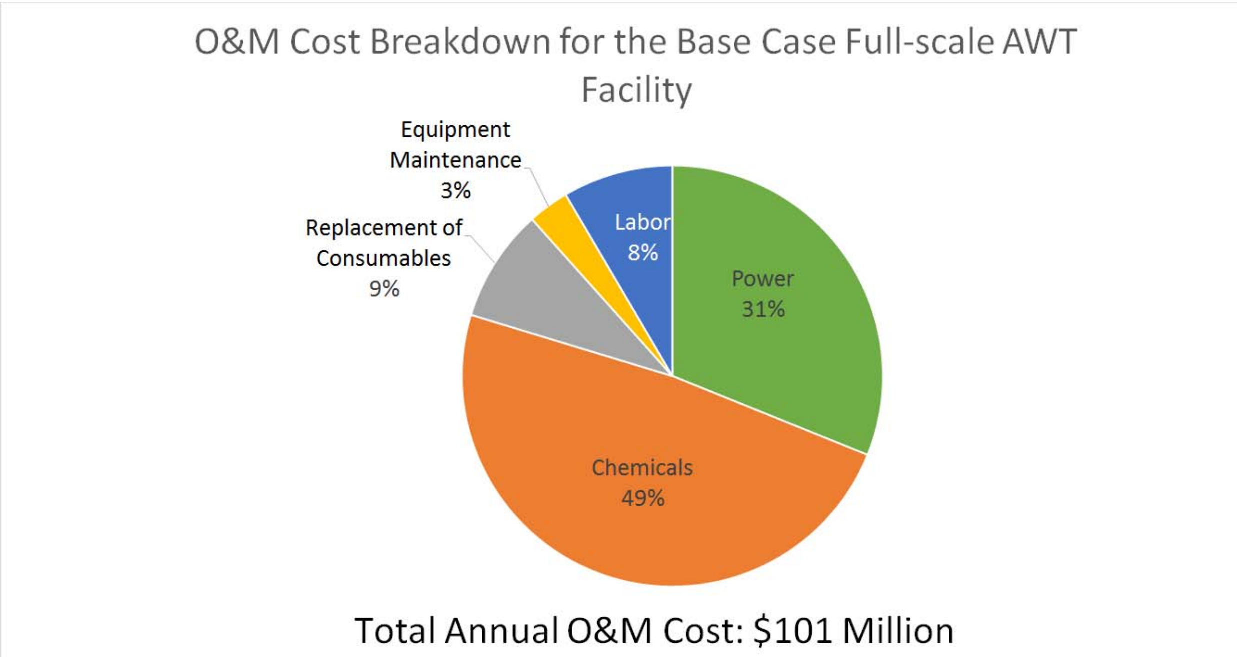

Figure 2: O&M Cost Breakdown for the Base Case Full-Scale AWT Facility

2 Development of BIM Model

BIM was employed to achieve a higher level of accuracy with the plant material take-off (MTOs) through the use of 3D space, intelligent elements and volumes extracted from the models. BIM models were developed for structures, process mechanical, civil yard piping and roadways. A total of 18 area BIM models were produced as part of the estimating and space planning exercise.

The structural models were developed based on certain structural assumptions that considered the existing geotechnical information from the JWPCP and nearby FORCO site and seismic requirements for this area. The assumptions used determined average thicknesses for foundations, slabs on grade, walls, and suspended slabs. Concrete quantities were extracted from the models using Bentley Structural and exported to excel sheets. Reinforcement was estimated on average pounds per cubic yard. Buildings for various structures, blower facility, RO facility, electrical buildings, administration/operations/maintenance, and high service pump stations are based on the square foot area pulled from the models with an average cost per square foot based on a typical pre-engineered metal building.

Process mechanical models were produced with major process piping and equipment based on vender supplied data sheets. These models were also placed on the site where interconnecting yard piping was installed. Piping systems were given unique line numbers and services based on MWH standard specifications developed for Open Plant Modeler (OPM). Line lists were then generated and exported to excel sheets for inclusion in the estimate.

The civil model was also used to calculate volumes for excavation and backfill using an average flat grade and keeping all process units in line with the hydraulic grade line as required. Backfill was based on a 1:1 side slope/excavation layback from the basic structure footprint. Roadway area was calculated along with basic landscaping areas.

3 Capital Cost Estimates

Capital cost estimates were prepared for the MBR-RO-UV/AOP process train, which represents the base case as described in the program feasibility study prepared by Metropolitan. Cost estimates were also developed for the MBR-MF-RO-UV/AOP process train if the MF system is deemed essential (following the MBR system) by the regulators for pathogen log reduction credit. For completeness, costs for both process trains (with and without MF) are presented in this section and summarized in Table 1.

3.1 Methodology and Assumptions

The OPCCs were prepared in accordance with the criteria established by the Association for the Advancement of Cost Engineering (AACE) for a Class 4 cost estimate. The estimate has an accuracy level ranging between -20% to +40%. The estimate is based on capacity factored parametric models, judgment, and analogy. The MTOs were obtained from the BIM model. Preliminary sizing of the structures was performed and initial quotes for major equipment/systems were solicited to improve the accuracy of the cost estimate.

3.1.1 Pricing

Pricing reflects the estimator's opinion as to the probable costs that a "prudent" contractor would include in his tender to construct the defined facilities. The OPCC does not capture framework costs borne by the owner for pre-construction activities or for expenses related to the management and support of field construction activities. The OPCC is intended to be an indication of fair market value and is not necessarily a predictor of the lowest bid. Fair market value is assumed to be a mid-range tender of competitive bids. Finally, OPCC pricing is predicated on the contractor's compliance with all contract specifications and design parameters during field execution activities.

3.1.2 Direct and Indirect Cost Development

Directs costs representing the project's fixed physical scope are estimated against a work breakdown structure to organize the estimate details. Software functionality allows the direct cost detail to be decomposed to multiple sub-levels, which are referred to as item activities. All-in unit prices are applied against the line item quantities.

Indirect costs representing the contractor's time related variable field management expenses or general conditions costs are factored in a top-down approach as a function of running direct costs.

3.1.3 Estimate Adders

Estimate add-ons representing the contractor's allowances for home office overhead expenses, sales taxes, insurance costs, risk provision and fee are added to the cost estimate as a function of running direct costs.

3.1.4 Allowances & Contingency

Allowances are added to the OPCC to anticipate expenses for known but undefined scope items. Ten percent of the total OPCC (excluding construction allowances) is added to provide an allowance for estimation accuracy and unlisted items. No additional contingencies have been included for design or construction as these contingencies will be added separately. Typically, these contingencies will be in the order of 10-15% of the OPCC and should be added to any use of these OPCC beyond the context of this TM.

3.1.5 OPCC General Assumptions

The following generic assumptions are incorporated into the OPCC:

- Competitive bid conditions will prevail at tender (e.g. +3 bidders)
- Standard industry commercial terms will attach to all procurements
- Stable market conditions will prevail without significant geo-political events or economic disruptions
- An optimized contracting strategy will be employed to efficiently sequence and coordinate the work scope
- No trade discounts are considered
- Bulk material quantities are based on manual quantity take-offs

3.1.6 OPCC Specific Assumptions

The following specific assumptions are incorporated into the OPCC:

- Pricing basis is second quarter of 2016. Forward escalation to the mid-point of construction is not included.
- An allowance to provide underpinning or soil stabilization to the building foundation is not included.
- Perimeter fencing is not required.
- Specialized laboratory equipment is not included.
- Imported bedding and gravel materials will serve as pipe backfill and be placed to the top of the pipe.
- Non-rippable rock strata will not be encountered in trench excavations.
- Excess soils will be disposed of in the adjacent site.
- Significant groundwater will not be encountered in pipe trenches.
- Where force mains and sanitary sewers occupy the same trench earthwork excavation costs will be assigned to the force main element.
- Over excavation mitigation includes the fill areas behind the secondary clarifiers. The facilities impacted include the electrical substation, the influent pump station, and portions of the aeration basins.
- All known major utilities will be relocated and abandoned. An additional placeholder is included for undefined less significant utility lines.

3.1.7 OPCC Exclusions/Exceptions

The developed estimate excludes the following:

- Non-conventional environmental, heritage and cultural mitigation measures
- All owner soft costs
- Removal of unforeseen underground obstructions
- Hazardous material remediation or disposal
- Electrical power, sanitary sewer service, and wastewater conveyance outside of project boundary limits
- Utility costs for power connects or incoming transmission
- Permits beyond those normally needed for the type of project

- Facility O&M costs
- New construction of bridges
- All local duties, import fees, port charges and local taxes
- No allowance has been included for additional shift work or weekend work
- Special inspections and testing
- Furnishings, moving costs, artwork, furniture
- Cost associated with loss of revenue or power production
- No allowances have been included to account for potential impacts of minority business requirements.

3.1.8 OPCC Bidding Assumptions

The following bidding assumptions are considered in the development of this OPCC:

- Regional contractors will compete and tender bids for the project
- Bidders will develop competitive proposals with regards to materials pricing and labor productivity, and will not include allowances for changes, extra work, unforeseen conditions or any other unplanned costs
- The prime contractor will self-perform all work scope except the following:
    - Electrical/SCADA/PLC
    - Pre-engineered Metal Building (PEMB)
    - Concrete/rebar, etc.
- Builder's Risk Insurance will be available to the contractor
- Contractors will structure their proposals to promote positive cash flow and to minimize operational finance.
- Additional costs may be incurred if the contracting strategy decomposes the work into too many overlapping construction packages, or due to lack of competition for a single large project procurement.

3.2 Summary of OPCCs

Table 1 provides a summary of the OPCC for the full-scale AWT facility with and without the MF system.

Table 1. Summary of OPCC for the Full-Scale AWT Facility (with and without MF).

Area	Area Title	Cost[1]	
		With MF	Without MF (Base Case)
0	General Site Development	$11,200,000	$11,170,000
1	Drum Screen & Influent Pump Station	$12,000,000	$12,000,000
2	Aeration, Anoxic, and Membrane Tanks for MBR & Blowers Structure	$124,100,000	$124,100,000
3	Maintenance Building	$1,500,000	$1,500,000
4	MF Facility and RO Feed Tank	$69,200,000	$3,600,000
5	Electrical Building	$1,500,000	$1,500,000
6	RO Cartridge Filters	$13,100,000	$13,100,000
7	RO Facility	$102,700,000	$102,700,000
8	UV Facility	$21,900,000	$21,920,000
9	RO Flush Tank	$3,100,000	$3,100,000
10	Electrical Substation	$2,200,000	$2,200,000
11	Chemical Facility	$2,900,000	$2,900,000
12	Lime System	$3,600,000	$3,600,000
13	Lime System Clarifiers	$2,500,000	$2,500,000
14	Chemical Storage & Dosing	$5,900,000	$5,900,000
15	Administrative Building	$5,800,000	$5,800,000
16	MicroC2000 Storage & Dosing	$2,000,000	$2,000,000
17	Generator Building (Slabs Only)	$150,000	$150,000
18	Yard Piping	$5,700,000	$6,280,000
19	Electrical, Instrumentation, and Controls	$100,500,000	$100,500,000
20	JWPCP Modifications[2]	$68,000,000	$68,000,000
21	FORCO Site Improvements[3]	$7,900,000	$7,900,000
	Startup/Commission/Owner Training	$400,000	$400,000
	Estimating Accuracy, Unlisted Items Allowance	$56,800,000	$50,300,000
	Construction Allowances	$145,700,000	$128,500,000
	Total	**$770 Million**	**$682 Million**

Notes:
(1) Rounded to the nearest $10,000
(2) Sidestream nitrogen removal and secondary effluent flow equalization
(3) Utility relocation only; site remediation and cleanup costs not included

4 Operations and Maintenance Costs

The O&M cost estimate is the expected cost to operate and maintain the full-scale AWT facility at average operating conditions over one year. O&M cost estimates were prepared for the MBR-RO-UV/AOP process train, which represents the base case as described in the program feasibility study prepared by Metropolitan. Cost estimates were also developed for the MBR-MF-RO-UV/AOP process train if the MF system is deemed essential by the regulators for pathogen log reduction credit. The subsections below include descriptions of the assumptions used in these calculations and the results of this analysis. Sections 4.1 through 4.5 discuss the details on the assumptions for the O&M cost estimate for the full-scale AWT facility, with MF. Section 4.6 summarizes the O&M cost estimates for the facility with and without MF.

4.1 Power Costs

Estimated power costs account for electricity consumption under average annual operating conditions for major process equipment at the full-scale AWT facility. This analysis includes the percentage of time each piece of equipment is expected to be operating during the course of a year, and the average annual power consumption for that equipment. The power consumption for the MBR system includes the rotary drum screen, influent pumps, aeration tank blowers, membrane blowers, membrane filtrate pumps, return activated sludge pumps and air compressors. The MF system includes its feed pumps, backwash pumps, air scour blowers and air compressor. The RO system includes its feed pumps, first-stage booster pumps, third-stage booster pumps, flush pumps and CIP pumps. The UV/AOP system includes the UV reactors and the product water stabilization included the lime feed pumps. The power consumption estimate also includes the chemical feed systems and building HVAC systems. **Table 2** has the power consumption rounded to the closest 1,000 kilowatt-hours (kWh) and corresponding annual cost rounded to the closest $1,000 assuming a power cost of $0.15/kWh.

Table 2. Annual Power Consumption and Cost Estimate (with MF)

Source of Power Consumption	Annual Power Consumption (kWh)	Cost(1),(2)
MBR System	74,644,000	$11,197,000
MF System	50,882,000	$7,632,000
RO System	110,161,000	$16,524,000
UV/AOP System	16,399,000	$2,460,000
Product Water Stabilization	1,114,000	$167,000
Chemical Feed Systems	1,071,000	$161,000
HVAC Systems	10,777,000	$1,617,000
Total	**265,048,000**	**$39,758,000**

Notes:
(1) Power cost assumed to be $0.15/kWh.
(2) Rounded to the nearest $1,000.

4.2 Chemical Costs

Chemical costs are calculated using the average doses for major chemical feed systems during the course of normal operation over one year. **Table 3** summarizes the chemicals included in this analysis, the estimated chemical costs, the sources of those costs and the uses for each chemical.

Table 4 summarizes annual chemical consumption by unit process rounded to the nearest 1,000 gallons or tons; it also summarizes the annual cost per unit process rounded to the closest $1,000.

Table 3. Chemical Unit Price for the O&M Cost Estimate (with MF)

Chemical	Concentration	Unit Price	Uses
Ammonium sulfate	40%	$3.54/gal[1]	Chloramine formation
Antiscalant	N/A	$8.63/gal[2]	RO scaling control
Carbon dioxide	N/A	$0.08/lb[3]	Product water stabilization
Carbon source	N/A	$1.50/gal[4]	Biochemical oxygen demand for MBR
Caustic soda	25%	$1.39/gal[5]	MBR/MF/RO cleaning
Citric acid	50%	$5.05/gal[5]	MBR/MF/RO cleaning
Hydrated lime	N/A	$0.25/lb[5]	Product water stabilization
Sodium bisulfite	25%	$1.10/gal[6]	Neutralizing MBR/MF cleaning solutions
Sodium hypochlorite	12.5%	$0.62/gal[7]	Chloramine formation, MBR/MF/RO cleaning, and disinfection
Sulfuric acid	93%	$1.84/gal[5]	RO scaling control

Notes:
[1] Price from Brenntag Pacific (Santa Fe Springs, CA)
[2] Price for Vitec 1400 from Avista Technologies (San Marcos, CA)
[3] Price from Burnett, Inc. (Campobello, SC) for carbon dioxide from Airgas (Long Beach, CA)
[4] Price for MicroC 2000 from Environmental Operating Solutions, Inc. (Bourne, MA)
[5] Price from Brenntag Pacific (Santa Fe Springs, CA)
[6] Price from Univar USA (Santa Fe Springs, CA)
[7] Price from Olin Chlor Alkali Products (Santa Fe Springs, CA)

Table 4. Annual Chemical Cost Estimate (with MF)

Unit Process	Annual Use[1]	Cost[2]
MBR System		
Carbon source to increase biochemical oxygen demand	13,557,000 gal	$20,336,000
MBR System Subtotal		***$20,336,000***
MF System		
Sodium hypochlorite for chloramines	3,911,000 gal	$2,425,000
Ammonium sulfate for chloramines	1,095,000 gal	$3,879,000
MF System Subtotal		***$6,304,000***
RO System		
Antiscalant for scaling control	282,000 gal	$2,430,000
Sulfuric acid for pH reduction	3,911,000 gal	$7,196,000
RO System Subtotal		***$9,626,000***
MBR/MF/RO Membrane Cleaning		
Caustic soda for cleaning	1,564,000 gal	$2,174,000
Citric acid for cleaning	156,000 gal	$790,000
Sodium bisulfite for neutralization	626,000 gal	$688,000
Sodium hypochlorite for cleaning	1,330,000 gal	$824,000
MBR/MF/RO Membrane Cleaning Subtotal		***$4,476,000***
UV/AOP System		
Free Chlorine for radical formation	1,080,000 gal	$670,600
UV/AOP System Subtotal		***$670,000***
Product Water Stabilization		
Hydrated lime for stabilization	21,900,000 tons	$5,475,000
Carbon dioxide for stabilization	9,386,000 tons	$751,000
Product Water Stabilization Subtotal		***$6,226,000***
Effluent Chlorination		
Sodium hypochlorite for disinfection	3,441,000 gal	$2,134,000
Effluent Chlorination Subtotal		***$2,134,000***
Total Annual Chemical Costs		**$49,772,000**

Notes:
[1] Rounded to the nearest 1,000 gallons or tons.
[2] Rounded to the nearest $1,000

4.3 Replacement of Consumables

Consumables are components of the unit processes that are known to wear out over time. Items included in this category are MBR membrane elements, MF membrane modules, RO cartridge filters, RO membrane elements, UV lamps, and UV ballasts. The replacement intervals shown in **Table 5** are developed from a combination of project experience and vendor input. Replacement costs are calculated by prorating the amount of equipment that must be replaced in one year. For example, MF modules have a replacement interval of ten years. Therefore, the annual replacement cost are calculated by assuming 10% of the MF modules would be replaced in one year. **Table 6** displays the annual replacement cost estimate for the consumable items, including 9% sales tax and rounded to the closest $1,000.

Table 5. Replacement Intervals and Costs for Consumables (with MF)

Consumable Item	Replacement Interval (yr)	Unit Cost	Quantity of Each Item at AWT facility[1]
MBR System			
MBR elements	15	$980/element	34,560 elements
MF System			
MF Modules	10	$3,000/module	4,608 modules
RO System			
RO Cartridge Filters	0.5	$16.76/filter	768 cartridge filters
RO Elements Stages 1 & 2	5	$365/element	21,504 elements
RO Elements Stages 3	1	$365/element	7,056 elements
UV/AOP System			
Lamps	1.6 (14,000 hrs)	$325/lamp	4,140 lamps
Ballasts	5	$660/ballast	2,070 ballasts

Notes:
[1] Based on the design criteria for the full-scale AWT facility, with MF.

Table 6. Annual Cost Estimate for Replacement of Consumables (with MF)

Unit Process	Replacement Cost[1]
MBR System	$2,461,000
MF System	$1,507,000
RO System	$5,402,000
UV/AOP System	$1,066,000
Total Annual Replacement Cost	**$10,436,000**

Notes:
[1] Rounded to the nearest $1,000

4.4 Maintenance Costs

Maintenance costs include the cost of supplies and replacement parts for the routine maintenance of process equipment such as pumps, valves, and instrumentation. **Table 7** provides the equipment capital cost estimates and the annual maintenance costs, which are calculated by multiplying the equipment capital cost estimates for each system by 2% and rounding to the closest $1,000.

Table 7. Annual Maintenance Cost Estimate (with MF)

Equipment Area	Equipment Capital Cost Estimate[1]	Maintenance Cost[1]
Drum Screens and Influent Pumps Station	$6,370,000	$127,000
MBR System	$73,246,000	$1,465,000
MF System	$41,500,000	$830,000
RO System	$62,600,000	$1,252,000
UV/AOP System	$11,300,000	$226,000
Product Water Conditioning	$4,609,000	$92,000
Chemical Feed Systems	$156,000	$3,000
Electrical Equipment	$1,500,000	$30,000
	Total Annual Maintenance Cost	**$4,025,000**

Notes:
[1] Rounded to the nearest $1,000

4.5 Labor Costs

Annual labor costs are based on the estimated number of full-time employees required to operate the facility and their average hourly rate, including overhead ($75). The estimated number of full-time employees required to operate the facility is 65 (with MF) and 55 (without MF; Base Case). At 2,080 work-hours per employee per year, the annual labor cost is estimated at $10,140,000.

4.6 Total Annual O&M Cost Estimate

Table 8 provides a summary of the total annual O&M cost estimate with the major components of each cost element shown and added together for both process trains, with and without MF.

Table 8. Total Annual O&M Cost Estimate (with and without MF)

Parameter	Annual O&M Cost[1]	
	with MF	without MF (Base Case)
Power Cost		
MBR System	$11,197,000	$10,607,000
MF System	$7,632,000	$0
RO System	$16,524,000	$16,524,000
UV/AOP System	$2,460,000	$2,460,000
Product Water Stabilization	$167,000	$167,000
Chemical Feed Systems	$161,000	$151,000

Parameter	Annual O&M Cost[1]	
	with MF	without MF (Base Case)
HVAC Systems	$1,617,000	$1,617,000
Power Cost Subtotal	***$39,758,000***	***$31,526,000***
Chemical Cost		
MBR System	$20,336,000	$19,266,000
MF System	$6,304,000[2]	$0
RO System	$9,626,000	$15,601,000[2]
MBR/MF/RO Membrane Cleaning	$4,476,000	$3,370,000
UV/AOP System	$670,000	$2,639,000
Product Water Stabilization	$6,226,000	$6,226,000
Effluent Chlorination	$2,134,000	$2,133,000
Chemical Cost Subtotal	***$49,772,000***	***$49,235,000***
Replacement of Consumables		
MBR System	$2,461,000	$2,332,000
MF System	$1,507,000	$0
RO System	$5,402,000	$5,402,000
UV/AOP System	$1,066,000	$1,066,000
Replacement of Consumables Cost Subtotal	***$10,436,000***	***$8,800,000***
Equipment Maintenance		
Drum Screens and Influent Pumps Station	$127,000	$127,000
MBR System	$1,465,000	$1,465,000
MF System	$830,000	$0
RO System	$1,252,000	$1,252,000
UV/AOP System	$226,000	$226,000
Product Water Conditioning	$92,000	$92,000
Chemical Feed Systems	$3,000	$3,000
Electrical Equipment	$30,000	$30,000
Maintenance Cost Subtotal	***$4,025,000***	***$3,195,000***
Labor Costs		
AWT facility Labor Cost	$10,140,000	$8,580,000
AWT facility Labor Cost Subtotal	***$10,140,000***	***$8,580,000***
Total Annual O&M Cost	**$114,157,000**	**$101,336,000**
Notes: [1] Rounded to the nearest $1,000 [2] Includes cost of chemical addition for chloramine formation		

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OPCC for the Full-scale AWT Facility with MF

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MWH   JLL
Pasadena   8/5/2016

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
With Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

					Grand Total Price:	$ 770,000,000		
					$/MGD:	$ 5.13		
Area	**GC**	**Description**	**Quantity**	**UOM**	**Unit Cost**	**Total Cost**	**Comments**	**Al-in Area Costs**
0		**General Site Development**	1	ls	*$11,167,420*	**$11,167,420**		*$15,160,000*
1	P	**Demolition**						
2	S	Remove Misc Debris, Pavements, Rubble, etc.	1	ls	$110,000	$110,000	55 acres	
3	S	Protect/Support/Repair (e) Utilities Allowance - TBD	1	ls	$100,000	$100,000	support, repair & replace during overexc activity	
4	S	**Civil Works**						
5	S	Over Excavation/Re-compaction Work at Area 10	100,000	cys	$10	$1,000,000	exc/stockpile 1/3 at area north of demo area,<500' haul	
6	S	General Site/Earthworks Grading/Pre-compaction	50	dys	$5,500	$275,000	55 acres	
7	P	New Site Drainage Facilities	1	ls	$1,500,000	$1,500,000	allowance for catch basins, piping, etc., ret basins, storm drng	
8	S	Relocate (e) 8" Pipelines	1,500	lf	$120	$180,000	abandon (e) lines in-place	
9	S	Sawcut Concrete/AC	500	lf	$4	$2,000		
10	S	New Plant Concrete Roads - 8"	*26,610*	*sy*	*$78*			
11	S	Roadway Excavation - 2.75'	24,400	cys	$6	$146,400		
12	S	Subgrade Prep/Compaction	26,610	sys	$2	$53,220		
13	S	Imported Select Materials - 18"	24,200	tns	$32	$774,400		
14	S	Imported Base Materials - 11"	14,800	tns	$35	$518,000		
15	S	Asphalt Base & Wearing Course - 4"	5,800	tns	$100	$580,000		
16	S	New Plant Concrete Roads G&C - 18"	5,280	lf	$30	$158,400	say 1 mile vs. 4 miles	
17	S	New Concrete Flatwork (DWs, SWs)	5,000	sf	$8	$40,000	allowance for catch basins, piping, etc., ret basins, storm drng	
18	S	Asphalt Paving at Non-Process Areas (3"/6")	-	sf	$3.50	$0		
19	S	Bollards	30	ea	$350.00	$10,500		
20	S	Parking Curbs	50	ea	$90.00	$4,500	n/a	
21	S	Landscaping Allowance	1	ls	$500,000	$500,000	xeriscaping mainly around the ops building	
22	S	Signage Allowance	1	ls	$15,000	$15,000		
23	S	**Connection to JWPCP Channel 3**						
24	S	Allowance	1	ls	$2,500,000	$2,500,000		
25	S	**Miscellanous Piping**						
26	S	Allowance	1	ls	$200,000	$200,000		
27	S	**Utility Water System (FS, Pot, Utility)**						
28	S	Allowance	1	ea	$2,500,000	$2,500,000		
1		**Drum Screen & Influent Pump Station**	1	ls	*$11,996,860*	**$11,996,860**		*$16,290,000*
1	P	***Civils***						
2	P	Structure Excavation	1,300	cy	$15	$19,500		
3	P	Grade/Compact Foundation	5,000	sys	$3	$12,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	3,000	tn	$35	$105,000		
7	P	F/P/S/F Concrete SOG	2,466	cys	$325	$801,450	model qty	
8	P	F/P/S/F Concrete Walls	1,407	cys	$675	$949,725	"	
9	P	F/P/S/F Concrete Elev Slab	800	cys	$950	$760,000	"	
10	P	F/P/S/F Concrete Equip Pads	39	cys	$1,250	$48,750	"	
11	S	Reinforcing Steel at 220#/cy avg	1,037,000	lbs	$0.90	$933,300	non-epoxy	
12	S	Epoxy Coating	2,400	sf	$2.50	$6,000		
13	S	Backfill Structure/Grading	650	cys	$20	$13,000		
14	P	***Superstructure Specialties***						
15	S	Column Support Steel	1,000	lbs	$3.00	$3,000		
16	S	Structural Steel Framing	15,190	lbs	$2.50	$37,975		
17	S	Steel Trusses - Light Gauge - 80' span	72	ea	$1,600	$115,200		
18	S	Roof Deck - 18 ga	12,400	sf	$3.00	$37,200		
19	S	Metal Stairs (2 sets) to Drum Screens	50	ri	$400	$20,000		
20	S	Metal Stairs at Drum Screens (7)	70	ri	$400	$28,000		
21	S	Deck Hatches (2'x2')	7	ea	$4,000	$28,000		
22	S	Misc Metals	1	ls	$40,000	$40,000		
23	P	***Process***						
24	P	***Equipment***						
25	P	Sluice Gates - Large w/ Rotec Actuators	10	ea	$53,000	$530,000	7'x25'	
26	P	Influent Pumps - 20 MGD	14	ea	$110,000	$1,540,000	budget quote	
27	P	Drum Screens	13	ea	$330,800	$4,300,400	estimate	
28	P	***Piping***						
29	P	36" B'Fly valve	14	ea	$23,400	$327,600		
30	P	84" B'Fly Valve	3	ea	$63,000	$189,000		
31	P	84" Blind Flg - Flat Face	1	ea	$1,680	$1,680		
32	P	36" Check Valve	14	ea	$23,400	$327,600		
33	P	84" C200 Elbow	4	ea	$26,880	$107,520		
34	P	84" x 36" Tees	14	ea	$21,000	$294,000		
35	P	36" C200 Flg	70	ea	$720	$50,400		
36	P	84" C200 Flg	5	ea	$1,680	$8,400		
37	P	36" C200	139	lf	$180	$25,080		
38	P	84" C200	295	lf	$420	$123,900		
39	S	84" C200 Tee	1	ea	$22,680	$22,680		
40	S	***Mechanical Install Crew***						
41	S	Labor, Misc Matls, small tools, Equip, Ohds, etc.	50	dys	$3,800	$190,000	say 2 mo for 5 man crew	
2		**Aeration, Anoxic, MBR Tank & Blowers**	1	ls	*$124,082,772*	**$124,082,772**		*$168,440,000*
1	P	***Civils***						
2	P	Structure Excavation	21,000	cy	$15	$315,000	includes, haul to waste	
3	P	Grade/Compact Foundation	46,700	sys	$3	$116,750		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	22,958	sf	$40	$918,320	at 26' deep excavations , east wall + 180' of N/S walls	
6	P	Aggregate Base at Foundation - 1'	27,700	tn	$35	$969,500		
7	P	F/P/S/F Concrete SOG	18,616	cys	$325	$6,050,200	model qty	
8	P	F/P/S/F Concrete Walls	12,225	cys	$675	$8,251,875	"	
9	P	F/P/S/F Concrete Elev Slab	1,030	cys	$950	$978,500	"	
10	P	F/P/S/F Concrete Stairs	10	cys	$1,500	$15,000	"	
11	P	F/P/S/F Concrete Equip Pads	100	cys	$1,000	$100,000	"	
12	S	Reinforcing Steel at 220#/cy avg	7,036,000	lbs	$0.90	$6,332,400	non-epoxy	
13	S	Epoxy Coating	24,000	sf	$2.00	$48,000		
14	S	Backfill Structure/Grading	10,500	cys	$20	$210,000		
15	P	***Superstructure Specialties***						
16	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
17	S	Deck Hatches (2'x2')	7	ea	$4,000	$28,000		
18	S	Misc Metals	1	ls	$150,000	$150,000	railings, stairs, etc.	
19	P	***Process***						
20	P	***Equipment***						
21	P	RAS Pumps	21	ea	$0	$0	included in ME pricing	
22	P	MBR Filtrate Pumps	27	ea	$0	$0	8,600 rpm, included in MBR scope	
23	P	MBR Blowers	30	ea	$0	$0	included in ME pricing	
24	P	Compressors for MBR, MF (75 hp)	3	ea	$0	$0	included in MBR vendor scope	

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
With Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

						Grand Total Price:	$ 770,000,000		
						$/MGD:	$ 5.13		
Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs	

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
25	P	Compressors for MF (15 hp)	10	ea	$0	$0	included in MF vendor scope	
26	P	Anoxic Mixers - 5 hp	48	ea	$14,500	$696,000		
27	P	Aeration Blowers	30	ea	$185,000	$5,550,000	JBI budgetary quote	
28	P	Membrane Equipment (ME)	1	ls	$67,000,000	$67,000,000	Avg of two budgetary quotes	
29	P	***Piping***						
30	P	4" CS B'Fly Valve - 150 psi	1,044	ea	$2,000	$2,088,000		
31	P	8" CS B'Fly Valve - 150 psi	24	ea	$4,000	$96,000		
32	P	12" CS B'Fly Valve - 150 psi	24	ea	$7,200	$172,800		
33	P	14" CS B'Fly Valve - 150 psi	60	ea	$8,400	$504,000		
34	P	18" CS B'Fly Valve - 150 psi	48	ea	$11,250	$540,000		
35	P	4" SS B'Fly Valve	612	ea	$2,600	$1,591,200		
36	P	8" SS B'Fly Valve	-	ea	$3,200	$0		
37	P	12" SS B'Fly Cap	24	ea	$480	$11,520		
38	P	20" SS B'Fly Cap	24	ea	$800	$19,200		
39	P	24" SS B'Fly Cap	12	ea	$960	$11,520		
40	P	30" SS B'Fly Cap	8	ea	$1,200	$9,600		
41	P	36" SS B'Fly Cap	8	ea	$1,440	$11,520		
42	P	48" SS B'Fly Cap	12	ea	$1,920	$23,040		
43	P	60" SS B'Fly Cap	4	ea	$2,400	$9,600		
44	P	8" CS Check Valve - 150 psi	24	ea	$4,800	$115,200		
45	P	12" LR SS Elbow - 316L	24	ea	$4,800	$115,200		
46	P	6" LR SS Elbow - 316L	432	ea	$2,400	$1,036,800		
47	P	4" SR SS Elbow - 316L	1,656	ea	$1,280	$2,119,680		
48	P	30" SR SS Elbow - 316L	4	ea	$38,400	$153,600		
49	P	36" SR SS Elbow - 316L	4	ea	$50,688	$202,752		
50	P	48" SR SS Elbow - 316L	2	ea	$73,728	$147,456		
51	P	60" SR SS Elbow - 316L	2	ea	$115,200	$230,400		
52	P	4" Flg , FF, SS Class 150	2,088	ea	$700	$1,461,600		
53	P	6" Flg , FF, SS Class 150	24	ea	$1,050	$25,200		
54	P	8" Flg , FF, SS Class 150	96	ea	$1,400	$134,400		
55	P	12" Flg , FF, SS Class 150	144	ea	$1,980	$285,120		
56	P	14" Flg , FF, SS Class 150	180	ea	$2,240	$403,200		
57	P	10" Flg , FF, SS Class 150	24	ea	$1,550	$37,200		
58	P	18" Flg , FF, SS Class 150	144	ea	$2,700	$388,800		
59	P	4" SS Schld 105, 316L	41,523	lf	$47	$1,951,585		
60	P	6" SS Schld 105, 316L	7,701	lf	$69	$531,398		
61	P	8" SS Schld 105, 316L	94	lf	$130	$12,220		
62	P	10" SS Schld 105, 316L	18	lf	$171	$3,021		
63	P	12" SS Schld 105, 316L	2,979	lf	$214	$637,595		
64	P	14" SS Schld 105, 316L	542	lf	$250	$135,403		
65	P	18" SS Schld 105, 316L	435	lf	$385	$167,498		
66	P	20" SS Schld 105, 316L	2,754	lf	$428	$1,178,498		
67	P	24" SS Schld 105, 316L	3,108	lf	$514	$1,596,098		
68	P	30" SS Schld 105, 316L	336	lf	$642	$215,391		
69	P	36" CS Schld 105, 150 psi	358	lf	$162	$57,983		
70	P	48" CS Schld 105, 150 psi	1,141	lf	$216	$246,348		
71	P	60" CS Schld 105, 150 psi	585	lf	$240	$140,460		
72	P	84" CS Schld 105, 150 psi	45	lf	$378	$16,979		
73	P	96" CS Schld 105, 150 psi	55	lf	$432	$23,904		
74	P	48" CS C200, 150 psi	617	lf	$192	$118,400		
75	P	8"x6" SS Reducer	24	ea	$2,240	$53,760		
76	P	10"x12" SS Reducer	24	ea	$3,520	$84,480		
77	P	12" SS Reducing Tee	432	ea	$8,800	$3,801,600		
78	P	30" SS Reducing Tee	30	ea	$21,600	$648,000		
79	P	36" SS Reducing Tee	24	ea	$26,400	$633,600		
80	P	48" C208 Tee	22	ea	$9,600	$211,200		
81	P	***Mechanical Install Crew***						
82	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	504	dys	$3,800	$1,915,200	say 12 mos for 2-5 man crew	
3		**Maintenance Bldg**	1	ls	*$1,477,209*	**$1,477,209**		***$2,010,000***
1	P	***Civils***						
2	P	Structure Excavation	2,200	cy	$15	$33,000		
3	P	Grade/Compact Foundation	2,125	sys	$3	$5,313		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	1,400	tn	$35	$49,000		
7	P	F/P/S/F Concrete SOG	706	cys	$325	$229,450	model qty	
8	P	F/P/S/F Concrete Floor Topping	374	cys	$450	$168,300		
9	P	F/P/S/F Concrete Equip Pads	4	cys	$1,250	$5,000	"	
10	S	Reinforcing Steel/WWF at 125#/cy avg	88,250	lbs	$0.90	$79,425	non-epoxy	
11	S	Epoxy Coating	-	sf	$2.50	$0		
12	S	Backfill Structure/Grading	1,100	cys	$20	$22,000		
13	S	***Superstructure Specialties***						
14	S	CMU - 12" Grouted	12,400	sf	$32.00	$396,800		
15	S	Windows - 3x5	6	ea	$900.00	$5,400		
16	S	Windows - 3x3	6	ea	$540.00	$3,240		
17	S	Exterior Doors 3'x8'	2	ea	$2,300.00	$4,600		
18	S	Roll-Up Doors - 15'x15' w/ motor	2	ea	$8,500.00	$17,000		
19	S	Steel Trusses - Light Gauge - 85' span	230	ea	$1,530	$351,900		
20	S	Roof Deck - 18 ga	21,675	sf	$3.00	$65,025		
21	S	Built-up Roofing System	217	sq	$75.00	$16,256		
22	S	Gutter/Downspouts	1	ls	$7,500.00	$7,500		
23	S	Utility Sink w/ Eyewash	2	ea	$5,000	$10,000	incls plumbing	
24	S	Wall Fans	8	ea	$1,000	$8,000		
4		**MF Facility & RO Feed Tank**	1	ls	*$69,232,710*	**$69,232,710**		***$93,980,000***
1	P	***Civils***						
2	P	Structure Excavation	800	cy	$15	$12,000	includes, haul to waste	
3	P	Grade/Compact Foundation	36,667	sys	$3	$91,667		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	2,300	tn	$35	$80,500		
7	P	F/P/S/F Concrete SOG	3,469	cys	$325	$1,127,425	model qty	
8	P	F/P/S/F Concrete Walls	1,284	cys	$675	$866,700	"	
9	P	F/P/S/F Concrete Elev Slab	3,192	cys	$950	$3,032,400	"	
10	P	F/P/S/F Concrete Curbs	6	cys	$1,750	$10,500	"	
11	P	F/P/S/F Concrete Equip Pads	269	cys	$1,250	$336,250	"	
12	S	Reinforcing Steel at 220#/cy avg	1,809,000	lbs	$0.90	$1,628,100	non-epoxy	

Metropolitan Water District
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					Grand Total Price:	$ 770,000,000		
					$/MGD:	$ 5.13		
Area	**GC**	**Description**	**Quantity**	**UOM**	**Unit Cost**	**Total Cost**	**Comments**	**Al-in Area Costs**
13	S	Epoxy Coating	-	sf	$2.00	$0		
14	S	Backfill Structure/Grading	400	cys	$20	$8,000		
15	P	***Superstructure Specialties***						
16	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
17	S	Deck Hatches (2'x2')	7	ea	$4,000	$28,000		
18	S	Misc Metals	1	ls	$150,000	$150,000	railings, stairs, etc.	
19	S	PEB Allowance	86,304	sf	$110	$9,493,440		
20	P	***Process***						
21	P	***Equipment***						
22	P	MF CIP Tanks	6	ea	$22,000	$132,000	5,500 gal, FRP	
23	P	MF CIP Pumps	20	ea	$0	$0	8600 rpm, included in MF system scope	
24	P	Membrane Equipment (MF)	1	ls	$41,500,000	$41,500,000	selected vendor budget	
25	P	***Piping***						
26	P	42" CS B'Fly Valve - 150 psi	10	ea	$31,500	$315,000		
27	P	16" CS Check Valve - 150 psi	10	ea	$10,400	$104,000		
28	P	96" FF Blind Flg	4	ea	$11,875	$47,500		
29	P	24" SS B'Fly Valve	30	ea	$2,600	$78,000		
30	P	8" CS B'Fly Valve - 150 psi	10	ea	$4,000	$40,000		
31	P	8" SS Pipe Cap	288	ea	$1,280	$368,640		
32	P	14" SS Pipe Cap	192	ea	$1,120	$215,040		
33	P	16" SS Pipe Cap	5	ea	$1,280	$6,400		
34	P	24" SS Pipe Cap	5	ea	$1,920	$9,600		
35	P	42" CS Elbow, C208	10	ea	$13,440	$134,400		
36	P	48" CS Elbow, C208	10	ea	$15,360	$153,600		
37	P	96" CS Elbow, C208	4	ea	$30,720	$122,880		
38	P	16" SR SS Elbow - 316L	30	ea	$20,480	$614,400		
39	P	24" SR SS Elbow - 316L	20	ea	$33,792	$675,840		
40	P	08" SR SS Elbow - 316L	10	ea	$12,288	$122,880		
41	P	42" Flg , FF, SS Class 150	70	ea	$7,350	$514,500		
42	P	48" Flg , FF, SS Class 150	10	ea	$8,400	$84,000		
43	P	96" Flg , FF, SS Class 150	4	ea	$16,800	$67,200		
44	P	8" Flg , FF, SS Class 150	50	ea	$1,400	$70,000		
45	P	14" Flg , FF, SS Class 150	96	ea	$2,240	$215,040		
46	P	16" Flg , FF, SS Class 150	30	ea	$2,480	$74,400		
47	P	24" Flg , FF, SS Class 150	160	ea	$3,600	$576,000		
48	p	24" SS Check Valve - 150 psi	30	ea	$46,800	$1,404,000		
49	P	42" CS Check Valve - 150 psi	10	ea	$28,350	$283,500		
50	P	8" CS Check Valve - 150 psi	10	ea	$4,800	$48,000		
51	P	48" CS Pipe Cap	10	ea	$4,800	$48,000		
52	P	8" SS Schld 105, 316L	12,916	lf	$130	$1,679,058		
53	P	14" SS Schld 105, 316L	1,268	lf	$250	$316,453		
54	P	16" SS Schld 105, 316L	591	lf	$385	$227,814		
55	P	24" SS Schld 105, 316L	684	lf	$514	$351,088		
56	P	42" CS Schld 105, 150 psi	190	lf	$189	$35,973		
57	P	48" CS Schld 105, 150 psi	551	lf	$216	$119,070		
58	P	96" CS Schld 105, 150 psi	359	lf	$432	$155,052		
59	P	16" SS Tee, 316L	5	ea	$10,240	$51,200		
60	P	24" SS Tee, 316L	5	ea	$15,360	$76,800		
61	P	8" SS Tee, 316L	5	ea	$5,120	$25,600		
62	P	***Mechanical Install Crew***						
63	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	336	dys	$3,800	$1,276,800	say 8 mos for 2-5 man crew	
5		**Electrical Building**	1	ls	*$1,459,956*	**$1,459,956**		***$1,990,000***
1	P	***Civils***						
2	P	Structure Excavation	700	cy	$15	$10,500		
3	P	Grade/Compact Foundation	1,570	sys	$3	$3,925		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	-	
6	P	Aggregate Base at Foundation - 1'	1,100	tn	$35	$38,500		
7	P	F/P/S/F Concrete SOG	343	cys	$325	$111,475	model qty	
8	P	F/P/S/F Concrete Floor Topping	156	cys	$375	$58,500		
9	P	F/P/S/F Concrete Wall Ftgs	103	cys	$450	$46,350		
10	P	F/P/S/F Concrete Walls	133	cys	$675	$89,775		
11	P	F/P/S/F Concrete Equip Pads	8	cys	$1,250	$10,000	-	
12	S	Reinforcing Steel/WWF at 175#/cy avg	60,025	lbs	$0.90	$54,023	non-epoxy	
13	S	Epoxy Coating	-	sf	$2.50	$0		
14	S	Backfill Structure/Grading	350	cys	$20	$7,000		
15	S	***Superstructure Specialties***						
16	S	CMU - 8" Grouted	8,669	sf	$26.00	$225,394		
17	S	Windows - 3'x5'	6	ea	$900.00	$5,400		
18	S	Windows - 3'x3'	6	ea	$540.00	$3,240		
19	S	Exterior Doors 3'x8'	2	ea	$2,300.00	$4,600		
20	S	Roll-Up Doors - 15'x15' w/ motor	1	ea	$8,500.00	$8,500		
21	S	Steel Trusses - Light Gauge - 85' span	230	ea	$1,530	$351,900		
22	S	Roof Deck - 18 ga	17,625	sf	$3.00	$52,875		
23	S	Built-up Roofing System	176	sq	$100.00	$17,625		
24	S	Gutter/Downspouts	1	ls	$7,500	$7,500		
25	S	Utility Sink w/ Eyewash	2	ea	$5,000	$10,000	incls plumbing	
26	S	Wall Fans	8	ea	$1,000	$8,000		
27	S	HVAC	17,625	sf	$15	$264,375	AC for elec equipment	
28	S	Fire Suppression/Fire Alarm	17,625	sf	$4	$70,500		
6		**RO Cartridge Filters**	1	ls	*$13,080,365*	**$13,080,365**		***$17,760,000***
1	P	***Civils***						
2	P	Structure Excavation	9,200	cy	$15	$138,000		
3	P	Grade/Compact Foundation	9,000	sys	$3	$22,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	-	
6	P	Aggregate Base at Foundation - 1'	5,500	tn	$35	$192,500		
7	P	F/P/S/F Concrete SOG	745	cys	$325	$242,125	model qty	
8	P	F/P/S/F Concrete Walls	351	cys	$675	$236,925	-	
9	P	F/P/S/F Concrete Elev Slab	477	cys	$950	$453,150	-	
10	P	F/P/S/F Concrete Equip Pads	169	cys	$1,250	$211,250	-	
11	S	Reinforcing Steel at 220#/cy avg	384,000	lbs	$0.90	$345,600	non-epoxy	
12	S	Epoxy Coating	9,648	sf	$1.50	$14,472		
13	S	Backfill Structure/Grading	4,600	cys	$20	$92,000		
14	P	***Superstructure Specialties***						
15	S	Metal Stairs (2 sets)	30	ri	$400	$12,000		

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
With Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 770,000,000
$/MGD: $ 5.13

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
16	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
17	S	Deck Hatches (2'x2')	5	ea	$4,000	$20,000		
18	S	Misc Metals	1	ls	$5,000	$5,000	railings, etc,	
19	S	Pre-engineered Metal Allowance	20,400	sf	$110	$2,244,000		
20	P	***Process***						
21	P	***Equipment***						
22	P	RO CIP Tanks	140,000	gal	$5.00	$700,000		
23	P	Auto Cartridge Filtes	1	ls	$2,300,000	$2,300,000	vendor budget	
24	P	RO Feed Pumps	6	ea	$370,000	$2,220,000	VTP, budget quote	
25	P	***Piping***						
26	P	12" SS B'Fly Valve, Class 150	128	ea	$2,600	$332,800		
27	P	12" SS Elbow, 316L	128	ea	$15,360	$1,966,080		
28	P	12" SS FF Flg, 316L, Class 150	128	ea	$1,920	$245,760		
29	P	30" CS Pipe Cap	25	ea	$600	$15,000		
30	P	42" CS Pipe Cap	2	ea	$840	$1,680		
31	P	72" CS Pipe Cap	6	ea	$1,440	$8,640		
32	P	12" SS, 316L, Plain End	998	lf	$214	$213,661		
33	P	30" CS, C200, Lined, Manifold	990	lf	$162	$160,353		
34	P	42" CS, C200, Lined, Manifold	30	lf	$227	$6,728		
35	P	72" CS, C200, Lined, Manifold	150	lf	$432	$64,908		
36	P	42" CS Tee	1	ea	$15,120	$15,120		
37	P	72" CS Tee	3	ea	$31,104	$93,312		
38	P	***Mechanical Install Crew***						
39	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	126	dys	$3,800	$478,800	say 3 mos for 2-5 man crews	
7		**RO Facility**	1	ls	*$102,744,551*	**$102,744,551**		***$139,480,000***
1	P	***Civils***						
2	P	Structure Excavation	43,000	cy	$15	$645,000		
3	P	Grade/Compact Foundation	46,111	sys	$3	$115,278		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	", 12' deep, use back slopes	
6	P	Aggregate Base at Foundation - 1'	28,100	tn	$35	$983,500		
7	P	F/P/S/F Concrete SOG	3,485	cys	$325	$1,132,625	model qty	
8	P	F/P/S/F Concrete Walls	573	cys	$675	$386,775	"	
9	P	F/P/S/F Concrete Elev Slab	3,485	cys	$950	$3,310,750	"	
10	P	F/P/S/F Concrete Equip Pads	60	cys	$1,250	$75,000	"	
11	P	F/P/S/F Concrete Curbs	17	cys				
12	S	Reinforcing Steel at 220#/cy avg	1,673,000	lbs	$0.90	$1,505,700	non-epoxy	
13	S	Epoxy Coating	14,976	sf	$1.50	$22,464		
14	S	Backfill Structure/Grading	5,000	cys	$20	$100,000	say 100 sf/lf	
15	P	***Superstructure Specialties***						
16	S	Metal Stairs (2 sets)	30	ri	$400	$12,000		
17	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
18	S	Deck Hatches (2'x2')	5	ea	$4,000	$20,000		
19	S	Misc Metals	1	ls	$35,000	$35,000	railings, etc,	
20	S	Pre-Engineered Metal Bldg Allowance	74,120	sf	$110	$8,153,200		
21	P	***Process***						
22	P	***Equipment***						
23	P	RO Equipment, controls	1	ls	$54,000,000	$54,000,000	selected vendor budget	
24	P	First Stage RO Booster Pumps	48	ea	$85,000	$4,080,000	2700 gpm, budget quote	
25	P	***Piping***						
26	P	4" CS Check Valve - 150 psi	48	ea	$2,600	$124,800		
27	P	8" CS Check Valve - 150 psi	21	ea	$5,200	$109,200		
28	P	14" CS Check Valve - 150 psi	48	ea	$9,100	$436,800		
29	P	16" CS B'Fly Valve - 150 psi, Wafer	48	ea	$8,800	$422,400		
30	P	04" CS B'Fly Valve - 150 psi, Wafer	144	ea	$2,600	$374,400		
31	P	06" CS B'Fly Valve - 150 psi, Wafer	48	ea	$3,900	$187,200		
32	P	08" CS B'Fly Valve - 150 psi, Wafer	69	ea	$5,200	$358,800		
33	P	10" CS B'Fly Valve - 150 psi, Wafer	21	ea	$6,750	$141,750		
34	P	12" CS B'Fly Valve - 150 psi, Wafer	96	ea	$8,400	$806,400		
35	P	14" CS B'Fly Valve - 150 psi, Wafer	103	ea	$10,150	$1,045,450		
36	P	04" SS Pipe Cap	96	ea	$320	$30,720		
37	P	06" SS Pipe Cap	480	ea	$480	$230,400		
38	P	08" SS Pipe Cap	288	ea	$640	$184,320		
39	P	14" SS Pipe Cap	21	ea	$1,568	$32,928		
40	P	18" SS Pipe Cap	7	ea	$2,016	$14,112		
41	P	14" LR SS Elbow - 316L	7	ea	$4,480	$31,360		
42	P	02" LR SS Elbow - 316L	11,232	ea	$320	$3,594,240		
43	P	08" LR SS Elbow - 316L	48	ea	$2,560	$122,880		
44	P	1.5" SR SS Elbow - 316L	5,616	ea	$240	$1,347,840		
45	P	04" SR SS Elbows - 316L	288	ea	$768	$221,184		
46	P	06" SR SS Elbows - 316L	432	ea	$1,728	$746,496		
47	P	08" SR SS Elbows - 316L	55	ea	$2,304	$126,720		
48	P	12" SR SS Elbow - 316L	240	ea	$3,168	$760,320		
49	P	14" SR SS Elbow - 316L	103	ea	$4,032	$415,296		
50	P	14" Flg , FF, SS Class 150	7	ea	$2,240	$15,680		
51	P	16" Flg , FF, CS Class 150	96	ea	$1,760	$168,960		
52	P	10" Flg, FF, SS, 316L 150 psi	63	ea	$1,600	$100,800		
53	P	12" Flg, FF, SS, 316L 150 psi	384	ea	$1,920	$737,280		
54	P	14" Flg, FF, SS, 316L 150 psi	309	ea	$2,240	$692,160		
55	P	16" Flg, FF, SS, 316L 150 psi	48	ea	$2,720	$130,560		
56	P	04" Flg, FF, SS, 316L 150 psi	528	ea	$600	$316,800		
57	P	06" Flg, FF, SS, 316L 150 psi	240	ea	$900	$216,000		
58	P	08" Flg, FF, SS, 316L 150 psi	297	ea	$1,280	$380,160		
59	P	08" Flg, FF, SS, 316L 150 psi, Weld-Neck	7	ea	$1,280	$8,960		
60	P	48" CS Pipe Cap	1	ea	$4,800	$4,800		
61	P	42" CS Pipe Cap	8	ea	$4,200	$33,600		
62	P	72" CS Pipe Cap	3	ea	$8,280	$24,840		
63	P	96" CS Pipe Cap	1	ea	$11,040	$11,040		
64	P	1.5" SS Schld 105, 316L	28,602	lf	$20	$572,045		
65	P	02" SS Schld 105, 316L	1,377	lf	$24	$33,038		
66	P	04" SS Schld 105, 316L	2,423	lf	$46	$111,477		
67	P	06" SS Schld 105, 316L	7,892	lf	$69	$544,571		
68	P	08" SS Schld 105, 316L	4,037	lf	$130	$524,756		
69	P	10" SS Schld 105, 316L	67	lf	$171	$11,500		
70	P	12" SS Schld 105, 316L	2,832	lf	$214	$606,084		
71	P	14" SS Schld 105, 316L	3,941	lf	$250	$984,040		
72	P	16" SS Schld 105, 316L	24	lf	$285	$6,848		

Metropolitan Water District
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150 MGD
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Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 770,000,000

$/MGD: $ 5.13

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
73	P	18" SS Schld 105, 316L	1,470	lf	$321	$472,004		
74	P	16" CS Schld 105, 150 psi	89	lf	$72	$6,396		
75	P	24" CS Schld 105, 150 psi	410	lf	$108	$44,316		
76	P	42" CS Schld 105, 150 psi	1,636	lf	$189	$309,157		
77	P	48" CS Schld 105, 150 psi	315	lf	$216	$67,986		
78	P	72" CS Schld 105, 150 psi	821	lf	$324	$266,058		
79	P	96" CS Schld 105, 150 psi	385	lf	$432	$166,464		
80	P	12" x 6" SS Concentric Reducer, 316L	48	ea	$1,440	$69,120		
81	P	12" x 8" SS Concentric Reducer, 316L	96	ea	$1,600	$153,600		
82	P	14" x 8" SS Concentric Reducer, 316L	7	ea	$1,760	$12,320		
83	P	16" x 14" SS Concentric Reducer, 316L	48	ea	$2,400	$115,200		
84	P	12" SS Reducing Tee	432	ea	$7,680	$3,317,760		
85	P	14" SS Reducing Tee	152	ea	$8,960	$1,361,920		
86	P	04" CS Black Pipe, Galvanized	48	lf	$18	$864		
87	P	04" SS Tee, 316L	48	ea	$2,560	$122,880		
88	P	06" SS Tee, 316L	48	ea	$3,840	$184,320		
89	P	12" SS Tee, 316L	48	ea	$7,680	$368,640		
90	P	14" SS Tee, 316L	14	ea	$8,960	$125,440		
91	P	***Mechanical Install Crew***						
92	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	756	dys	$3,800	$2,872,800	say 12 mos for 3-5 man crews	
8		**UV Facility**	1	ls	*$21,921,088*	**$21,921,088**		***$29,760,000***
1	P	***Civils***						
2	P	Structure Excavation	9,200	cy	$15	$138,000		
3	P	Grade/Compact Foundation	3,889	sys	$3	$9,722		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	-	
6	P	Aggregate Base at Foundation - 1'	2,400	tn	$35	$84,000		
7	P	F/P/S/F Concrete SOG	456	cys	$325	$148,200	model qty	
8	P	F/P/S/F Concrete Walls	1,279	cys	$675	$863,325	-	
9	P	F/P/S/F Concrete Elev Slab	823	cys	$950	$781,850	-	
10	P	F/P/S/F Concrete Equip Pads	-	cys	$1,250	$0	-	
11	S	Reinforcing Steel at 220#/cy avg	563,000	lbs	$0.90	$506,700	non-epoxy	
12	S	Epoxy Coating	5,936	sf	$1.50	$8,904		
13	S	Backfill Structure/Grading	1,000	cys	$20	$20,000		
14	S	Excavation Haul Off	8,200	cys	$12	$98,400		
15	P	***Superstructure Specialties***						
16	S	Column Support Steel	-	lbs	$3.00	$0		
17	S	Structural Steel Framing	9,717	lbs	$3.00	$29,152		
18	S	Metal Stairs (2 sets)	30	ri	$400	$12,000		
19	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
20	S	Deck Hatches (2'x2')	-	ea	$4,000	$0		
21	S	Misc Metals	1	ls	$40,000	$40,000	railings, etc,	
22	S	Pre-Engineered Metal Bldg Allowance	34,430	sf	$110	$3,787,300		
23	P	***Process***						
24	P	***Equipment***						
25	P	UV Equipment, Includes Controls	1	ls	$11,300,000	$11,300,000	selected vendor budget	
26	P	***Piping***						
27	P	36" CS B'Fly Valve, Class 150	36	ea	$23,400	$842,400		
28	P	96" CS B'Fly Valve, Class 150	4	ea	$72,000	$288,000		
29	P	120" x 96" CS Concentric Reducer	4	ea	$38,880	$155,520		
30	P	48" x 36" CS Concentric Reducer	36	ea	$13,230	$476,280		
31	P	36" CS Elbow, C208	36	ea	$9,720	$349,920		
32	P	120" CS Flg, FF, C207 - 86 psi	12	ea	$13,800	$165,600		
33	P	36" CS Flg, FF C207	144	ea	$3,600	$518,400		
34	P	48" CS Flg, FF C207	36	ea	$4,800	$172,800		
35	P	96" CS Flg, FF C207	8	ea	$9,600	$76,800		
36	P	96" CS Pipe Cap, C208 Lined	4	ea	$6,720	$26,880		
37	P	36" CS, C200, Lined, Manifold	648	lf	$194	$125,971		
38	P	96" CS, C200, Lined, Manifold	515	lf	$518	$266,933		
39	P	120" CS, C200, Lined, Manifold	27	lf	$648	$17,550		
40	P	120" CS Tee	2	ea	$51,840	$103,680		
41	P	***Mechanical Install Crew***						
42	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	126	dys	$3,800	$478,800	say 3 mos for 2-5 man crews	
9		**RO Flush Tank**	1	ls	*$3,079,452*	**$3,079,452**		***$4,190,000***
1	P	***Civils***						
2	P	Structure Excavation	12,000	cy	$15	$180,000		
3	P	Grade/Compact Foundation	3,222	sys	$3	$8,056		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	5,670	sf	$40	$226,800	assume 1/2 of structure needs shoring at 21' deep	
6	P	Aggregate Base at Foundation - 1'	2,000	tn	$35	$70,000		
7	P	F/P/S/F Concrete SOG	603	cys	$325	$195,975	model qty	
8	P	F/P/S/F Concrete Walls	576	cys	$675	$388,800	-	
9	P	F/P/S/F Concrete Elev Slab	323	cys	$950	$306,850	-	
10	P	F/P/S/F Concrete Equip Pads	-	cys	$1,250	$0	-	
11	S	Reinforcing Steel at 220#/cy avg	331,000	lbs	$0.90	$297,900	non-epoxy	
12	S	Epoxy Coating	10,520	sf	$1.50	$15,780		
13	S	Backfill Structure/Grading	6,000	cys	$20	$120,000		
14	S	Excavation Haul Off	6,000	cys	$12	$72,000		
15	P	***Superstructure Specialties***						
16	S	Metal Exterior Stairs (2 sets)	30	ri	$400	$12,000		
17	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
18	S	Misc Metals	1	ls	$40,000	$40,000	railings, etc,	
19	P	***Process***						
20	P	***Equipment***						
21	P	n/a	-	ea	$0	$0		
22	P	***Piping***						
23	P	36" CS B'Fly Valve, Class 150	7	ea	$25,200	$176,400		
24	P	36" Check Valve, Class 150	7	ea	$22,500	$157,500		
25	P	36" CS Elbow, 5 Pike, C208, Lined	11	ea	$9,720	$106,920		
26	P	36" CS Flg, FF, C207	35	ea	$3,600	$126,000		
27	P	36" CS C200, Lined	202	lf	$162	$32,792		
28	P	36" CS Tee	4	ea	$9,720	$38,880		
29	P	***Mechanical Install Crew***						
30	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	126	dys	$3,800	$478,800	say 3 mos for 2-5 man crews	
10		**Electrical Substation**	1	ls	*$2,226,988*	**$2,226,988**		***$3,030,000***

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Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
					Grand Total Price:	$ 770,000,000		
					$/MGD:	$ 5.13		
1	P	***Civils***						
2	P	Structure Excavation	1,000	cy	$15	$15,000		
3	P	Grade/Compact Foundation	5,852	sys	$3	$14,629		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	-	
6	P	Aggregate Base at Foundation - 1'	3,600	tn	$35	$126,000		
7	P	F/P/S/F Concrete SOG	988	cys	$325	$321,100	model qty	
8	P	F/P/S/F Concrete Floor Topping	-	cys	$450	$0		
9	P	F/P/S/F Concrete Elevated Slab	963	cys	$675	$650,025		
10	P	F/P/S/F Concrete Equip Pads	4	cys	$1,250	$5,000	-	
11	S	Reinforcing Steel/WWF at 125#/cy avg	123,500	lbs	$0.90	$111,150	non-epoxy	
12	S	Epoxy Coating	-	sf	$2.50	$0		
13	S	Backfill Structure/Grading	500	cys	$20	$10,000		
14	S	***Superstructure Specialties***						
15	S	CMU - 12" Grouted	11,200	sf	$32.00	$358,400		
16	S	Windows - 3x5	6	ea	$900.00	$5,400		
17	S	Windows - 3x3	6	ea	$540.00	$3,240		
18	S	Exterior Doors 3'x8'	2	ea	$2,300.00	$4,600		
19	S	Roll-Up Doors - 15'x15' w/ motor	2	ea	$8,500.00	$17,000		
20	S	Gutter/Downspouts	1	ls	$7,500.00	$7,500		
21	S	Utility Sink w/ Eyewash	2	ea	$5,000	$10,000	incls plumbing	
22	S	Wall Fans	8	ea	$1,000	$8,000		
23	S	HVAC	26,664	sf	$17	$453,288	AC for elec equipment	
24	S	Fire Suppression/Fire Alarm	26,664	sf	$4	$106,656		
11		**Chemical Facility**	1	ls	*$2,930,049*	**$2,930,049**		***$3,980,000***
1	P	***Civils***						
2	P	Structure Excavation	1,300	cy	$15	$19,500		
3	P	Grade/Compact Foundation	7,667	sys	$3	$19,167		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	-	
6	P	Aggregate Base at Foundation - 1'	4,700	tn	$35	$164,500		
7	P	F/P/S/F Concrete SOG	1,259	cys	$325	$409,175	model qty	
8	P	F/P/S/F Concrete Floor Topping	-	cys	$450	$0		
9	P	F/P/S/F Concrete Walls	267	cys	$675	$180,225		
10	P	F/P/S/F Concrete Elevated Slab	963	cys	$675	$650,025		
11	P	F/P/S/F Concrete Equip Pads	25	cys	$1,250	$31,250	-	
12	S	Reinforcing Steel/WWF at 125#/cy avg	157,375	lbs	$0.90	$141,638	non-epoxy	
13	S	Epoxy Coating	-	sf	$2.50	$0		
14	S	Backfill Structure/Grading	650	cys	$20	$13,000		
15	S	Waste Haul-Off	650	cys	$12	$7,800		
16	S	***Superstructure Specialties***						
17	S	Windows - 3x5	6	ea	$900.00	$5,400		
18	S	Windows - 3x3	6	ea	$540.00	$3,240		
19	S	Exterior Doors 3'x8'	4	ea	$2,300.00	$9,200		
20	S	Roll-Up Doors - 15'x15' w/ motor	2	ea	$8,500.00	$17,000		
21	S	Steel Trusses - Light Gauge -115' span	296	ea	$2,070	$612,720		
22	S	Roof Deck - 18 ga	34,040	sf	$3.00	$102,120		
23	S	Built-up Roofing System	340	sq	$75.00	$25,530		
24	S	Gutter/Downspouts	1	ls	$10,000.00	$10,000		
25	S	Utility Sink w/ Eyewash	4	ea	$5,000	$20,000	incls plumbing	
26	S	Wall Fans	12	ea	$1,000	$12,000		
27	S	HVAC	34,040	sf	$10	$340,400	AC for elec equipment	
28	S	Fire Suppression/Fire Alarm	34,040	sf	$4	$136,160		
12		**Lime System**	1	ls	*$3,577,226*	**$3,577,226**		***$4,860,000***
1	P	***Civils***						
2	P	Structure Excavation	210	cy	$15	$3,150		
3	P	Grade/Compact Foundation	600	sys	$3	$1,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	400	tn	$35	$14,000		
7	P	F/P/S/F Concrete SOG	492	cys	$325	$159,900	model qty	
8	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0	-	
9	P	F/P/S/F Concrete Equip Pads	5	cys	$1,250	$6,250	-	
10	S	Reinforcing Steel at 220#/cy avg	110,000	lbs	$0.90	$99,000	non-epoxy	
11	S	Epoxy Coating	-	sf	$2.00	$0		
12	S	Backfill Structure/Grading	210	cys	$20	$4,200		
13	S	Waste Haul-off	-	cys	$12	$0		
14	P	***Superstructure Specialties***						
15	S	12" Grouted CMU	5,043	sf	$32	$161,376		
16	S	Metal Stairs at Lime Silos (4)	108	ri	$575	$62,100		
17	S	Metal Walkway Between Silos - 5'	860	sf	$100	$86,000	support frame & decking	
18	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
19	P	***Process***						
20	P	***Equipment***						
21	S	Lime Silos, Slaking System	1	ls	$2,745,150	$2,745,150	Merrick budget quote	
22	P	***Piping***						
23	P	Allowance	1	ls	$50,000	$50,000		
24	P	***Mechanical Install Crew***						
25	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	42	dys	$3,800	$159,600	say 2 mos for 1-5 man crew	
13		**Lime System Clarifiers**	1	ls	*$2,544,689*	**$2,544,689**		***$3,460,000***
1	P	***Civils***						
2	P	Structure Excavation	375	cy	$15	$5,625		
3	P	Grade/Compact Foundation	556	sys	$3	$1,389		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	3,500	sf	$50	$175,000		
6	P	Aggregate Base at Foundation - 1'	400	tn	$35	$14,000		
7	P	F/P/S/F Concrete SOG	417	cys	$325	$135,525	model qty	
10	P	F/P/S/F Concrete Walls	188	cys	$675	$126,900	-	
11	P	F/P/S/F Concrete Elev Slab	-	cys	$950	$0	-	
14	S	Reinforcing Steel at 220#/cy avg	134,000	lbs	$0.90	$120,600	non-epoxy	
15	S	Epoxy Coating	-	sf	$2.00	$0		
16	S	Backfill Structure/Grading	375	cys	$20	$7,500		
17	S	Waste Haul-off	-	cys	$12	$0		
18	P	***Superstructure Specialties***						
19	S	Metal Stairs at Clarifiers (2)	50	ri	$575	$28,750		

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
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Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
					Grand Total Price:	$ 770,000,000		
					$/MGD:	$ 5.13		
20	S	Metal Walkway Between Clarifiers (1)	520	sf	$100	$52,000	4'	
21	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
22	P	***Process***						
23	P	***Equipment***						
24	P	Lime Clarifiers (3)	105	lf	$10,000	$1,050,000	rotating equipment	
25	P	Solution Water Pumps	3	ea	$38,000	$114,000		
26	P	***Piping***						
27	P	Allowance	1	ls	$50,000	$50,000		
28	P	***Mechanical Install Crew***						
29	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	168	dys	$3,800	$638,400	say 4 mos for 2-5 man crew	
14		**Chemical Storage & Dosing**	1	ls	*$5,874,725*	**$5,874,725**		***$7,980,000***
1	P	***Civils***						
2	P	Structure Excavation	760	cy	$15	$11,400		
3	P	Grade/Compact Foundation	3,000	sys	$3	$7,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	1,900	tn	$35	$66,500		
7	P	F/P/S/F Concrete SOG	713	cys	$325	$231,725	model qty	
8	P	F/P/S/F Concrete Walls	108	cys	$750	$81,000		
9	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0	"	
10	P	F/P/S/F Concrete Equip Pads	5	cys	$1,250	$6,250	"	
11	S	Reinforcing Steel at 220#/cy avg	182,000	lbs	$0.90	$163,800	non-epoxy	
12	S	Epoxy Coating	-	sf	$2.00	$0		
13	S	Backfill Structure/Grading	760	cys	$20	$15,200		
14	S	Waste Haul-off	-	cys	$12	$0		
15	P	***Superstructure Specialties***						
16	S	Caged Ladder to Elevated Walkway (2)	50	lf	$275	$13,750		
17	S	Metal Walkway Between Tanks - 5'	430	sf	$100	$43,000	support frame & decking	
18	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
19	P	***Process***						
20	P	Carbon Dixode Feed System	1	ls	$700,000	$700,000		
21	P	***Equipment***						
22	S	Signage/Safety	1	ls	$7,500	$7,500		
23	P	Chemical Sumps	4	ea	$6,000	$24,000	incls piping, etc.	
24	S	Emergency Eye Wash	4	ea	$1,250	$5,000		
25	S	Safety Shower	2	ea	$1,750	$3,500		
26	P	***Process***						
27	P	***Tanks***						
28	P	Purchase Hypeochloride Storage Tanks - 10,000 gal (FRP)	18	ea	$50,000	$900,000	covered	
29	P	Chemical Tanks - 6,000 gal FRP	28	ea	$30,000	$840,000		
30	P	Covered off-site Storage Silos - Pressure Tanks	6	ea	$400,000	$2,400,000		
31	P	**Pumps**						
32	S	Purchase Carbon Source Pump - 6 gph	2	ea	$7,000	$14,000		
33	P	Purchase Sodium Hypochlorite Pumps - 6 gph	2	ea	$7,000	$14,000		
34	P	Purchase Sodium Hypochlorite Pumps - 1.4 gph	3	ea	$4,500	$13,500		
35	P	Purchase Sodium Hypochlorite Pump - 0.013 gph	1	ea	$4,500	$4,500		
36	P	Purchase Sodium Hypochlorite Pump - 160 gph	1	ea	$8,500	$8,500		
37	P	Purchase Liquid Ammonium Sulfate Pumps - 1.6 gph	2	ea	$6,500	$13,000		
38	P	Purchase Sulfuric Acid Pump - 1.4 gph	6	ea	$4,000	$24,000		
39	P	Purchase Antiscalant Pump - 0.11 gph	3	ea	$4,500	$13,500		
40	S	Purchase Hydrogen Peroxide Pump 0.4 gph	3	ea	$4,500	$13,500		
41	P	Purchase Citric Acid Pump - 60 gph	1	ea	$7,500	$7,500		
42	P	Purchase Sodium Hydroxide Pump - 120 gph	1	ea	$8,500	$8,500		
43	P	Purchase Bisulfate Pump - 60 gph	1	ea	$7,500	$7,500		
44	P	***Piping***						
45	P	1/2" to 1-1/2" Chemical Piping - 7 ea	1,400	lf	$20	$28,000	incls ftgs, valves, etc.at 200' system	
46	P	**Mechanical Install Crew**						
47	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	42	dys	$3,800	$159,600	say 1 mo for 2-4 man crews	
15		**Administrative Building**	1	ls	*$201*	**$5,822,730**		***$7,910,000***
1	S	***Civils***						
2	S	Structure Excavation	600	cy	$15	$9,000		
3	S	Grade/Compact Foundation	5,556	sys	$3	$13,889		
4	S	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	S	Aggregate Base at Foundation - 1'	2,900	tn	$35	$101,500		
7	S	F/P/S/F Concrete SOG & at Second Floor Deck	1,053	cys	$325	$342,129	model qty	
8	S	F/P/S/F Concrete Stairs	8	cys	$1,500	$12,500		
9	S	Reinforcing Steel/WWF at 125#/cy avg	131,588	lbs	$0.90	$118,429	non-epoxy	
10	S	Epoxy Coating	5,000	sf	$1.50	$7,500		
11	S	Backfill Structure/Grading	300	cys	$20	$6,000		
12	S	Waste Haul-Off	300	cys	$12	$3,600		
13	S	***Superstructure Specialties***						
14	S	Metal Decking - 18 ga	27,086	sf	$5	$135,430		
15	S	CMU - 12" Grouted	15,165	sf	$35	$530,775	split face	
16	S	CMU - 08" Grouted	5,856	sf	$28	$163,968		
17	S	CMU - 04"	15,164	sf	$25	$379,100		
18	S	Insulation Rigid	15,164	sf	$4	$60,656		
19	S	Gyp Wall Board	5,200	sf	$15	$78,000		
20	S	Metal Stud Walls	25,918	sf	$5	$129,590		
21	S	Damp Proofing	15,164	sf	$1	$15,164		
22	S	Curtain Wall	850	sf	$75	$63,750		
23	S	Interior Doors 3'x7'	58	ea	$1,500	$87,000		
24	S	Exterior Doors 3'x7'	10	ea	$2,500	$25,000		
25	S	Windows	7,200	sf	$55	$396,000		
26	S	Roofing Structural	15,000	sf	$35	$525,000		
27	S	Built-up Roofing System w/ Specialties	150	sq	$200.00	$30,000		
28	S	Gutter/Downspouts	1	ls	$15,000	$15,000		
29	S	Electrical	28,000	sf	$30	$840,000	incls plumbing	
30	S	HVAC	28,000	sf	$20	$560,000		

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Grand Total Price: $ 770,000,000
$/MGD: $ 5.13

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
31	S	Fire Suppression/Fire Alarm	28,000	sf	$5	$140,000		
32	S	Laboratory - Finishes	225	sf	$150	$33,750		
33	S	Flooring	28,000	sf	$7	$196,000		
34	S	Paint	28,000	sf	$3	$84,000		
35	S	Specialties	1	ls	$300,000	$300,000		
36	S	Comm.	28,000	sf	$15	$420,000		
16		**MicroC2000 Storage & Dosing**	1	ls	*$2,033,100*	**$2,033,100**		*$2,760,000*
1	P	***Civils***						
2	P	Structure Excavation	500	cy	$15	$7,500		
3	P	Grade/Compact Foundation	3,000	sys	$3	$7,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	1,900	tn	$35	$66,500		
7	P	F/P/S/F Concrete SOG	712	cys	$325	$231,400	model qty	
8	P	F/P/S/F Concrete Walls	96	cys	$750	$72,000		
9	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0	"	
10	P	F/P/S/F Concrete Equip Pads	5	cys	$1,250	$6,250	"	
11	S	Reinforcing Steel at 220#/cy avg	179,000	lbs	$0.90	$161,100	non-epoxy	
12	S	Epoxy Coating	-	sf	$2.00	$0		
13	S	Backfill Structure/Grading	250	cys	$20	$5,000		
14	S	Waste Haul-off	250	cys	$12	$3,000		
15	P	***Superstructure Specialties***						
16	S	Caged Ladder to Elevated Walkway (2)	50	lf	$275	$13,750		
17	S	Metal Walkway Between Tanks - 5'	430	sf	$100	$43,000	support frame & decking	
18	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
19	P	***Process***						
20	P	***Equipment***						
21	S	Signage/Safety	1	ls	$7,500	$7,500		
22	P	Chemical Sumps	4	ea	$6,000	$24,000	incls piping, etc.	
23	S	Emergency Eye Wash	2	ea	$1,250	$2,500		
24	S	Safety Shower	2	ea	$1,750	$3,500		
25	P	***Process***						
26	P	***Tanks***						
27	P	Purchase Storage Tank - 18000 gal (FRP)	14	ea	$90,000	$1,260,000		
29	P	**Pumps**						
30	S	*need details*		ea	$0	$0		
42	P	***Piping***						
43	P	1/2" to 1-1/2" Chemical Piping - 14 ea	500	lf	$20	$10,000	incls ftgs, valves, etc.at 200' system	
44	P	**Mechanical Install Crew**						
45	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	22	dys	$3,800	$83,600	say 1 mo for 1-4 man crews	
17		**Generator Building (Slabs only)**	1	ls	*$150,316*	**$150,316**		*$210,000*
1	P	***Civils***				$0		
2	P	Structure Excavation	111	cy	$15	$1,665		
3	P	Grade/Compact Foundation	3,000	sys	$3	$7,500		
4	P	Dewatering Allowance	1	ls	$0	$0		
5	S	Shoring Allowance	1	ls	$0	$0		
6	P	Aggregate Base at Foundation - 1'	1,900	tn	$35	$66,500		
7	P	F/P/S/F Concrete SOG	111	cys	$325	$36,075		
8	P	F/P/S/F Concrete Walls	-	cys	$750	$0		
9	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0		
10	P	F/P/S/F Concrete Equip Pads	10	cys	$1,250	$12,500		
11	S	Reinforcing Steel at 220#/cy avg	27,000	lbs	$0.90	$24,300		
12	S	Epoxy Coating	-	sf	$2.00	$0		
13	S	Backfill Structure/Grading	56	cys	$20	$1,110		
14	S	Waste Haul-off	56	cys	$12	$666		
19		**Yard Piping**	1	ls	*$5,662,197*	**$5,662,197**		*$7,690,000*
1	S	***Piping***						
2	S	144" x 96" CS Concentric Reducer	1	ea	$7,824	$7,824		
3	S	120" CS Elbow, C208 Lined	3	ea	$54,000	$162,000		
4	S	144" CS Elbow, C208 Lined	1	ea	$64,800	$64,800		
5	S	30" CS Elbow, C208 Lined	14	ea	$8,100	$113,400		
6	S	42" CS Elbow, C208 Lined	2	ea	$11,340	$22,680		
7	S	48" CS Elbow, C208 Lined	13	ea	$12,960	$168,480		
8	S	84" CS Elbow, C208 Lined	4	ea	$22,680	$90,720		
9	S	96" CS Elbow, C208 Lined	5	ea	$25,920	$129,600		
10	S	24" CS Pipe Cap, C208	1	ea	$2,760	$2,760		
11	S	30" CS Pipe Cap, C208	2	ea	$3,450	$6,900		
12	S	48" CS Pipe Cap, C208	2	ea	$5,520	$11,040		
13	S	120" CS Pipe, C200 Lined	577	lf	$540	$311,535		
14	S	144" CS Pipe, C200 Lined	1,095	lf	$648	$709,776		
15	S	24" CS Pipe, C200 Lined	78	lf	$108	$8,370		
16	S	30" CS Pipe, C200 Lined	661	lf	$135	$89,179		
17	S	42" CS Pipe, C200 Lined	9	lf	$189	$1,717		
18	S	48" CS Pipe, C200 Lined	2,591	lf	$216	$559,728		
19	S	84" CS Pipe, C200 Lined	141	lf	$378	$53,141		
20	S	96" CS Pipe, C200 Lined	1,143	lf	$432	$493,956		
21	S	48"x48" CS Tee	1	ea	$12,960	$12,960		
22	S	Other Underfiend Yarf Piping	1	ls	$2,500,000	$2,500,000		
23	S	**Mechanical Install Crew**						
24	S	Labor, Misc Matls, small tools, Equip, Ohds, etc.	31	dys	$4,500	$141,632	at 200'/day	
18		**Electrical & IC**	1	ls	*$100,500,000*	**$100,500,000**		*$136,430,000*
1	S	Medium Voltage Power Distribution	1	ls	4.0%	$14,000,000	on running subtotal, all areas, controls are with equip pricing	
2	S	Balance of Electrical	1	ls	10.0%	$34,000,000		
3	S	Instrumentation & Controls	1	ls	9.0%	$31,000,000		
4	S	SCE Substation	1	ls	$20,000,000	$20,000,000		
5	S	Generators	6	ea	$250,000	$1,500,000	includes site electrical. VFDs and power substation	
19		**Improvements at the JWPCP**	1	ls	*$68,000,000*	**$68,000,000**		*$92,200,000*
1		Sidestream Nitrogen Removal at JWPCP	1	ls	$67,000,000	$67,000,000	MWD input, markups included, contingency excluded	
2		Modifications for Clarifier Equilization	1	ls	$1,000,000	$1,000,000	"	

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					Grand Total Price:	$ 770,000,000		
					$/MGD:	$ 5.13		
Area	**GC**	**Description**	**Quantity**	**UOM**	**Unit Cost**	**Total Cost**	**Comments**	**Al-in Area Costs**
20		**Improvements at the FORCO Site**	1	ls	*$7,911,773*	**$7,911,773**		*$10,630,000*
1	S	**Utility Relocates**						
2	S	10" HP Gas Line	2,000	lf	$200	$400,000		
3	S	10" HP Gas Line (Abandoned)	1,200	lf	$40	$48,000	grout	
4	S	72" Sewer Line	2,205	lf	$1,008	$2,222,640		
5	S	72" Sewer Line (Remove/Abandon)	950	lf	$324	$307,800		
6	S	10'x12' Conc Box Culvert	1,400	lf	$1,500	$2,100,000		
7	S	10'x12' Conc Box Culvert (Abandon)	500	lf	$667	$333,333		
8	S	Allowance for Undefined Utility Relocates	1	ls	$2,500,000	$2,500,000		
					Running Subtotal:	**$567,476,175**		
A		**Startup/Commission/Owner Training**	1	ls		**$353,750**		
1	P	Pre-commissioning	750	hrs	$75	**$56,250**		
2	P	Vendor Support	1	ls	$5,000	**$5,000**		
3	P	Commissioning	750	hrs	$75	**$56,250**		
4	P	Training	400	hrs	$100	**$40,000**		
5	P	Startup Expendables	1	ls	$5,000	**$5,000**	testing water by others	
6	P	90 day Break-in Period	90	dys	$2,125	**$191,250**	2-men	
					Running Subtotal:	**$567,829,925**		
6	P	Estimating Accuracy, Unlisted Items Allowance	1	ls	10.0%	**$56,782,992**	on running subtotal	
					Running Subtotal:	**$624,612,917**	**Direct Construction Cost (DCC)**	
B		**Construction Allowances**				**$145,708,706**		
1		Prime Contractor General Conditions at 4 yrs	1	ls	5%	**$18,990,000**	$395,625	
2		Subcontractor General Conditions	1	ls	6%	**$10,620,000**		
3		Market Factor	1	ls	0%	**$0**	Premium for uncompetitive conditions, logistics, complexity,	
4		Construction Phasing Factor	1	ls	0%	**$0**	Premium for interfaces, constraints, etc.	
5		Subcontractor Markups	1	ls	11.5%	**$21,563,073**	H/O Overheads, Job Fee & Risk, insur, bond	
6		Prime Contractor OH&P on Subs	1	ls	4.0%	**$8,362,722**	Oversight + Risk	
7		Prime Contractor OH&P on Self-Perform	1	ls	10.0%	**$39,871,800**	Job Fee + Risk	
8		Contractor Insurance Program	1	ls	2.5%	**$18,100,513**	Performance/Payments Bonds, Genl Liability	
9		State Sales Taxes	1	ls	9.5%	**$28,200,599**	On Materials at 40% of running subtotal	
10		Design/Estimating Contingency	1	ls	0%	**$0**	Excluded, client allowance	
				1.3575	**Running Subtotal:**	**$770,321,620**	**Base Construction Cost (BCC)**	
C		**Project Allowances**				**$0**		
1		Escalation from Pricing Level to NTP	1	ls	0%	**$0**	Excluded, client allowance	
2		Escalation from NTP to MPC	1	ls	0%	**$0**	Excluded, client allowance	
3		Construction Change Contingency	1	ls	0%	**$0**	Excluded, client allowance	
					Running Subtotal:	**$770,320,000**	**Total Construction Costs (TCC)**	
D		**Owner Allowances**				**$0**		
1		Design to Construction Documents Allowance	1	ls	0.0%	**$0**	Excluded	
2		CM Oversight	1	ls	0.0%	**$0**	"	
3		Owner PM, Permitting, Legal, Procurement, Etc.	1	ls	0.0%	**$0**	"	
				1.3574				*Chk Total:*
					Grand Total:	**$770,320,000**	**Total Project Cost (TPC)**	*$770,200,000*

OPCC for the Full-scale AWT Facility without MF

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Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
Without Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 682,000,000
$/MGD: $ 4.55

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
0		**General Site Development**	1	ls	*$11,167,420*	**$11,167,420**		*$15,150,000*
1	P	**Demolition**						
2	S	Remove Misc Debris, Pavements, Rubble, etc.	1	ls	$110,000	$110,000	55 acres	
3	S	Protect/Support/Repair (e) Utilities Allowance - TBD	1	ls	$100,000	$100,000	support, repair & replace during overexc activity	
4	S	**Civil Works**						
5	S	Over Excavation/Re-compaction Work at Area 10	100,000	cys	$10	$1,000,000	exc/stockpile 1/3 at area north of demo area,<500' haul	
6	S	General Site/Earthworks Grading/Pre-compaction	50	dys	$5,500	$275,000	55 acres	
7	P	New Site Drainage Facilities	1	ls	$1,500,000	$1,500,000	allowance for catch basins, piping, etc., ret basins, storm drng	
8	S	Relocate (e) 8" Pipelines	1,500	lf	$120	$180,000	abandon (e) lines in-place	
9	S	Sawcut Concrete/AC	500	lf	$4	$2,000		
10	S	New Plant Concrete Roads - 8"	*26,610*	*sy*	*$78*			
11	S	Roadway Excavation - 2.75'	24,400	cys	$6	$146,400		
12	S	Subgrade Prep/Compaction	26,610	sys	$2	$53,220		
13	S	Imported Select Materials - 18"	24,200	tns	$32	$774,400		
14	S	Imported Base Materials - 11"	14,800	tns	$35	$518,000		
15	S	Asphalt Base & Wearing Course - 4"	5,800	tns	$100	$580,000		
16	S	New Plant Concrete Roads G&C - 18"	5,280	lf	$30	$158,400	say 1 mile vs. 4 miles	
17	S	New Concrete Flatwork (DWs, SWs)	5,000	sf	$8	$40,000	allowance for catch basins, piping, etc., ret basins, storm drng	
18	S	Asphalt Paving at Non-Process Areas (3"/6")	-	sf	$3.50	$0		
19	S	Bollards	30	ea	$350.00	$10,500		
20	S	Parking Curbs	50	ea	$90.00	$4,500	n/a	
21	S	Landscaping Allowance	1	ls	$500,000	$500,000	xeriscaping mainly around the ops building	
22	S	Signage Allowance	1	ls	$15,000	$15,000		
23	S	**Connection to JWPCP Channel 3**						
24	S	Allowance	1	ls	$2,500,000	$2,500,000		
25	S	**Miscellanous Piping**						
26	S	Allowance	1	ls	$200,000	$200,000		
27	S	**Utility Water System (FS, Pot, Utility)**						
28	S	Allowance	1	ea	$2,500,000.00	$2,500,000		
1		**Drum Screen & Influent Pump Station**	1	ls	*$11,996,860*	**$11,996,860**		*$16,280,000*
1	P	***Civils***						
2	P	Structure Excavation	1,300	cy	$15	$19,500		
3	P	Grade/Compact Foundation	5,000	sys	$3	$12,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	3,000	tn	$35	$105,000		
7	P	F/P/S/F Concrete SOG	2,466	cys	$325	$801,450	model qty	
8	P	F/P/S/F Concrete Walls	1,407	cys	$675	$949,725	"	
9	P	F/P/S/F Concrete Elev Slab	800	cys	$950	$760,000	"	
10	P	F/P/S/F Concrete Equip Pads	39	cys	$1,250	$48,750	"	
11	S	Reinforcing Steel at 220#/cy avg	1,037,000	lbs	$0.90	$933,300	non-epoxy	
12	S	Epoxy Coating	2,400	sf	$2.50	$6,000		
13	S	Backfill Structure/Grading	650	cys	$20	$13,000		
14	P	***Superstructure Specialties***						
15	S	Column Support Steel	1,000	lbs	$3.00	$3,000		
16	S	Structural Steel Framing	15,190	lbs	$2.50	$37,975		
17	S	Steel Trusses - Light Gauge - 80' span	72	ea	$1,600	$115,200		
18	S	Roof Deck - 18 ga	12,400	sf	$3.00	$37,200		
19	S	Metal Stairs (2 sets) to Drum Screens	50	ri	$400	$20,000		
20	S	Metal Stairs at Drum Screens (7)	70	ri	$400	$28,000		
21	S	Deck Hatches (2'x2')	7	ea	$4,000	$28,000		
22	S	Misc Metals	1	ls	$40,000	$40,000		
23	P	***Process***						
24	P	***Equipment***						
25	P	Sluice Gates - Large w/ Rotec Actuators	10	ea	$53,000	$530,000	7'x25'	
26	P	Influent Pumps - 20 MGD	14	ea	$110,000	$1,540,000	budget quote	
27	P	Drum Screens	13	ea	$330,800	$4,300,400	estimate	
28	P	***Piping***						
29	P	36" B'Fly valve	14	ea	$23,400	$327,600		
30	P	84" B'Fly Valve	3	ea	$63,000	$189,000		
31	P	84" Blind Flg - Flat Face	1	ea	$1,680	$1,680		
32	P	36" Check Valve	14	ea	$23,400	$327,600		
33	P	84" C200 Elbow	4	ea	$26,880	$107,520		
34	P	84" x 36" Tees	14	ea	$21,000	$294,000		
35	P	36" C200 Flg	70	ea	$720	$50,400		
36	P	84" C200 Flg	5	ea	$1,680	$8,400		
37	P	36" C200	139	lf	$180	$25,080		
38	P	84" C200	295	lf	$420	$123,900		
39	S	84" C200 Tee	1	ea	$22,680	$22,680		
40	S	***Mechanical Install Crew***						
41	S	Labor, Misc Matls, small tools, Equip, Ohds, etc.	50	dys	$3,800	$190,000	say 2 mo for 5 man crew	
2		**Aeration, Anoxic, MBR Tank & Blowers**	1	ls	*$124,082,772*	**$124,082,772**		*$168,340,000*
1	P	***Civils***						
2	P	Structure Excavation	21,000	cy	$15	$315,000	includes, haul to waste	
3	P	Grade/Compact Foundation	46,700	sys	$3	$116,750		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	22,958	sf	$40	$918,320	at 26' deep excavations , east wall + 180' of N/S walls	
6	P	Aggregate Base at Foundation - 1'	27,700	tn	$35	$969,500		
7	P	F/P/S/F Concrete SOG	18,616	cys	$325	$6,050,200	model qty	
8	P	F/P/S/F Concrete Walls	12,225	cys	$675	$8,251,875	"	
9	P	F/P/S/F Concrete Elev Slab	1,030	cys	$950	$978,500	"	
10	P	F/P/S/F Concrete Stairs	10	cys	$1,500	$15,000	"	
11	P	F/P/S/F Concrete Equip Pads	100	cys	$1,000	$100,000	"	
12	S	Reinforcing Steel at 220#/cy avg	7,036,000	lbs	$0.90	$6,332,400	non-epoxy	
13	S	Epoxy Coating	24,000	sf	$2.00	$48,000		
14	S	Backfill Structure/Grading	10,500	cys	$20	$210,000		
15	P	***Superstructure Specialties***						
16	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
17	S	Deck Hatches (2'x2')	7	ea	$4,000	$28,000		
18	S	Misc Metals	1	ls	$150,000	$150,000	railings, stairs, etc.	
19	P	***Process***						
20	P	***Equipment***						
21	P	RAS Pumps	21	ea	$0	$0	included in ME pricing	
22	P	MBR Filtrate Pumps	27	ea	$0	$0	8,600 rpm, included in MBR scope	
23	P	MBR Blowers	30	ea	$0	$0	included in ME pricing	
24	P	Compressors for MBR, MF (75 hp)	3	ea	$0	$0	included in MBR vendor scope	

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
Without Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 682,000,000
$/MGD: $ 4.55

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
25	P	Compressors for MF (15 hp)	10	ea	$0	$0	included in MF vendor scope	
26	P	Anoxic Mixers - 5 hp	48	ea	$14,500	$696,000		
27	P	Aeration Blowers	30	ea	$185,000	$5,550,000	JBI budgetary quote	
28	P	Membrane Equipment (ME)	1	ls	$67,000,000	$67,000,000	Avg of two budgetary quotes	
29	P	***Piping***						
30	P	4" CS B'Fly Valve - 150 psi	1,044	ea	$2,000	$2,088,000		
31	P	8" CS B'Fly Valve - 150 psi	24	ea	$4,000	$96,000		
32	P	12" CS B'Fly Valve - 150 psi	24	ea	$7,200	$172,800		
33	P	14" CS B'Fly Valve - 150 psi	60	ea	$8,400	$504,000		
34	P	18" CS B'Fly Valve - 150 psi	48	ea	$11,250	$540,000		
35	P	4" SS B'Fly Valve	612	ea	$2,600	$1,591,200		
36	P	8" SS B'Fly Valve	-	ea	$3,200	$0		
37	P	12" SS B'Fly Cap	24	ea	$480	$11,520		
38	P	20" SS B'Fly Cap	24	ea	$800	$19,200		
39	P	24" SS B'Fly Cap	12	ea	$960	$11,520		
40	P	30" SS B'Fly Cap	8	ea	$1,200	$9,600		
41	P	36" SS B'Fly Cap	8	ea	$1,440	$11,520		
42	P	48" SS B'Fly Cap	12	ea	$1,920	$23,040		
43	P	60" SS B'Fly Cap	4	ea	$2,400	$9,600		
44	P	8" CS Check Valve - 150 psi	24	ea	$4,800	$115,200		
45	P	12" LR SS Elbow - 316L	24	ea	$4,800	$115,200		
46	P	6" LR SS Elbow - 316L	432	ea	$2,400	$1,036,800		
47	P	4" SR SS Elbow - 316L	1,656	ea	$1,280	$2,119,680		
48	P	30" SR SS Elbow - 316L	4	ea	$38,400	$153,600		
49	P	36" SR SS Elbow - 316L	4	ea	$50,688	$202,752		
50	P	48" SR SS Elbow - 316L	2	ea	$73,728	$147,456		
51	P	60" SR SS Elbow - 316L	2	ea	$115,200	$230,400		
52	P	4" Flg , FF, SS Class 150	2,088	ea	$700	$1,461,600		
53	P	6" Flg , FF, SS Class 150	24	ea	$1,050	$25,200		
54	P	8" Flg , FF, SS Class 150	96	ea	$1,400	$134,400		
55	P	12" Flg , FF, SS Class 150	144	ea	$1,980	$285,120		
56	P	14" Flg , FF, SS Class 150	180	ea	$2,240	$403,200		
57	P	10" Flg , FF, SS Class 150	24	ea	$1,550	$37,200		
58	P	18" Flg , FF, SS Class 150	144	ea	$2,700	$388,800		
59	P	4" SS Schld 105, 316L	41,523	lf	$47	$1,951,585		
60	P	6" SS Schld 105, 316L	7,701	lf	$69	$531,398		
61	P	8" SS Schld 105, 316L	94	lf	$130	$12,220		
62	P	10" SS Schld 105, 316L	18	lf	$171	$3,021		
63	P	12" SS Schld 105, 316L	2,979	lf	$214	$637,595		
64	P	14" SS Schld 105, 316L	542	lf	$250	$135,403		
65	P	18" SS Schld 105, 316L	435	lf	$385	$167,498		
66	P	20" SS Schld 105, 316L	2,754	lf	$428	$1,178,498		
67	P	24" SS Schld 105, 316L	3,108	lf	$514	$1,596,098		
68	P	30" SS Schld 105, 316L	336	lf	$642	$215,391		
69	P	36" CS Schld 105, 150 psi	358	lf	$162	$57,983		
70	P	48" CS Schld 105, 150 psi	1,141	lf	$216	$246,348		
71	P	60" CS Schld 105, 150 psi	585	lf	$240	$140,460		
72	P	84" CS Schld 105, 150 psi	45	lf	$378	$16,979		
73	P	96" CS Schld 105, 150 psi	55	lf	$432	$23,904		
74	P	48" CS C200, 150 psi	617	lf	$192	$118,400		
75	P	8"x6" SS Reducer	24	ea	$2,240	$53,760		
76	P	10"x12" SS Reducer	24	ea	$3,520	$84,480		
77	P	12" SS Reducing Tee	432	ea	$8,800	$3,801,600		
78	P	30" SS Reducing Tee	30	ea	$21,600	$648,000		
79	P	36" SS Reducing Tee	24	ea	$26,400	$633,600		
80	P	48" C208 Tee	22	ea	$9,600	$211,200		
81	P	***Mechanical Install Crew***						
82	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	504	dys	$3,800	$1,915,200	say 12 mos for 2-5 man crew	
3		**Maintenance Bldg**	1	ls	*$1,477,209*	**$1,477,209**		***$2,010,000***
1	P	***Civils***						
2	P	Structure Excavation	2,200	cy	$15	$33,000		
3	P	Grade/Compact Foundation	2,125	sys	$3	$5,313		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	1,400	tn	$35	$49,000		
7	P	F/P/S/F Concrete SOG	706	cys	$325	$229,450	model qty	
8	P	F/P/S/F Concrete Floor Topping	374	cys	$450	$168,300		
9	P	F/P/S/F Concrete Equip Pads	4	cys	$1,250	$5,000	"	
10	S	Reinforcing Steel/WWF at 125#/cy avg	88,250	lbs	$0.90	$79,425	non-epoxy	
11	S	Epoxy Coating	-	sf	$2.50	$0		
12	S	Backfill Structure/Grading	1,100	cys	$20	$22,000		
13	S	***Superstructure Specialties***						
14	S	CMU - 12" Grouted	12,400	sf	$32.00	$396,800		
15	S	Windows - 3x5	6	ea	$900.00	$5,400		
16	S	Windows - 3x3	6	ea	$540.00	$3,240		
17	S	Exterior Doors 3'x8'	2	ea	$2,300.00	$4,600		
18	S	Roll-Up Doors - 15'x15' w/ motor	2	ea	$8,500.00	$17,000		
19	S	Steel Trusses - Light Gauge - 85' span	230	ea	$1,530	$351,900		
20	S	Roof Deck - 18 ga	21,675	sf	$3.00	$65,025		
21	S	Built-up Roofing System	217	sq	$75.00	$16,256		
22	S	Gutter/Downspouts	1	ls	$7,500.00	$7,500		
23	S	Utility Sink w/ Eyewash	2	ea	$5,000	$10,000	incls plumbing	
24	S	Wall Fans	8	ea	$1,000	$8,000		
4		**RO Feed Tank**	1	ls	*$3,602,471*	**$3,602,471**		***$4,890,000***
1	P	***Civils***						
2	P	Structure Excavation	400	cy	$15	$6,000	includes, haul to waste	
3	P	Grade/Compact Foundation	18,333	sys	$3	$45,833		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	1,150	tn	$35	$40,250		
7	P	F/P/S/F Concrete SOG	1,735	cys	$325	$563,713	model qty	
8	P	F/P/S/F Concrete Walls	642	cys	$675	$433,350	"	
9	P	F/P/S/F Concrete Elev Slab	1,596	cys	$950	$1,516,200	"	
10	P	F/P/S/F Concrete Curbs	6	cys	$1,750	$10,500	"	
11	P	F/P/S/F Concrete Equip Pads	135	cys	$1,250	$168,125	"	
12	S	Reinforcing Steel at 220#/cy avg	905,000	lbs	$0.90	$814,500	non-epoxy	

Metropolitan Water District
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150 MGD
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Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

					Grand Total Price:	$ 682,000,000		
					$/MGD:	$ 4.55		
Area	**GC**	**Description**	**Quantity**	**UOM**	**Unit Cost**	**Total Cost**	**Comments**	**Al-in Area Costs**
13	S	Epoxy Coating	-	sf	$2.00	$0		
14	S	Backfill Structure/Grading	200	cys	$20	$4,000		
5		**Electrical Building**	1	ls	*$1,459,956*	**$1,459,956**		***$1,990,000***
1	P	***Civils***						
2	P	Structure Excavation	700	cy	$15	$10,500		
3	P	Grade/Compact Foundation	1,570	sys	$3	$3,925		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	1,100	tn	$35	$38,500		
7	P	F/P/S/F Concrete SOG	343	cys	$325	$111,475	model qty	
8	P	F/P/S/F Concrete Floor Topping	156	cys	$375	$58,500		
9	P	F/P/S/F Concrete Wall Ftgs	103	cys	$450	$46,350		
10	P	F/P/S/F Concrete Walls	133	cys	$675	$89,775		
11	P	F/P/S/F Concrete Equip Pads	8	cys	$1,250	$10,000	"	
12	S	Reinforcing Steel/WWF at 175#/cy avg	60,025	lbs	$0.90	$54,023	non-epoxy	
13	S	Epoxy Coating	-	sf	$2.50	$0		
14	S	Backfill Structure/Grading	350	cys	$20	$7,000		
15	S	***Superstructure Specialties***						
16	S	CMU - 8" Grouted	8,669	sf	$26.00	$225,394		
17	S	Windows - 3'x5'	6	ea	$900.00	$5,400		
18	S	Windows - 3'x3'	6	ea	$540.00	$3,240		
19	S	Exterior Doors 3'x8'	2	ea	$2,300.00	$4,600		
20	S	Roll-Up Doors - 15'x15' w/ motor	1	ea	$8,500.00	$8,500		
21	S	Steel Trusses - Light Gauge - 85' span	230	ea	$1,530	$351,900		
22	S	Roof Deck - 18 ga	17,625	sf	$3.00	$52,875		
23	S	Built-up Roofing System	176	sq	$100.00	$17,625		
24	S	Gutter/Downspouts	1	ls	$7,500	$7,500		
25	S	Utility Sink w/ Eyewash	2	ea	$5,000	$10,000	incls plumbing	
26	S	Wall Fans	8	ea	$1,000	$8,000		
27	S	HVAC	17,625	sf	$15	$264,375	AC for elec equipment	
28	S	Fire Suppression/Fire Alarm	17,625	sf	$4	$70,500		
6		**RO Cartridge Filters**	1	ls	*$13,080,365*	**$13,080,365**		***$17,750,000***
1	P	***Civils***						
2	P	Structure Excavation	9,200	cy	$15	$138,000		
3	P	Grade/Compact Foundation	9,000	sys	$3	$22,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	5,500	tn	$35	$192,500		
7	P	F/P/S/F Concrete SOG	745	cys	$325	$242,125	model qty	
8	P	F/P/S/F Concrete Walls	351	cys	$675	$236,925	"	
9	P	F/P/S/F Concrete Elev Slab	477	cys	$950	$453,150	"	
10	P	F/P/S/F Concrete Equip Pads	169	cys	$1,250	$211,250	"	
11	S	Reinforcing Steel at 220#/cy avg	384,000	lbs	$0.90	$345,600	non-epoxy	
12	S	Epoxy Coating	9,648	sf	$1.50	$14,472		
13	S	Backfill Structure/Grading	4,600	cys	$20	$92,000		
14	P	***Superstructure Specialties***						
15	S	Metal Stairs (2 sets)	30	ri	$400	$12,000		
16	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
17	S	Deck Hatches (2'x2')	5	ea	$4,000	$20,000		
18	S	Misc Metals	1	ls	$5,000	$5,000	railings, etc,	
19	S	Pre-engineering Bldg Allowance	20,400	sf	$110	$2,244,000		
20	P	***Process***						
21	P	***Equipment***						
22	P	RO CIP Tanks	140,000	gal	$5.00	$700,000		
23	P	Auto Cartridge Filtes	1	ls	$2,300,000	$2,300,000	vendor budget	
24	P	RO Feed Pumps	6	ea	$370,000	$2,220,000	VTP, budget quote	
25	P	***Piping***						
26	P	12" SS B'Fly Valve, Class 150	128	ea	$2,600	$332,800		
27	P	12" SS Elbow, 316L	128	ea	$15,360	$1,966,080		
28	P	12" SS FF Flg, 316L, Class 150	128	ea	$1,920	$245,760		
29	P	30" CS Pipe Cap	25	ea	$600	$15,000		
30	P	42" CS Pipe Cap	2	ea	$840	$1,680		
31	P	72" CS Pipe Cap	6	ea	$1,440	$8,640		
32	P	12" SS, 316L, Plain End	998	lf	$214	$213,661		
33	P	30" CS, C200, Lined, Manifold	990	lf	$162	$160,353		
34	P	42" CS, C200, Lined, Manifold	30	lf	$227	$6,728		
35	P	72" CS, C200, Lined, Manifold	150	lf	$432	$64,908		
36	P	42" CS Tee	1	ea	$15,120	$15,120		
37	P	72" CS Tee	3	ea	$31,104	$93,312		
38	P	***Mechanical Install Crew***						
39	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	126	dys	$3,800	$478,800	say 3 mos for 2-5 man crews	
7		**RO Facility**	1	ls	*$102,744,551*	**$102,744,551**		***$139,390,000***
1	P	***Civils***						
2	P	Structure Excavation	43,000	cy	$15	$645,000		
3	P	Grade/Compact Foundation	46,111	sys	$3	$115,278		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	", 12' deep, use back slopes	
6	P	Aggregate Base at Foundation - 1'	28,100	tn	$35	$983,500		
7	P	F/P/S/F Concrete SOG	3,485	cys	$325	$1,132,625	model qty	
8	P	F/P/S/F Concrete Walls	573	cys	$675	$386,775	"	
9	P	F/P/S/F Concrete Elev Slab	3,485	cys	$950	$3,310,750	"	
10	P	F/P/S/F Concrete Equip Pads	60	cys	$1,250	$75,000	"	
11	P	F/P/S/F Concrete Curbs	17	cys				
12	S	Reinforcing Steel at 220#/cy avg	1,673,000	lbs	$0.90	$1,505,700	non-epoxy	
13	S	Epoxy Coating	14,976	sf	$1.50	$22,464		
14	S	Backfill Structure/Grading	5,000	cys	$20	$100,000	say 100 sf/lf	
15	P	***Superstructure Specialties***						
16	S	Metal Stairs (2 sets)	30	ri	$400	$12,000		
17	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
18	S	Deck Hatches (2'x2')	5	ea	$4,000	$20,000		
19	S	Misc Metals	1	ls	$35,000	$35,000	railings, etc,	
20	S	Pre-Engineered Metal Bldg Allowance	74,120	sf	$110	$8,153,200		
21	P	***Process***						
22	P	***Equipment***						
23	P	RO Equipment, controls	1	ls	$54,000,000	$54,000,000	selected vendor budget	

Metropolitan Water District

Advanced Water Treatment Plant

150 MGD

Without Micro Filtration

<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 682,000,000

$/MGD: $ 4.55

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
24	P	First Stage RO Booster Pumps	48	ea	$85,000	$4,080,000	2700 gpm, budget quote	
25	P	***Piping***						
26	P	4" CS Check Valve - 150 psi	48	ea	$2,600	$124,800		
27	P	8" CS Check Valve - 150 psi	21	ea	$5,200	$109,200		
28	P	14" CS Check Valve - 150 psi	48	ea	$9,100	$436,800		
29	P	16" CS B'Fly Valve - 150 psi, Wafer	48	ea	$8,800	$422,400		
30	P	04" CS B'Fly Valve - 150 psi, Wafer	144	ea	$2,600	$374,400		
31	P	06" CS B'Fly Valve - 150 psi, Wafer	48	ea	$3,900	$187,200		
32	P	08" CS B'Fly Valve - 150 psi, Wafer	69	ea	$5,200	$358,800		
33	P	10" CS B'Fly Valve - 150 psi, Wafer	21	ea	$6,750	$141,750		
34	P	12" CS B'Fly Valve - 150 psi, Wafer	96	ea	$8,400	$806,400		
35	P	14" CS B'Fly Valve - 150 psi, Wafer	103	ea	$10,150	$1,045,450		
36	P	04" SS Pipe Cap	96	ea	$320	$30,720		
37	P	06" SS Pipe Cap	480	ea	$480	$230,400		
38	P	08" SS Pipe Cap	288	ea	$640	$184,320		
39	P	14" SS Pipe Cap	21	ea	$1,568	$32,928		
40	P	18" SS Pipe Cap	7	ea	$2,016	$14,112		
41	P	14" LR SS Elbow - 316L	7	ea	$4,480	$31,360		
42	P	02" LR SS Elbow - 316L	11,232	ea	$320	$3,594,240		
43	P	08" LR SS Elbow - 316L	48	ea	$2,560	$122,880		
44	P	1.5" SR SS Elbow - 316L	5,616	ea	$240	$1,347,840		
45	P	04" SR SS Elbows - 316L	288	ea	$768	$221,184		
46	P	06" SR SS Elbows - 316L	432	ea	$1,728	$746,496		
47	P	08" SR SS Elbows - 316L	55	ea	$2,304	$126,720		
48	P	12" SR SS Elbow - 316L	240	ea	$3,168	$760,320		
49	P	14" SR SS Elbow - 316L	103	ea	$4,032	$415,296		
50	P	14" Flg , FF, SS Class 150	7	ea	$2,240	$15,680		
51	P	16" Flg , FF, CS Class 150	96	ea	$1,760	$168,960		
52	P	10" Flg, FF, SS, 316L 150 psi	63	ea	$1,600	$100,800		
53	P	12" Flg, FF, SS, 316L 150 psi	384	ea	$1,920	$737,280		
54	P	14" Flg, FF, SS, 316L 150 psi	309	ea	$2,240	$692,160		
55	P	16" Flg, FF, SS, 316L 150 psi	48	ea	$2,720	$130,560		
56	P	04" Flg, FF, SS, 316L 150 psi	528	ea	$600	$316,800		
57	P	06" Flg, FF, SS, 316L 150 psi	240	ea	$900	$216,000		
58	P	08" Flg, FF, SS, 316L 150 psi	297	ea	$1,280	$380,160		
59	P	08" Flg, FF, SS, 316L 150 psi, Weld-Neck	7	ea	$1,280	$8,960		
60	P	48" CS Pipe Cap	1	ea	$4,800	$4,800		
61	P	42" CS Pipe Cap	8	ea	$4,200	$33,600		
62	P	72" CS Pipe Cap	3	ea	$8,280	$24,840		
63	P	96" CS Pipe Cap	1	ea	$11,040	$11,040		
64	P	1.5" SS Schld 105, 316L	28,602	lf	$20	$572,045		
65	P	02" SS Schld 105, 316L	1,377	lf	$24	$33,038		
66	P	04" SS Schld 105, 316L	2,423	lf	$46	$111,477		
67	P	06" SS Schld 105, 316L	7,892	lf	$69	$544,571		
68	P	08" SS Schld 105, 316L	4,037	lf	$130	$524,756		
69	P	10" SS Schld 105, 316L	67	lf	$171	$11,500		
70	P	12" SS Schld 105, 316L	2,832	lf	$214	$606,084		
71	P	14" SS Schld 105, 316L	3,941	lf	$250	$984,040		
72	P	16" SS Schld 105, 316L	24	lf	$285	$6,848		
73	P	18" SS Schld 105, 316L	1,470	lf	$321	$472,004		
74	P	16" CS Schld 105, 150 psi	89	lf	$72	$6,396		
75	P	24" CS Schld 105, 150 psi	410	lf	$108	$44,316		
76	P	42" CS Schld 105, 150 psi	1,636	lf	$189	$309,157		
77	P	48" CS Schld 105, 150 psi	315	lf	$216	$67,986		
78	P	72" CS Schld 105, 150 psi	821	lf	$324	$266,058		
79	P	96" CS Schld 105, 150 psi	385	lf	$432	$166,464		
80	P	12" x 6" SS Concentric Reducer, 316L	48	ea	$1,440	$69,120		
81	P	12" x 8" SS Concentric Reducer, 316L	96	ea	$1,600	$153,600		
82	P	14" x 8" SS Concentric Reducer, 316L	7	ea	$1,760	$12,320		
83	P	16" x 14" SS Concentric Reducer, 316L	48	ea	$2,400	$115,200		
84	P	12" SS Reducing Tee	432	ea	$7,680	$3,317,760		
85	P	14" SS Reducing Tee	152	ea	$8,960	$1,361,920		
86	P	04" CS Black Pipe, Galvanized	48	lf	$18	$864		
87	P	04" SS Tee, 316L	48	ea	$2,560	$122,880		
88	P	06" SS Tee, 316L	48	ea	$3,840	$184,320		
89	P	12" SS Tee, 316L	48	ea	$7,680	$368,640		
90	P	14" SS Tee, 316L	14	ea	$8,960	$125,440		
91	P	***Mechanical Install Crew***						
92	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	756	dys	$3,800	$2,872,800	say 12 mos for 3-5 man crews	
8		**UV Facility**	1	ls	*$21,921,088*	**$21,921,088**		***$29,740,000***
1	P	***Civils***						
2	P	Structure Excavation	9,200	cy	$15	$138,000		
3	P	Grade/Compact Foundation	3,889	sys	$3	$9,722		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	2,400	tn	$35	$84,000		
7	P	F/P/S/F Concrete SOG	456	cys	$325	$148,200	model qty	
8	P	F/P/S/F Concrete Walls	1,279	cys	$675	$863,325	"	
9	P	F/P/S/F Concrete Elev Slab	823	cys	$950	$781,850	"	
10	P	F/P/S/F Concrete Equip Pads	-	cys	$1,250	$0	"	
11	S	Reinforcing Steel at 220#/cy avg	563,000	lbs	$0.90	$506,700	non-epoxy	
12	S	Epoxy Coating	5,936	sf	$1.50	$8,904		
13	S	Backfill Structure/Grading	1,000	cys	$20	$20,000		
14	S	Excavation Haul Off	8,200	cys	$12	$98,400		
15	P	***Superstructure Specialties***						
16	S	Column Support Steel	-	lbs	$3.00	$0		
17	S	Structural Steel Framing	9,717	lbs	$3.00	$29,152		
18	S	Metal Stairs (2 sets)	30	ri	$400	$12,000		
19	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
20	S	Deck Hatches (2'x2')	-	ea	$4,000	$0		
21	S	Misc Metals	1	ls	$40,000	$40,000	railings, etc,	
22	S	Pre-Engineered Metal Bldg Allowance	34,430	sf	$110	$3,787,300		
23	P	***Process***						
24	P	***Equipment***						
25	P	UV Equipment, Includes Controls	1	ls	$11,300,000	$11,300,000	selected vendor budget	
26	P	***Piping***						
27	P	36" CS B'Fly Valve, Class 150	36	ea	$23,400	$842,400		

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
Without Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
					Grand Total Price:	$ 682,000,000		
					$/MGD:	$ 4.55		
28	P	96" CS B'Fly Valve, Class 150	4	ea	$72,000	$288,000		
29	P	120" x 96" CS Concentric Reducer	4	ea	$38,880	$155,520		
30	P	48" x 36" CS Concentric Reducer	36	ea	$13,230	$476,280		
31	P	36" CS Elbow, C208	36	ea	$9,720	$349,920		
32	P	120" CS Flg, FF, C207 - 86 psi	12	ea	$13,800	$165,600		
33	P	36" CS Flg, FF C207	144	ea	$3,600	$518,400		
34	P	48" CS Flg, FF C207	36	ea	$4,800	$172,800		
35	P	96" CS Flg, FF C207	8	ea	$9,600	$76,800		
36	P	96" CS Pipe Cap, C208 Lined	4	ea	$6,720	$26,880		
37	P	36" CS, C200, Lined, Manifold	648	lf	$194	$125,971		
38	P	96" CS, C200, Lined, Manifold	515	lf	$518	$266,933		
39	P	120" CS, C200, Lined, Manifold	27	lf	$648	$17,550		
40	P	120" CS Tee	2	ea	$51,840	$103,680		
41	P	***Mechanical Install Crew***						
42	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	126	dys	$3,800	$478,800	say 3 mos for 2-5 man crews	
9		**RO Flush Tank**	1	ls	*$3,079,452*	**$3,079,452**		***$4,180,000***
1	P	***Civils***						
2	P	Structure Excavation	12,000	cy	$15	$180,000		
3	P	Grade/Compact Foundation	3,222	sys	$3	$8,056		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	5,670	sf	$40	$226,800	assume 1/2 of structure needs shoring at 21' deep	
6	P	Aggregate Base at Foundation - 1'	2,000	tn	$35	$70,000		
7	P	F/P/S/F Concrete SOG	603	cys	$325	$195,975	model qty	
8	P	F/P/S/F Concrete Walls	576	cys	$675	$388,800	"	
9	P	F/P/S/F Concrete Elev Slab	323	cys	$950	$306,850	"	
10	P	F/P/S/F Concrete Equip Pads	-	cys	$1,250	$0	"	
11	S	Reinforcing Steel at 220#/cy avg	331,000	lbs	$0.90	$297,900	non-epoxy	
12	S	Epoxy Coating	10,520	sf	$1.50	$15,780		
13	S	Backfill Structure/Grading	6,000	cys	$20	$120,000		
14	S	Excavation Haul Off	6,000	cys	$12	$72,000		
15	P	***Superstructure Specialties***						
16	S	Metal Exterior Stairs (2 sets)	30	ri	$400	$12,000		
17	S	Metal Stairs at Process Equipment	70	ri	$400	$28,000		
18	S	Misc Metals	1	ls	$40,000	$40,000	railings, etc,	
19	P	***Process***						
20	P	***Equipment***						
21	P	n/a	-	ea	$0	$0		
22	P	***Piping***						
23	P	36" CS B'Fly Valve, Class 150	7	ea	$25,200	$176,400		
24	P	36" Check Valve, Class 150	7	ea	$22,500	$157,500		
25	P	36" CS Elbow, 5 Pike, C208, Lined	11	ea	$9,720	$106,920		
26	P	36" CS Flg, FF, C207	35	ea	$3,600	$126,000		
27	P	36" CS C200, Lined	202	lf	$162	$32,792		
28	P	36" CS Tee	4	ea	$9,720	$38,880		
29	P	***Mechanical Install Crew***						
30	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	126	dys	$3,800	$478,800	say 3 mos for 2-5 man crews	
10		**Electrical Substation**	1	ls	*$2,226,988*	**$2,226,988**		***$3,030,000***
1	P	***Civils***						
2	P	Structure Excavation	1,000	cy	$15	$15,000		
3	P	Grade/Compact Foundation	5,852	sys	$3	$14,629		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	3,600	tn	$35	$126,000		
7	P	F/P/S/F Concrete SOG	988	cys	$325	$321,100	model qty	
8	P	F/P/S/F Concrete Floor Topping	-	cys	$450	$0		
9	P	F/P/S/F Concrete Elevated Slab	963	cys	$675	$650,025		
10	P	F/P/S/F Concrete Equip Pads	4	cys	$1,250	$5,000	"	
11	S	Reinforcing Steel/WWF at 125#/cy avg	123,500	lbs	$0.90	$111,150	non-epoxy	
12	S	Epoxy Coating	-	sf	$2.50	$0		
13	S	Backfill Structure/Grading	500	cys	$20	$10,000		
14	S	***Superstructure Specialties***						
15	S	CMU - 12" Grouted	11,200	sf	$32.00	$358,400		
16	S	Windows - 3x5	6	ea	$900.00	$5,400		
17	S	Windows - 3x3	6	ea	$540.00	$3,240		
18	S	Exterior Doors 3'x8'	2	ea	$2,300.00	$4,600		
19	S	Roll-Up Doors - 15'x15' w/ motor	2	ea	$8,500.00	$17,000		
20	S	Gutter/Downspouts	1	ls	$7,500.00	$7,500		
21	S	Utility Sink w/ Eyewash	2	ea	$5,000	$10,000	incls plumbing	
22	S	Wall Fans	8	ea	$1,000	$8,000		
23	S	HVAC	26,664	sf	$17	$453,288	AC for elec equipment	
24	S	Fire Suppression/Fire Alarm	26,664	sf	$4	$106,656		
11		**Chemical Facility**	1	ls	*$2,930,049*	**$2,930,049**		***$3,980,000***
1	P	***Civils***						
2	P	Structure Excavation	1,300	cy	$15	$19,500		
3	P	Grade/Compact Foundation	7,667	sys	$3	$19,167		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	P	Aggregate Base at Foundation - 1'	4,700	tn	$35	$164,500		
7	P	F/P/S/F Concrete SOG	1,259	cys	$325	$409,175	model qty	
8	P	F/P/S/F Concrete Floor Topping	-	cys	$450	$0		
9	P	F/P/S/F Concrete Walls	267	cys	$675	$180,225		
10	P	F/P/S/F Concrete Elevated Slab	963	cys	$675	$650,025		
11	P	F/P/S/F Concrete Equip Pads	25	cys	$1,250	$31,250	"	
12	S	Reinforcing Steel/WWF at 125#/cy avg	157,375	lbs	$0.90	$141,638	non-epoxy	
13	S	Epoxy Coating	-	sf	$2.50	$0		
14	S	Backfill Structure/Grading	650	cys	$20	$13,000		
15	S	Waste Haul-Off	650	cys	$12	$7,800		
16	S	***Superstructure Specialties***						
17	S	Windows - 3x5	6	ea	$900.00	$5,400		
18	S	Windows - 3x3	6	ea	$540.00	$3,240		
19	S	Exterior Doors 3'x8'	4	ea	$2,300.00	$9,200		
20	S	Roll-Up Doors - 15'x15' w/ motor	2	ea	$8,500.00	$17,000		
21	S	Steel Trusses - Light Gauge -115' span	296	ea	$2,070	$612,720		
22	S	Roof Deck - 18 ga	34,040	sf	$3.00	$102,120		
23	S	Built-up Roofing System	340	sq	$75.00	$25,530		

MWH | JLL
Pasadena | 8/5/2016

Metropolitan Water District
Advanced Water Treatment Plant
150 MGD
Without Micro Filtration
<10% Design

Opinion of Probable Construction Costs (OPCC)

Currency: USD-United States-JULY 2016 Dollar

					Grand Total Price:	$ 682,000,000		
					$/MGD:	$ 4.55		
Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
24	S	Gutter/Downspouts	1	ls	$10,000.00	$10,000		
25	S	Utility Sink w/ Eyewash	4	ea	$5,000	$20,000	incls plumbing	
26	S	Wall Fans	12	ea	$1,000	$12,000		
27	S	HVAC	34,040	sf	$10	$340,400	AC for elec equipment	
28	S	Fire Suppression/Fire Alarm	34,040	sf	$4	$136,160		
12		**Lime System**	1	ls	*$3,577,226*	**$3,577,226**		*$4,860,000*
1	P	***Civils***						
2	P	Structure Excavation	210	cy	$15	$3,150		
3	P	Grade/Compact Foundation	600	sys	$3	$1,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	400	tn	$35	$14,000		
7	P	F/P/S/F Concrete SOG	492	cys	$325	$159,900	model qty	
8	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0	"	
9	P	F/P/S/F Concrete Equip Pads	5	cys	$1,250	$6,250	"	
10	S	Reinforcing Steel at 220#/cy avg	110,000	lbs	$0.90	$99,000	non-epoxy	
11	S	Epoxy Coating	-	sf	$2.00	$0		
12	S	Backfill Structure/Grading	210	cys	$20	$4,200		
13	S	Waste Haul-off	-	cys	$12	$0		
14	P	***Superstructure Specialties***						
15	S	12" Grouted CMU	5,043	sf	$32	$161,376		
16	S	Metal Stairs at Lime Silos (4)	108	ri	$575	$62,100		
17	S	Metal Walkway Between Silos - 5'	860	sf	$100	$86,000	support frame & decking	
18	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
19	P	***Process***						
20	P	***Equipment***						
21	S	Lime Silos, Slaking System	1	ls	$2,745,150	$2,745,150	Merrick budget quote	
22	P	***Piping***						
23	P	Allowance	1	ls	$50,000	$50,000		
24	P	***Mechanical Install Crew***						
25	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	42	dys	$3,800	$159,600	say 2 mos for 1-5 man crew	
13		**Lime System Clarifiers**	1	ls	*$2,544,689*	**$2,544,689**		*$3,460,000*
1	P	***Civils***						
2	P	Structure Excavation	375	cy	$15	$5,625		
3	P	Grade/Compact Foundation	556	sys	$3	$1,389		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	3,500	sf	$50	$175,000		
6	P	Aggregate Base at Foundation - 1'	400	tn	$35	$14,000		
7	P	F/P/S/F Concrete SOG	417	cys	$325	$135,525	model qty	
10	P	F/P/S/F Concrete Walls	188	cys	$675	$126,900	"	
11	P	F/P/S/F Concrete Elev Slab	-	cys	$950	$0	"	
14	S	Reinforcing Steel at 220#/cy avg	134,000	lbs	$0.90	$120,600	non-epoxy	
15	S	Epoxy Coating	-	sf	$2.00	$0		
16	S	Backfill Structure/Grading	375	cys	$20	$7,500		
17	S	Waste Haul-off	-	cys	$12	$0		
18	P	***Superstructure Specialties***						
19	S	Metal Stairs at Clarifiers (2)	50	ri	$575	$28,750		
20	S	Metal Walkway Between Clarifiers (1)	520	sf	$100	$52,000	4'	
21	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
22	P	***Process***						
23	P	***Equipment***						
24	P	Lime Clarifiers (3)	105	lf	$10,000	$1,050,000	rotating equipment	
25	P	Solution Water Pumps	3	ea	$38,000	$114,000		
26	P	***Piping***						
27	P	Allowance	1	ls	$50,000	$50,000		
28	P	***Mechanical Install Crew***						
29	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	168	dys	$3,800	$638,400	say 4 mos for 2-5 man crew	
14		**Chemical Storage & Dosing**	1	ls	*$5,874,725*	**$5,874,725**		*$7,970,000*
1	P	***Civils***						
2	P	Structure Excavation	760	cy	$15	$11,400		
3	P	Grade/Compact Foundation	3,000	sys	$3	$7,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	P	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	1,900	tn	$35	$66,500		
7	P	F/P/S/F Concrete SOG	713	cys	$325	$231,725	model qty	
8	P	F/P/S/F Concrete Walls	108	cys	$750	$81,000		
9	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0	"	
10	P	F/P/S/F Concrete Equip Pads	5	cys	$1,250	$6,250	"	
11	S	Reinforcing Steel at 220#/cy avg	182,000	lbs	$0.90	$163,800	non-epoxy	
12	S	Epoxy Coating	-	sf	$2.00	$0		
13	S	Backfill Structure/Grading	760	cys	$20	$15,200		
14	S	Waste Haul-off	-	cys	$12	$0		
15	P	***Superstructure Specialties***						
16	S	Caged Ladder to Elevated Walkway (2)	50	lf	$275	$13,750		
17	S	Metal Walkway Between Tanks - 5'	430	sf	$100	$43,000	support frame & decking	
18	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
19	P	***Process***						
20	P	Carbon Dixode Feed System	1	ls	$700,000	$700,000		
21	P	***Equipment***						
22	S	Signage/Safety	1	ls	$7,500	$7,500		
23	P	Chemical Sumps	4	ea	$6,000	$24,000	incls piping, etc.	
24	S	Emergency Eye Wash	4	ea	$1,250	$5,000		
25	S	Safety Shower	2	ea	$1,750	$3,500		
26	P	***Process***						
27	P	***Tanks***						
28	P	Purchase Hypeochloride Storage Tanks - 10,000 gal (FRP)	18	ea	$50,000	$900,000	covered	
29	P	Chemical Tanks - 6,000 gal FRP	28	ea	$30,000	$840,000		
30	P	Covered off-site Storage Silos - Pressure Tanks	6	ea	$400,000	$2,400,000		
31	P	**Pumps**						
32	S	Purchase Carbon Source Pump - 6 gph	2	ea	$7,000	$14,000		
33	P	Purchase Sodium Hypochlorite Pumps - 6 gph	2	ea	$7,000	$14,000		
34	P	Purchase Sodium Hypochlorite Pumps - 1.4 gph	3	ea	$4,500	$13,500		
35	P	Purchase Sodium Hypochlorite Pump - 0.013 gph	1	ea	$4,500	$4,500		
36	P	Purchase Sodium Hypochlorite Pump - 160 gph	1	ea	$8,500	$8,500		
37	P	Purchase Liquid Ammonium Sulfate Pumps - 1.6 gph	2	ea	$6,500	$13,000		

Metropolitan Water District
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150 MGD
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Opinion of Probable Construction Costs (OPCC)

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Grand Total Price: $ 682,000,000
$/MGD: $ 4.55

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
38	P	Purchase Sulfuric Acid Pump - 1.4 gph	6	ea	$4,000	$24,000		
39	P	Purchase Antiscalant Pump - 0.11 gph	3	ea	$4,500	$13,500		
40	S	Purchase Hydrogen Peroxide Pump 0.4 gph	3	ea	$4,500	$13,500		
41	P	Purchase Citric Acid Pump - 60 gph	1	ea	$7,500	$7,500		
42	P	Purchase Sodium Hydroxide Pump - 120 gph	1	ea	$8,500	$8,500		
43	P	Purchase Bisulfate Pump - 60 gph	1	ea	$7,500	$7,500		
44	P	***Piping***						
45	P	1/2" to 1-1/2" Chemical Piping - 7 ea	1,400	lf	$20	$28,000	incls ftgs, valves, etc.at 200' system	
46	P	**Mechanical Install Crew**						
47	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	42	dys	$3,800	$159,600	say 1 mo for 2-4 man crews	
15		**Administrative Building**	1	ls	*$201*	**$5,822,730**		*$7,900,000*
1	S	***Civils***						
2	S	Structure Excavation	600	cy	$15	$9,000		
3	S	Grade/Compact Foundation	5,556	sys	$3	$13,889		
4	S	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	"	
6	S	Aggregate Base at Foundation - 1'	2,900	tn	$35	$101,500		
7	S	F/P/S/F Concrete SOG & at Second Floor Deck	1,053	cys	$325	$342,129	model qty	
8	S	F/P/S/F Concrete Stairs	8	cys	$1,500	$12,500		
9	S	Reinforcing Steel/WWF at 125#/cy avg	131,588	lbs	$0.90	$118,429	non-epoxy	
10	S	Epoxy Coating	5,000	sf	$1.50	$7,500		
11	S	Backfill Structure/Grading	300	cys	$20	$6,000		
12	S	Waste Haul-Off	300	cys	$12	$3,600		
13	S	***Superstructure Specialties***						
14	S	Metal Decking - 18 ga	27,086	sf	$5	$135,430		
15	S	CMU - 12" Grouted	15,165	sf	$35	$530,775	split face	
16	S	CMU - 08" Grouted	5,856	sf	$28	$163,968		
17	S	CMU - 04"	15,164	sf	$25	$379,100		
18	S	Insulation Rigid	15,164	sf	$4	$60,656		
19	S	Gyp Wall Board	5,200	sf	$15	$78,000		
20	S	Metal Stud Walls	25,918	sf	$5	$129,590		
21	S	Damp Proofing	15,164	sf	$1	$15,164		
22	S	Curtain Wall	850	sf	$75	$63,750		
23	S	Interior Doors 3'x7'	58	ea	$1,500	$87,000		
24	S	Exterior Doors 3'x7'	10	ea	$2,500	$25,000		
25	S	Windows	7,200	sf	$55	$396,000		
26	S	Roofing Structural	15,000	sf	$35	$525,000		
27	S	Built-up Roofing System w/ Specialties	150	sq	$200.00	$30,000		
28	S	Gutter/Downspouts	1	ls	$15,000	$15,000		
29	S	Electrical	28,000	sf	$30	$840,000	incls plumbing	
30	S	HVAC	28,000	sf	$20	$560,000		
31	S	Fire Suppression/Fire Alarm	28,000	sf	$5	$140,000		
32	S	Laboratory - Finishes	225	sf	$150	$33,750		
33	S	Flooring	28,000	sf	$7	$196,000		
34	S	Paint	28,000	sf	$3	$84,000		
35	S	Specialties	1	ls	$300,000	$300,000		
36	S	Comm.	28,000	sf	$15	$420,000		
16		**MicroC2000 Storage & Dosing**	1	ls	*$2,033,100*	**$2,033,100**		*$2,760,000*
1	P	***Civils***						
2	P	Structure Excavation	500	cy	$15	$7,500		
3	P	Grade/Compact Foundation	3,000	sys	$3	$7,500		
4	P	Dewatering Allowance	1	ls	$0	$0	not anticipated	
5	S	Shoring Allowance	1	ls	$0	$0	not anticipated	
6	P	Aggregate Base at Foundation - 1'	1,900	tn	$35	$66,500		
7	P	F/P/S/F Concrete SOG	712	cys	$325	$231,400	model qty	
8	P	F/P/S/F Concrete Walls	96	cys	$750	$72,000		
9	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0	"	
10	P	F/P/S/F Concrete Equip Pads	5	cys	$1,250	$6,250	"	
11	S	Reinforcing Steel at 220#/cy avg	179,000	lbs	$0.90	$161,100	non-epoxy	
12	S	Epoxy Coating	-	sf	$2.00	$0		
13	S	Backfill Structure/Grading	250	cys	$20	$5,000		
14	S	Waste Haul-off	250	cys	$12	$3,000		
15	P	***Superstructure Specialties***						
16	S	Caged Ladder to Elevated Walkway (2)	50	lf	$275	$13,750		
17	S	Metal Walkway Between Tanks - 5'	430	sf	$100	$43,000	support frame & decking	
18	S	Misc Metals	1	ls	$25,000	$25,000	railings at Elev walkway	
19	P	***Process***						
20	P	***Equipment***						
21	S	Signage/Safety	1	ls	$7,500	$7,500		
22	P	Chemical Sumps	4	ea	$6,000	$24,000	incls piping, etc.	
23	S	Emergency Eye Wash	2	ea	$1,250	$2,500		
24	S	Safety Shower	2	ea	$1,750	$3,500		
25	P	***Process***						
26	P	***Tanks***						
27	P	Purchase Storage Tank - 18000 gal (FRP)	14	ea	$90,000	$1,260,000		
29	P	**Pumps**						
30	S	*need details*		ea	$0	$0		
42	P	***Piping***						
43	P	1/2" to 1-1/2" Chemical Piping - 14 ea	500	lf	$20	$10,000	incls ftgs, valves, etc.at 200' system	
44	P	**Mechanical Install Crew**						
45	P	Labor, Misc Matls, small tools, Equip, Ohds, etc.	22	dys	$3,800	$83,600	say 1 mo for 1-4 man crews	
17		**Generator Building (Slabs only)**	1	ls	*$150,316*	**$150,316**		*$210,000*
1	P	***Civils***				$0		
2	P	Structure Excavation	111	cy	$15	$1,665		
3	P	Grade/Compact Foundation	3,000	sys	$3	$7,500		
4	P	Dewatering Allowance	1	ls	$0	$0		
5	S	Shoring Allowance	1	ls	$0	$0		
6	P	Aggregate Base at Foundation - 1'	1,900	tn	$35	$66,500		
7	P	F/P/S/F Concrete SOG	111	cys	$325	$36,075		
8	P	F/P/S/F Concrete Walls	-	cys	$750	$0		
9	P	F/P/S/F Concrete Curbs	-	cys	$1,750	$0		
10	P	F/P/S/F Concrete Equip Pads	10	cys	$1,250	$12,500		
11	S	Reinforcing Steel at 220#/cy avg	27,000	lbs	$0.90	$24,300		
12	S	Epoxy Coating	-	sf	$2.00	$0		
13	S	Backfill Structure/Grading	56	cys	$20	$1,110		

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Advanced Water Treatment Plant
150 MGD
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Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 682,000,000
$/MGD: $ 4.55

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	AI-in Area Costs
14	S	Waste Haul-off	56	cys	$12	$666		
18		**Yard Piping**	1	ls	*$6,227,605*	**$6,227,605**		***$8,450,000***
1	S	***Piping***						
2	S	144" x 96" CS Concentric Reducer	1	ea	$7,824	$7,824		
3	S	120" CS Elbow, C208 Lined	3	ea	$54,000	$162,000		
4	S	144" CS Elbow, C208 Lined	1	ea	$64,800	$64,800		
5	S	30" CS Elbow, C208 Lined	14	ea	$8,100	$113,400		
6	S	42" CS Elbow, C208 Lined	2	ea	$11,340	$22,680		
7	S	48" CS Elbow, C208 Lined	13	ea	$12,960	$168,480		
8	S	84" CS Elbow, C208 Lined	4	ea	$22,680	$90,720		
9	S	96" CS Elbow, C208 Lined	5	ea	$25,920	$129,600		
10	S	24" CS Pipe Cap, C208	1	ea	$2,760	$2,760		
11	S	30" CS Pipe Cap, C208	2	ea	$3,450	$6,900		
12	S	48" CS Pipe Cap, C208	2	ea	$5,520	$11,040		
13	S	120" CS Pipe, C200 Lined	577	lf	$540	$311,535		
14	S	144" CS Pipe, C200 Lined	1,095	lf	$648	$709,776		
15	S	24" CS Pipe, C200 Lined	78	lf	$108	$8,370		
16	S	30" CS Pipe, C200 Lined	661	lf	$135	$89,179		
17	S	42" CS Pipe, C200 Lined	9	lf	$189	$1,717		
18	S	48" CS Pipe, C200 Lined	2,591	lf	$216	$559,728		
19	S	84" CS Pipe, C200 Lined	141	lf	$378	$53,141		
20	S	96" CS Pipe, C200 Lined	1,143	lf	$432	$493,956		
21	S	48"x48" CS Tee	1	ea	$12,960	$12,960		
22	S	96" CS Pipe, C200 Lined	1,220	lf	$432	$527,040	adder required for the deletion of the MF facility	
23	S	Other Underfiend Yarf Piping	1	ls	$2,500,000	$2,500,000		
24	S	**Mechanical Install Crew**						
25	S	Labor, Misc Matls, small tools, Equip, Ohds, etc.	40	dys	$4,500	$180,000	at 200'/day	
18		**Electrical & IC**	1	ls	*$100,500,000*	**$100,500,000**		***$136,350,000***
1	S	Medium Voltage Power Distribution	1	ls	4.0%	$14,000,000	on running subtotal, all areas, controls are with equip pricing	
2	S	Balance of Electrical	1	ls	10.0%	$34,000,000		
3	S	Instrumentation & Controls	1	ls	9.0%	$31,000,000		
4	S	SCE Substation	1	ls	$20,000,000	$20,000,000		
5	S	Generators	6	ea	$250,000	$1,500,000	includes site electrical. VFDs and power substation	
19		**Improvements at the JWPCP**	1	ls	*$68,000,000*	**$68,000,000**		***$92,140,000***
1		Sidestream Nitrogen Removal at JWPCP	1	ls	$67,000,000	$67,000,000	MWD input, markups included, contingency excluded	
2		Modifications for Clarifier Equilization	1	ls	$1,000,000	$1,000,000	"	
20		**Improvements at the FORCO Site**	1	ls	*$7,911,773*	**$7,911,773**		***$10,630,000***
1	S	**Utility Relocates**						
2	S	10" HP Gas Line	2,000	lf	$200	$400,000		
3	S	10" HP Gas Line (Abandoned)	1,200	lf	$40	$48,000	grout	
4	S	72" Sewer Line	2,205	lf	$1,008	$2,222,640		
5	S	72" Sewer Line (Remove/Abandon)	950	lf	$324	$307,800		
6	S	10'x12' Conc Box Culvert	1,400	lf	$1,500	$2,100,000		
7	S	10'x12' Conc Box Culvert (Abandon)	500	lf	$667	$333,333		
8	S	Underfined Utility Relocation Allowance	1	ls	$2,500,000	$2,500,000		
					Running Subtotal:	**$502,411,344**		

Metropolitan Water District

Advanced Water Treatment Plant

150 MGD

Without Micro Filtration

<10% Design

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Currency: USD-United States-JULY 2016 Dollar

Grand Total Price: $ 682,000,000

$/MGD: $ 4.55

Area	GC	Description	Quantity	UOM	Unit Cost	Total Cost	Comments	Al-in Area Costs
A		Startup/Commission/Owner Training	1	ls		$353,750		
1	P	Pre-commissioning	750	hrs	$75	$56,250		
2	P	Vendor Support	1	ls	$5,000	$5,000		
3	P	Commissioning	750	hrs	$75	$56,250		
4	P	Training	400	hrs	$100	$40,000		
5	P	Startup Expendables	1	ls	$5,000	$5,000	testing water by others	
6	P	90 day Break-in Period	90	dys	$2,125	$191,250	2-men	
					Running Subtotal:	$502,765,094		
6	P	Estimating Accuracy, Unlisted Items Allowance	1	ls	10.0%	$50,276,509	on running subtotal	
					Running Subtotal:	$553,041,603	Direct Construction Cost (DCC)	
B		Construction Allowances				$128,540,893		
1		Prime Contractor General Conditions at 4 yrs	1	ls	5%	$15,910,000	$331,458	
2		Subcontractor General Conditions	1	ls	6%	$10,020,000		
3		Market Factor	1	ls	0%	$0	Premium for uncompetitive conditions, logistics, complexity,	
4		Construction Phasing Factor	1	ls	0%	$0	Premium for interfaces, constraints, etc.	
5		Subcontractor Markups	1	ls	11.5%	$20,349,635	H/O Overheads, Job Fee & Risk, insur, bond	
6		Prime Contractor OH&P on Subs	1	ls	4.0%	$7,892,119	Oversight + Risk	
7		Prime Contractor OH&P on Self-Perform	1	ls	10.0%	$33,401,800	Job Fee + Risk	
8		Contractor Insurance Program	1	ls	2.5%	$16,015,379	Performance/Payments Bonds, Genl Liability	
9		State Sales Taxes	1	ls	9.5%	$24,951,960	On Materials at 40% of running subtotal	
10		Design/Estimating Contingency	1	ls	0%	$0	Excluded, client allowance	
				1.3566	Running Subtotal:	$681,582,500	Base Construction Cost (BCC)	
C		Project Allowances				$0		
1		Escalation from Pricing Level to NTP	1	ls	0%	$0	Excluded, client allowance	
2		Escalation from NTP to MPC	1	ls	0%	$0	Excluded, client allowance	
3		Construction Change Contingency	1	ls	0%	$0	Excluded, initial construction costs only	
					Running Subtotal:	$681,580,000	Total Construction Costs (TCC)	
D		Owner Allowances				$0		
1		Design to Construction Documents Allowance	1	ls	0.0%	$0	Excluded	
2		CM Oversight	1	ls	0.0%	$0	"	
3		Owner PM, Permitting, Legal, Procurement, Etc.	1	ls	0.0%	$0	"	
				1.3566				Chk Total:
					Grand Total:	$681,580,000	Total Project Cost (TPC)	$681,460,000

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Supporting Calculations for the O&M Cost Estimates for the Full-scale AWT Facility with MF

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O&M Power Costs – Treatment Processes

Process Area	Equipment	No. of Units	Design Flow for Unit Processs (mgd)	No. of Units on-line	Capacity, each	Units	Head (ft)	Max Power per Unit (hp)	Max Power Total (hp)	Max Power total (kW)	Average Annual Online factor	Average Power Load (hp)	Average Power Load (kW)	Average Power Load per system (kW)	Rounded average annual energy requirement (kWh)	Average annual energy cost* (rounded)	System
PROCESS/EQUIPMENT																	
Drum Screen- Influent Pump Station	Perforated In-Channel Rotary Drum Screen	5+2	190	5	40	mgd		0	0	0	95%	0	0	8521	74,644,000	$ 11,197,000	MBR
Drum Screen- Influent Pump Station	Influent Pumps	12+2		12	20		40	195	2338	1744	95%	2221	1656				
Aeration and MBR	Aeration Tank Blowers	18+3		18	6000	cfm		250	4500	3356	95%	4275	3188				
Aeration and MBR	Membrane Cassettes per Basin	27+1		27				0	0	0		0	0				
Aeration and MBR	Membrane Blowers	27+3		27	3000	cfm		120	3240	2416	95%	3078	2295				
Aeration and MBR	Membrane Filtrate Pumps	27		27	7.3	mgd		40	1080	805	95%	1026	765				
Aeration and MBR	Return Activated Sludge Pumps	18+3		18	42.1	mgd		40	720	537	95%	684	510				
Aeration and MBR	Air Compressors	2+1		2	360	cfm		75	150	112	95%	143	106				
Membrane Filtration	MF Feed Pumps	15+3	186	15	13	mgd	160	507	7599	5667	95%	7219	5383	5808	50,882,000	$ 7,632,000	MF
Membrane Filtration	MF Skids	21+3		21	8.9	mgd		0	0	0		0	0				
Membrane Filtration	Modules Per Skid	192		192				0	0	0		0	0				
Membrane Filtration	CIP Tanks	6		6	5500	gal		0	0	0		0	0				
Membrane Filtration	Backwash Pumps	3+1		3	11	mgd	160	429	1286	959	21%	270	201				
Membrane Filtration	Air Compressors	2+1		2				75	150	112	95%	143	106				
Membrane Filtration	Air Blowers	10+2		10	630	cfm		75	750	559	21%	158	117				
Membrane Filtration	RO Feed Pumps	10+2	176	10	17.6	mgd	51	218	2178	1625	95%	2070	1543	12575	110,161,000	$ 16,524,000	RO
Cartridge Filters	Cartridge Filters	64		64				0	0	0		0	0				
Reverse Osmosis	RO Skids	45+3		45				0	0	0		0	0				
Reverse Osmosis	Pressure Vessels Array per skid	64:32:21		n.a.				0	0	0		0	0				
Reverse Osmosis	First Stage RO Booster Pumps	48		48	3.67	mgd	347	309	14853	11076	95%	14111	10522				
Reverse Osmosis	Third Stage RO Booster Pumps	48		48	0.59	mgd	72	10	491	366	95%	467	348				
Reverse Osmosis	CIP Tanks	7		7				0	0	0		0	0				
Reverse Osmosis	CIP Pumps	14+7		14	1800	gpm		100	1400	1044	13%	182	136				
RO Flush Tank	RO Flush Pumps	7		7	1800	gpm		100	700	522	5%	35	26				
UV/AOP	UV Reactors	15+3	150	15	10.00	mgd		174	2615	1950	96%	2510	1872	1872	16,399,000	$ 2,460,000	UV/AOP
Clearwell & Effluent	Effluent Pumps	12+3		12	12.50	mgd	n.a.	n.a.	n.a.	n.a.	n.a	n.a.	n.a.	0	-	$ -	Plant Effluent & Clearwell
Clearwell & Effluent	Surge Tanks	6		6				0	0	0		0	0				
Lime System	Lime Silos	6		6				28	171	127	100%	171	127	127	1,114,000	$ 167,000	Lime System
Chlorine Storage & Dosing	Storage tanks	18	n.a.	18				2	36	27	100%	36	27	122	1,071,000	$ 161,000	Chemical Feed Systems
Methanol Storage & Dosing	Storage tanks	14		14				2	28	21	100%	28	21				
Chemical Area	Sodium Hypochlorite tanks	12		12				0	0	0		0	0				
Chemical Area	Liquid Ammonium Sulfate tanks	4		4				0	0	0		0	0				
Chemical Area	Sulfuric Acid tanks	4		4				0	0	0		0	0				
Chemical Area	Antiscalant tanks	4		4				0	0	0		0	0				
Chemical Area	Hydrogen Peroxide tanks	4		4				0	0	0		0	0				
Chemical Area	Citric Acid tanks	4		4				0	0	0		0	0				
Chemical Area	Sodium Hydroxide tanks	4		4				0	0	0		0	0				
Chemical Area	Sodium Bisulfite tanks	4		4				0	0	0		0	0				
Chemical Feed and Transfer Pumps	Chemical Feed and Storage Pumps	50		50				2	100	75	100%	100	75				
Generators	Generators	6		6				0	0	0		0	0				
								Sub-Total	**44,386**	**33,099**		38,925	29,026	**29026**	**254,271,000**	**$ 38,141,000**	

* Power cost = $0.15/kWh

O&M Power Costs – HVAC

Process Area	No. of Units on-line	Total Volume - cf	Total PureWater Volume - cf	PureWater power - hp	Max Power per Unit (hp)	Max Power Total (hp)	Max Power total (kW)	Average Annual Online factor	Average Power Load (hp)	Average Power Load (kW)	Rounded average annual energy requirement (kWh)	Rounded average annual energy cost*
O&M Building HVAC	1	907,150	703,080	315	407	407	303	60%	244	182	1,594,000	$ 239,000
Influent Pump Station HVAC	1	669,600	141,021	20	96	96	71	100%	96	71	624,000	$ 94,000
Process Building HVAC	1	7,501,400	3,251,832	396	982	982	732	60%	589	439	3,848,000	$ 577,000
UV-AOP Electrical Room	1			30	Assumed included in Process Building for MWD facility							
Electrical Building HVAC	1	278,304	87,000	329	1051	1051	784	60%	631	470	4,119,000	$ 618,000
Finished Water Pump Station	1	640,640	141,021	20	91	91	68	100%	91	68	597,000	$ 90,000
								Total HVAC	1,651	1,231	**10,782,000**	**$ 1,618,000**

* Power cost = $0.15/kWh

O&M Costs – Chemicals

System	Chemical	Average 7-day usage from stoarge tank size in design criteria table (gal)	Average daily usage (gal)	Average chemical usage (gal)	Unit cost per gallon	Rounded Annual Cost	Rounded Annual Cost by System
MBR	MicroC2000	260,000	37,143	13,557,000	$ 1.50	$ 20,336,000	$ 20,336,000
MF	sodium hypochlorite	75,000	10,714	3,911,000	$ 0.62	$ 2,425,000	$ 6,304,000
	amonium sulfate	21,000	3,000	1,095,000	$ 3.54	$ 3,879,000	
RO	sulfuric acid	75,000	10,714	3,911,000	$ 1.84	$ 7,196,000	$ 9,630,000
	antiscalant	5,400	771	282,000	$ 8.63	$ 2,434,000	
Membrane cleaning	sodium hypochlorite	25,500	3,643	1,330,000	$ 0.62	$ 825,000	$ 4,476,000
	citric acid	3,000	429	156,000	$ 5.05	$ 788,000	
	sodium hydroxide	30,000	4,286	1,564,000	$ 1.39	$ 2,174,000	
	sodium bisulfite	12,000	1,714	626,000	$ 1.10	$ 689,000	
UV/AOP	sodium hypochlorite	21,000	3,000	1,095,000	$ 0.62	$ 679,000	$ 679,000
Stabilization	lime*	420,000	60,000	21,900,000	$ 0.25	$ 5,475,000	$ 6,226,000
	carbon dioxide*	180,000	25,714	9,386,000	$ 0.08	$ 751,000	
Post Cl2	sodium hypochlorite	66,000	9,429	3,441,000	$ 0.62	$ 2,133,000	$ 2,133,000
					Total	**$ 49,784,000**	**$ 49,784,000**

*cost and usage is in pounds, not gallons

O&M Costs – Labor

Avg. hourly rate (incl. burden)	Work hours per year	# of employees*	Labor cost per year
$75	2080	65	$10,140,000

* Groundwater Replenishment System (55 full-time employees) used as reference.

O&M Costs – Maintenance

Item No.	Description	Equipment Cost	Maintenance Cost (2% of Equipment Cost)	Equipment Included (Area on OPCC)
1	Drum Screens and Influent Pump Station	$6,370,000	$ 127,000	Sluice gates, influent pumps and drum screens (Area 1)
2	MBR System	$73,246,000	$ 1,465,000	Anoxic mixers, aeration blowers and membrane equipment (Area 2)
3	MF System	$41,500,000	$ 830,000	Membrane equipment (Area 4)
4	RO Cartridge Filters	$4,520,000	$ 90,000	Auto cartridge filters and RO feed pumps (Area 6)
5	RO System	$58,080,000	$ 1,162,000	RO equipment, controls and first stage booster pumps
6	UV/AOP System	$11,300,000	$ 226,000	UV equipment, including controls (Area 8)
7	Product Water Conditioning System	$4,609,000	$ 92,000	Lime silos, slaking system, clarifiers and solution water pumps; carbon dioxide feed system (Areas 13, 14 and 15)
8	Chemical Feed System	$156,000	$ 3,000	Emergency eye washes, safety showers, and chemical feed pumps (Areas 15 and 17)
9	Electrical Equipment	$1,500,000	$ 30,000	Generators (Area 20)
	Total Annual Maintenance Cost		**$ 4,025,000**	

O&M Costs – Replacement of Consumables

MBR system

Number of membrane basins	Cassettes per basin	Modules per cassette	Total modules	Cost per module	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Module life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
24	30	48	34560	$ 980	$ 33,868,800	9.0%	$ 36,916,992	15	$ 2,461,133	**$ 2,461,000**

MF/UF system

Modules per rack	Total duty racks	Total modules	Cost per module	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Module life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
192	24	4608	$ 3,000	$ 13,824,000	9.0%	$ 15,068,160	10	$ 1,506,816	**$ 1,507,000**

RO system - Stages 1 and 2

Duty + standby skids	Elements per pressure vessel	Stage 1 pressure vessels per	Stage 1 elements	Stage 2 pressure vessels per	Stage 2 elements	Total Stage 1/2 elements	Cost per element	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Element life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
48	7	64	21,504	32	10,752	32,256	$ 365	$ 11,773,440	9.0%	$ 12,833,050	5	$ 2,566,610	**$ 2,567,000**

RO system - Stage 3

Duty + standby skids	Elements per pressure vessel	Stage 3 pressure vessels per	Total Stage 3 elements	Cost per element	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Element life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
48	7	21	7056	$ 365	$ 2,575,440	9.0%	$ 2,807,230	1	$ 2,807,230	**$ 2,807,000**

RO system - Cartridge Filters

Filters per Vessel	Vessels	Total filters	Cost per filter	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Filter life (yr)	Annual replacement cost	**Prorated annual replacement cost (rounded)**
12	64	768	$ 16.76	$ 12,872	9.0%	$ 14,030	0.500	$ 28,060	**$ 28,000**

Total Annual RO Replacement Cost	**$ 5,402,000**

UV/AOP Lamps

Reactors (duty + standby)	Lamps per reactor	Total number of lamps	Lamp life (hrs)	Annual replacement per lamp	Total annual lamp replacement	Cost per lamp	Prorated annual lamp replacement cost	Sales tax	Annual lamp replacement cost plus sales tax
5	828	4140	14000	0.63	2590	$ 325	$ 841,750	9.0%	$ 917,508

UV/AOP Ballasts

Lamps per ballast	Total number of ballasts	Ballast replacement interval (yr)	Annual ballast replacement	Cost per ballast	Annual prorated ballast replacement cost	Sales tax	Annual prorated ballast replacement cost plus sales tax
2	2070	10	207	$ 660	$ 136,620	9.0%	$ 148,916

Rounded total lamp & ballast replacement cost	**$ 1,066,000**

Supporting Calculations for the O&M Cost Estimates for the Full-scale AWT Facility without MF

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O&M Power Costs – Treatment Processes

Process Area	Equipment	No. of Units	Design Flow for Unit Processs (mgd)	No. of Units on-line	Capacity, each	Units	Head (ft)	Max Power per Unit (hp)	Max Power Total (hp)	Max Power total (kW)	Average Annual Online factor	Average Power Load (hp)	Average Power Load (kW)	Flow Factor for removing MF	Average Power Load per system (kW)	Rounded average annual energy requirement	Average annual energy cost* (rounded)	System
PROCESS/EQUIPMENT																		
Drum Screen- Influent Pump Station	Perforated In-Channel Rotary Drum Screen	5+2		5	40	mgd		0	0	0	95%	0	0					
Drum Screen- Influent Pump Station	Influent Pumps	12+2		12	20		40	195	2338	1744	95%	2221	1656					
Aeration and MBR	Aeration Tank Blowers	18+3	180	18	6000	cfm		250	4500	3356	95%	4275	3188	0.947	8072	70,715,000	$10,607,000	MBR
Aeration and MBR	Membrane Cassettes per Basin	27+1		27				0	0	0		0	0					
Aeration and MBR	Membrane Blowers	27+3		27	3000	cfm		120	3240	2416	95%	3078	2295					
Aeration and MBR	Membrane Filtrate Pumps	27		27	7.3	mgd		40	1080	805	95%	1026	765					
Aeration and MBR	Return Activated Sludge Pumps	18+3		18	42.1	mgd		40	720	537	95%	684	510					
Aeration and MBR	Air Compressors	2+1		2	360	cfm		75	150	112	95%	143	106					
Membrane Filtration	RO Feed Pumps	10+2		10	17.6	mgd	51	218	2178	1625	95%	2070	1543	n/a				
Cartridge Filters	Cartridge Filters	64		64				0	0	0		0	0	n/a				
Reverse Osmosis	RO Skids	45+3		45				0	0	0		0	0	n/a				
Reverse Osmosis	Pressure Vessels Array per skid	64:32:21		n.a.				0	0	0		0	0	n/a				
Reverse Osmosis	First Stage RO Booster Pumps	48	176	48	3.67	mgd	347	309	14853	11076	95%	14111	10522	n/a	12575	110,161,000	$16,524,000	RO
Reverse Osmosis	Third Stage RO Booster Pumps	48		48	0.59	mgd	72	10	491	366	95%	467	348	n/a				
Reverse Osmosis	CIP Tanks	7		7				0	0	0		0	0	n/a				
Reverse Osmosis	CIP Pumps	14+7		14	1800	gpm		100	1400	1044	13%	182	136	n/a				
RO Flush Tank	RO Flush Pumps	7		7	1800	gpm		100	700	522	5%	35	26	n/a				
UV/AOP	UV Reactors	15+3		15	10.00	mgd		174	2615	1950	96%	2510	1872	n/a	1872	16,399,000	$ 2,460,000	UV/AOP
Clearwell & Effluent	Effluent Pumps	12+3	150	12	12.50	mgd	n.a.	n.a.	n.a.	n.a.	n.a	n.a.	n.a.	n/a	0	-	$ -	Plant Effluent & Clearwell
Clearwell & Effluent	Surge Tanks	6		6				0	0	0		0	0	n/a				
Lime System	Lime Silos	6		6				28	171	127	100%	171	127	n/a	127	1,114,000	$ 167,000	Lime System
Chlorine Storage & Dosing	Storage tanks	18		18				2	36	27	100%	36	27	n/a				
Methanol Storage & Dosing	Storage tanks	14		14				2	28	21	100%	28	21	n/a				
Chemical Area	Sodium Hypochlorite tanks	12		12				0	0	0		0	0	n/a				
Chemical Area	Liquid Ammonium Sulfate tanks	4		4				0	0	0		0	0	n/a				
Chemical Area	Sulfuric Acid tanks	4		4				0	0	0		0	0	n/a				
Chemical Area	Antiscalant tanks	4		4				0	0	0		0	0	n/a				
Chemical Area	Hydrogen Peroxide tanks	4	n.a.	4				0	0	0		0	0	n/a	122	1,071,000	$ 161,000	Chemical Feed Systems
Chemical Area	Citric Acid tanks	4		4				0	0	0		0	0	n/a				
Chemical Area	Sodium Hydroxide tanks	4		4				0	0	0		0	0	n/a				
Chemical Area	Sodium Bisulfite tanks	4		4				0	0	0		0	0	n/a				
Chemical Feed and Transfer Pumps	Chemical Feed and Storage Pumps	50		50				2	100	75	100%	100	75	n/a				
Generators	Generators	6		6				0	0	0		0	0	n/a				
								Sub-Total	**34,601**	**25,802**		31,136	23,218		**22769**	**199,460,000**	**$29,919,000**	

* Power cost = $0.15/kWh

O&M Power Costs – HVAC

Process Area	No. of Units on-line	Total Volume - cf	Total PureWater Volume - cf	PureWater power - hp	Max Power per Unit (hp)	Max Power Total (hp)	Max Power total (kW)	Average Annual Online factor	Average Power Load (hp)	Average Power Load (kW)	Rounded average annual energy requirement (kWh)	Rounded average annual energy cost*
O&M Building HVAC	1	907,150	703,080	315	407	407	303	60%	244	182	1,594,000	$ 239,000
Influent Pump Station HVAC	1	669,600	141,021	20	96	96	71	100%	96	71	624,000	$ 94,000
Process Building HVAC	1	7,501,400	3,251,832	396	982	982	732	60%	589	439	3,848,000	$ 577,000
UV-AOP Electrical Room	1			30	Assumed included in Process Building for MWD facility							
Electrical Building HVAC	1	278,304	87,000	329	1051	1051	784	60%	631	470	4,119,000	$ 618,000
Finished Water Pump Station	1	640,640	141,021	20	91	91	68	100%	91	68	597,000	$ 90,000
								Total HVAC	1,651	1,231	**10,782,000**	**$ 1,618,000**

* Power cost = $0.15/kWh

O&M Costs – Chemicals

System	Chemical	Average 7-day usage from stoarge tank size in design	Average daily usage (gal)	Scaling for inf flow reduction	Average chemical usage (gal)	Unit cost per gallon	Rounded Annual Cost	Rounded Annual Cost by System
MBR	MicroC2000	260,000	37,143	0.947	12,844,000	$ 1.50	$ 19,266,000	$ 19,266,000
Chloramine Formation	sodium hypochlorite	75,000	10,714	0.947	3,705,000	$ 0.62	$ 2,297,000	$ 5,971,000
	amonium sulfate	21,000	3,000		1,037,000	$ 3.54	$ 3,674,000	
RO	sulfuric acid	75,000	10,714	n/a	3,911,000	$ 1.84	$ 7,196,000	$ 9,626,000
	antiscalant	5,400	771	n/a	281,571	$ 8.63	$ 2,430,000	
Membrane cleaning	sodium hypochlorite	25,500	3,643	n/a	766,434	$ 0.62	$ 475,000	$ 3,368,000
	citric acid	3,000	429	n/a	80,807	$ 5.05	$ 408,000	
	sodium hydroxide	30,000	4,286	n/a	1,425,637	$ 1.39	$ 1,982,000	
	sodium bisulfite	12,000	1,714	n/a	457,693	$ 1.10	$ 503,000	
UV/AOP	sodium hypochlorite	21,000	3,000	n/a	1,095,000	$ 0.62	$ 679,000	$ 679,000
Stabilization	lime*	420,000	60,000	n/a	21,900,000	$ 0.25	$ 5,475,000	$ 6,226,000
	carbon dioxide*	180,000	25,714	n/a	9,385,714	$ 0.08	$ 751,000	
Post Cl2	sodium hypochlorite	66,000	9,429	n/a	3,441,429	$ 0.62	$ 2,134,000	$ 2,134,000
						Total	**$ 47,270,000**	**$ 47,270,000**

*cost and usage is in pounds, not gallons

O&M Costs – Labor

Avg. hourly rate (incl. burden)	Work hours per year	# of employees*	Labor cost per year
$75	2080	55	$8,580,000

* Groundwater Replenishment System (55 full-time employees) used as reference.

O&M Costs – Maintenance

Item No.	Description	Equipment Cost	Maintenance Cost (2% of Equipment Cost)	Equipment Included (Area on OPCC)
1	Drum Screens and Influent Pump Station	$6,370,000	$ 127,000	Sluice gates, influent pumps and drum screens (Area 1)
2	MBR System	$73,246,000	$ 1,465,000	Anoxic mixers, aeration blowers and membrane equipment (Area 2)
3	RO Cartridge Filters	$4,520,000	$ 90,000	Auto cartridge filters and RO feed pumps (Area 5)
4	RO System	$58,080,000	$ 1,162,000	RO equipment, controls and first stage booster pumps (Area 6)
5	UV/AOP System	$11,300,000	$ 226,000	UV equipment, including controls (Area 7)
6	Product Water Conditioning System	$4,609,000	$ 92,000	Lime silos, slaking system, clarifiers and solution water pumps; carbon dioxide feed system (Areas 12, 13 and 14)
7	Chemical Feed System	$156,000	$ 3,000	Emergency eye washes, safety showers, and chemical feed pumps (Areas 14 and 16)
8	Electrical Equipment	$1,500,000	$ 30,000	Generators (Area 19)
Total Annual Maintenance Cost			**$ 3,195,000**	

O&M Costs – Replacement of Consumables

MBR system

Number of membrane basins	Cassettes per basin	Modules per cassette	Total modules	Flow factor to account for no MF	Adjusted number of modules	Cost per module	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Module life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
24	30	48	34560	0.947	32741	$ 980	$ 32,086,180	9.0%	$ 34,973,936	15	$ 2,331,596	**$ 2,332,000**

RO system - Stages 1 and 2

Duty + standby skids	Elements per pressure vessel	Stage 1 pressure vessels per skid	Stage 1 elements	Stage 2 pressure vessels per skid	Stage 2 elements	Total Stage 1/2 elements	Cost per element	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Element life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
48	7	64	21,504	32	10,752	32,256	$ 365	$ 11,773,440	9.0%	$ 12,833,050	5	$ 2,566,610	**$ 2,567,000**

RO system - Stage 3

Duty + standby skids	Elements per pressure vessel	Stage 3 pressure vessels per skid	Total Stage 3 elements	Cost per element	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Element life (yr)	Prorated annual replacement cost	**Prorated annual replacement cost (rounded)**
48	7	21	7056	$ 365	$ 2,575,440	9.0%	$ 2,807,230	1	$ 2,807,230	**$ 2,807,000**

RO system - Cartridge Filters

Filters per Vessel	Vessels	Total filters	Cost per filter	Cost of complete replacement	Sales tax	Cost of complete replacement plus 9% sales tax	Filter life (yr)	Annual replacement cost	**Prorated annual replacement cost (rounded)**
12	64	768	$ 16.76	$ 12,872	9.0%	$ 14,030	0.500	$ 28,060	**$ 28,000**

Total Annual RO Replacement Cost	**$ 5,402,000**

UV/AOP Lamps

Reactors (duty + standby)	Lamps per reactor	Total number of lamps	Lamp life (hrs)	Annual replacement per lamp	Total annual lamp replacement	Cost per lamp	Prorated annual lamp replacement cost	Sales tax	Annual lamp replacement cost plus sales tax
5	828	4140	14000	0.63	2590	$ 325	$ 841,750	9.0%	$ 917,508

UV/AOP Ballasts

Lamps per ballast	Total number of ballasts	Ballast replacement interval (yr)	Annual ballast replacement	Cost per ballast	Annual prorated ballast replacement cost	Sales tax	Annual prorated ballast replacement cost plus sales tax
2	2070	10	207	$ 660	$ 136,620	9.0%	$ 148,916

Rounded total lamp & ballast replacement cost	**$ 1,066,000**

APPENDIX E:

Engineer's Opinion of Probable Construction Cost for Pipelines for the Base Case

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DRAFT

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST FOR PIPELINES ASSOCIATED WITH THE RRWSP BASE CASE

B&V PROJECT NO. 191628

PREPARED FOR

Metropolitan Water District of Southern California

31 OCTOBER 2016

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7. Opinion of Probable Construction Cost and Duration

7.1 INTRODUCTION

This section of the report develops the engineer's opinion of probable construction cost (EOPCC) and provides an estimate of construction duration for the alignment segments which comprise the Base Case alignment.

Development of the EOPCC is broken down into a discussion of; Alignment Types and Associated Construction Methods, Unit Costs, Quantity Take-Off and EOPCC. The Methodology section below highlights the manner in which the EOPCC is developed and responds to the data and information available at the conceptual study level.

An estimate of the construction duration is provided for individual segments in the Base Case alignment. Start and completion dates are not given as these are being developed by the program management team, but the length of time from NTP through completion are provided for each segment.

Figure 7-1 depicts the Base Case alignment and the numbering of the segments that make up the alignment. These segment numbers will be referred to in various tables in this section of the report.

7.2 METHODOLOGY

The methodology employed was designed to develop the EOPCC from data available at the conceptual study phase. This approach includes development of typical construction methods that will be consistently applied along each of the four major alignment types as well as identification of the non-standard features found along the various segments which were to be added to the EOPCC when and where present. The key steps are further defined as follows.

Alignment Types and Associated Construction Method: The route traversed by the proposed reclaimed water pipeline are classified into four general alignment types. A standard construction method was developed for each. The standard construction method is intended to cover the work and materials that will be consistently utilized for pipe installation anywhere along that alignment type. The four standard construction methods, and the locations where they are applied, include:

- Construction Method 1 – Roadways
- Construction Method 2 – Southern California Edison Easements
- Construction Method 3 – Los Angeles Flood Control District Easements
- Construction Method 4 – Trenchless (Tunnels)

Adders: Variations from the standard construction methods which are encountered along each alignment are addressed as "Adders". Adders cover features and work methods which were not included in the standard construction method because they are not consistently required or uniformly found along each segment. Consistent with a conceptual study, Adders are items which are readily discernable and measurable from the desktop analysis, visual

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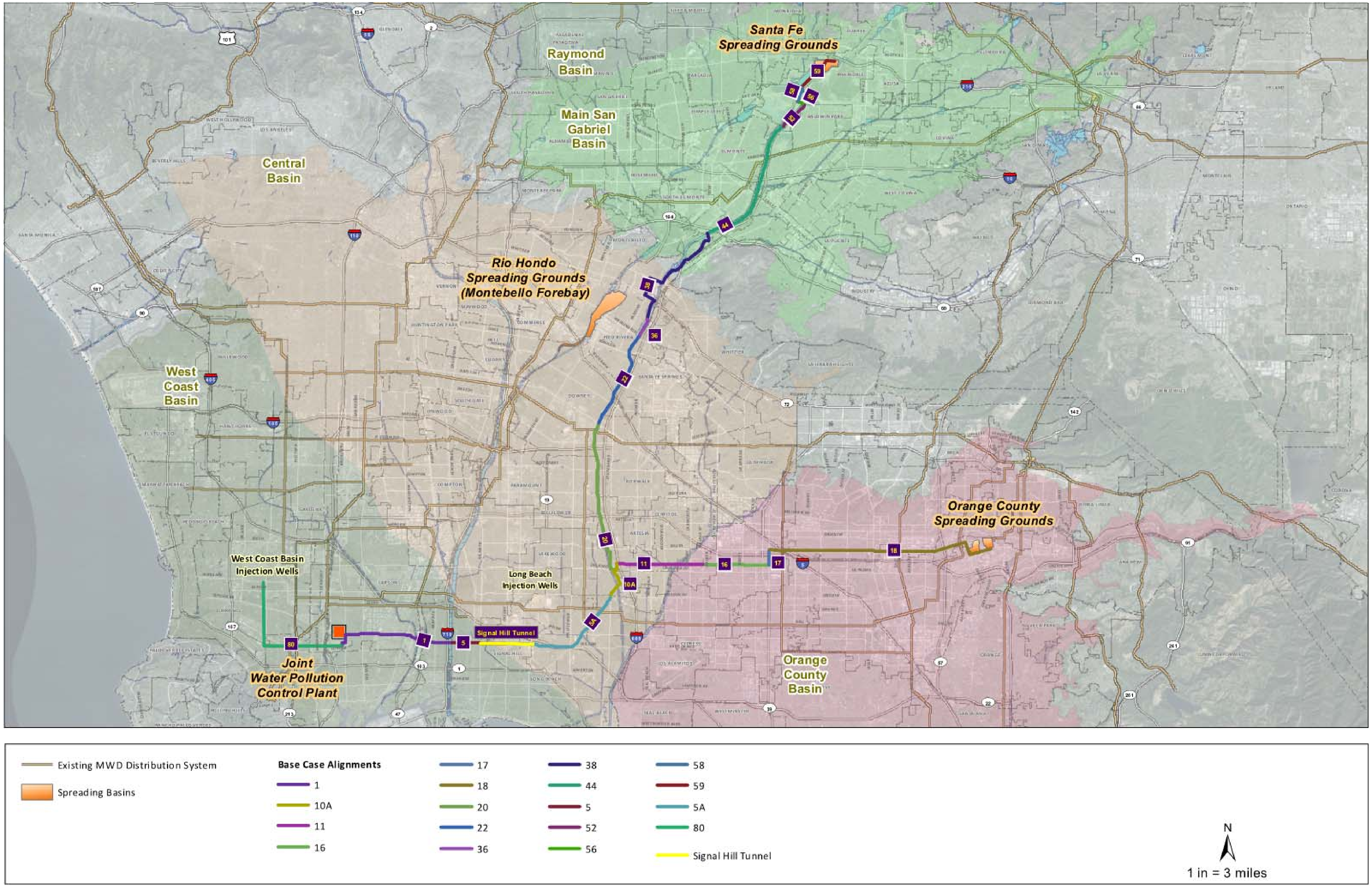

Figure 7-1– Base Alignment

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observations made in the field, review of utility information, analysis of traffic control requirements, desktop study of geotechnical and groundwater conditions, and so on. A GIS based pipeline alignment was developed from these evaluations including establishing sides of streets or easements for the installation. “Adders” were developed from this evaluation.

Unit Prices: A standard unit prices were developed for each construction method and its related adders.

Quantity Take-Off: A quantity take-off (QTO) was performed along the baseline alignment as described above and a count was made of the lengths and quantity of each alignment type and the related “Adders”.

EOPCC: The EOPCC was produced for the baseline alignment from the unit costs and the QTO.

7.3 ALIGNMENT TYPES AND ASSOCIATED CONSTRUCTION METHODS

This section discusses the development of the standard construction methods and associated adders four each of the four alignment types considered.

7.3.1 Construction Method 1 – Roadways

Construction Method 1 (CM1) is the standard method applied in all roadway/street locations. CM1 utilizes open-trench construction and is intended for use along local, collector or arterial roadways where the curb to curb distance is 60 feet or greater. Figure 7-2 shows the typical manner in which CM1 is applied to construction along roadways.

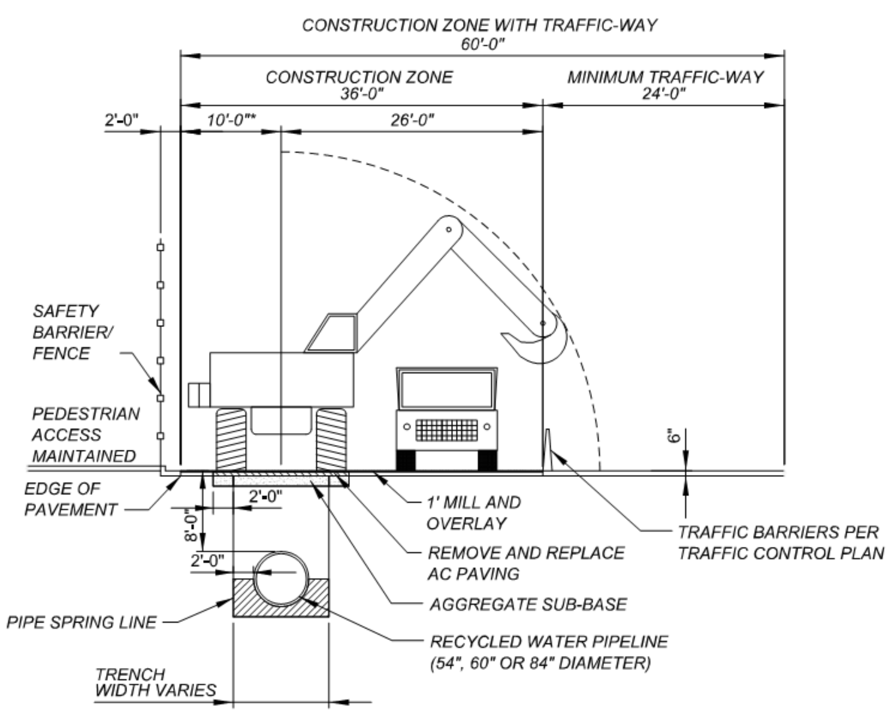

Figure 7-2– Construction Method 1 - Roadways

Sixty feet provides the minimum width required for a 36-foot wide construction zone and two 12-ft lanes thereby maintaining two-way traffic and leaving the sidewalks free for pedestrian traffic and store-front access. The 36-foot wide construction zone is governed by the clearances required for operation of construction equipment of the type and size envisioned. For purposes of this conceptual analysis the construction zone width does not vary as the trench width or pipe diameter / depth varies. Additional width beyond 60 feet does not invalidate the configuration shown for CM1, but simply permits an even wider construction zone and/or additional traffic lanes beyond the minimum. Those instances where there was less than 60 feet curb to curb were special cases utilizing either one lane with a flagman or requiring full closure to traffic with a detour.

CM-1 covers all work and materials needed for construction of a finished and functional pipeline along a typical roadway section. The following are included in the standard unit cost.

- Sitework including; surveying, dust/erosion control, etc.
- Pavement removal and restoration
- Standard vehicular traffic control and pedestrian safety measures
- Earthwork; excavation, shoring, hauling and compaction of all bedding and backfill.
- Pipe material, installation, welding, testing cleaning and disinfection.
- Appurtenances and ancillary items air valves, blow-offs and cathodic protection
- Utility protection, repair and relocation

Adders for roadway work cover the special features and additional work items which were not included in the list of standard items above, but which are to be counted separately and added to the overall cost of the relevant segment. Adders associated with roadway work include the following:

- Intersection Traffic Control: Applied to all signalized intersections and includes the cost of all barriers, cones, signage, lighting, re-stripping and re-signalizing required. Intersections requiring traffic control were identified in the Traffic Control Study (provided under separate cover) along with the manner in which the intersection is to be crossed and the type of traffic control to be applied.
  - Open-Cut intersections have traffic control designed to support cutting an open trench across the intersection and installing the pipe one half (side) at a time.
  - Trenchless intersections have traffic control designed to support pipeline construction by tunneling from launching and receiving pits set back from each side of the intersection.
- Median Removal & Replacement: Applied to roadways with an improved center median (other than a striped center turning lane) whenever the outer curb to median distance measured less than 36 feet. All street alignments have been measured and locations with less than 36-ft curb to median have been recorded in the QTO.
- Major Utility Crossings: The added cost for crossing a major utility using trenchless installation methods (see the major utility definition in Section 3).

- Trench Dewatering: A standard dewatering cost adder is applied at all locations where the trench bottom is below the groundwater level as described in the Desktop Geotechnical Study (provided under separate cover). A cost premium is added if permeable soils such as sand are also present.

Additional details regarding CM1 - Roadways and related "Adders" can be found in Exhibit A.

7.3.2 Construction Method 2 – SCE Easements

Construction Method 2 (CM2) is the standard method applied along all SCE Easements. CM2 utilizes vertically shored trenches and a 36-ft wide construction zone plus additional clearance from transmission towers and energized lines as shown on Figure 7-3. The clearance from the towers provides a corridor of travel for SCE to use during construction whereas the clearance from the energized lines (conductors) is required to comply with the National Electric Safety Code.

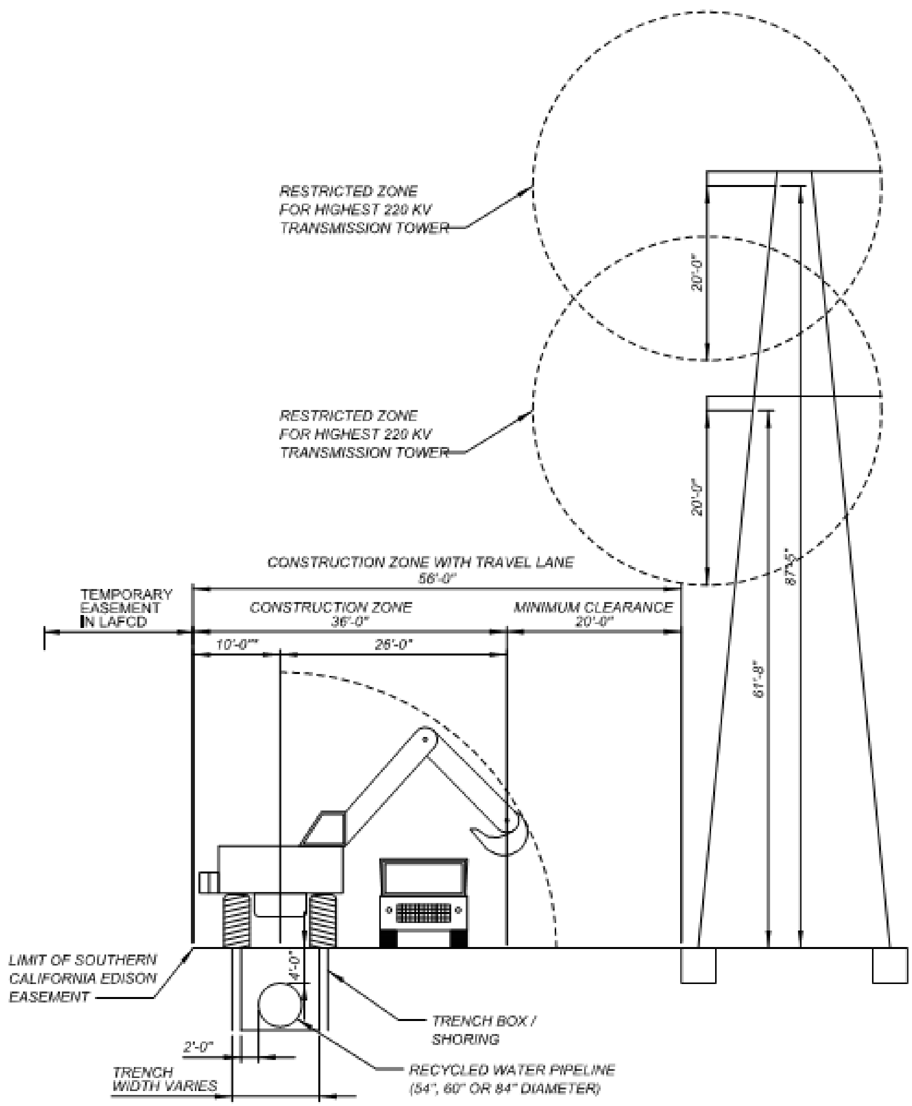

Figure 7-3 – Construction Method 2 – SCE Easement

The width of the construction zone does not vary based on the diameter of the pipe because the equipment used to build the pipeline will require the 36 foot width regardless of the diameter of the pipe being installed. In certain cases where the full 36-foot width was not available within the interior of the SCE easement, it was found that the pipeline could still be installed within the SCE easement if a temporary easement was obtained to permit a portion of the construction zone to overlay an adjacent Los Angeles Flood Control District (LAFCD) corridor. Conversely additional width available for construction activities, beyond the 36 foot minimum does not invalidate the configuration shown for CM2, but simply permits an even wider construction zone and would potentially lower construction costs.

CM2 covers all work and materials needed for construction of a finished and functional pipeline along a typical SCE easement. The following are included in the standard unit cost.

- Sitework; surveying, clearing and grubbing, dust / erosion control, etc.
- Earthwork; excavation, shoring hauling and compaction of bedding and backfill
- Pipe material, installation, welding, testing and cleaning
- Appurtenances and ancillary items; air valves, blow-offs, cathodic protection, etc.
- Site restoration

Adders for pipeline installation in an SCE easement cover the special features and additional work items which were not included in the list of standard items above, but which are to be counted separately and added to the overall cost of the relevant segment. SCE Adders include the following:

- Major utility crossings: (see Major Utility Crossings in Roadway Adders above)
- Dewatering: (see Dewatering in Roadway Adders above)

Additional details regarding CM2 – SCE easements and related adders can be found in Exhibit A.

7.3.3 Construction Method 3 – LAFCD Easements

Construction Method 3 (CM3) utilizes open-trench construction and is the standard method applied within LAFCD easements. Figures 7-4 show the possible variations for use depending on the pipeline location in relation to the river channel. The three CM3 construction variations are:

- **<u>CM3A – River Bank</u>:** This method is for open cut construction where there was sufficient space outside of the river channel to install the pipeline either at the top of the bank or adjacent to the toe of the levee.
- **<u>CM3B – River Channel (Unlined)</u>:** This method is for open cut construction where a concrete encased pipe is installed in an earthen river bottom.
- **<u>CM3C – River Channel (Lined)</u>:** This method is for open cut construction where a concrete encased pipe is installed in a concrete lined river bottom.

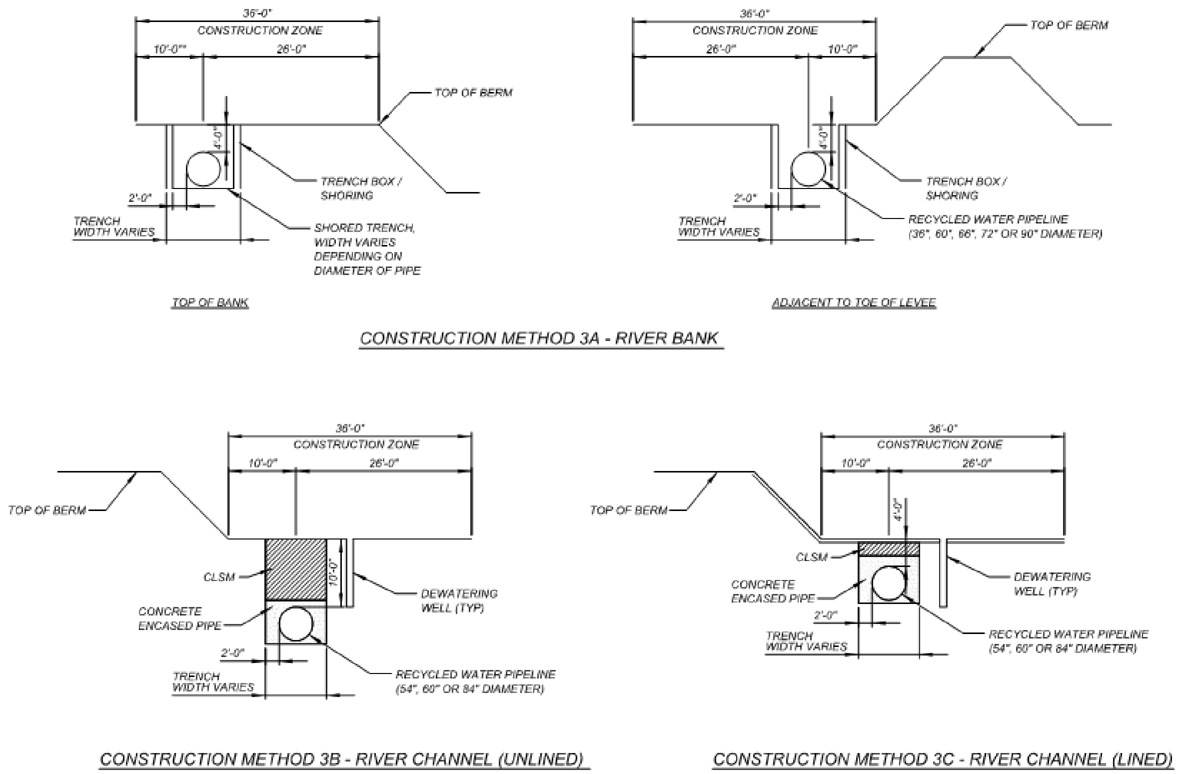

Figure 7-4– Construction Method 3 – LAFCD Easement

As shown in Figure 7-4, 36 feet provides the minimum required width for pipeline installation and clearances for construction activities. This report assumes that all three methods utilize a vertically shored open cut in order to stay within the construction zone and to minimize impacts to the river bank, river bed or its lining. In certain cases where the full 36-foot width was not available within the interior of the LAFCD easement, it was found that the pipeline could still be installed within the LAFCD easement if a temporary easement was obtained to permit a portion of the construction zone to overlay the adjacent SCE corridor. Conversely, additional width available for construction activities, beyond the 36 foot minimum did not invalidate the configuration shown for CM3, but simply permits an even wider construction zone and would potentially lower construction costs.

Adders for pipeline installation in an LAFCD easement cover the special features and additional work items which were not included in the list of standard items above, but which are to be counted separately and added to the overall cost of the relevant segment. LAFCD Adders include the following:

- Major utility crossings: (see Major Utility Crossings in Roadway Adders above)
- Dewatering: (see Dewatering in Roadway Adders above)

It should be noted that check dam crossings encountered along the river course were not counted as an adder under CM3 but were counted as a change in basic construction method; as CM4 – Trenchless (tunneling). Additional details regarding CM3 – LAFCD easements and related adders can be found in Exhibit A.

7.3.4 Construction Method 4 – Trenchless

Construction Method 4 (CM4) covers all of the trenchless (tunneling) applications on this project, as described in the Desktop Geotechnical Study and the Trenchless Methodology Evaluation (both provided under separate cover). One of the following three methods is utilized depending on conditions:

- **CM4A – Jack & Bore:** This method uses a jacking system to push casing pipe (or carrier pipe) into place. A simple cutting head mines the face and a conveyor or muck car removes spoils from inside the casing pipe. Jack & bore was selected for tunnel lengths up to 2,000 feet under appropriate conditions.
- **CM4B – Microtunneling:** Micro-tunneling also uses a jacking system to push the casing pipe (or carrier pipe) into place but with a tunnel boring machine (TBM) mounted at the head of the pipe string instead of the simple cutter head. Micro-tunneling was generally selected for tunnel lengths up to 2,000 feet where the tunneling conditions were beyond those readily handled by a jack & bore system. CM4B assumes utilization of an earth pressure balanced TBM unless more challenging conditions required the use of a slurry-faced TBM.
- **CM4C – Traditional Tunneling:** Traditional tunneling will be utilized for longer trenchless applications where the friction from pipe jacking would become too great. This method does not require a pipe jacking system but instead constructs the tunnel from segmental liners using a self-advancing TBM. The reclaimed water carrier pipe is then skidded into the tunnel after completion. Traditional tunneling was generally selected for tunnel lengths of 1,500 feet or greater and assumes an earth pressure balanced TBM unless more challenging conditions require use of a slurry-faced TBM.

Figure 7-5 shows the typical set-up for each of the three trenchless construction methods considered. The standard unit cost for CM4A, 4B and 4C covers all work and materials needed for construction of a finished and functional pipeline along those segments identified for trenchless construction including the following:

- Demolition, site work, earthwork, and site restoration for launching and receiving pits
- Tunneling Equipment; pipe jacking system, TBM, spoils removal, etc.
- Casing pipe or segmental tunnel liners, grouting and annular spacers/fill
- Pipe material and installation (carrier pipe or direct jack pipe)

Selection of the recommended method, 4A, 4B or 4C was a two-step process taking into consideration geotechnical feasibility and constructability. Geotechnical feasibility was addressed in the Desktop Geotechnical Evaluation report which mapped out relevant tunneling conditions throughout the project area and provided a short-list of geotechnically feasible tunneling methods for consideration at each trenchless location. The recommended method was then selected from this shortlist by considering cost and construction practicality for the specific application.

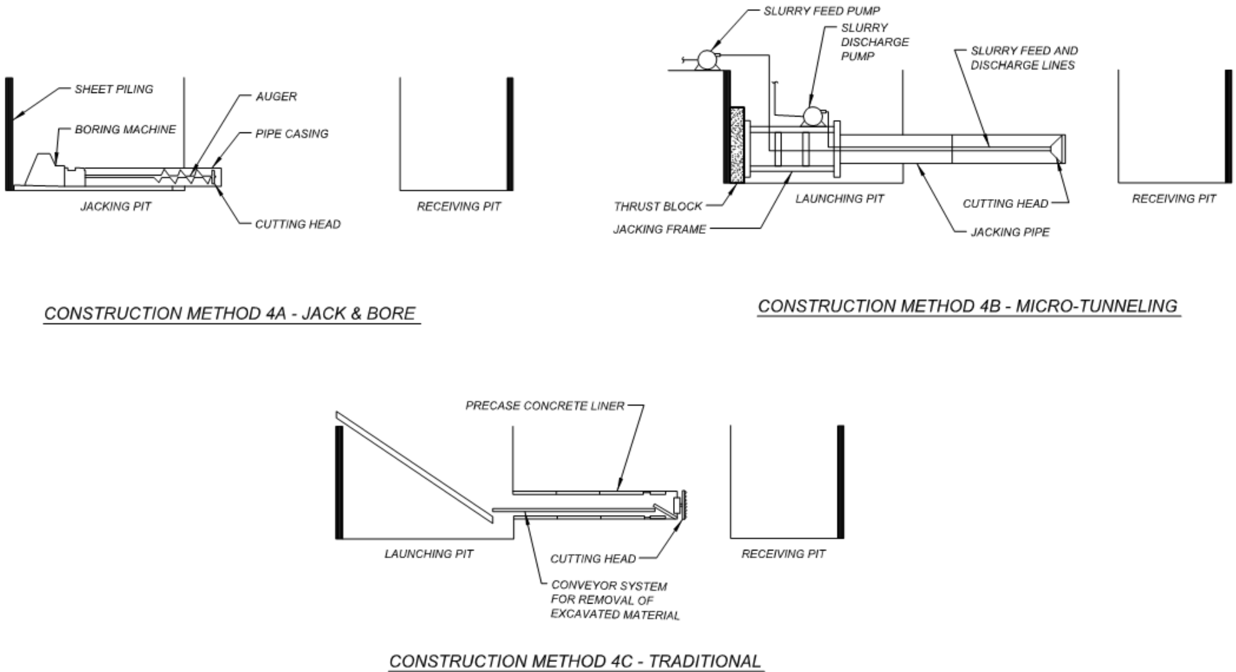

Figure 7-5– Construction Method 4 – Trenchless

Adders for trenchless work cover the special features and additional work items which were not included in the list of standard items above, but which are to be counted separately and added to the overall cost of the relevant segment. CM4 – Trenchless adders include the following:

- Microtunneling and Traditional Tunneling Dewatering: A cost adder is applied at all locations where the bottom of the tunnel launching and receiving pits are below the groundwater level. A cost premium is added if permeable soils are also present.
- Jack & Bore Dewatering: Dewatering of the tunnel alignment, from the launching pit to receiving pit, is provided when the jack & bore method (CM4A) is utilized for an intersection crossing and the tunnel invert is below the water level. A premium is added to the dewatering cost to account for the additional work associated with slant drilling and/or permeation grouting to reach out and dewater and/or stabilize the soils below the intersection.
- Seismic hazards/fault zones

Additional details regarding CM4 – Trenchless construction and related adders can be found in Exhibit A.

7.4 UNIT COSTS

The standard unit costs associated with each construction method and related adders are presented in Tables 7-1 and 7-2 below. The unit costs are direct costs presented in 2016 dollars and do not include indirect costs or contingency. Cost data was obtained from the following primary sources. Additional sources and the details of unit cost development are provided in Exhibit A.

- RS Means 2nd Quarter of 2016 for LA California
- Preliminary Design Report, Prepared by IEM for AECOM, October 2015
- Northwest Pipe Company Budgetary Quote dated June 17, 2016
- Preliminary Traffic Control Assessment, Prepared by Minagar & Associates, Inc, July 2016
- Black & Veatch, Heavy Civil Cost Data Base
- Desktop Geotechnical Study for RRWSP, Prepared by GeoPentech, Sep 2016

7-1 Construction Method Unit Costs

CONSTRUCTION METHOD		UNIT COST
CM1 – Roadways		
84”	LF	$ 1,719
60”	LF	$ 1,225
54”	LF	$ 1,142
CM2 – SCE Easements		
84”	LF	$ 1,279
60”	LF	$ 791
54”	LF	$ 710
CM-3A – River Bank		
84”	LF	$ 1,268
60”	LF	$ 785
54”	LF	$ 704
CM-3B – Open Cut Earthen Channel		
84”	LF	$ 1,944
60”	LF	$ 1,323
54”	LF	$ 1,205
CM-3C – Open Cut Concrete Lined Channel		
84”	LF	$ 2,157
60”	LF	$ 1,499
54”	LF	$ 1,377
CM-4A – Jack & Bore		
84”		

<200 ft length	LF	$ 4,888
200-2000 ft length	LF	$ 3,360
60"		
<200 ft length	LF	$ 3,813
200-2000 ft length	LF	$ 2,700
54"		
<200 ft length	LF	$ 3,276
200-2000 ft length	LF	$ 2,268
CM-4B – Microtunnel		
84"		
<200 ft length, No Boulders	LF	$ 6,148
<200 ft length, With Boulders	LF	$ 6,568
200-2000 ft length, No Boulders	LF	$ 4,620
200-2000 ft length, With Boulders	LF	$ 5,040
60"		
<200 ft length, No Boulders	LF	$ 4,413
<200 ft length, With Boulders	LF	$ 4,713
200-2000 ft length, No Boulders	LF	$ 3,300
200-2000 ft length, With Boulders	LF	$ 3,600
54"		
<200 ft length, No Boulders	LF	$ 3,978
<200 ft length, With Boulders	LF	$ 4,248
200-2000 ft length, No Boulders	LF	$ 2,970
200-2000 ft length, With Boulders	LF	$ 3,240
CM4C – Traditional Tunnel		
84"		
EPBM (>2000 ft)	LF	$ 3,780
Slurry TBM (>2000 ft)	LF	$ 4,032
60"		
EPBM (>2000 ft)	LF	$ 2,700
Slurry TBM (>2000 ft)	LF	$ 2,880

54"		
EPBM (>2000 ft)	LF	$ 2,430
Slurry TBM (>2000 ft)	LF	$ 2,592

7-2 Construction Unit Costs for Adders

ADDED CONSTRUCTION COSTS DESCRIPTION	UNIT	UNIT COST
Intersection Traffic Control (Open Cut)	EA	$ 78,500
Intersection Traffic Control (Trenchless)	EA	$ 12,500
Landscaped Median (demo & replace)	LF	$ 108
Raised Median (demo & replace)	LF	$ 98
Major Utility Crossings		
84"	EA	$ 146,652
60"	EA	$ 114,378
54"	EA	$ 98,292
Seismic Hazards/Fault Zones		
84"	EA	$ 938,036
60"	EA	$ 410,182
54"	EA	$ 314,326
Dewatering		
CM-1 – Roadway	LF	$ 29
CM-2 – SCE Easement	LF	$ 6
CM-3A – River Bank	LF	$ 6
CM-3B & C – River Channel	LF	$ 8
CM-4A – Jack & Bore	LF	$ 47
CM-4B – Microtunnel	LF	$ 33
CM-4C – Traditional Tunneling	LF	$ 41
Permeable Soils		
CM-1 – Roadway	LF	$ 14
CM-2 – SCE Easement	LF	$ 3
CM-3A – River Bank	LF	$ 3

CM-3B & C – River Channel	LF	$	4
CM-4A – Jack & Bore	LF	$	23
CM-4B – Microtunnel	LF	$	16
CM-4C – Traditional Tunneling	LF	$	21

The following observations apply:

- CM-2 and CM-3A, construction along SCE easements and within LAFCD riverbanks have the lowest cost per linear foot of the construction methods considered. This is primarily due to the shallower pipe installation, limited utility impacts and the lack of need for traffic control and pavement removal/replacement.
- CM-3B and CM-3C, construction along LAFCD easements is similar in cost to CM-2 when the pipeline is located outside of the river channel as it is with CM-3A. Costs increase if the pipeline is located within the river channel (CM-3B and CM-3C) due to increased depth required to protect from scour, concrete lining removal/replacement and reduced available working period due to rainy seasons.
- CM-1, construction along roadways has a high cost per linear foot. Elements contributing to the higher pipeline installation cost along roadways include; depth of the pipe, removal and replacement of paving and other surface improvements and the need to provide traffic control.
- CM4, trenchless construction methods have the highest cost per linear foot. Longer trenchless installations have a lower unit cost than short installations using the same method due to economies of scale that come into play with fixed costs (launching and receiving pits) and variable costs associated with the length of tunnel.

7.5 QUANTITY TAKE-OFF

Using the GIS based alignment developed as described earlier, a quantity take-off (QTO) was performed along each segment of the Base Case alignment and the QTO database was populated with the respective quantity of each CM utilized and adder found along the segment. Table 7-3 provides a summary of the total length of each CM type utilized for the Base Case alignment segments. The complete and detailed QTO is provided in Exhibit B.

Table 7-3: Summary of Base Alignment Construction Methods

CONSTRUCTION METHOD	LENGTH (FEET)	PERCENT OF SUBCATEGORY	PERCENT OF TOTAL
CM1 - Roadways	139,506	100%	49%
CM2 – SCE Easements	64,815	100%	23%
CM3 – LAFCD Easements			
CM3A – River Bank	22,430	48%	8%

CM3B – River Bed (unlined)	22,396	48%	8%
CM3C – River Bed (lined)	1,720	4%	1%
CM4 – Trenchless			
CM4A – Jack & Bore	11,501	33%	4%
CM4B – Microtunneling	8,654	25%	3%
CM4C – Traditional	14,275	41%	5%
Base Alignment Total =	285,297	-	100%

The following observations apply regarding the segments which make up the Base Case:

- The Base Case alignment is comprised primarily of CM-1 Roadway alignments (49%) followed by CM-2 SCE alignments (23%) and then CM-3 LAFCD easements (17%). CM-4 Trenchless methods make up the remaining balance with 34,430 ft of tunneling at 12% of the total.
- About half of the LAFCD alignments (8%) were selected to run outside of the river channel, either at the top of the bank or at the toe of the levee. Only 9% of the LAFCD alignments are assumed to run within the river bed.
- A total of 69 trenchless sub-segments are included and cover a total of 34,430 ft along the roadways and SCE / LAFCD easements of the Base Case. CM-4.1 (Jack & Bore) was selected most frequently due to its low cost for the many shorter intersection, railroad and utility crossings. Micro-tunneling (CM4B) and traditional tunneling (CM4C) were used less frequently but represent more than half of the tunneling length due to their use for the longer and/or more challenging tunneling conditions.

7.6 ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

An engineer's opinion of the probable construction cost (EOPCC) for the Base Case was prepared from the unit costs and QTO. The following parameters apply to the EOPCC:

- All prices have been escalated to and are presented in 2016 dollars
- The EOPCC is AACE Class 4 with an accuracy range of -30% to +50%
- The EOPCC includes indirect costs of 33.6% for overhead, profit, bonding and insurance.
- The EOPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWSP by the program team.

A summary of the Base Case EOPCC is presented in Table 7-4 below and Figure 7-5 identifies the locations of the Base Case segments listed below. A detailed breakdown of the line items and costs associated with all of the segments included in the base alignment can be found in Exhibit C.

Table 7-4: Summary of Costs for the Base Alignment

BASE CASE SEGMENTS	LENGTH (FT)	DIAMETER (IN)	TOTAL COST ($)
1	25,333	84	$ 76,600,000
5	5,729	84	$ 15,900,000
Signal Hill	10,687	84	$ 56,300,000
5A	21,322	84	$ 59,200,000
10	7,596	84, 54	$ 20,000,000
11	17,498	54	$ 22,000,000
16	13,375	54	$ 16,300,000
17	3,149	54	$ 5,500,000
18	47,453	54	$ 80,800,000
20	31,764	60	$ 64,300,000
22	19,969	60	$ 39,600,000
36	4,265	60	$ 4,500,000
38	27,872	60	$ 50,600,000
44	28,892	60	$ 46,400,000
52	6,717	60	$ 11,500,000
56	1,080	60	$ 1,900,000
58	3,349	60	$ 6,000,000
59	9,246	60	$ 11,800,000
80	34,320	30	$ 28,500,000
		Base Alignment Total =	**$ 617,700,000**

7.7 CONSTRUCTION DURATION

An estimate of the construction duration was developed for each segment of the Base Case alignment. The following conditions and parameters apply:

- A total of 6 months is required for mobilization and demobilization. 4 months is assumed on the front-end for mobilization and 2 month on the back-end for demobilization.
- The rate of construction progress is 40ft/day for CM1 – Roadway work and 200 ft/day for CM2 and CM3 work in SCE and LAFCD easements respectively.

- CM4 – Trenchless (tunneling) work will be performed by a separate tunneling contractor in parallel with CM1, CM2 and CM3 work and will not therefore add to the duration of work for each segment.

Table 7-5 shows the resulting construction duration calculated for each of the individual segments.

Table 7-5: Construction Duration for the Base Alignment

CONTRACT	SEGMENTS	LENGTH (FEET)	CONST METHOD	CONST RATE (LF/DAY)	PIPELINE CONST (MO)	MOB/ DEMOB (MO)	TOTAL (MO)
1	1	22,301	CM-1	40	26	6	38
	5	5,521	CM-1	40	6		
	Signal Hill	5,281	CM-4C	40	See third bullet above		
2	Signal Hill	5,406	CM-4C	40	See third bullet above	6	36
	5A	19,778	CM-1	40	23		
	10A	5,825	CM-1	40	7		
		655	CM-2	200	0.2		
3	11	15,446	CM-2	200	4	6	16
		501	CM-3C	200	0.1		
	16	12,385	CM-2	200	3		
	17	3,032	CM-1	40	3		
4	18 to Harbor	18,683	CM-1	40	22	6	28
		1,329	CM-2	200	0.3		
5	18 Harbor to OC	24,511	CM-1	40	28	6	34
6	20	13,030	CM-1	40	15	6	25
		9,819	CM-2	200	2		
		1,318	CM-3A	200	0.3		
		4,047	CM-3B	200	1		
7	22	17,749	CM-3B	200	4	6	36
		1,219	CM-3C	200	0.3		
	36	4,265	3A	200	1		
	38	19,628	CM-1	40	23		
		7,107	CM-3A	200	2		

8	44	22,793	CM-2	200	5	6	23
		1,286	CM-3A	200	0.3		
	52	6,117	CM-1	40	7		
		600	CM-3B	200	0.1		
	56	1,080	CM-1	40	1		
	58	2,388	CM-2	200	1		
	59	8,454	CM-3A	200	2		
						Base Alignment Total =	**235**

Construction duration observations include:

- The longest contract is No. 1 which includes segments 1, 5 and part of the Signal Hill tunnel and has a total construction duration of 38 months.
- The shortest is No. 3 which requires 16 months and is comprised of segments which are primarily in easements.

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Exhibit A – Unit Cost Development for Construction Methods and Adders

A.1 CM1 – Roadways

A.2 CM2 – SCE Easements

A.3 CM3 – LAFCD Easements

A.4 CM4 – Trenchless

A.5 Cost "Adders"

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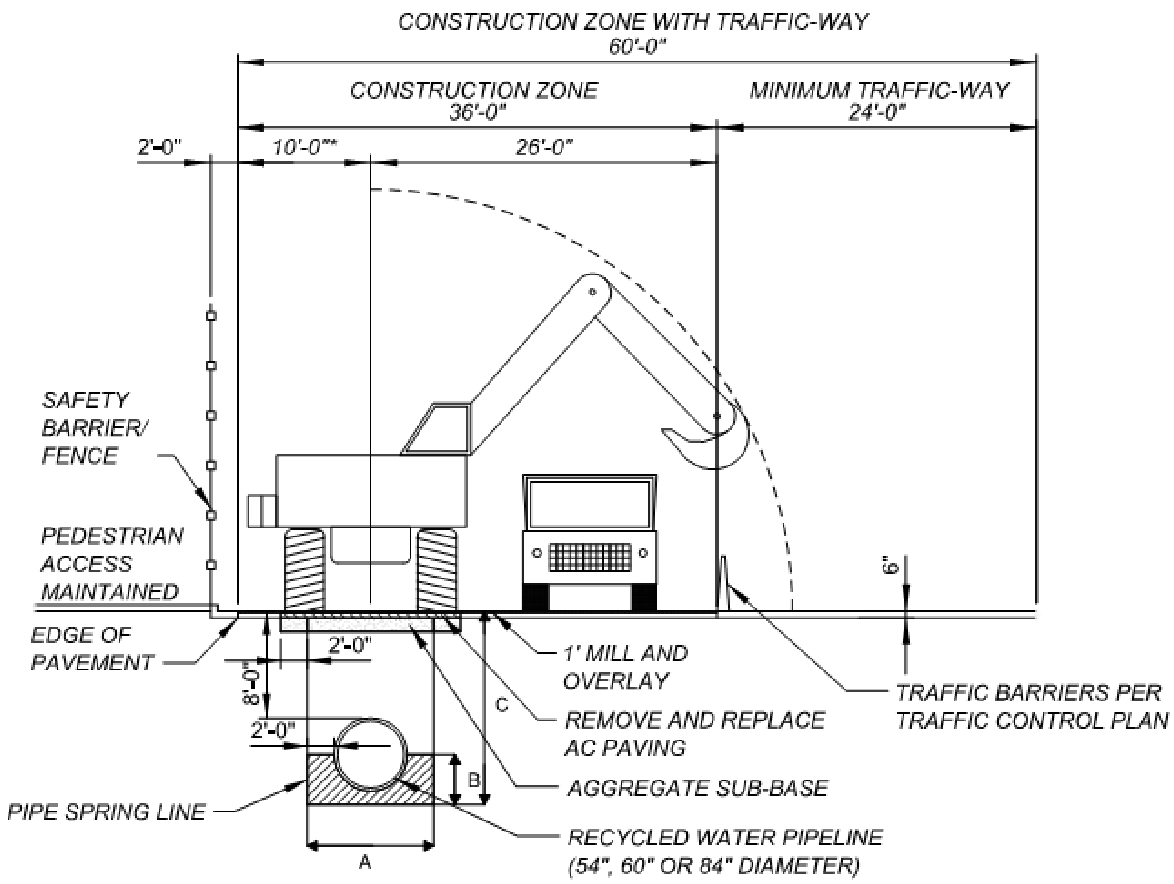
Construction Method 1 – Roadways

Description: Typical construction method for use in all roadway-street locations. Dimensions and required clearances are shown in the figure and table below.



NOTE:

1. MEDIUM IMPACTS (IF APPLICABLE) ARE COVERED IN COST ADDERS.

CONSTRUCTION METHOD 1 - ROADWAY

ID (in)	OD (in)	A	B	C
84	87.5	11’-4”	4’-2”	15’-10”
60	63.5	9’-4”	3’-2”	13’-10”
54	57.5	8’-10”	2’-11”	13’-4”

BLACK & VEATCH

Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Construction Method 1 - Roadways

Assumptions

1 Units listed as LF are for 1 linear foot of the Construction Method
2 Units listed as areas or volumes are for 1 linear foot of the Construction Method
3 Units listed as areas or volumes are for 1 linear foot of the Construction Method
4 Asphalt Paving is assumed to be 6" thick
5 For Every linear foot of pipe there will be a linear foot of temporary fencing
6 For every 8 feet of pipe there will be 1 foot of fabric silt fence
7 Pipe joint welds will be inspected every 40 ft
8 Pipe joints will be welded every 40 ft
9 Air Vacuum/Air Release Valves are assumed to be installed every 2500 feet.
10 Blow offs are assumed to be installed every 2500 feet.
11 Speed shoring is the standard shoring method

Calculate Cost per Linear Foot for Construction Method 1 - 84-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Sawcutting	2.000	LF	$ 2.00	$ 4.00	Quantity = 2 LF per 1 LF of pipe
Asphalt Paving Removal	15.000	SF	$ 0.75	$ 11.25	Quantity = (Trench Width + 4 ft) X 1 LF of Pipe
1" Milling	2.333	SY	$ 1.60	$ 3.73	Quantity = (Width of construction zone - (Trench Width + 4ft)) X 1 LF of Pipe
Transportation and Disposal Fees (Recycle A/C)	0.278	CY	$ 200.00	$ 55.56	Quantity = (AC Paving Removal X Thickness X 1 LF)/27
Subtotal				$ 74.54	Per linear foot
Site Work					
Temporary Fencing	1.000	LF	$ 6.00	$ 6.00	Quantity = 1 LF per 1 LF of pipe
Traffic Control	1.000	LF	$ 28.85	$ 28.85	Quantity = 1 LF per 1 LF of pipe
Sweeper & Water Truck	1.000	LF	$ 36.92	$ 36.92	Quantity = 1 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 34.62	$ 34.62	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 150.00	$ 150.00	Quantity = 1 LF per 1 LF of pipe
Utility Crossings					
Gas	0.001	LF	$ 2,370.00	$ 2.69	Quantity = average of 2 1-mile sample segments
Telephone/Cable TV	0.001	LF	$ 240.00	$ 0.14	Quantity = average of 2 1-mile sample segments
Electric	0.001	LF	$ 1,190.00	$ 0.68	Quantity = average of 2 1-mile sample segments
Sewer	0.002	LF	$ 360.00	$ 0.75	Quantity = average of 2 1-mile sample segments
Water	0.001	LF	$ 360.00	$ 0.20	Quantity = average of 2 1-mile sample segments
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 261.29	Per linear foot
Earthwork					
Mass Trench Excavation - Vertical Trenching	6.60	CY	$ 10.00	$ 66.04	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	31.58	SF	$ 2.00	$ 63.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	6.60	CY	$ 3.50	$ 23.11	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.96	CY	$ 32.00	$ 30.74	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.255	SY	$ 2.00	$ 2.51	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	4.097	CY	$ 3.50	$ 14.34	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	4.097	CY	$ 18.00	$ 73.75	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	2.507	CY	$ 9.00	$ 22.56	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.255	SY	$ 3.00	$ 3.76	Quantity = Fine Grading & Compaction
Subtotal				$ 299.99	
Pipeline					
84" WSP CML	1.000	LF	$ 703.00	$ 703.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 140.00	$ 140.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 4,200.00	$ 105.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 420.00	$ 10.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 2.76	$ 2.76	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.0004	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.0004	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 971.54	Per linear foot
Site Restoration					
Asphalt Paving	1.667	SY	$ 54.00	$ 90.00	Quantity = Asphalt Paving Removal / 9
1" Asphalt Overlay	2.333	SY	$ 1.25	$ 2.92	Quantity = Milling / 9
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.69	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 111.61	Per linear foot
Total Cost per Linear Foot				**$ 1,718.97**	Per linear foot

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Construction Method 1 - Roadways

Calculate Cost per Linear Foot for Construction Method 1 - 60-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Sawcutting	2.000	LF	$ 2.00	$ 4.00	Quantity = 2 LF per 1 LF of pipe
Asphalt Paving Removal	15.000	SF	$ 0.75	$ 11.25	Quantity = (Trench Width + 4 ft) X 1 LF of Pipe
1" Milling	2.333	SY	$ 1.60	$ 3.73	Quantity = (Width of construction zone - (Trench Width + 4ft)) X 1 LF of Pipe
Transportation and Disposal Fees (Recycle A/C)	0.278	CY	$ 200.00	$ 55.56	Quantity = (AC Paving Removal X Thickness X 1 LF)/27
Subtotal				$ 74.54	Per linear foot
Site Work					
Temporary Fencing	1.000	LF	$ 6.00	$ 6.00	Quantity = 1 LF per 1 LF of pipe
Traffic Control	1.000	LF	$ 28.85	$ 28.85	Quantity = 1 LF per 1 LF of pipe
Sweeper & Water Truck	1.000	LF	$ 36.92	$ 36.92	Quantity = 1 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 34.62	$ 34.62	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 150.00	$ 150.00	Quantity = 1 LF per 1 LF of pipe
Utility Crossings					
Gas	0.001	LF	$ 2,370.00	$ 2.69	Quantity = average of 2 1-mile sample segments
Telephone/Cable TV	0.001	LF	$ 240.00	$ 0.14	Quantity = average of 2 1-mile sample segments
Electric	0.001	LF	$ 1,190.00	$ 0.68	Quantity = average of 2 1-mile sample segments
Sewer	0.002	LF	$ 360.00	$ 0.75	Quantity = average of 2 1-mile sample segments
Water	0.001	LF	$ 360.00	$ 0.20	Quantity = average of 2 1-mile sample segments
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 261.29	Per linear foot
Earthwork					
Mass Trench Excavation - Vertical Trenching	4.75	CY	$ 10.00	$ 47.46	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	27.58	SF	$ 2.00	$ 55.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	4.75	CY	$ 3.50	$ 16.61	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.68	CY	$ 32.00	$ 21.61	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.032	SY	$ 2.00	$ 2.06	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	3.256	CY	$ 3.50	$ 11.40	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	3.256	CY	$ 18.00	$ 58.61	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	1.490	CY	$ 9.00	$ 13.41	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.032	SY	$ 3.00	$ 3.10	Quantity = Fine Grading & Compaction
Subtotal				$ 229.43	
Pipeline					
60" WSP CML	1.000	LF	$ 364.00	$ 364.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.67	$ 1.67	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.0004	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.0004	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 548.45	Per linear foot
Site Restoration					
Asphalt Paving	1.667	SY	$ 54.00	$ 90.00	Quantity = Asphalt Paving Removal / 9
1" Asphalt Overlay	2.333	SY	$ 1.25	$ 2.92	Quantity = Milling / 9
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.69	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 111.61	Per linear foot
Total Cost per Linear Foot				**$ 1,225.32**	Per linear foot

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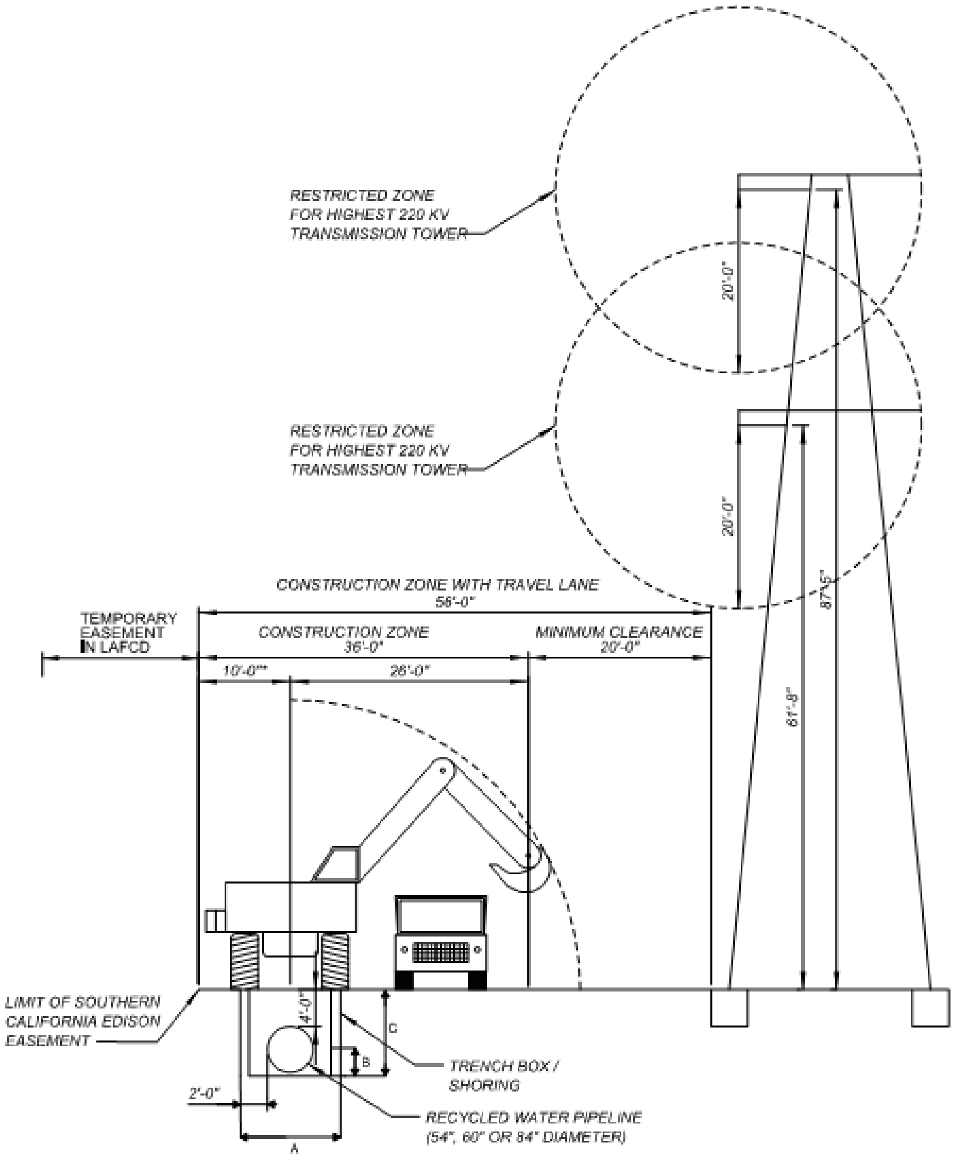
Construction Method 1 - Roadways

Calculate Cost per Linear Foot for Construction Method 1 - 54-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Sawcutting	2.000	LF	$ 2.00	$ 4.00	Quantity = 2 LF per 1 LF of pipe
Asphalt Paving Removal	15.000	SF	$ 0.75	$ 11.25	Quantity = (Trench Width + 4 ft) X 1 LF of Pipe
1" Milling	2.333	SY	$ 1.60	$ 3.73	Quantity = (Width of construction zone - (Trench Width + 4ft)) X 1 LF of Pipe
Transportation and Disposal Fees (Recycle A/C)	0.278	CY	$ 200.00	$ 55.56	Quantity = (AC Paving Removal X Thickness X 1 LF)/27
Subtotal				$ 74.54	Per linear foot
Site Work					
Temporary Fencing	1.000	LF	$ 6.00	$ 6.00	Quantity = 1 LF per 1 LF of pipe
Traffic Control	1.000	LF	$ 28.85	$ 28.85	Quantity = 1 LF per 1 LF of pipe
Sweeper & Water Truck	1.000	LF	$ 36.92	$ 36.92	Quantity = 1 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 34.62	$ 34.62	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 150.00	$ 150.00	Quantity = 1 LF per 1 LF of pipe
Utility Crossings					
Gas	0.001	LF	$ 2,370.00	$ 2.69	Quantity = average of 2 1-mile sample segments
Telephone/Cable TV	0.001	LF	$ 240.00	$ 0.14	Quantity = average of 2 1-mile sample segments
Electric	0.001	LF	$ 1,190.00	$ 0.68	Quantity = average of 2 1-mile sample segments
Sewer	0.002	LF	$ 360.00	$ 0.75	Quantity = average of 2 1-mile sample segments
Water	0.001	LF	$ 360.00	$ 0.20	Quantity = average of 2 1-mile sample segments
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 261.29	Per linear foot
Earthwork					
Mass Trench Excavation - Vertical Trenching	4.33	CY	$ 10.00	$ 43.28	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	26.58	SF	$ 2.00	$ 53.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	4.33	CY	$ 3.50	$ 15.15	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.61	CY	$ 32.00	$ 19.49	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	0.977	SY	$ 2.00	$ 1.95	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	3.051	CY	$ 3.50	$ 10.68	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	3.051	CY	$ 18.00	$ 54.92	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	1.277	CY	$ 9.00	$ 11.49	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	0.977	SY	$ 3.00	$ 2.93	Quantity = Fine Grading & Compaction
Subtotal				$ 213.06	
Pipeline					
54" WSP CML	1.000	LF	$ 297.00	$ 297.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.47	$ 1.47	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.0004	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.0004	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 481.25	Per linear foot
Site Restoration					
Asphalt Paving	1.667	SY	$ 54.00	$ 90.00	Quantity = Asphalt Paving Removal / 9
1" Asphalt Overlay	2.333	SY	$ 1.25	$ 2.92	Quantity = Milling / 9
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.69	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 111.61	Per linear foot
Total Cost per Linear Foot				**$ 1,141.75**	Per linear foot

Construction Method 2 – SCE Easement

Description: Typical open-trench construction method for use in all Southern California Edison Easements.



CONSTRUCTION METHOD 2 - SCE EASEMENT

ID (in)	OD (in)	A	B	C
84	87.5	11’-4”	4’-2”	11’-10”
60	63.5	9’-4”	3’-2”	9’-10”
54	57.5	8’-10”	2’-11”	9’-4”

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Construction Method 2 - SCE Easement

Assumptions

1 Units listed as LF are for 1 linear foot of the Construction Method
2 Units listed as areas or volumes are for 1 linear foot of the Construction Method
3 Units listed as areas or volumes are for 1 linear foot of the Construction Method
4 For Every linear foot of pipe there will be a linear foot of temporary fencing
5 For every 8 feet of pipe there will be 1 foot of fabric silt fence
6 Pipe joint welds will be inspected every 40 ft
7 Pipe joints will be welded every 40 ft
8 Air Vacuum/Air Release Valves are assumed to be installed every 2500 feet.
9 Blow offs are assumed to be installed every 2500 feet.
10 Speed shoring is the standard shoring method

Calculate Cost per Linear Foot for Construction Method 2 - 84-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	4.93	CY	$ 10.00	$ 49.31	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	23.58	SF	$ 2.00	$ 47.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	4.93	CY	$ 3.50	$ 17.26	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.96	CY	$ 32.00	$ 30.74	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.255	SY	$ 2.00	$ 2.51	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	2.424	CY	$ 3.50	$ 8.48	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	2.424	CY	$ 18.00	$ 43.64	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	2.507	CY	$ 9.00	$ 22.56	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.255	SY	$ 3.00	$ 3.76	Quantity = Fine Grading & Compaction
Subtotal				$ 225.44	Per LF
Pipeline					
84" WSP CML	1.000	LF	$ 703.00	$ 703.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 140.00	$ 140.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 4,200.00	$ 105.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 420.00	$ 10.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 13.82	$ 13.82	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 982.59	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.64	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 18.64	Per LF
Total Cost per Linear Foot				**$ 1,279.10**	Per LF

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Construction Method 2 - SCE Easement

Calculate Cost per Linear Foot for Construction Method 2 - 60-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	3.37	CY	$ 10.00	$ 33.70	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	19.58	SF	$ 2.00	$ 39.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	3.37	CY	$ 3.50	$ 11.79	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.68	CY	$ 32.00	$ 21.61	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.032	SY	$ 2.00	$ 2.06	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	1.880	CY	$ 3.50	$ 6.58	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	1.880	CY	$ 18.00	$ 33.84	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	1.490	CY	$ 9.00	$ 13.41	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.032	SY	$ 3.00	$ 3.10	Quantity = Fine Grading & Compaction
Subtotal				$ 165.25	Per LF
Pipeline					
60" WSP CML	1.000	LF	$ 364.00	$ 364.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 8.35	$ 8.35	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 555.12	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.64	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 18.64	Per LF
Total Cost per Linear Foot				**$ 791.45**	Per LF

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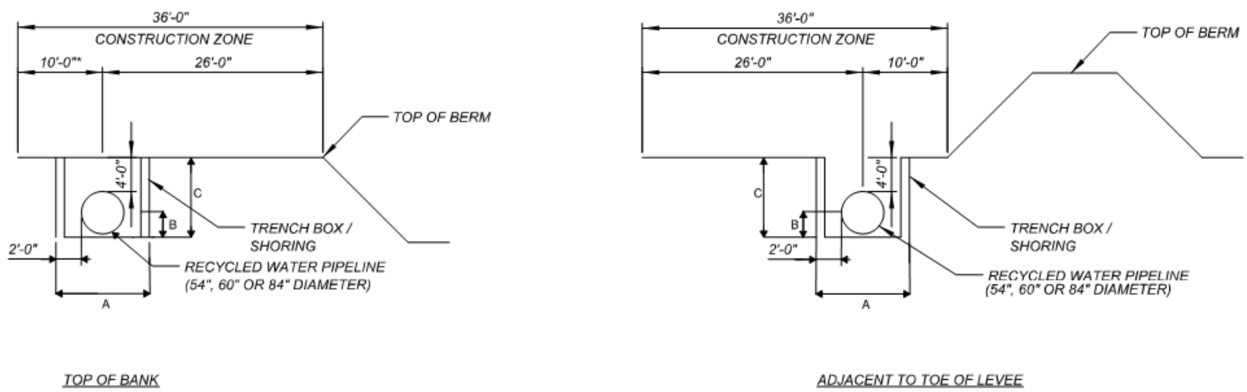
Construction Method 2 - SCE Easement

Calculate Cost per Linear Foot for Construction Method 2 - 54-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	3.03	CY	$ 10.00	$ 30.26	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	18.58	SF	$ 2.00	$ 37.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	3.03	CY	$ 3.50	$ 10.59	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.61	CY	$ 32.00	$ 19.49	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	0.977	SY	$ 2.00	$ 1.95	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	1.749	CY	$ 3.50	$ 6.12	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	1.749	CY	$ 18.00	$ 31.48	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	1.277	CY	$ 9.00	$ 11.49	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	0.977	SY	$ 3.00	$ 2.93	Quantity = Fine Grading & Compaction
Subtotal				$ 151.47	Per LF
Pipeline					
54" WSP CML	1.000	LF	$ 297.00	$ 297.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 7.36	$ 7.36	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 487.14	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.64	Quantity = ((Width of Const Zone + Travel Zone) X 1 LF of Pipe)/43560
Subtotal				$ 18.64	Per LF
Total Cost per Linear Foot				**$ 709.68**	Per LF

Construction Method 3A – LAFCD Easement (Adjacent to River)

Description: Typical construction method for use in Los Angeles County Flood Control District Easements where there is sufficient space at the top of the bank or toe of levee to install the pipe. Dimensions and required clearances are shown in the figure and table below.



CONSTRUCTION METHOD 3A - RIVER BANK

ID (in)	OD (in)	A	B	C
84	87.5	11'-4"	4'-2"	11'-10"
60	63.5	9'-4"	3'-2"	9'-10"
54	57.5	8'-10"	2'-11"	9'-4"

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Construction Method 3A - LAFCD Easement (River Bank)

Assumptions

1. Units listed as LF are for 1 linear foot of the Construction Method
2. Units listed as areas or volumes are for 1 linear foot of the Construction Method
3. Units listed as areas or volumes are for 1 linear foot of the Construction Method
4. For Every linear foot of pipe there will be a linear foot of temporary fencing
5. For every 8 feet of pipe there will be 1 foot of fabric silt fence
6. Pipe joint welds will be inspected every 40 ft
7. Pipe joints will be welded every 40 ft
8. Air Vacuum/Air Release Valves are assumed to be installed every 2500 feet.
9. Blow offs are assumed to be installed every 2500 feet.
10. Speed shoring is the standard shoring method

Calculate Cost per Linear Foot for Construction Method 3A - 84-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	4.93	CY	$ 10.00	$ 49.31	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	23.58	SF	$ 2.00	$ 47.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	4.93	CY	$ 3.50	$ 17.26	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.96	CY	$ 32.00	$ 30.74	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.255	SY	$ 2.00	$ 2.51	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	2.424	CY	$ 3.50	$ 8.48	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	2.424	CY	$ 18.00	$ 43.64	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	2.507	CY	$ 9.00	$ 22.56	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.255	SY	$ 3.00	$ 3.76	Quantity = Fine Grading & Compaction
Subtotal				$ 225.44	Per LF
Pipeline					
84" WSP CML	1.000	LF	$ 703.00	$ 703.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 140.00	$ 140.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 4,200.00	$ 105.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 420.00	$ 10.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 2.76	$ 2.76	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 971.54	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 18.41	Per LF
Total Cost per Linear Foot				**$ 1,267.82**	Per LF

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Construction Method 3A - LAFCD Easement (River Bank)

Calculate Cost per Linear Foot for Construction Method 3A - 60-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	3.37	CY	$ 10.00	$ 33.70	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	19.58	SF	$ 2.00	$ 39.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	3.37	CY	$ 3.50	$ 11.79	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.68	CY	$ 32.00	$ 21.61	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.032	SY	$ 2.00	$ 2.06	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	1.880	CY	$ 3.50	$ 6.58	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	1.880	CY	$ 18.00	$ 33.84	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	1.490	CY	$ 9.00	$ 13.41	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.032	SY	$ 3.00	$ 3.10	Quantity = Fine Grading & Compaction
Subtotal				$ 165.25	Per LF
Pipeline					
60" WSP CML	1.000	LF	$ 364.00	$ 364.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.67	$ 1.67	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 548.45	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 18.41	Per LF
Total Cost per Linear Foot				**$ 784.55**	Per LF

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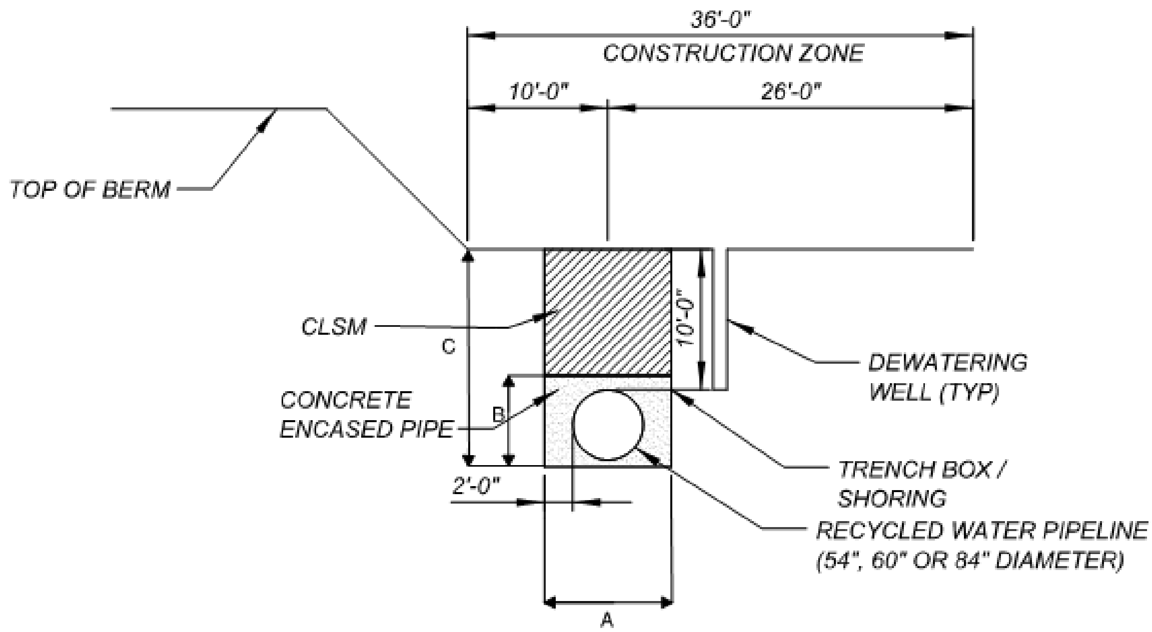
Construction Method 3A - LAFCD Easement (River Bank)

Calculate Cost per Linear Foot for Construction Method 3A - 54-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	3.03	CY	$ 10.00	$ 30.26	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	18.58	SF	$ 2.00	$ 37.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils to Laydown Area	3.03	CY	$ 3.50	$ 10.59	Quantity = Excavation
Gravel Bedding & Pipe Cover	0.61	CY	$ 32.00	$ 19.49	Quantity = (((Trench Width X ½ Pipe Dia) - (½ Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	0.977	SY	$ 2.00	$ 1.95	Quantity = ((Trench Width) X 1 LF) / 9
Load/Haul Laydown Soils to Trench Areas	1.749	CY	$ 3.50	$ 6.12	Quantity = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	1.749	CY	$ 18.00	$ 31.48	Quantity = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	1.277	CY	$ 9.00	$ 11.49	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	0.977	SY	$ 3.00	$ 2.93	Quantity = Fine Grading & Compaction
Subtotal				$ 151.47	Per LF
Pipeline					
54" WSP CML	1.000	LF	$ 297.00	$ 297.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.47	$ 1.47	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 481.25	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 18.41	Per LF
Total Cost per Linear Foot				**$ 703.57**	Per LF

Construction Method 3B – LAFCD Easement River Channel (Unlined)

Description: Typical construction method for use in Los Angeles County Flood Control District Easements where there the pipe is installed in an earthen river bottom. Dimensions and required clearances are shown in the figure and table.



CONSTRUCTION METHOD 3B - RIVER CHANNEL (UNLINED)

ID (in)	OD (in)	A	B	C
84	87.5	11’-4”	8’-4”	17’-10”
60	63.5	9’-4”	6’-4”	15’-10”
54	57.5	8’-10”	5’-10”	15’-4”

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Construction Method 3B- LAFCD Easement (Open Cut Earthen Channel)

Assumptions

1. Units listed as LF are for 1 linear foot of the Construction Method
2. Units listed as areas or volumes are for 1 linear foot of the Construction Method
3. Units listed as areas or volumes are for 1 linear foot of the Construction Method
4. For Every linear foot of pipe there will be a linear foot of temporary fencing
5. For every 8 feet of pipe there will be 1 foot of fabric silt fence
6. Pipe joint welds will be inspected every 40 ft
7. Pipe joints will be welded every 40 ft
8. Air Vacuum/Air Release Valves are assumed to be installed every 2500 feet.
9. Blow offs are assumed to be installed every 2500 feet.
10. Speed shoring is the standard shoring method

Calculate Cost per Linear Foot for Construction Method 3B - 84-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	7.48	CY	$ 10.00	$ 74.80	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	36.58	SF	$ 2.00	$ 73.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils	7.480	CY	$ 3.50	$ 26.18	Quantity = Excavation
Concrete encasement	1.921	CY	$ 200.00	$ 384.21	Quantity = (((Trench Width X Pipe Dia + 1) - (Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.255	SY	$ 2.00	$ 2.51	Quantity = ((Trench Width) X 1 LF) / 9
CLSM Backfill	4.013	CY	$ 80.00	$ 321.02	Quantity = Excavation - Concrete Encasement - Pipe
Off-Site Disposal Stockpile Spoils	1.921	CY	$ 9.00	$ 17.29	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.255	SY	$ 3.00	$ 3.76	Quantity = Fine Grading & Compaction
Subtotal				$ 902.94	Per LF
Pipeline					
84" WSP CML	1.000	LF	$ 703.00	$ 703.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 140.00	$ 140.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 4,200.00	$ 105.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 420.00	$ 10.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.89	$ 1.89	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 970.67	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 18.41	Per LF
Total Cost per Linear Foot				**$ 1,944.46**	Per LF

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Construction Method 3B- LAFCD Easement (Open Cut Earthen Channel)

Calculate Cost per Linear Foot for Construction Method 3B - 60-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	5.61	CY	$ 10.00	$ 56.07	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	32.58	SF	$ 2.00	$ 65.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils	5.607	CY	$ 3.50	$ 19.62	Quantity = Excavation
Concrete encasement	1.351	CY	$ 200.00	$ 270.13	Quantity = (((Trench Width X Pipe Dia + 1) - (Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.032	SY	$ 2.00	$ 2.06	Quantity = ((Trench Width) X 1 LF) / 9
CLSM Backfill	3.441	CY	$ 80.00	$ 275.31	Quantity = Excavation - Concrete Encasement - Pipe
Off-Site Disposal Stockpile Spoils	1.351	CY	$ 9.00	$ 12.16	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.032	SY	$ 3.00	$ 3.10	Quantity = Fine Grading & Compaction
Subtotal				$ 703.61	Per LF
Pipeline					
60" WSP CML	1.000	LF	$ 364.00	$ 364.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.67	$ 1.67	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 548.45	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				18.41	Per LF
Total Cost per Linear Foot				**$ 1,322.90**	Per LF

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Probable Construction Cost

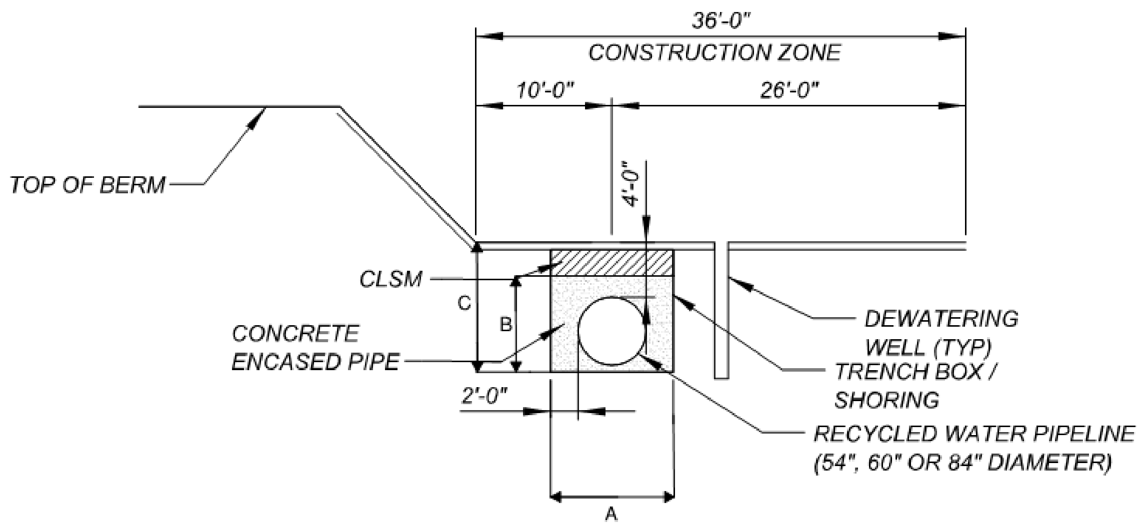
Construction Method 3B- LAFCD Easement (Open Cut Earthen Channel)

Calculate Cost per Linear Foot for Construction Method 3B - 54-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Clearing and Grubbing	0.001	AC	$ 3,700.00	$ 3.06	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 3.06	Per LF
Site Work					
Temporary Fencing	2.000	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.000	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.000	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.125	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.019	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	5.14	CY	$ 10.00	$ 51.42	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	31.58	SF	$ 2.00	$ 63.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils	5.142	CY	$ 3.50	$ 18.00	Quantity = Excavation
Concrete encasement	1.218	CY	$ 200.00	$ 243.60	Quantity = (((Trench Width X Pipe Dia + 1) - (Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	0.977	SY	$ 2.00	$ 1.95	Quantity = ((Trench Width) X 1 LF) / 9
CLSM Backfill	3.256	CY	$ 80.00	$ 260.49	Quantity = Excavation - Concrete Encasement - Pipe
Off-Site Disposal Stockpile Spoils	1.218	CY	$ 9.00	$ 10.96	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	0.977	SY	$ 3.00	$ 2.93	Quantity = Fine Grading & Compaction
Subtotal				$ 652.52	Per LF
Pipeline					
54" WSP CML	1.000	LF	$ 297.00	$ 297.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.000	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.025	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.025	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.000	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.000	LF	$ 1.47	$ 1.47	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.000	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.000	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.000	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 481.25	Per LF
Site Restoration					
General Site Restoration	36.000	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Final Site Cleanup	0.001	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 18.41	Per LF
Total Cost per Linear Foot				**$ 1,204.62**	Per LF

Construction Method 3C – LAFCD Easement (Concrete-lined Channel)

Description: Typical construction method for use in Los Angeles County Flood Control District Easements where there the pipe is installed in a concrete lined river bottom. Dimensions and required clearances are shown in the figure and table below.



CONSTRUCTION METHOD 3C - RIVER CHANNEL (LINED)

ID (in)	OD (in)	A	B	C
84	87.5	11'-4"	8'-4"	11'-10"
60	63.5	9'-4"	6'-4"	9'-10"
54	57.5	8'-10"	5'-10"	9'-4"

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Construction Method 3C - LAFCD Easement (Open Cut Concrete Lined Channel)

Assumptions

1. Units listed as LF are for 1 linear foot of the Construction Method
2. Units listed as areas or volumes are for 1 linear foot of the Construction Method
3. Units listed as areas or volumes are for 1 linear foot of the Construction Method
4. For Every linear foot of pipe there will be a linear foot of temporary fencing
5. For every 8 feet of pipe there will be 1 foot of fabric silt fence
6. Pipe joint welds will be inspected every 40 ft
7. Pipe joints will be welded every 40 ft
8. Air Vacuum/Air Release Valves are assumed to be installed every 2500 feet.
9. Blow offs are assumed to be installed every 2500 feet.
10. Speed shoring is the standard shoring method

Calculate Cost per Linear Foot for Construction Method 3C - 84-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Concrete Slab Removal	15.00	SF	$ 4.50	$ 67.50	Quantity = (Trench Width + 4ft) X 1 LF of Pipe
Subtotal				$ 178.61	Per LF
Site Work					
Temporary Fencing	2.00	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.00	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.00	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.13	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.02	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	4.93	CY	$ 10.00	$ 49.31	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	23.58	SF	$ 2.00	$ 47.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils	4.931	CY	$ 3.50	$ 17.26	Quantity = Excavation
Concrete Pipe Encasement	1.921	CY	$ 200.00	$ 384.21	Quantity = (((Trench Width X Pipe Dia + 1) - (Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.255	SY	$ 2.00	$ 2.51	Quantity = ((Trench Width) X 1 LF) / 9
CLSM Backfill	1.464	CY	$ 80.00	$ 117.10	Quantity = Excavation - Concrete Encasement - Pipe
Off-Site Disposal Stockpile Spoils	1.921	CY	$ 9.00	$ 17.29	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.255	SY	$ 3.00	$ 3.76	Quantity = Fine Grading & Compaction
Subtotal				$ 638.61	Per LF
Pipeline					
84" WSP CML	1.00	LF	$ 703.00	$ 703.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.00	LF	$ 140.00	$ 140.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.03	EA	$ 4,200.00	$ 105.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.03	EA	$ 420.00	$ 10.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.00	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.00	LF	$ 2.76	$ 2.76	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.00	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.00	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.00	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 971.54	Per LF
Site Restoration					
General Site Restoration	36.00	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Concrete Slabs	15.00	SF	$ 20.00	$ 300.00	Quantity = Concrete Slab Removal
Final Site Cleanup	0.00	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 318.41	Per LF
Total Cost per Linear Foot				**$ 2,156.55**	Per LF

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Construction Method 3C - LAFCD Easement (Open Cut Concrete Lined Channel)

Calculate Cost per Linear Foot for Construction Method 3C - 60-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Concrete Slab Removal	13.00	SF	$ 4.50	$ 58.50	Quantity = (Trench Width + 4ft) X 1 LF of Pipe
Subtotal				$ 154.80	Per LF
Site Work					
Temporary Fencing	2.00	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.00	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.00	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.13	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.02	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	3.37	CY	$ 10.00	$ 33.70	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	19.58	SF	$ 2.00	$ 39.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils	3.370	CY	$ 3.50	$ 11.79	Quantity = Excavation
Concrete Pipe Encasement	1.351	CY	$ 200.00	$ 270.13	Quantity = (((Trench Width X Pipe Dia + 1) - (Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	1.032	SY	$ 2.00	$ 2.06	Quantity = ((Trench Width) X 1 LF) / 9
CLSM Backfill	1.204	CY	$ 80.00	$ 96.36	Quantity = Excavation - Concrete Encasement - Pipe
Off-Site Disposal Stockpile Spoils	1.351	CY	$ 9.00	$ 12.16	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	1.032	SY	$ 3.00	$ 3.10	Quantity = Fine Grading & Compaction
Subtotal				$ 468.46	Per LF
Pipeline					
60" WSP CML	1.00	LF	$ 364.00	$ 364.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.00	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.03	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.03	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.00	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.00	LF	$ 1.67	$ 1.67	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.00	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.00	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.00	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 548.45	Per LF
Site Restoration					
General Site Restoration	36.00	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Concrete Slabs	13.00	SF	$ 20.00	$ 260.00	Quantity = Concrete Slab Removal
Final Site Cleanup	0.00	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 278.41	Per LF
Total Cost per Linear Foot				**$ 1,499.49**	Per LF

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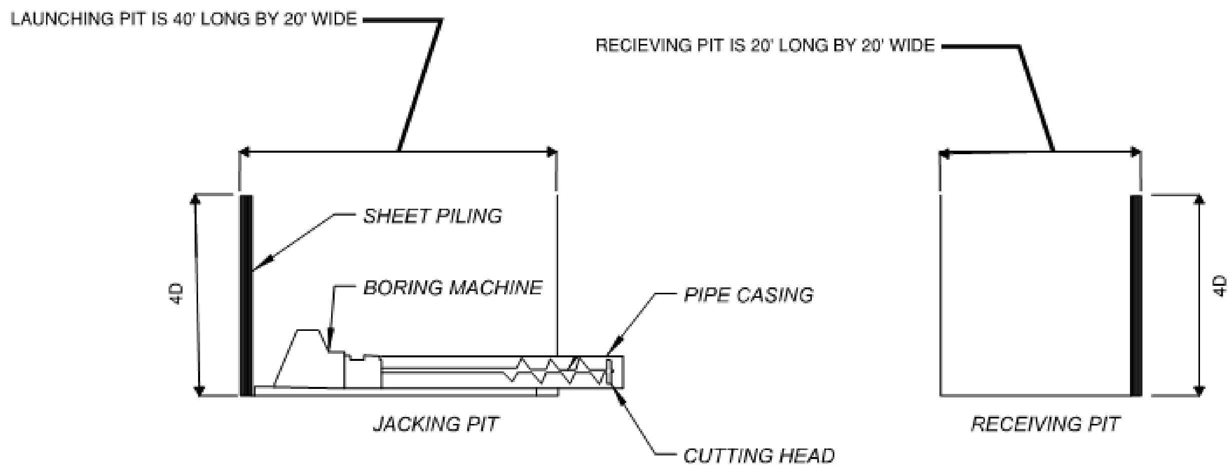
Construction Method 3C - LAFCD Easement (Open Cut Concrete Lined Channel)

Calculate Cost per Linear Foot for Construction Method 3C - 54-inch Pipe

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
Demolition					
Concrete Slab Removal	12.50	SF	$ 4.50	$ 56.25	Quantity = (Trench Width + 4ft) X 1 LF of Pipe
Subtotal				$ 148.84	Per LF
Site Work					
Temporary Fencing	2.00	LF	$ 6.00	$ 12.00	Quantity = 2 LF per 1 LF of pipe
Dust Control	1.00	LF	$ 6.92	$ 6.92	Quantity = 1 LF per 1 LF of pipe
Survey & Layout	1.00	LF	$ 30.00	$ 30.00	Quantity = 1 LF per 1 LF of pipe
Erosion Control					
Fabric Silt Fence - Installation & Maintenance	0.13	LF	$ 3.00	$ 0.38	Quantity = 1 ft of silt fence per 8 ft of pipe
Hay Rolls	0.02	LF	$ 4.00	$ 0.08	Quantity = 1 ft of hay roll per 52 ft of pipe
Subtotal				$ 49.37	Per LF
Earthwork					
Mass Trench Excavation - Vertical Trenching	3.03	CY	$ 10.00	$ 30.26	Quantity = (Trench Depth X Width X 1 LF) / 27
Trench Shoring	18.58	SF	$ 2.00	$ 37.17	Quantity = Trench Depth X 1 LF of Pipe X 2
Load/Haul Excavated Soils	3.026	CY	$ 3.50	$ 10.59	Quantity = Excavation
Concrete Pipe Encasement	1.218	CY	$ 200.00	$ 243.60	Quantity = (((Trench Width X Pipe Dia + 1) - (Pipe Area)) X 1 LF)/27
Fine Grading & Compaction	0.977	SY	$ 2.00	$ 1.95	Quantity = ((Trench Width) X 1 LF) / 9
CLSM Backfill	1.140	CY	$ 80.00	$ 91.17	Quantity = Excavation - Concrete Encasement - Pipe
Off-Site Disposal Stockpile Spoils	1.218	CY	$ 9.00	$ 10.96	Quantity = Excavation - Laydown Soils
Rough Surface Compaction	0.977	SY	$ 3.00	$ 2.93	Quantity = Fine Grading & Compaction
Subtotal				$ 428.63	Per LF
Pipeline					
54" WSP CML	1.00	LF	$ 297.00	$ 297.00	Quantity = 1 LF per 1 LF of Pipe
Pipeline Install - L & EQ	1.00	LF	$ 90.00	$ 90.00	Quantity = 1 LF per 1 LF of Pipe
Welding Pipe Joints	0.03	EA	$ 3,000.00	$ 75.00	Quantity = 1 per 40 LF of Pipe
Welding Inspections	0.03	EA	$ 300.00	$ 7.50	Quantity = 1 per 40 LF of Pipe
Hydrostatic Testing	1.00	LF	$ 1.50	$ 1.50	Quantity = 1 LF per 1 LF of Pipe
Cathodic Protection					
Anode Bed	1.00	LF	$ 1.47	$ 1.47	Quantity = 1 LF per 1 LF of Pipe
Incidentals (Test Stations)	1.00	LF	$ 0.38	$ 0.38	Quantity = 1 LF per 1 LF of Pipe
Air Vacuum/Air Release Valves	0.00	EA	$ 11,000.00	$ 4.40	Quantity = 1 per 2500 LF of Pipe
Blow Off Assembly	0.00	EA	$ 10,000.00	$ 4.00	Quantity = 1 per 2500 LF of Pipe
Subtotal				$ 481.25	Per LF
Site Restoration					
General Site Restoration	36.00	SF	$ 0.50	$ 18.00	Quantity = Width of Const Zone per 1 LF of Pipe
Concrete Slabs	12.50	SF	$ 20.00	$ 250.00	Quantity = Concrete Slab Removal
Final Site Cleanup	0.00	AC	$ 500.00	$ 0.41	Quantity = (Width of Const Zone X 1 LF of Pipe)/43560
Subtotal				$ 268.41	Per LF
Total Cost per Linear Foot				**$ 1,376.51**	Per LF

Construction Method 4A – JACK & BORE

Description: The primary trenchless solution considered. Dimensions and required clearances are shown in the figure below.



CONSTRUCTION METHOD 4A - JACK & BORE

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Construction Method 4A - Jack & Bore

Assumptions

1. Launching pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	Notes
84" Jack & Bore (<200 ft)					
Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
Pipe Jacking	200	LF	$ 3,190.18	$ 638,035.44	
Total Cost per LF				**4,888**	**$/LF**
60" Jack & Bore (<200 ft)					
Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Pipe Jacking	200	LF	$ 2,576.38	$ 515,275.56	
Total Cost per LF				**3,813**	**$/LF**
54" Jack & Bore (<200 ft)					
Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$ 18.00	$ 8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
Pipe Jacking	200	LF	$ 2,155.95	$ 431,190.77	
Total Cost per LF				**3,276**	**$/LF**

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Construction Method 4A - Jack & Bore

Assumptions

1. Launching pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

84" Jack & Bore (200 ft - 2000 ft)

Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
Pipe Jacking	2,000	LF	$ 3,190.18	$ 6,380,354.38	
Total Cost per LF				**$ 3,360.00**	**$/LF**

60" Jack & Bore (200 ft - 2000 ft)

Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Pipe Jacking	2,000	LF	$ 2,576.38	$ 5,152,755.62	
Total Cost per LF				**$ 2,700.00**	**$/LF**

54" Jack & Bore (200 ft - 2000 ft)

Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$ 18.00	$ 8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
Pipe Jacking	2,000	LF	$ 2,155.95	$ 4,311,907.75	
Total Cost per LF				**$ 2,268.00**	**$/LF**

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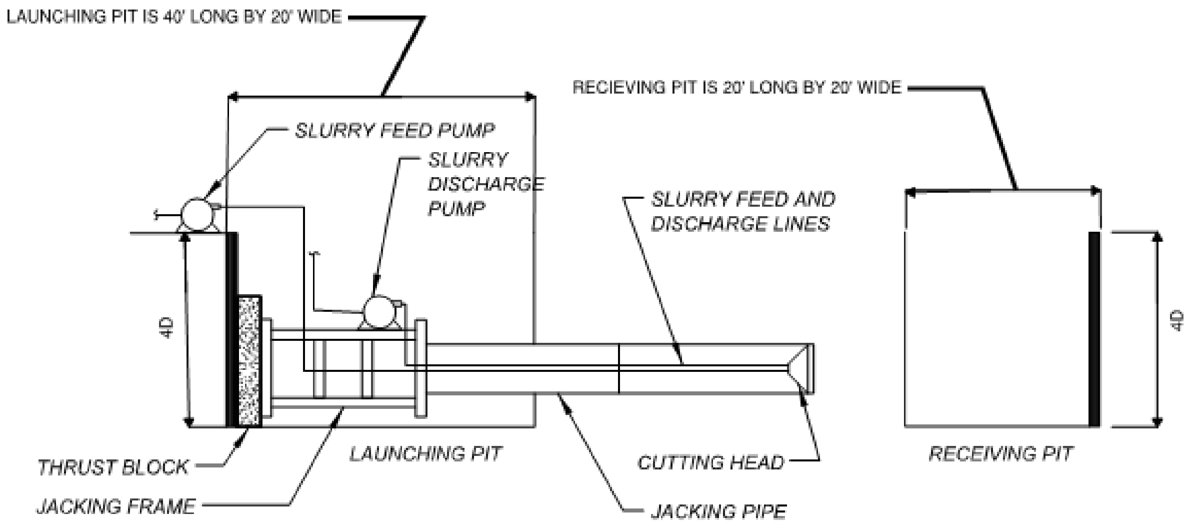
Construction Method 4B – Microtunneling

Description: Microtunneling was considered for all crossings not suitable for Jack & Bore. Dimensions and required clearances are shown in the figure below.



CONSTRUCTION METHOD 4B - MICRO-TUNNELING

BLACK & VEATCH

Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Construction Method 4B - Microtunneling

Assumptions

1. Bore pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	
84" Microtunnel (<200 ft, No Boulders)					
Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
Microtunneling	200	LF	$ 4,450.18	$ 890,035.44	
Total Cost per LF				**$ 6,148.41**	**$/LF**
60" Microtunnel (<200 ft, No Boulders)					
Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Microtunneling	200	LF	$ 3,176.38	$ 635,275.56	
Total Cost per LF				**$ 4,412.60**	**$/LF**
54" Microtunnel (<200 ft, No Boulders)					
Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$ 18.00	$ 8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
Microtunneling	200	LF	$ 2,857.95	$ 571,590.77	
Total Cost per LF				**$ 3,978.42**	**$/LF**

BLACK & VEATCH

Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Construction Method 4B - Microtunneling

Assumptions

1. Bore pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

84" Microtunnel (<200 ft, With Boulders)

Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
Microtunneling	200	LF	$ 4,870.18	$ 974,035.44	
Total Cost per LF				**$ 6,568.41**	**$/LF**

60" Microtunnel (<200 ft, With Boulders)

Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Microtunneling	200	LF	$ 3,476.38	$ 695,275.56	
Total Cost per LF				**$ 4,712.60**	**$/LF**

54" Microtunnel (<200 ft, With Boulders)

Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
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Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
Microtunneling	200	LF	$ 3,127.95	$ 625,590.77	
Total Cost per LF				**$ 4,248.42**	**$/LF**

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Construction Method 4B - Microtunneling

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4. Source of unit costs are based on cost histories from previous construction bids.

84" Microtunnel (200 - 2000 ft, No Boulders)

Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
Microtunneling	2,000	LF	$ 4,450.18	$ 8,900,354.38	
Total Cost per LF				**$ 4,620.00**	**$/LF**

60" Microtunnel (200 - 2000 ft, No Boulders)

Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Microtunneling	2,000	LF	$ 3,176.38	$ 6,352,755.62	
Total Cost per LF				**$ 3,300.00**	**$/LF**

54" Microtunnel (200 - 2000 ft, No Boulders)

Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$ 18.00	$ 8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
Microtunneling	2,000	LF	$ 2,857.95	$ 5,715,907.75	
Total Cost per LF				**$ 2,970.00**	**$/LF**

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Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Construction Method 4B - Microtunneling

Assumptions
1. Bore pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

84" Microtunnel (200 - 2000 ft, With Boulders)							
Launching Pit							
Excavation	864	CY	$	10.00	$	8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$	50.00	$	175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$	3.50	$	3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$	35.00	$	3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$	2.00	$	177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$	3.50	$	2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$	18.00	$	12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$	9.00	$	1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$	3.00	$	266.67	Quantity = Length X Width
					$	206,985.97	
Receiving Pit							
Excavation	432	CY	$	10.00	$	4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$	50.00	$	116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$	3.50	$	1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$	35.00	$	1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$	2.00	$	88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$	3.50	$	1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$	18.00	$	6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$	9.00	$	691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$	3.00	$	133.33	Quantity = Length X Width
					$	132,659.65	
Microtunneling	2,000	LF	$	4,870.18	$	9,740,354.38	
Total Cost per LF					**$**	**5,040.00**	**$/LF**
60" Microtunnel (200 - 2000 ft, With Boulders)							
Launching Pit							
Excavation	627	CY	$	10.00	$	6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$	50.00	$	127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$	3.50	$	2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$	35.00	$	2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$	2.00	$	177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$	3.50	$	1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$	18.00	$	9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$	9.00	$	985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$	3.00	$	266.67	Quantity = Length X Width
					$	150,718.47	
Receiving Pit							
Excavation	314	CY	$	10.00	$	3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$	50.00	$	84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$	3.50	$	1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$	35.00	$	1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$	2.00	$	88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$	3.50	$	905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$	18.00	$	4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$	9.00	$	492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$	3.00	$	133.33	Quantity = Length X Width
					$	96,525.90	
Microtunneling	2,000	LF	$	3,476.38	$	6,952,755.62	
Total Cost per LF					**$**	**3,600.00**	**$/LF**
54" Microtunnel (200 - 2000 ft, With Boulders)							
Launching Pit							
Excavation	568	CY	$	10.00	$	5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$	50.00	$	115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$	3.50	$	1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$	35.00	$	2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$	2.00	$	177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$	3.50	$	1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$	18.00	$	8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$	9.00	$	892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$	3.00	$	266.67	Quantity = Length X Width
					$	136,617.06	
Receiving Pit							
Excavation	284	CY	$	10.00	$	2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$	50.00	$	76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$	3.50	$	993.83	Quantity = Excavation
Gravel Bedding	36	CY	$	35.00	$	1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$	2.00	$	88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$	3.50	$	820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$	18.00	$	4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$	9.00	$	446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$	3.00	$	133.33	Quantity = Length X Width
					$	87,475.19	
Microtunneling	2,000	LF	$	3,127.95	$	6,255,907.75	
Total Cost per LF					**$**	**3,240.00**	**$/LF**

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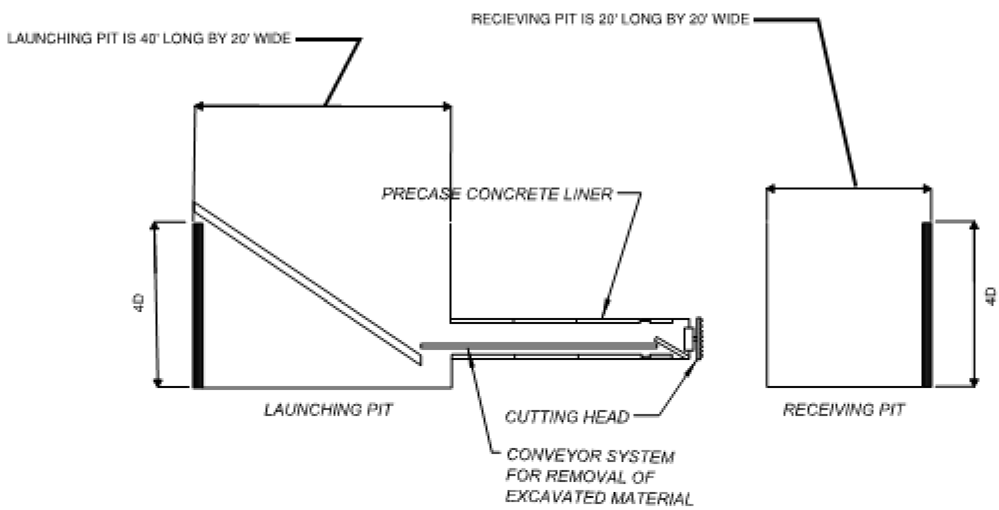
Construction Method 4C – Traditional Tunneling

Description: Traditional tunneling allows long distances between shafts but requires an excavated diameter large enough for the man operated equipment to function. The two alignment sections of significant length are also large enough in diameter for conventional tunneling to be considered. Multiple methods of traditional tunneling are available, two of which are potentially applicable to portions of the base alignment: open shielded tunnel boring machine (TBM) and earth pressure balance tunnel boring machine (EPBM). Dimensions and required clearances for an EPBM are shown in the figure below.



CONSTRUCTION METHOD 4C - TRADITIONAL

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Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Construction Method 4C - Traditional Tunneling

Assumptions

1. Bore pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	
84" EPBM (>2000 ft)					
Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
EPBM	2,000	LF	$ 3,610.18	$ 7,220,354.38	
Total Cost per LF				**$ 3,780.00**	**$/LF**
60" EPBM (>2000 ft)					
Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Microtunneling	2,000	LF	$ 2,576.38	$ 5,152,755.62	
Total Cost per LF				**$ 2,700.00**	**$/LF**
54" EPBM (>2000 ft)					
Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$ 18.00	$ 8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
EPBM	2,000	LF	$ 2,317.95	$ 4,635,907.75	
Total Cost per LF				**$ 2,430.00**	**$/LF**

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Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Construction Method 4C - Traditional Tunneling

Assumptions

1. Bore pits are assumed to be 40 feet long, 20 feet wide , and 4 Diameters Deep
2. Receiving Pits are assumed to be 20 feet long, 20 feet wide, and 4 Diameters Deep
3. Launching and receiving pits will be fully shored excavations with soldier piles and lagging
4. Source of unit costs are based on cost histories from previous construction bids.

84" Slurry TBM (>2000 ft)

Launching Pit					
Excavation	864	CY	$ 10.00	$ 8,641.98	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	3,500	SF	$ 50.00	$ 175,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	864	CY	$ 3.50	$ 3,024.69	Quantity = Excavation
Gravel Bedding	92	CY	$ 35.00	$ 3,216.76	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	710	CY	$ 3.50	$ 2,486.49	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	710	CY	$ 18.00	$ 12,787.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	154	CY	$ 9.00	$ 1,383.94	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 206,985.97	
Receiving Pit					
Excavation	432	CY	$ 10.00	$ 4,320.99	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,333	SF	$ 50.00	$ 116,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	432	CY	$ 3.50	$ 1,512.35	Quantity = Excavation
Gravel Bedding	46	CY	$ 35.00	$ 1,608.38	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	355	CY	$ 3.50	$ 1,243.25	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	355	CY	$ 18.00	$ 6,393.83	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	77	CY	$ 9.00	$ 691.97	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 132,659.65	
Slurry TBM	2,000	LF	$ 3,862.18	$ 7,724,354.38	
Total Cost per LF				**$ 4,032.00**	**$/LF**

60" Slurry TBM (>2000 ft)

Launching Pit					
Excavation	627	CY	$ 10.00	$ 6,271.60	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,540	SF	$ 50.00	$ 127,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	627	CY	$ 3.50	$ 2,195.06	Quantity = Excavation
Gravel Bedding	77	CY	$ 35.00	$ 2,692.17	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	518	CY	$ 3.50	$ 1,811.81	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	518	CY	$ 18.00	$ 9,317.88	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	110	CY	$ 9.00	$ 985.51	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 150,718.47	
Receiving Pit					
Excavation	314	CY	$ 10.00	$ 3,135.80	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,693	SF	$ 50.00	$ 84,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	314	CY	$ 3.50	$ 1,097.53	Quantity = Excavation
Gravel Bedding	38	CY	$ 35.00	$ 1,346.08	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	259	CY	$ 3.50	$ 905.90	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	259	CY	$ 18.00	$ 4,658.94	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	55	CY	$ 9.00	$ 492.75	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 96,525.90	
Slurry TBM	2,000	LF	$ 2,756.38	$ 5,512,755.62	
Total Cost per LF				**$ 2,880.00**	**$/LF**

54" Slurry TBM (>2000 ft)

Launching Pit					
Excavation	568	CY	$ 10.00	$ 5,679.01	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	2,300	SF	$ 50.00	$ 115,000.00	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	568	CY	$ 3.50	$ 1,987.65	Quantity = Excavation
Gravel Bedding	72	CY	$ 35.00	$ 2,535.57	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	89	SY	$ 2.00	$ 177.78	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	469	CY	$ 3.50	$ 1,640.59	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	469	CY	$ 18.00	$ 8,437.34	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	99	CY	$ 9.00	$ 892.44	Quantiy = Excavation - Backfill
Rough Surface Compaction	89	SY	$ 3.00	$ 266.67	Quantity = Length X Width
				$ 136,617.06	
Receiving Pit					
Excavation	284	CY	$ 10.00	$ 2,839.51	Quantity = Length X Width X 4 Dia
Launching Pit Shoring	1,533	SF	$ 50.00	$ 76,666.67	Quantity = ((Length X 4 Dia) X 2)+((Width X 4 Dia) X 2)
Load Haul Excavated Soils	284	CY	$ 3.50	$ 993.83	Quantity = Excavation
Gravel Bedding	36	CY	$ 35.00	$ 1,267.78	Quantity = (Length X Width X (0.5 Dia + 0.5')) - (Pipe Area X Length)/2
Fine Grade Compaction	44	SY	$ 2.00	$ 88.89	Quantity = Length X Width
Load/Haul Laydown Soils to Trench Areas	234	CY	$ 3.50	$ 820.30	Quantiy = Excavation - Gravel Bedding - Pipe
Backfill & Compact Native Soil	234	CY	$ 18.00	$ 4,218.67	Quantiy = Excavation - Gravel Bedding - Pipe
Off-Site Disposal Stockpile Spoils	50	CY	$ 9.00	$ 446.22	Quantiy = Excavation - Backfill
Rough Surface Compaction	44	SY	$ 3.00	$ 133.33	Quantity = Length X Width
				$ 87,475.19	
Slurry TBM	2,000	LF	$ 2,479.95	$ 4,959,907.75	
Total Cost per LF				**$ 2,592.00**	**$/LF**

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Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

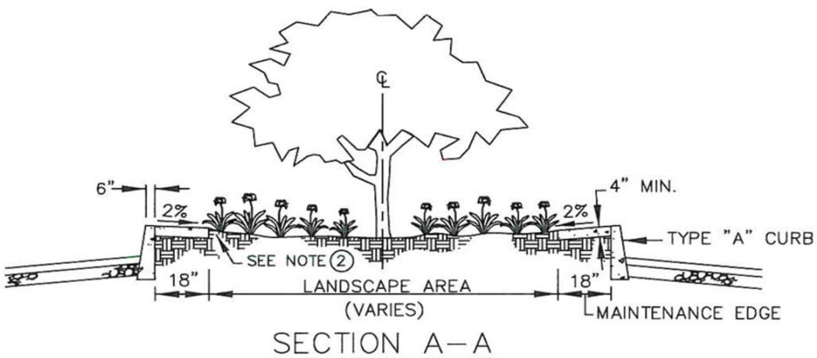
Cost Adder Major Utility Crossings

Assumptions

1 Jacking length is 30 feet.
2 Costs are all inclusive and include:
 • Demolition, sitework, earthwork, dewatering, and site restoration costs for launching and receiving pits.
 • Piping costs associated with casing, steel pipe, annular space grout, casing spacers, pipe welding, testing, cathodic protection , air valves, and blow offs.
3 Bore pits are assumed to be 40 feet long and 20 feet wide
4 Receiving Pits are assumed to be 20 feet long and 20 feet wide
5 Add diamters of utilties that qualify as major utility crossings

Item Description	Quantity	Unit	Unit Cost $	Total Cost $	
Major Utility Crossing Adder					
84"	30	LF	$ 4,888.41	146,652	Jack & Bore
60"	30	LF	$ 3,812.60	114,378	Jack & Bore
54"	30	LF	$ 3,276.42	98,292	Jack & Bore

Cost Adder Landscaped Medians (demo & replace)



Assumptions

1. Trees are spaced every 25 feet
2. Average width of median = 10 feet
3. Quantities are calucation for 1 linear foot of landscaped median.

Demolition					
Concrete Slab Removal	1	SF	$ 4.50	$ 4.50	
Concrete Curb Removal	2	LF	$ 5.00	$ 10.00	
Transportation and Disposal Fees (Recycle Concrete)	0.10	CY	$ 200.00	$ 20.58	
Tree Removal	0.04	EA	$ 850.00	$ 34.00	
Clearing and Grubbing	0.0002	AC	$ 3,700.00	$ 0.68	
subtotal				$ 69.76	
Site Restoration					
Concrete Curbs	2	LF	$ 35.00	$ 70.00	
Concrete Slabs	1	SF	$ 20.00	$ 20.00	
Trees	0.04	EA	$ 450.00	$ 18.00	
subtotal				$ 38.00	
Total				$ 107.76	per linear foot

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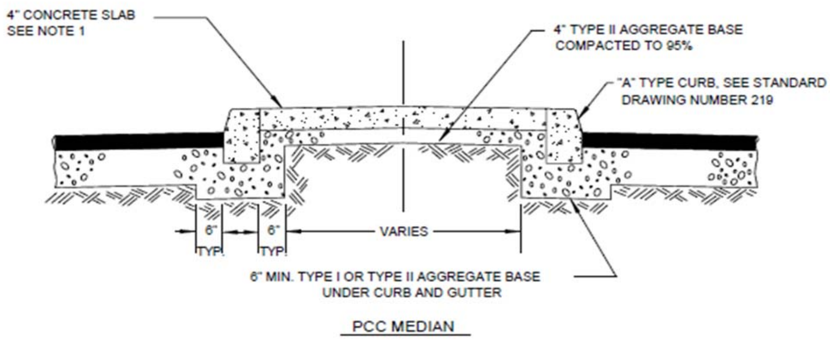
Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Cost Adder Raised Medians (demo & replace)



Assumptions
1. No trees
2. Average width of median = 8 feet
3. Quantities are calucation for 1 linear foot of landscaped median.

Demolition						
Concrete Slab Removal	2.3	SF	$	4.50	$	10.50
Concrete Curb Removal	2.0	LF	$	5.00	$	10.00
Transportation and Disposal Fees (Recycle Concrete)	0.15	CY	$	200.00	$	30.45
subtotal					$	50.95
Site Restoration						
Concrete Curb	2	LF	$	35.00	$	70.00
Concrete Slabs	2.3	SF	$	20.00	$	46.67
Type II Aggregate base		SY	$	6.00		
subtotal					$	46.67
Total					$	97.62 per linear foot

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Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Cost Adder Seismic Hazards/Fault Zones

Assumptions:
1. Fault zone is 50 ft on each side of fault
2. D/t = 80 for 100 ft beyond D/t=60 zone
3. Unit cost of steel pipe is the price difference between the thicker pipe used in the fault zone and the standard pipe used in the construction methods

Calculate Cost per Linear Foot for 84-inch Pipe

Item Description	Quantity	Unit	Unit Cost	Total Cost
Seismic Hazards/Fault Zones				
1" Thick Pipe	300	LF	$100	$30,000
Ball Joint	2	EA	$454,018	$908,036
Subtotal				$938,036

Calculate Cost per Linear Foot for 60-inch Pipe

Item Description	Quantity	Unit	Unit Cost	Total Cost
Seismic Hazards/Fault Zones				
0.75" Pipe	300	LF	$60	$18,000
Ball Joint	2	EA	$196,091	$392,182
Subtotal				$410,182

Calculate Cost per Linear Foot for 54-inch Pipe

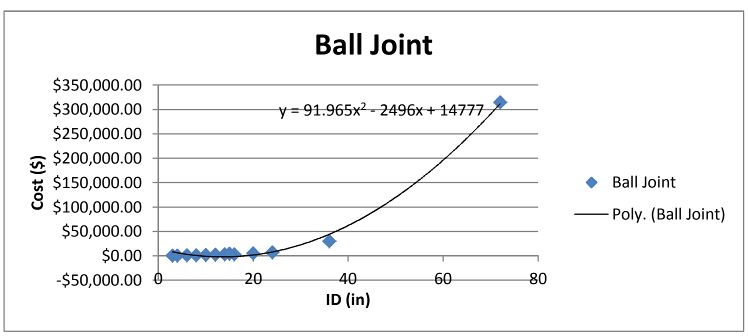
Item Description	Quantity	Unit	Unit Cost	Total Cost
Seismic Hazards/Fault Zones				
0.75" Pipe	300	LF	$60	$18,000
Ball Joint	2	EA	$148,163	$296,326
Subtotal				$314,326

Ball Joint

Create trendline to interpolate ball joint costs

References:
1. EBAA Budgetary Quotation Emails, September 27 & 28, 2016

ID (in)	Cost ($)
3	$225.00
4	$638.00
6	$1,050.00
8	$1,416.00
10	$1,937.00
12	$2,582.00
14	$2,902.00
16	$3,340.00
15	$4,211.00
20	$4,936.00
24	$7,260.00
36	$30,201.00
72	$314,252.00



Use $y=91.965x^2 - 2496x+14777$ to interpolate cost for ball joint diameters not included in the EBAA budgetary quote.

ID (in)	Cost ($)
54	$148,162.94
60	$196,091.00
84	$454,018.04

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Los Angeles, California
Metropolitan Water District of Southern California
Feasibility Level Engineering Analysis of Conveyance/Distribution System for Potential Regional Recycled Water Supply System
Probable Construction Cost

Cost Adder Dewatering

Notes
1. Microtunneling and traditional tunneling only require dewatering at the launching and receiving pits.
2. Jack & Bore requires dewatering at the pits and alongth the alignment.

Dewatering Location	Unit Cost ($/MO)	Construction Rate (ft/day)	Unit Cost ($/ft)
Roadway	$ 35,000	40	$ 28.77
SCE Easement	$ 35,000	200	$ 5.75
LAFCD Easement (River Bank)	$ 35,000	200	$ 5.75
LAFCD Easement (River Channel)	$ 50,000	200	$ 8.22
Trenchless			
Pits (Jack & Bore)	$ 50,000	60	$ 27.40
Alignment (Jack & Bore)	$ 35,000	60	$ 19.18
		subtotal =	$ 46.58
Pits (Microtunnel)	$ 50,000	50	$ 32.88
Pits (Traditional)	$ 50,000	40	$ 41.10

Cost Adder Permiable Soils

Notes:
1. Where permiable soils such as sand are present the cost of dewatering will be increased by 50%

Dewatering Location	Unit Cost ($/MO)	Construction Rate (ft/day)	Unit Cost ($/ft)
Roadway	$ 17,500	40	$ 14.38
SCE Easement	$ 17,500	200	$ 2.88
LAFCD Easement (River Bank)	$ 17,500	200	$ 2.88
LAFCD Easement (River Channel)	$ 25,000	200	$ 4.11
Trenchless			
Pits (Jack & Bore)	$ 25,000	60	$ 13.70
Alignment (Jack & Bore)	$ 17,500	60	$ 9.59
		subtotal =	$ 23.29
Pits (Microtunnel)	$ 25,000	50	$ 16.44
Pits (Traditional)	$ 25,000	40	$ 20.55

APPENDIX F:

Pump Station Planning Level Construction Cost Analysis for the Potential Regional Recycled Water Program

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Memorandum

To: *Matt Thomas and Andy Stanton, Black & Veatch*

From: *Chris Ott and Bill Brick, CDM Smith*

Date: *October 12, 2016*

Subject: *Pump Station Planning Level Construction Cost Analysis*
Metropolitan Water District Potential Regional Recycled Water Supply Program

The initial planning efforts for the Metropolitan Water District of Southern California (Metropolitan) Potential Regional Recycled Water Supply Program (RRWSP) (project) requires the development of planning-level construction cost data for the three new pump stations that are currently being considered. This memo summarizes the current design criteria of each pump station, the approach for developing the cost data, and the results of the analysis.

Please note that the project is in the very early stages of planning, so the size, location, and features of the pump station facilities are still being developed. The pump station facilities as described herein are reflective of a collaborative effort of Metropolitan and the B&V/CDM Smith team; although they remain subject to further analysis and refinement, it is anticipated that the facilities as described will be largely in keeping with the pump station concepts that will be presented in the final RRWSP Feasibility Study to be completed later this year.

Background

Metropolitan has developed a "Base Case" conveyance system for its RRWSP which includes three pump stations: PS1, PS2, and PS3. A summary of the pumping and storage configurations for these pump stations, as currently envisioned by Metropolitan, is presented in Table 1.

Table 1 Summary of Pump Station Facilities

Pump Station Facility	Total Pumping Capacity (mgd)	Total Pumping Capacity (gpm)	Firm Storage Capacity (MG)
PS1	165	114,600	2.0
PS2	140	97,200	2.0
PS3	80	55,600	1.5

Notes:
mgd: million gallons per day
gpm: gallons per minute
MG: million gallons

The Base Case design assumes a general pump station configuration similar to that developed in the April 2016 Feasibility Assessment with certain modifications as discussed at the pump station design kickoff meeting on June 15, 2016. Subsequent meetings were held on July 18 and 19, 2016, in which further changes were made to the configuration of the stations; these changes are described in the sections that follow.

Design Criteria

At PS1 and PS2, it is anticipated that there will be two discharge pipelines conveying flow to two distinct locations and pressure areas; therefore, these pump stations are anticipated to have pumps dedicated to each discharge pipeline. Specifically, PS1 will be capable of pumping 150 mgd to PS2 and 15 mgd to injection wells located in the area of Torrance to inject water into the West Coast Basin. PS2 will be capable of delivering 60 mgd to recharge basins located in Anaheim with simultaneous delivery of 80 mgd to PS3. PS3 is assumed to consist of only one discharge pipeline and corresponding pumps.

A summary of each pump station's key design criteria is as follows:

- Pump Station 1 (PS1):
  - Includes a 2 mg, above grade, circular, pre-stressed concrete storage tank,
  - Includes vertical turbine can pumps located outside,
  - Includes surge mitigation facilities,
  - Includes a building for electrical and controls equipment, compressors, storage, etc.
- Pump Station 2 (PS2):
  - Includes a 2 mg, below grade, circular, pre-stressed concrete storage tank,
  - Includes vertical turbine can pumps,
  - Includes surge mitigation facilities,
  - Includes a building sized to contain all vertical turbine pumps, electrical and controls equipment, compressors, HVAC storage, etc.
- Pump Station 3 (PS3):
  - Includes a 1.5 mg, above grade, circular, pre-stressed concrete storage tank, located adjacent to the pump station (rather than beneath the pump station as per earlier layout configurations),
  - Includes vertical turbine can pumps,
  - Includes surge mitigation facilities,
  - Includes a building sized to contain all vertical turbine pumps, electrical and controls equipment, compressors, HVAC storage, etc.

Appendix A contains a marked-up preliminary plan and section of the proposed general configuration for the pump stations. Additional detailed preliminary drawings are being developed as a part of the project.

Pump Configuration

The number and size of pumps was updated to reflect the Base Case design. The updated preliminary pump sizing is shown in Table 2 below.

Table 2 Preliminary Pump Sizing

Pump Station	General Location	Preliminary Firm Capacity	Pumps To
PS-1	JWPCP, Carson	Set A: 15 mgd at 180 ft (2-350 HP duty pumps + 1 standby) Set B: 150 mgd at 100 ft (4-900 HP duty pumps + 1 standby)	Set A: West Basin Set B: PS-2 Forebay
PS-2	Adjacent to San Gabriel River near Carson Street	Set A: 60 mgd at 340 ft (3-1750 HP duty pumps + 1 standby) Set B: 80 mgd at 340 ft (3-2500 HP duty pumps + 1 standby)	Set A: Orange County Spreading Basin Set B: PS-3 Forebay
PS-3	Near Whittier Narrows, Pico Rivera	Set A: 80 mgd at 370 ft (3-2500 HP duty pumps + 1 standby)	Santa Fe Spreading Basin

Pump Station Storage

The wet well designs for each pump station were revised to reflect the appropriate storage and visual impact mitigations anticipated for the three pump station areas. At all three pump stations, the storage volume (whether buried or above ground) was also relocated to a position adjacent to the pumps/pump station; this layout differs from that contained in the April 2016 Feasibility Assessment which shows the wet well located directly beneath and part of the pump station. This separation of the storage volume from the pump station allows for the storage to be located either above grade or partially buried (where desired), resulting in an anticipated reduction of the potential depths and associated excavation costs of a combined storage and pumping facility arrangement.

There are several design considerations when determining the optimal storage for a water transmission system such as the RRWSP. Table 3 summarizes these design considerations and how they apply to this project.

Table 3 Storage Design Considerations

Design Consideration	Storage Function	Applies to RRWSP?	Remarks
Diurnal Equalization	Necessary if there is a need to smooth the diurnal flow from the treatment plant so the conveyance system can pump a steady flow and not be sized for peak periods.	No	The advanced treatment plant is expected to operate at a fairly constant rate (i.e. equalization occurs upstream at the advanced treatment plant), so this storage function is not required.
Off-Peak Power Operation	Necessary if there is a desire to only operate the conveyance system during off-peak power periods.	No	The advanced treatment plant is expected to operate continuously at a near constant flow, which would require a prohibitively large storage reservoir to avoid off-peak pumping. Thus, this storage function is not being considered. If pumps at JWPCP are shut-down during off-peak periods, or for O&M, the treatment plant flows can be diverted to the existing plant outfall.
Continuous Delivery	Necessary if there is a need for the system to supply demands/customers even if the pump stations are shut down.	No	The only customers planned on the system are injection wells and spreading basins, so the temporary disruption of flow will not have critical impacts.
Pump Cycling	If constant speed pumps are used and incoming flow does not match pumping rate enough storage must be provided to limit pump starts and stops.	No	All pumps on the RRWSP will be equipped with variable frequency drives to match flow rates with adjacent stations.
Risk Management	If a pump station fails to shut off due to upstream low reservoir level or downstream high reservoir level, pumps could be damaged or tank overflow could damage adjacent property or the environment.	Limited	The risk of such a failure can be reduced by implementation of robust control systems (as noted elsewhere in this document). If the control system fails, the facility can be located in an area that can safely convey an overflow to a drainage way.
Surge	Different surge control approaches require different amounts of storage to supply or accept water during a surge event.	Limited	The concept of using pressurized hydro-pneumatic tanks on the discharge side of pump stations means most of the volume is contained in pressure tanks. Currently the most volume for surge tanks is expected at PS1, with a total volume of less than 0.5 MG; therefore, this volume would need to be available in the downstream storage facility.
Control	Storage between pump stations provides a hydraulic break and facilitates controlled ramping up and down of pumps	Yes	The RRWSP includes multiple pumps stations all with multiple pumping units as well as long transmission mains. Thus, storage facilities are necessary for operational control.
Balancing	Provides storage for short duration, low-magnitude imbalances between upstream and downstream pump stations.	Yes	Coordinated and synchronized controls between stations will limit the magnitude and duration of the imbalances.

As noted in Table 3, the storage sizing approach for the RRWSP is controlled based on the storage necessary for control and balancing. This approach requires sufficient storage for short duration differences in inlet and outlet flows and will require that the project develop a control system that provides close coordination and synchronization between the pumping facilities and the treatment plant. Appendix B contains additional pump station control strategy concepts-related presentation materials from the pump station workshop with MWD on July 27, 2016.

In general, it is assumed that the system will be controlled such that ramping times for controlled starting and stopping of the facilities will not exceed 20 minutes and that the flow imbalance between storage inlet and outlet flows will not exceed the capacity of the largest pump upstream or downstream of the facility. Table 4 shows the available storage times for these flows, and peak station flows are also included for reference. The storage sizing approach presented herein is not intended to provide significant storage time for a major flow imbalance, which would only occur if the control system malfunctions; to mitigate this case, an overflow path will need to be provided to the nearest drainage way.

Table 4 Storage Times

Station	PS-1	PS-2	PS-3
Working Storage Volume (mg)	2.0	2.0	1.5
Available Volume with Mid Point Operation Level (mg)	1.0	1.0	0.75
Storage Time (min) with 7.5 mgd flow imbalance	192	192	144
Storage Time (min) with 20 mgd flow imbalance	72	72	54
Storage Time (min) with 26.7 mgd flow imbalance	54	54	40
Storage Time (min) with 37.5 mgd flow imbalance	38	38	29
Storage Time (min) with 60 mgd flow imbalance	24	24	18
Storage Time (min) with 80 mgd flow imbalance	18	18	14
Storage Time (min) with 140 mgd flow imbalance	10	10	NA
Storage Time (min) with 150 mgd flow imbalance	10	10	NA

Note: Highlighted rows above reflect the unlikely condition that a pump station is operated at or near full capacity without an upstream or downstream pump station online.
NA = Not applicable

The storage volume sizing reflects the design intent that each storage structure will typically operate approximately half-full such that 1) stored water is available for temporary periods in which a downstream pump station may be operating at a flowrate slightly higher than an upstream pump station, and 2) additional storage space is available for temporary periods in which an upstream pump station may be operating at a flowrate slightly higher than a downstream pump station.

The primary control system is anticipated to include coordinated flow set points for each station based on the flow being generated by the treatment plant. The stations will operate with the necessary number of pumps and speeds to achieve the flow set point at the most efficient point, and will modulate to maintain the set point as necessary. The pump speed will also be trimmed based on the level in the upstream storage tank to further stabilize the system. A number of features will be incorporated to protect against tank overflows and pumps running dry. These features may include: redundant level instruments; hardwired shutdown interlocks for high and low tank levels, low and high pressure switches, peer-to-peer 'heartbeat' routines between stations that will trigger controlled shut-downs of all stations if communications are lost, and controlled shut-downs of adjacent stations if one station fails.

Surge Mitigation

Facilities were added to reflect the need for surge mitigation equipment at each site. A detailed sizing of the surge system is not possible at this time, so initial tank capacities were estimated using the methodology documented by Stephenson (2002). The estimated tank sizes are shown in Table 5. It is assumed surge tanks and piping will be installed exposed, above grade, on concrete pads.

Table 5 Preliminary Surge Tank Size Estimates

Pump Station Facility	Surge Tank Size	Approximate Pad Size
PS1	8 tanks at 8,000 cu-ft	270-ft x 100-ft
PS2	4 tanks at 5,500 cu-ft	2 at 80-ft x 60-ft
PS3	2 tanks at 3,200 cu-ft	75-ft x 100-ft

Pump Station Buildings

At PS-1 the building was revised to provide room for the following functions: electrical equipment (VFD's, MCC's, PLC's, etc.) administration (control room, communications room, restroom), and mechanical equipment (miscellaneous storage, air compressors).

At PS-2 and PS-3, the layout was revised to include a building for the items noted above as well as a building over the pumping and piping equipment.

The overall building dimensions assumed reflect the increased clearance space associated with medium voltage electrical gear. The buildings at all locations are assumed to consist of steel structural members with metal roof system and masonry block walls with architectural façade. At least one rollup door with bridge crane is included to facilitate movement of heavy loads. Backup power at all locations is limited to a low voltage generator or uninterruptible power supply (UPS) system for the continued operation of critical instrumentation and controls; it is not intended to be sized to operate the pumps.

Feasibility-level Construction Cost Analysis

The feasibility-level costs in this memo were developed by adjusting Opinion of Probable Construction Costs (OPCC) developed for comparable pump station projects, including the OPCCs in the April 2016 Feasibility Assessment, and reservoir projects to reflect the current (July 2016) Engineering News Record Construction Cost Index (ENRCCI) value for Los Angeles of 11,155.03. If the historic ENRCCI for an OPCC was greater than the July 2016 value, the unit price from the historic OPCC was retained for conservatism.

Based on the design criteria and approach discussed above, Table 6 summarizes the construction cost analysis for each pump station facility. Detailed cost breakdowns are attached in Appendix C.

The detailed cost breakdowns include the following construction cost-related prorates:

- General Conditions = 3%
- Design Contingency = 0% (a contingency is being applied by the MWD Program Management team to the combination of project elements)
- Escalation = 0%
- Mobilization = 2%
- Permits = 0.25%
- Bonds and Insurance = 1.5%
- Overhead and Profit = 10%

Table 6 Pump Station Facility Construction Cost Summary

Pump Station Facility	Total Cost ($M)
PS1	$27.0M
PS2	$28.3M
PS3	$17.6M

If the historically applied 25% Design Contingency were included in the costs above, the values in Table 6 would be shown to have increased from those presented by AECOM in the Feasibility Assessment primarily due to the increased storage volume and inclusion of surge mitigation equipment. The costs at all three pump stations also include the costs of a building, which will be larger at PS2 and PS3 in order to enclose all of the pumps; the cost of the buildings partially offsets the reduction in cost developed by bringing the wet well/storage above grade and reducing its volume at each pump station.

The data presented herein is intended to provide input to the overall planning and cost development process. A more detailed Class 4 OPCC will be produced once initial designs are further developed.

Appendices

Appendix A – Typical Pump Station Layout
Appendix B – Pump Station Control Strategy Concepts
Appendix C – Detailed Cost Data

References

Metropolitan Water District; Potential Regional Recycled Water Supply Program, Conveyance System Feasibility Assessment; April, 2016.

Stephenson, D; Simple Guide for Design of Air Vessels for Water Hammer Protection of Pumping Lines; ASCE Journal of Hydraulic Engineering; August, 2002.

cc: Ernie Sturtz, CDM Smith
Arthur Goh, CDM Smith
Mike Lin, CDM Smith

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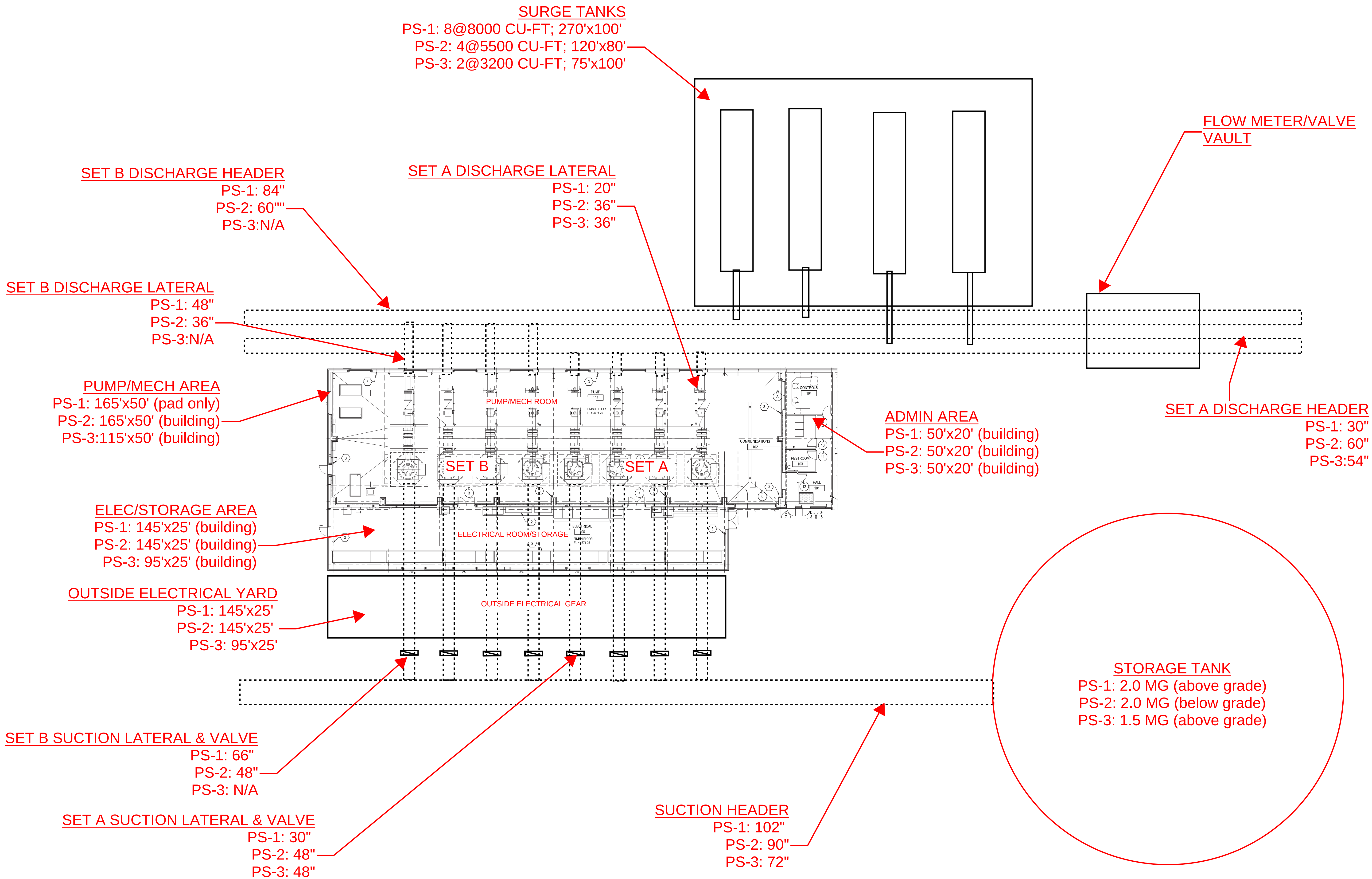
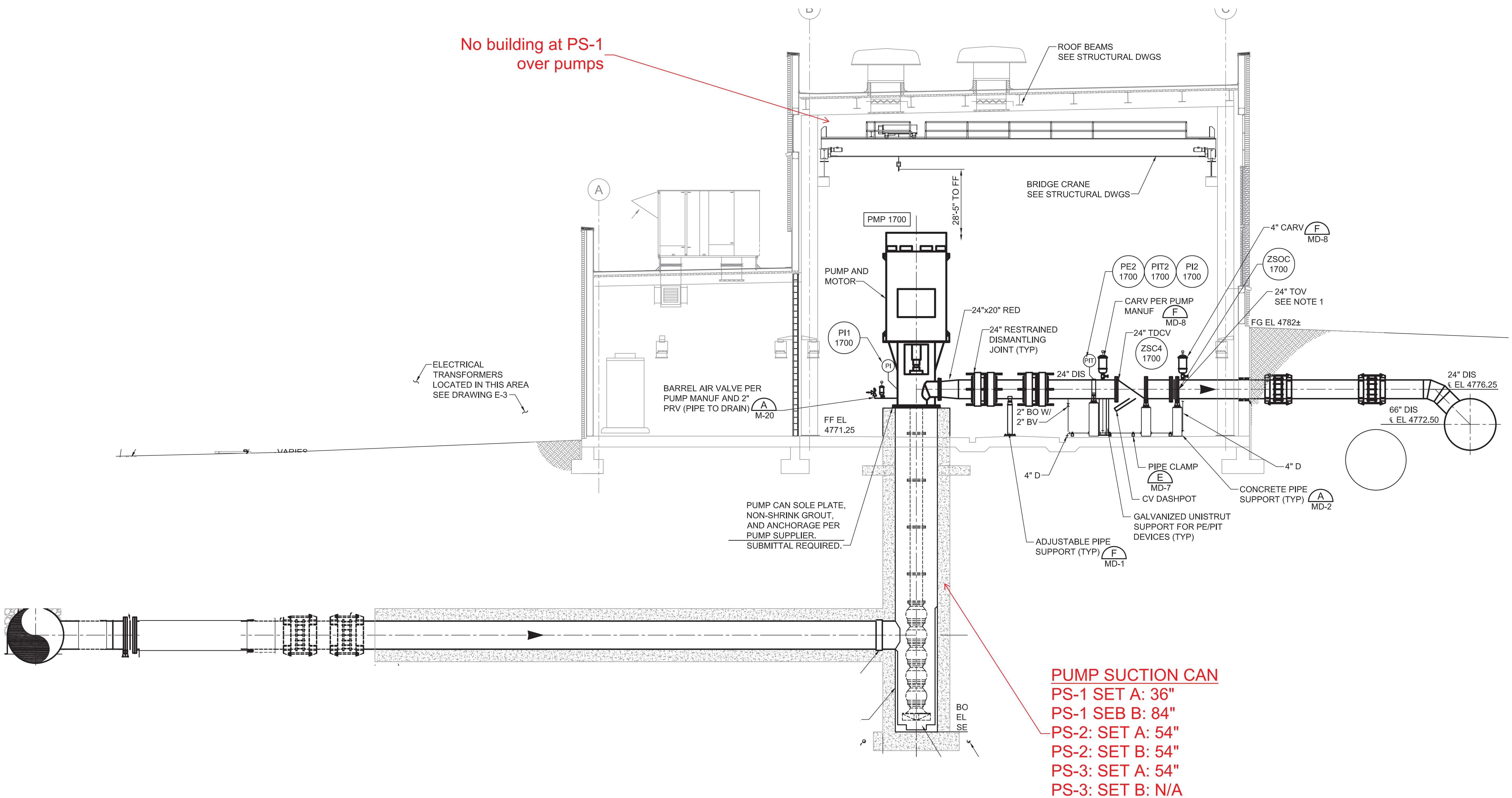
Appendix A – Typical Pump Station Layout



Appendix A - Preliminary Typical Plan



Appendix A - Preliminary Typical Section

Appendix B – Pump Station Control Strategy Concepts

CDM Smith

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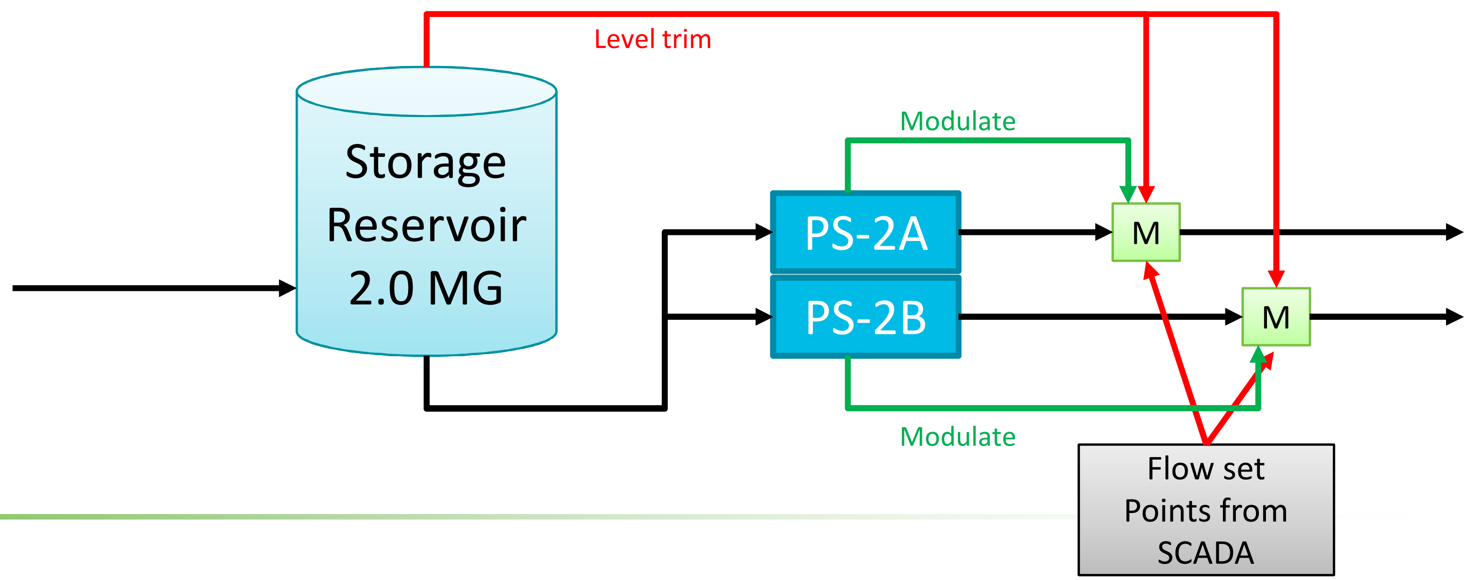
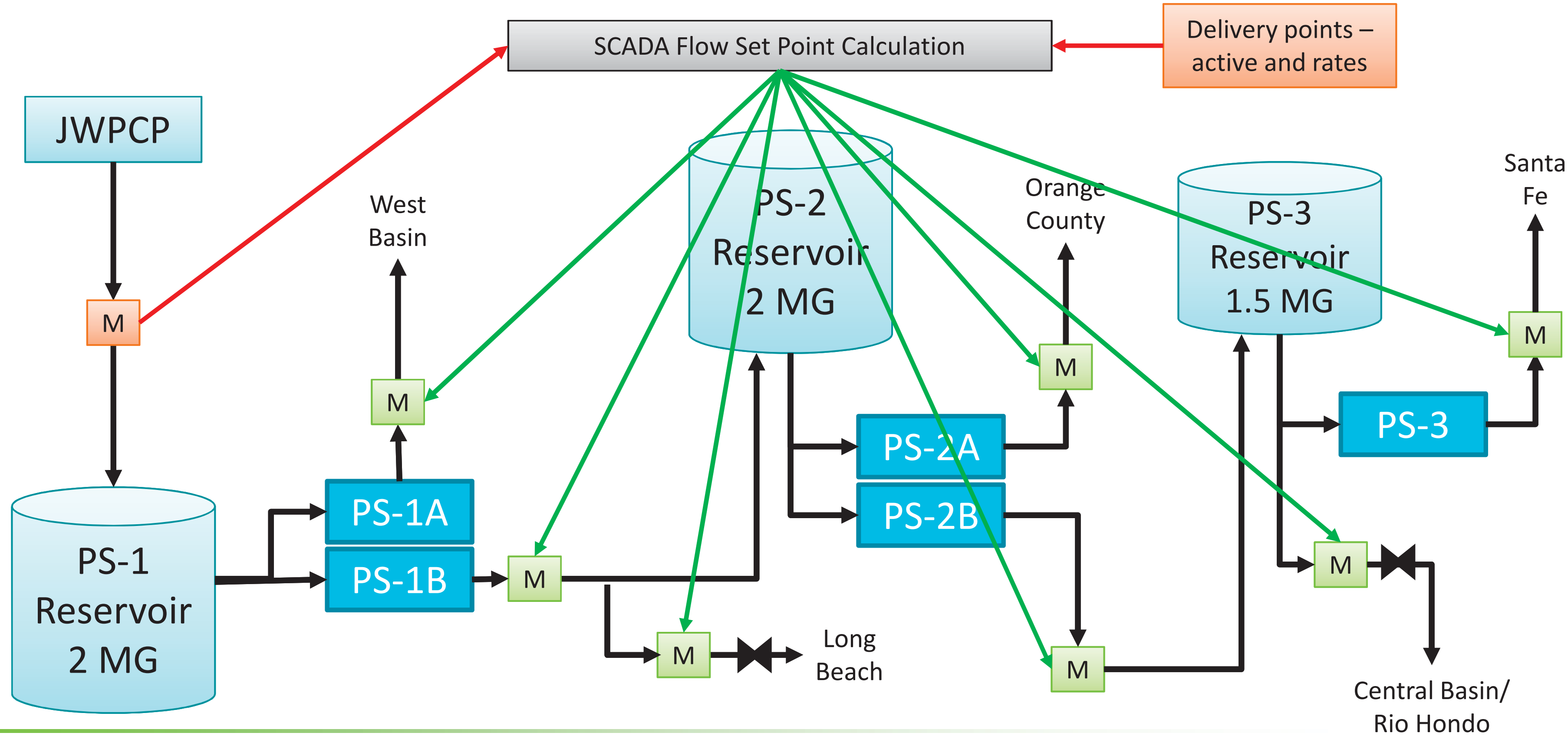
Control Strategy Concepts

Control Strategy Concepts - General

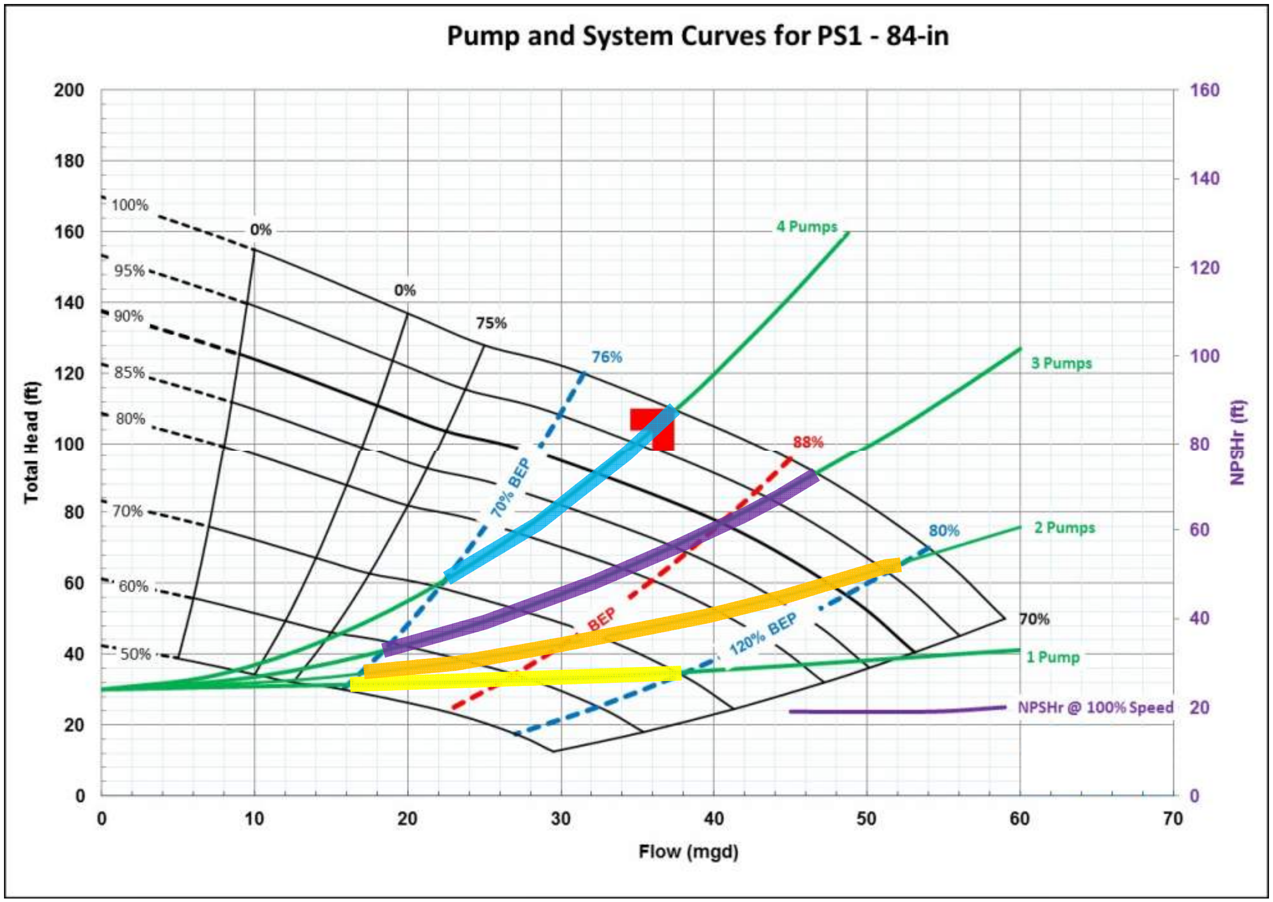
- Flow set point calculated for each station so that incoming flow is equal to outgoing flow
- Trim flow set point based on tank level
- Station control coordinated and synchronized



Control Strategy Concepts – Overall System

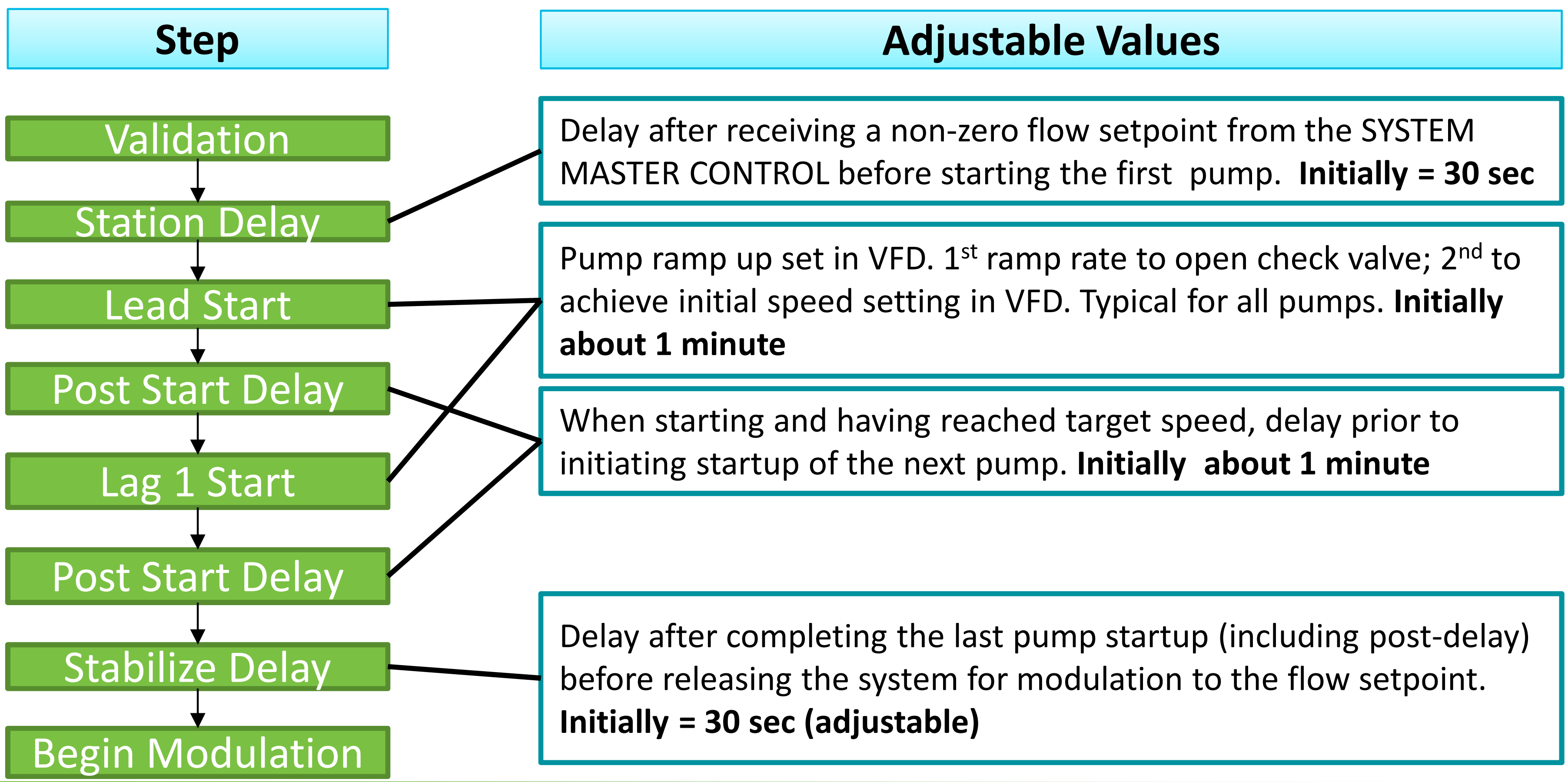


Control Strategy Concepts – Pump Range/VFD



Number of pumps	Left POR (mgd)	BEP (mgd)	Right POR (mgd)
1	16	26	34
2	34	60	104
3	54	120	138
4	92	180	150

Control Strategy Concepts – Starting Sequence



Control Strategy Concepts – Controlled Shutdown

Step

- End Modulation
- Station Delay
- Lag 1 Stop
- Post Stop Delay
- Lead Stop
- Station Off

Adjustable Values

- Station Delay: Delay after receiving a zero flow setpoint from the SYSTEM MASTER CONTROL before initiating shutdown of the first pump. **Initially =30 sec**
- Lag 1 Stop, Lead Stop: Pump ramp down set in VFD. Typical for all pumps. **Initially about 1 minute**
- Post Stop Delay: When stopping and having completed pump shutdown, delay prior to initiating shutdown of the next pump. . **Initially = 30 sec**

Appendix C – Detailed Cost Data

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PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 1**	CHECKED BY:	**WB**
	WWTP LOCATION	ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.10	DEMOLITION				**42,200**
2.20	SITE WORK				**53,500**
2.30	EARTHWORK				**606,250**
3.00	CONCRETE				**3,638,578**
3.50	BUILDING				**693,750**
2.60	SITE RESTORATION				**105,000**
4.00	MECHANICAL				**11,700,000**
5.00	ELECTRICAL				**2,175,000**
6.00	STORAGE TANK				**4,000,000**
	SUBTOTAL				**$ 23,014,278**
	PRORATES				
	GENERAL CONDITIONS	**3.00%**			**690,428**
	DESIGN CONTINGENCY	**0.00%**			**0**
	ESCALATION	**0.00%**			**0**
	MOBILIZATION	**2.00%**			**460,286**
	PERMITS	**0.25%**			**57,536**
	DIRECT COST & PRORATES SUBTOTAL				**$ 24,222,527**
	CONTRACTOR BURDENS				
	BONDS & INSURANCE	**1.50%**			**363,338**
	OVERHEAD & PROFIT	**10.00%**			**2,422,253**
	TOTAL				**$ 27,008,118**
2.10	**DEMOLITION**				
	TREE REMOVAL	-	EA	850.00	-
	SELECTIVE CLEARING	4,000	SY	1.50	**6,000**
	SAWCUTTING	-	LF	2.00	-
	ASPHALT PAVING REMOVAL - ALLOWANCE	3,000	SF	0.50	**1,500**
	CONCRETE SLAB REMOVAL - ALLOWANCE	200	SF	5.00	**1,000**
	CONCRETE CURB & GUTTER REMOVAL - ALLOWANCE	200	LF	5.00	**1,000**
	CONCRETE SIDEWALK REMOVAL - ALLOWANCE	200	SF	2.00	**400**
	TRANSPORTATION & DISPOSAL FEES Vegetation (NON-HAZ)	1	LS	500.00	**500**
	TRANSPORTATION & DISPOSAL RECYCLE CONCRETE (NON-HAZ)	3	LD	375.00	**1,125**
	GENERAL SITE WORK				
	STORM WATER POLLUTION PREVENTION PLAN	1	LS	15,000.00	**15,000**
	HEALTH & SAFETY PLAN	1	LS	2,500.00	**2,500**
	TRAFFIC CONTROLS				
	TRAFFIC CONTROLS - ALLOWANCE	1	LS	5,000.00	**5,000**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 1**	CHECKED BY:	**WB**
	WWTP LOCATION	ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
	EROSION CONTROLS				
	FABRIC SILT FENCE - INSTALLATION & MAINTENANCE	2,500	LF	2.75	**6,875**
	HAY ROLLS	400	LF	3.25	**1,300**
	SUBTOTAL 2.10				**$ 42,200**
2.20	**SITE WORK**				
	MAINTAIN ROADWAYS - SWEEPER & WATER TRUCK	0.5	MO	32,000.00	**16,000**
	TEMPORARY FENCING	2,500	LF	5.00	**12,500**
	DEWATERING - (NOT REQUIRED)				
	UTILITIES - PROJECT & REPAIR EXISTING	1	LS	5,000.00	**5,000**
	SURVEYS & LAYOUT	1	WK	15,000.00	**15,000**
	MISC. GRADING MAINTAIN ACCESS ROAD (ALLOWANCE)	1	LS	5,000.00	**5,000**
	SUBTOTAL 2.20				**$ 53,500**
2.30	**EARTHWORK**				
	EARTHWORK				
	EXCAVATION	16,000	CY	10.00	**160,000**
	SHORING (NOT USED. 1/1 BANKED EXCAVATION)	-	SF	-	**-**
	LOAD/HAUL EXCAVATED SOILS TO LAYDOWN AREA	16,000	CY	2.00	**32,000**
	GRAVEL BEDDING SUBASE - 2'	6,000	TN	42.50	**255,000**
	FINE GRADING & COMPACTION	25,000	SF	0.20	**5,000**
	DUST CONTROL - EARTHWORK	0.5	MO	30,000.00	**15,000**
	LOAD/HAUL LAYDOWN SOILS TO JS	5,333	CY	2.00	**10,667**
	BACKFILL & COMPACT SOIL	5,333	CY	15.00	**80,000**
	OFF-SITE DISPOSAL STOCKPILE SPOILS	5,333	CY	7.00	**37,333**
	ROUGH SURFACE COMPACTION	4,500	SY	2.50	**11,250**
	SUBTOTAL 2.30				**$ 606,250**
3.00	**CONCRETE**				
	PUMP CANS - 7' DIA X 30'D X 8 EA	350	CY	700.00	**245,000**
	MATT SLAB 3'	4,450	CY	700.00	**3,115,000**
	EXTERIOR WALLS - 2'	284	CY	850.00	**241,778**
	INTERIOR WALLS - 1'	0	CY	850.00	**0**
	DECK - 2'	0	CY	1,250.00	**0**
	EQUIPMENT PADS - SLAB 8 EA	16	CY	600.00	**9,600**
	EQUIPMENT PADS - DECK - 8 EA	45	CY	600.00	**27,200**
	SUBTOTAL 3.00				**$ 3,638,578**
3.50	BUILDING	4,625	SF	150.00	**693,750**
	SUBTOTAL 3.50				**$ 693,750**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 1**	CHECKED BY:	**WB**
	WWTP LOCATION	ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.60	SITE RESTORATION				
	ASPHALT PAVING 4" THICK OVER 8' BASE	1,000	SY	44.00	**44,000**
	CONCRETE SLABS - ALLOWANCE	1,000	SF	20.00	**20,000**
	CONCRETE CURB & GUTTERS - ALLOWANCE	200	LF	50.00	**10,000**
	GENERAL SITE RESTORATION	500	SF	10.00	**5,000**
	LANDSCAPE RESTORATION (BY OTHERS)	50,000	SF	0.50	**25,000**
	FINAL SITE CLEANUP	2	AC	500.00	**1,000**
	SUBTOTAL 2.60				**$ 105,000**
4.00	MECHANICAL				
	VERTICAL PUMPS & MOTORS 900 HP	5	EA	500,000.00	**2,500,000**
	SUCTION MAINFOLD - 102"	1	EA	500,000.00	**500,000**
	SUCTION LATERALS - 66"	5	EA	120,000.00	**600,000**
	DISCHARGE LATERALS - 48"	5	SETS	100,000.00	**500,000**
	DISCHARGE MANIFOLD 84"	1	EA	300,000.00	**300,000**
	SUCTION LATERALS - 30"	3	EA	50,000.00	**150,000**
	DISCHARGE LATERALS - 20"	3	SETS	50,000.00	**150,000**
	DISCHARGE MANIFOLD - 30"	1	EA	100,000.00	**100,000**
	HVAC SYSTEM	1	LS	750,000.00	**750,000**
	MISC. MECHANICAL	1	LS	50,000.00	**50,000**
	PLUMBING - ALLOWANCE	1	LS	100,000.00	**100,000**
	SURGE TANKS (8000 CU-FT) AND COMPRESSORS	8	EA	750,000.00	**6,000,000**
	SUBTOTAL 4.00				**$ 11,700,000**
5.00	ELECTRICAL				
	ELECTRICAL - ALLOWANCE	1	LS	1,500,000.00	**1,500,000**
	EMERGENCY GENERATORS	1	LS	500,000.00	**500,000**
	I & C - ALLOWANCE	1	LS	175,000.00	**175,000**
	SUBTOTAL 5.00				**$ 2,175,000**
6.00	STORAGE TANK	2,000,000	GAL	2.00	**4,000,000**
	SUBTOTAL 6.00				**$ 4,000,000**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 2**	CHECKED BY:	**WB**
		ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.10	DEMOLITION				**35,250**
2.20	SITE WORK				**51,000**
2.30	EARTHWORK				**776,250**
3.00	CONCRETE				**2,207,874**
3.50	BUILDING				**1,931,250**
2.60	SITE RESTORATION				**107,500**
4.00	MECHANICAL				**12,830,000**
5.00	ELECTRICAL				**2,175,000**
6.00	STORAGE TANK				**4,000,000**
	SUBTOTAL				**$ 24,114,124**
	PRORATES				
	GENERAL CONDITIONS	**3.00%**			**723,424**
	DESIGN CONTINGENCY	**0.00%**			**0**
	ESCALATION	**0.00%**			**0**
	MOBILIZATION	**2.00%**			**482,282**
	PERMITS	**0.25%**			**60,285**
	DIRECT COST & PRORATES SUBTOTAL				**$ 25,380,116**
	CONTRACTOR BURDENS				
	BONDS & INSURANCE	**1.50%**			**380,702**
	OVERHEAD & PROFIT	**10.00%**			**2,538,012**
	TOTAL				**$ 28,298,829**
2.10	**DEMOLITION**				
	TREE REMOVAL	-	EA	850.00	-
	SELECTIVE CLEARING	2,777	SY	1.50	**4,166**
	SAWCUTTING	-	LF	2.00	-
	ASPHALT PAVING REMOVAL - ALLOWANCE	2,500	SF	0.50	**1,250**
	CONCRETE SLAB REMOVAL - ALLOWANCE	63	SF	5.00	**313**
	CONCRETE CURB & GUTTER REMOVAL - ALLOWANCE	75	LF	5.00	**375**
	CONCRETE SIDEWALK REMOVAL - ALLOWANCE	83	SF	2.00	**165**
	TRANSPORTATION & DISPOSAL FEES Vegetation (NON-HAZ)	1	LS	500.00	**500**
	TRANSPORTATION & DISPOSAL RECYCLE CONCRETE (NON-HAZ)	3	LD	375.00	**1,125**
	GENERAL SITE WORK				
	STORM WATER POLLUTION PREVENTION PLAN	1	LS	15,000.00	**15,000**
	HEALTH & SAFETY PLAN	1	LS	2,500.00	**2,500**
	TRAFFIC CONTROLS				
	TRAFFIC CONTROLS - ALLOWANCE	1	LS	5,000.00	**5,000**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 2**	CHECKED BY:	**WB**
		ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
	EROSION CONTROLS				
	FABRIC SILT FENCE - INSTALLATION & MAINTENANCE	1,500	LF	2.75	**4,125**
	HAY ROLLS	225	LF	3.25	**731**
	SUBTOTAL 2.10				**$ 35,250**
2.20	**SITE WORK**				
	MAINTAIN ROADWAYS - SWEEPER & WATER TRUCK	0.5	MO	32,000.00	**16,000**
	TEMPORARY FENCING	2,000	LF	5.00	**10,000**
	DEWATERING - (NOT REQUIRED)				
	UTILITIES - PROJECT & REPAIR EXISTING	1	LS	5,000.00	**5,000**
	SURVEYS & LAYOUT	1	WK	15,000.00	**15,000**
	MISC. GRADING MAINTAIN ACCESS ROAD (ALLOWANCE)	1	LS	5,000.00	**5,000**
	SUBTOTAL 2.20				**$ 51,000**
2.30	**EARTHWORK**				
	EARTHWORK				
	EXCAVATION	24,000	CY	10.00	**240,000**
	SHORING (NOT USED. 1/1 BANKED EXCAVATION)	-	SF	-	**-**
	LOAD/HAUL EXCAVATED SOILS TO LAYDOWN AREA	24,000	CY	2.00	**48,000**
	GRAVEL BEDDING SUBASE - 2'	6,000	TN	42.50	**255,000**
	FINE GRADING & COMPACTION	25,000	SF	0.20	**5,000**
	DUST CONTROL - EARTHWORK	1	MO	30,000.00	**30,000**
	LOAD/HAUL LAYDOWN SOILS TO JS	8,000	CY	2.00	**16,000**
	BACKFILL & COMPACT SOIL	8,000	CY	15.00	**120,000**
	OFF-SITE DISPOSAL STOCKPILE SPOILS	8,000	CY	7.00	**56,000**
	ROUGH SURFACE COMPACTION	2,500	SY	2.50	**6,250**
	SUBTOTAL 2.30				**$ 776,250**
3.00	**CONCRETE**				
	PUMP CANS - 4.5' DIA X 30'D X 8 EA	150	CY	700.00	**105,000**
	MATT SLAB 3'	2,500	CY	700.00	**1,750,000**
	EXTERIOR WALLS - 2'	308	CY	850.00	**261,926**
	INTERIOR WALLS - 1'	64	CY	850.00	**54,148**
	SECONDARY DECK - 2'	0	CY	1,250.00	**0**
	ROOF DECK - 2'	0	CY	1,250.00	**0**
	EQUIPMENT PADS - SLAB 8 EA	16	CY	600.00	**9,600**
	EQUIPMENT PADS - DECK - 8 EA	45	CY	600.00	**27,200**
	SUBTOTAL 3.00				**$ 2,207,874**
3.50	BUILDING	12,875	SF	150.00	**1,931,250**
	SUBTOTAL 3.50				**$ 1,931,250**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 2**	CHECKED BY:	**WB**
		ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.60	SITE RESTORATION				
	ASPHALT PAVING 4" THICK OVER 8' BASE	1,000	SY	44.00	**44,000**
	CONCRETE SLABS - ALLOWANCE	1,000	SF	20.00	**20,000**
	CONCRETE CURB & GUTTERS - ALLOWANCE	250	LF	50.00	**12,500**
	GENERAL SITE RESTORATION	500	SF	10.00	**5,000**
	LANDSCAPE RESTORATION (BY OTHERS)	50,000	SF	0.50	**25,000**
	FINAL SITE CLEANUP	2	AC	500.00	**1,000**
	SUBTOTAL 2.60				**$ 107,500**
4.00	MECHANICAL				
	VERTICAL PUMPS & MOTORS 1750 HP	4	EA	700,000.00	**2,800,000**
	SUCTION HEADER - 90"	1	EA	400,000.00	**400,000**
	SUCTION LATERALS - 48"	8	SETS	75,000.00	**600,000**
	DISCHARGE LATERASL - 36"	8	SETS	100,000.00	**800,000**
	DISCHARGE HEADER - 60"	1	EA	200,000.00	**200,000**
	VERTICAL PUMPS & MOTORS 2500 HP	4	EA	800,000.00	**3,200,000**
	DISCHARGE HEADER - 54"	1	EA	180,000.00	**180,000**
	HVAC SYSTEM	1	LS	1,500,000.00	**1,500,000**
	MISC. MECHANICAL	1	LS	50,000.00	**50,000**
	PLUMBING - ALLOWANCE	1	LS	100,000.00	**100,000**
	SURGE TANKS (5500 CU-FT) AND COMPRESSORS	4	EA	750,000.00	**3,000,000**
	SUBTOTAL 4.00				**$ 12,830,000**
5.00	ELECTRICAL				
	ELECTRICAL - ALLOWANCE	1	LS	1,500,000.00	**1,500,000**
	EMERGENCY GENERATORS	1	LS	500,000.00	**500,000**
	I & C - ALLOWANCE	1	LS	175,000.00	**175,000**
	SUBTOTAL 5.00				**$ 2,175,000**
6.00	STORAGE TANK	2,000,000	GAL	2.00	**4,000,000**
	SUBTOTAL 6.00				**$ 4,000,000**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**			MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**			CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**			PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 3**			CHECKED BY:	**WB**
				ESTIMATE DATE:	**10/12/2016**
				ENRCCI FOR LA (JULY 2016):	**11,155.03**
	PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016				
ITEM #	**DESCRIPTION**	**QUANTITY**	**UNIT**	**COST**	**TOTAL COST**
2.10	DEMOLITION				**35,250**
2.20	SITE WORK				**51,000**
2.30	EARTHWORK				**436,750**
3.00	CONCRETE				**1,711,548**
3.50	BUILDING				**1,368,750**
2.60	SITE RESTORATION				**107,500**
4.00	MECHANICAL				**6,125,000**
5.00	ELECTRICAL				**2,175,000**
6.00	STORAGE TANK				**3,000,000**
	SUBTOTAL				**$ 15,010,798**
	PRORATES				
	GENERAL CONDITIONS	**3.00%**			**450,324**
	DESIGN CONTINGENCY	**0.00%**			**0**
	ESCALATION	**0.00%**			**0**
	MOBILIZATION	**2.00%**			**300,216**
	PERMITS	**0.25%**			**37,527**
	DIRECT COST & PRORATES SUBTOTAL				**$ 15,798,865**
	CONTRACTOR BURDENS				
	BONDS & INSURANCE	**1.50%**			**236,983**
	OVERHEAD & PROFIT	**10.00%**			**1,579,887**
	TOTAL				**$ 17,615,735**
2.10	**DEMOLITION**				
	TREE REMOVAL	-	EA	850.00	-
	SELECTIVE CLEARING	2,777	SY	1.50	**4,166**
	SAWCUTTING	-	LF	2.00	-
	ASPHALT PAVING REMOVAL - ALLOWANCE	2,500	SF	0.50	**1,250**
	CONCRETE SLAB REMOVAL - ALLOWANCE	63	SF	5.00	**313**
	CONCRETE CURB & GUTTER REMOVAL - ALLOWANCE	75	LF	5.00	**375**
	CONCRETE SIDEWALK REMOVAL - ALLOWANCE	83	SF	2.00	**165**
	TRANSPORTATION & DISPOSAL FEES Vegetation (NON-HAZ)	1	LS	500.00	**500**
	TRANSPORTATION & DISPOSAL RECYCLE CONCRETE (NON-HAZ)	3	LD	375.00	**1,125**
	GENERAL SITE WORK				
	STORM WATER POLLUTION PREVENTION PLAN	1	LS	15,000.00	**15,000**
	HEALTH & SAFETY PLAN	1	LS	2,500.00	**2,500**
	TRAFFIC CONTROLS				
	TRAFFIC CONTROLS - ALLOWANCE	1	LS	5,000.00	**5,000**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 3**	CHECKED BY:	**WB**
		ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
	EROSION CONTROLS				
	FABRIC SILT FENCE - INSTALLATION & MAINTENANCE	1,500	LF	2.75	**4,125**
	HAY ROLLS	225	LF	3.25	**731**
	SUBTOTAL 2.10				**$ 35,250**
2.20	**SITE WORK**				
	MAINTAIN ROADWAYS - SWEEPER & WATER TRUCK	0.5	MO	32,000.00	**16,000**
	TEMPORARY FENCING	2,000	LF	5.00	**10,000**
	DEWATERING - (NOT REQUIRED)				
	UTILITIES - PROJECT & REPAIR EXISTING	1	LS	5,000.00	**5,000**
	SURVEYS & LAYOUT	1	WK	15,000.00	**15,000**
	MISC. GRADING MAINTAIN ACCESS ROAD (ALLOWANCE)	1	LS	5,000.00	**5,000**
	SUBTOTAL 2.20				**$ 51,000**
2.30	**EARTHWORK**				
	EARTHWORK				
	EXCAVATION	7,100	CY	10.00	**71,000**
	SHORING (NOT USED. 1/1 BANKED EXCAVATION)	-	SF	-	**-**
	LOAD/HAUL EXCAVATED SOILS TO LAYDOWN AREA	7,100	CY	2.00	**14,200**
	GRAVEL BEDDING SUBASE - 2'	6,000	TN	42.50	**255,000**
	FINE GRADING & COMPACTION	25,000	SF	0.20	**5,000**
	DUST CONTROL - EARTHWORK	1	MO	30,000.00	**30,000**
	LOAD/HAUL LAYDOWN SOILS TO JS	2,367	CY	2.00	**4,733**
	BACKFILL & COMPACT SOIL	2,367	CY	15.00	**35,500**
	OFF-SITE DISPOSAL STOCKPILE SPOILS	2,367	CY	7.00	**16,567**
	ROUGH SURFACE COMPACTION	1,900	SY	2.50	**4,750**
	SUBTOTAL 2.30				**$ 436,750**
3.00	**CONCRETE**				
	PUMP CANS - 4.5' DIA X 30'D X 4 EA	150	CY	700.00	**105,000**
	MATT SLAB 3'	1,900	CY	700.00	**1,330,000**
	EXTERIOR WALLS - 2'	255	CY	850.00	**216,593**
	INTERIOR WALLS - 1'	49	CY	850.00	**41,556**
	SECONDARY DECK - 2'	0	CY	1,250.00	**0**
	ROOF DECK - 2'	0	CY	1,250.00	**0**
	EQUIPMENT PADS - SLAB 4 EA	8	CY	600.00	**4,800**
	EQUIPMENT PADS - DECK - 4 EA	23	CY	600.00	**13,600**
	SUBTOTAL 3.00				**$ 1,711,548**
3.50	BUILDING	9,125	SF	150.00	**1,368,750**
	SUBTOTAL 3.50				**$ 1,368,750**

PROJECT:	**POTENTIAL REGIONAL RECYCLED WATER SUPPLY PROGRAM**	MWD AGREEMENT NO:	**160524**
LOCATION:	**LOS ANGELES & ORANGE COUNTIES, CA**	CDM SMITH PROJECT NO:	**114706**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	PREPARED BY:	**CO**
DESCRIPTION:	**PUMP STATION NO. 3**	CHECKED BY:	**WB**
		ESTIMATE DATE:	**10/12/2016**
		ENRCCI FOR LA (JULY 2016):	**11,155.03**

PRELIMINARY FEASIBILITY STUDY - DRAFT JULY 2016

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.60	SITE RESTORATION				
	ASPHALT PAVING 4" THICK OVER 8' BASE	1,000	SY	44.00	**44,000**
	CONCRETE SLABS - ALLOWANCE	1,000	SF	20.00	**20,000**
	CONCRETE CURB & GUTTERS - ALLOWANCE	250	LF	50.00	**12,500**
	GENERAL SITE RESTORATION	500	SF	10.00	**5,000**
	LANDSCAPE RESTORATION (BY OTHERS)	50,000	SF	0.50	**25,000**
	FINAL SITE CLEANUP	2	AC	500.00	**1,000**
	SUBTOTAL 2.60				**$ 107,500**
4.00	MECHANICAL				
	SUCTION HEADER - 72"	1	EA	350,000.00	**350,000**
	SUCTION LATERALS - 48"	4	SETS	75,000.00	**300,000**
	DISCHARGE LATERASL - 36"	4	SETS	100,000.00	**400,000**
	DISCHARGE HEADER - 60"	1	EA	200,000.00	**200,000**
	VERTICAL PUMPS & MOTORS 2500 HP	4	EA	800,000.00	**3,200,000**
	HVAC SYSTEM	1	LS	125,000.00	**125,000**
	MISC. MECHANICAL	1	LS	50,000.00	**50,000**
	PLUMBING - ALLOWANCE	1	LS	100,000.00	**100,000**
	SURGE TANKS (3200 CU-FT) AND COMPRESSORS	2	EA	700,000.00	**1,400,000**
	SUBTOTAL 4.00				**$ 6,125,000**
5.00	ELECTRICAL				
	ELECTRICAL - ALLOWANCE	1	LS	1,500,000.00	**1,500,000**
	EMERGENCY GENERATORS	1	LS	500,000.00	**500,000**
	I & C - ALLOWANCE	1	LS	175,000.00	**175,000**
	SUBTOTAL 5.00				**$ 2,175,000**
6.00	STORAGE TANK	1,500,000	GAL	2.00	**3,000,000**
	SUBTOTAL 6.00				**$ 3,000,000**

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APPENDIX G:

Technical Memo: Case Study Compilations – Methods of Recovering Revenue Requirements from Significant Capital Projects

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TECHNICAL MEMO

To: June Skillman, Program Manager II – Budget & Financial Planning Section
Metropolitan Water District of Southern California

From: Rick Giardina, Project Manager

Date: September 20, 2016

Re: Case Study Compilations - Methods of Recovering Revenue Requirements from Significant Capital Projects

Introduction

The Metropolitan Water District of Southern California (Metropolitan) has asked Raftelis Financial Consultants, Inc. (RFC) to present case studies of how water utilities choose to recover costs from significant capital projects such as desalination projects, seismic retrofits, and recycled water.

Executing these types of projects has the potential to provide benefits to all customers, either directly or indirectly. Seismic retrofits can provide reliability to the supply, transmission, and distribution systems in the event of an earthquake. Desalination and recycled water treatment plants can increase water supply reliability by providing a water supply that is effectively drought-proof, thereby benefiting all users. Even recycled water that is treated to non-potable standards offsets water demand that would typically be met through consumption of potable water.

This Technical Memorandum presents information on how six utilities recover the costs of such projects from both retail and wholesale customers. RFC has collected and compiled information regarding the case study projects and the methods of cost recovery, but does not express an opinion as to the appropriateness of the cost recovery methods selected by the utilities. Throughout this Memorandum RFC makes numerous references to findings, statements, etc., regarding each case study. These findings and statements are those of the case study agency and are sourced to various documents produced by or for the agency and are not RFC's findings, statements, or opinions.

East Bay Municipal Utility District, CA

The Loma Prieta earthquake of 1989 highlighted the risk that seismic events pose to water utilities. The East Bay Municipal Utility District (EBMUD), a retail water and wastewater utility, assessed its seismic vulnerability and found that a magnitude 7.0 earthquake could interrupt service to two-thirds of EBMUD's customers for weeks through damage to reservoirs, pumping stations, major transmission components, and treatment plants.[1] The likelihood of a magnitude 7.0 occurring along the Hayward Fault in the next 30 years (as of 2005) was assessed to be 32%.

EBMUD established four goals for how it should perform in the event of a major earthquake:

- **Life Safety:** Prevent the loss of life due to the failure of any EBMUD facility.
- **Fire Service:** Improve water service in all areas, especially high fire-danger zones.
- **Customer Service:** Restore water service quickly.
- **Water Quality and Public Health:** Guarantee that all water entering the distribution system is fully treated.

To achieve these goals, in 1993 EBMUD undertook a Seismic Improvement Program (SIP) that identified $189 million in capital projects to improve the seismic resiliency of reservoirs, pumping facilities, treatment plants, transmission assets, and buildings. The SIP also included the construction of new transmission assets to provide redundancy to EBMUD's ability to deliver water to its service area.

EBMUD issued debt to pay for the SIP. To recover the costs associated with the SIP, EBMUD added a SIP Surcharge to the monthly service charge for potable water service. The Surcharge is based on the equivalent capacity of the customer's meter. As of July 1, 2014, the SIP Surcharge ranged from $1.37 per month for 5/8″ and ¾″ meters to $433.53 per month for 18″ meters.

The SIP Surcharge was originally intended to be in effect until February 28, 2025 until the debt incurred by the program was retired. However, due to a variety of factors including the timing of the SIP Surcharge initiation and related Surcharge collections, debt issuance, and project performance, EBMUD was able to cash-fund a greater than expected portion of projects and eliminated the SIP Surcharge as of July 1, 2015.

City of Santa Barbara, CA

The City of Santa Barbara, a municipal retail water utility, is reactivating the Charles E. Meyer Desalination Facility (Facility) that had been de-activated shortly after its construction in 1991. The Facility had been intended to provide an emergency supply in response to severe drought conditions in the late 1980's. This initial effort was a cooperative effort between the City of Santa

[1] 2004 – 2005 Progress Report: 10 Years of Accomplishments, Seismic Improvement Program, EBMUD.

Barbara, the Goleta Water District, and the Montecito Water District. The drought ended shortly after construction was completed, and the Facility was mothballed and the two water districts exited the project.

In the last several years, California has again entered a long-lasting, severe drought, and given these conditions, the City of Santa Barbara has decided to update and reactivate the Facility. The City has obtained a $61 million State Revolving Fund (SRF) loan to pay for the capital costs of reactivating the Facility. Repayment of the 20-year SRF loan will be accomplished via debt service payments of $3.5 million per year. Operating and maintenance (O&M) expenses are estimated at $4.1 million per year at full production levels of 3,125 acre-feet per year. Even in standby mode, O&M expenses are estimated at $1.4 million per year.[2]

The Facility is expected to begin production in November of 2016. The City first began to develop rates that include cost recovery for desalinated water in a memorandum that developed Fiscal Year 2016 rates.[3] According to the memorandum developing the 2016 rates,

> "For the Desal cost component, the capital expenses related to Desal are allocated based on the equivalent meters while the operating costs related to Desal are allocated based on the total water usage."[4]

The memo later states that policy discussions with City staff led to the decision that,

> "The capital component of the Desalination costs would be included in the fixed monthly meter service charge because it is a fixed cost that benefits all customers and should be recovered accordingly."

Including desalinated water, the City is served through six sources of supply. In setting volume rates by customer class and, when appropriate, by tier within customer classes, desalinated water is treated the same as the City's other five sources of supply. The unit costs are calculated for each source of supply. Each source of supply is allocated to each customer class proportionally to that class's relative consumption. The average unit cost of each customer class's allocation is then calculated if they are served through flat volumetric rates. For those customer classes with tiered rates, the sources of supply are ordered according to increasing unit costs. The volume rate for each tier is determined by the average unit cost of water assigned to each tier. For example, if 30% of residential water is sold in the first tier, and the two least expensive sources of water supply each provide 20% of residential customers' water, the first tier's volume rate will be equal to two-thirds of the unit cost of the cheapest source of supply plus one-third of the unit cost of the next cheapest source of supply.

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[2] http://www.santabarbaraca.gov/gov/depts/pw/resources/system/sources/desalination.asp, last accessed Sept. 16, 2016.

[3] RFC, *Water Rates Development for Fiscal Year 2016* [Memorandum], City of Santa Barbara.

[4] *Ibid*

The City conducts its cost-of-service allocations of desalinated water as if it were any other of their sources of supply. The unit costs of desalinated water are not the highest of the various sources of supply.[5]

San Francisco Public Utilities Commission, CA

The San Francisco Public Utilities Commission (SFPUC) is a retail water provider to the residents of the City of San Francisco, but approximately two-thirds of the water it sells is to wholesale customers in the Bay Area of California. The sale of water to wholesale customers is governed by the Water Supply Agreement (WSA) between SFPUC and the members of the Bay Area Water Supply and Conservation Agency (BAWSCA)[6]. The WSA establishes parameters regarding the relationship between SFPUC and BAWSCA. Notably, it provides individual supply guarantees of SFPUC water to BAWSCA members, governs how drought restrictions are to be enacted, and determines how costs are to be allocated between parties.

SFPUC divides its revenue requirements into "local" requirements that benefit only its retail customers and "regional" requirements that benefit all customers, including wholesale customers. BAWSCA explains how these regional revenue requirements are converted into wholesale water rates:

> "Wholesale water rates are determined based upon the Wholesale Customers' collective share of the expenses incurred by the SFPUC in delivering water to them on the basis of proportional annual use. This collective share is defined as the "Wholesale Revenue Requirement." Wholesale rates are set prospectively based on the budget of the Wholesale Revenue Requirement and estimates of water purchases in the following fiscal year. As such, rates may increase or decrease from year to year.
>
> After the close of each fiscal year, the difference of the actual costs allocable to the Wholesale Customers and the amounts billed to the Wholesale Customers for that fiscal year will be posted to a "balancing account". The amount in the balancing account shall be taken into consideration in establishing the following year's wholesale rates."[7]

The SFPUC is currently executing a $4.8 billion capital program known as the Water System Improvement Program (WSIP)[8]. Just as with all other revenue requirements, the WSIP's costs are divided between local and regional cost pools. The WSIP's objectives are identified as:

[5] City of Santa Barbara, *Council Agenda Report*, August 9, 2016, http://services.santabarbaraca.gov/CAP/MG132763/AS132767/AS132797/AI136571/DO136572/DO_136572.pdf, last accessed Sept. 16, 2016.
[6] Water Supply Agreement between The City and County of San Francisco and Wholesale Customers in Alameda County, San Mateo County and Santa Clara County, June 2009.
[7] http://bawsca.org/water/rates/wholesale, last accessed Sept. 16, 2016.
[8] WSIP Overview, https://sfwater.org/index.aspx?page=115, last accessed Sept. 16, 2016.

- Improve the system to provide high-quality water that reliably meets all current and foreseeable local, State, and Federal requirements.
- Reduce vulnerability of the water system to damage from earthquakes.
- Increase system reliability to deliver water by providing the redundancy needed to accommodate outages.
- Provide improvements related to water supply / drought protection.
- Enhance sustainability through improvements that optimize protection of the natural and human environment.

The WSIP includes regional projects, such as the replacement of the Calaveras Dam, which will improve its seismic performance as well as restore the reservoir storage to its original storage capacity, seismic upgrades to transmission lines, regional groundwater storage and recovery, and the addition of redundant transmission assets to improve reliability.

The costs of the regional WSIP projects are recovered from BAWSCA members just as all other revenue requirements are recovered from them according to the WSA. The Wholesale Customers' costs represent their collective share of expenses incurred by SFPUC in delivering water to them.

San Diego County Water Authority, CA

The San Diego County Water Authority (SDCWA) is a wholesale water supplier to 24 member agencies. The SDCWA is meeting its water supply needs through a long-term diversification of its water supply sources. One of its newer sources of supply is a 30-year Water Purchase Agreement to, on an annual basis, purchase up to 56,000 acre-feet of desalinated water from Poseidon Water (Poseidon).

Poseidon constructed the Claude "Bud" Lewis Carlsbad Desalination Plant after the parties agreed to terms of the Water Purchase Agreement. Poseidon also constructed transmission assets to deliver the desalinated water to SDCWA's own transmission assets. SDCWA in turn upgraded some of its transmission assets in order to receive Poseidon's water.

The desalination plant began operations at the end of 2015. According to the price structure contained in the Water Purchase Agreement, SDCWA estimates that unit costs for desalinated water will range between $2,131 and $2,367 per acre-foot in 2016.[9]

The SDCWA formed a Desalination Cost of Service Study Phase II Member Agency Workgroup to identify "…the methodology to be used for incorporating the costs of the Carlsbad Seawater

[9] http://www.sdcwa.org/seawater-desalination, last accessed September 16, 2016.

Desalination Project into the Water Authority's rate and charge structure."[10] The Workgroup concluded:

> "Ultimately, the Workgroup discussion resulted in the following proposed allocation of Carlsbad desalination costs:
>
> 1. Pipeline costs connecting the desalination plant to the Water Authority's system are allocated to Transportation
>   a. Costs associated with required modifications to the Water Authority's existing Pipeline #3 due to desalination are allocated to Transportation
>   b. Improvements for delivering desalinated water to Twin Oaks Valley Water Treatment Plant for blending and to redistribute water through the aqueduct are allocated to Transportation
>   c. The new Desalinated Product Water Pipeline between the Carlsbad Desalination Plant and the Second Aqueduct is allocated to Transportation
> 2. Because its primary function is to produce water, the primary cost allocation of the desalination plant is to Supply, but with an allocation of the incidental treatment benefit resulting from the fact that produced desalinated water meets all state and federal drinking water regulations being allocated to treatment.
> 3. The allocated treatment benefit associated with desalination is based on existing Water Authority melded treatment costs and will be benchmarked to the current Water Authority melded treated water surcharge payable by treated water customers only"[11]

The SDCWA produced a 2016 Cost of Service Study in May 2015 to determine calendar year 2016 rates and charges.[12] Per this study, total costs to be recovered for desalinated water were estimated at $91.8 million in 2016. According to the Study, $80 million of the total is allocated to the Supply functional cost category and is recovered through the Supply Reliability Charge and the Melded Supply Rate. The Melded Supply Rate combines the unit costs of supply from the SDCWA's numerous water supply sources into a single Melded Supply Rate ($ per acre-foot).

The Supply Reliability Charge is a new charge in 2016. The Supply Reliability Charge is a fixed charge specifically designed to recover costs associated with reliability enhancements and its revenues offset the Melded Supply Rate revenue requirements. According to the 2016 Cost of Service Study:

> "This charge will recover the functional incremental supply costs allocated to enhanced supply reliability. The Committee recognized the importance of equitably recovering the

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[10] Resolution setting a Public Hearing date for the Water Authority's proposed calendar year 2015 Rate and Charge Increases, May 14, 2014, San Diego County Water Authority.
[11] Resolution setting a Public Hearing date for the Water Authority's proposed calendar year 2015 Rate and Charge Increases, May 14, 2014, San Diego County Water Authority.
[12] Cost of Service Study, May 2015, Carollo Engineers.

> costs of the Water Authority's investments in long-term water supply reliability in accordance with the cost of service requirements. The concept of a fixed charge for supply reliability was to balance the impact of the fixed costs on member agencies with the allocation of costs associated with long-term investments in supply reliability to member agencies based on a rolling average of M&I deliveries. Access to reliable supply benefits all member agencies regardless of whether the agency uses water every day or intermittently."

The SDCWA chose to calculate the Supply Reliability Charge according to the following formula:

$$Supply\ Reliability\ Charge = [Desal\ Water\ Cost + IID\ Water\ Transfer\ Costs - MWD\ Tier\ 1\ Untreated\ Equivalent\ Costs] \times 0.25$$

The revenues recovered through the fixed Supply Reliability Charge are used as an offset for the revenue requirements that must be recovered volumetrically as part of the Melded Supply Rate.

The $11.8 million in desalination costs allocated to the Treatment functional cost category are recovered through the Melded Treatment Rate. Its calculation and justification are completed in the same manner as the Melded Supply Rate.

Orange County Groundwater Replenishment System, CA

The Orange County Groundwater Replenishment System (GWRS) is a cooperative effort between the Orange County Water District (OCWD) and the Orange County Sanitation District (OCSD). The OCWD and OCSD recognized an opportunity to cooperate on a project that would provide benefits to both organizations as well as to the region as a whole.

The GWRS takes treated wastewater from the OCSD and treats it to levels exceeding State and federal drinking water regulations with a treatment regime of microfiltration, reverse osmosis, and ultraviolet light with hydrogen peroxide. This highly treated effluent is then pumped into a seawater barrier and recharge basins to resupply the Orange County Groundwater Basin. For the OCSD, the primary benefit of the GWRS is the perhaps indefinite postponement of the need to build a second ocean outfall. For the OCWD, the benefits include a local supply that protects and augments existing groundwater supplies more reliably and at lower cost than the imported water that was being used for this purpose.[13]

The initial project agreement called for the OCSD and OCWD to split (50-50) the capital costs of constructing the 70 MGD treatment facility. The OCSD would provide the wastewater effluent at

[13] http://www.ocwd.com/gwrs/about-gwrs/, last accessed September 19, 2016.

no charge, and the OCWD would operate and maintain the GWRS facility. The capital cost of the initial facility, which began operation in 2008, was approximately $485 million, comprised of:

- Advanced Water Purification Plant $326 million
- GWRS Pipeline $64 million
- Barrier Injection Facilities $21 million
- Integrated information system, wells, workshops, insurance $17 million
- Design $31 million
- Construction Management and Administration $26 million

Grant funding paid for $92 million of the capital costs, and OCWD and OCSD each contributed $195 million.[14] In 2015, the treatment facility was expanded to 100 MGD at a cost of $142 million funded by OCWD.[15]

O&M expenses vary from year to year, but in fiscal year (FY) 2014-15 were $341/acre-foot. Debt service and replacement and refurbishment costs raised total per acre-foot costs to $569. Metropolitan agreed to subsidize operations for a period of 10 years at approximately $121 per acre-foot.

The primary source of revenues for OCWD is an assessment of $402 for each acre-foot of water that each of the OCWD's 19 member agencies pump from the Orange County Groundwater Basin for FY 2016 - 2017.[16] The OCWD's water supply sources are all placed into a single groundwater basin from which all wholesale customers pump. This revenue source accounts for approximately 74% of the OCWD total revenue.

The second largest revenue source for OCWD is a property tax, which produces approximately 14% of the OCWD total revenue.

There is a minor revenue source known as the Basin Equity Assessment (BEA) which produces approximately 1% of the OCWD total revenue. The BEA is based on a formula that takes into account the treated full service Metropolitan water rate and each Producer's individual energy cost to pump groundwater. This minor assessment is the only cost differentiator between the wholesale customers. Miscellaneous revenues and investment revenues comprise the remaining sources of OCWD revenues.

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[14] Email from Tan Lo, Senior Engineer, OCWD, July 26, 2016.
[15] http://www.ocwd.com/gwrs/the-ocwdocsd-partnership/, last accessed September 16, 2016.
[16] Orange County Water District, Budget Report, FY 2016 – 2017.

Water Replenishment District of Southern California, CA

The Water Replenishment District of Southern California (WRD) was established in 1959 to protect the groundwater resources of the Central and West Coast groundwater basins in southern Los Angeles County. From its inception, both the rates and the structure of WRD have been determined by the hydrogeology of the underlying groundwater basins. Even though the Central and West Coast basins are distinct from one another, there are significant flows that cross the geologic barrier that separates them. The quantity and quality of the water in each basin is greatly determined by how the other basin is managed.

The 2016 Cost of Service Report[17] provides extensive justification for the District's practice of charging a uniform volume rate to all of its customers, regardless of which basin the pumping occurs in or where in a basin the pumping occurs. Section 5 of the Report (Water Replenishment District Formation, pages 7 to 26) is largely a historical and geologic justification for the single uniform rate, and Section 8 of the Report (Uniform Rate, pages 81 to 86) is an explicit justification for a single uniform rate. The justifications extend to the founding of the District. Consideration was made to forming two separate districts, but the founding entity recognized the need for conjunctive management of the two basins. The District argues that if the two basins were independently managed, two districts would not likely be able to manage the basins as effectively as if they were managed conjunctively.

The District notes in Section 8 of the 2016 Cost of Service Report (Uniform Rate, pages 81 to 86) that adjudicated pumping rights within the basins allow pumpers to pump from anywhere within the basin. Thus, the pumping within the basins is transitory both temporally and spatially. The hydrogeology of the basins, combined with the characteristics of pumping regimes, create a system in which the District argues that it is impossible to assign costs and benefits on a molecular level to actors within the basins. Given this environment, the District has chosen to recover costs through a uniform volume rate. The rate is calculated by dividing the District's revenue requirements by the expected volume of water to be pumped.

The District operates the Leo J. Vander Lans Water Treatment Facility to recycle treated wastewater from the Los Angeles County Sanitation Districts. The recovered water is used to supply the Alamitos Barrier to prevent saltwater intrusion, and this recovered water replaces water that is otherwise imported into the District at significantly higher cost. This project both increases the reliability of the system and reduces costs.[18] Its revenue requirements are recovered through the uniform volume rate as are all other revenue requirements in the District.

[17] Water Replenishment District of Southern California Cost of Service Report, April 7, 2016.
[18] http://www.wrd.org/engineering/groundwater-los-angeles.php?url_proj=vander-lans-water-treatment, last accessed September 19, 2016.

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APPENDIX H:

Revision Summary

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REVISION SUMMARY

Page	Item	Original Text	Revised Text
TOC Page iii	Appendices		*Added* Appendix H: Revision Summary
1-5	Table 1.2 (3rd column, 3rd row)	Recharge capacity limited in winter	None
1-5	Table 1.2 (3rd column, 4th row)	No	None
1-5	Table 1.2 (5th column, 3rd row)	Up to 5 new extraction wells (relocated)	Up to 5 new extraction wells (relocated) Up to 13 new injection wells
1-5	Table 1.2 (5th column, 4th row)	Up to 13 new injection wells	Up to 7 new extraction wells (relocated)
1-5	Table 1.2 (5th column, 5th row)	Up to 7 new extraction wells (relocated)	Up to 1 new extraction well (relocated)
1-10	Figure 1.6	Rio Hondo Spreading Grounds (Montebello Forebay)	Montebello Forebay Injection Wells
2-22	Figure 2.11	Rio Hondo Spreading Grounds (blue dashed circle)	Rio Hondo Spreading Grounds (green dashed circle)
3-3	Figure 3.1	Rio Hondo Spreading Grounds (blue dashed circle)	Rio Hondo Spreading Grounds Montebello Forebay Injection Wells 12 MGD (green dashed circle)
4-1	Figure 4.1	Rio Hondo Spreading Grounds	New Injection Wells
4-15	Table 4.5 (2nd column, 3rd row, 1st bullet)	Existing spreading basins in Montebello Forebay or up to 13 new injection wells	Up to 13 new injection wells
4-15	Table 4.5 (2nd column, 4th row, 2nd bullet)	Up to 7 new extraction wells	Up to 7 new extraction wells relocated
4-16	Table 4.6 (3rd column, 3rd row)	Recharge capacity limited in winter	None
4-16	Table 4.6 (3rd column, 4th row)	No	None
6-1	Table 6.1 (2nd column, 5th row)	Rio Hondo Spreading Grounds, Pico Rivera	Central Basin, Montebello Forebay
6-1	Table 6.1 (3rd column, 5th row)	Recharge Basins	Injection Wells
6-1	Table 6.1 (4th column, 5th row)	WRD/LA County Flood Control District	WRD

Page	Item	Original Text	Revised Text
6-3	Figure 6.1	Rio Hondo Spreading Grounds (blue dashed circle)	Rio Hondo Spreading Grounds Montebello Forebay Injection Wells 12 MGD (green dashed circle)
6-4	Figure 6.2	Rio Hondo Spreading Grounds (Montebello Forebay)	Montebello Forebay Injection Wells
6-5	Table 6.2 (1st column, 5th row)	Rio Hondo Spreading Grounds (Montebello Forebay)	Central Basin, Montebello Forebay Injection Wells
6-10	2nd paragraph, 3rd sentence	From this location, water can be conveyed to either the Rio Hondo Spreading Grounds or the Santa Fe Spreading Grounds.	From this location, water would be conveyed to injection wells at the Montebello Forebay, and to a pump station with the capability to lift the water from Whittier Narrows to the Santa Fe Spreading Grounds.
6-10	Table 6.5 (1st column, 3rd row)	Central Basin	Central Basin (Long Beach)
6-10	Table 6.5 (1st column, 4th row)	Central Basin	Central Basin (Montebello Forebay)
8-8	4th paragraph, last sentence	… southwestern willow flycatcher (*Empidonax trailii*), and coastal California gnatcatcher (*Polioptila californica*)	… Southwestern Willow flycatcher (*Empidonax traillii extimus*) and Coastal California gnatcatcher (*Polioptila californica californica*)
9-2	2nd paragraph, 5th sentence	***Full-Scale Advanced Water Treatment Facility*** It is assumed that the EIR/EIS process will be complete and approved by the Metropolitan board prior to the completion of final design.	***Full-Scale Advanced Water Treatment Facility*** It is assumed that the EIR/EIS documents will be complete and certified by the Metropolitan board prior to the completion of final design.
9-18	Acronyms	SDCWA – San Diego County Water Authority	*Text deleted*
C-56	Appendix C	• Existing spreading basins at the Montebello Forebay area. An alternative to the base case includes 13 new injection wells in the Montebello Forebay area, between the Rio Hondo and San Gabriel Spreading Grounds;	• 13 new injection wells in the Montebello Forebay area, between the Rio Hondo and San Gabriel Spreading Grounds;

Page	Item	Original Text	Revised Text
C-57	Appendix C 4th paragraph	For this feasibility assessment, the conceptual Base Case assumption was to use the existing spreading basins owned by the OCWD to deliver 15 mgd of purified water and to develop an additional dedicated spreading basin capable of percolating a minimum of 43 mgd of purified water. For the additional spreading basin, it was assumed that the basin would have an average percolation rate of 6 ft/day and would require approximately 24 acres of wetted surface. The location of the additional basin was assumed to be greater than ½ mile downgradient (west) of OCWD's existing Kramer and La Palma Basins. This presumably will provide enough offset between the basins to minimize mounding interference while at the same time allowing the new facility to be constructed in an area that OCWD staff considers to have high percolation rates and communicates well with the underlying aquifer.	For this feasibility assessment, the conceptual Base Case assumption was to use the existing spreading basins owned by the OCWD to deliver the purified water.
C-58	Appendix C	**Main San Gabriel** Potentially impacted facilities in the West Coast Basin under the Base Case include:	**Main San Gabriel** Potentially impacted facilities in the Main San Gabriel Basin under the Base Case include:
5	Appendix D	**3.1 Methodology and Assumptions** The OPCCs were prepared in accordance with the criteria established by the Association for the Advancement of Cost Engineering (AACE) for a Class 5 cost estimate. The estimate has an accuracy level ranging between -20% to -50% and +30% to +100%.	**3.1 Methodology and Assumptions** The OPCCs were prepared in accordance with the criteria established by the Association for the Advancement of Cost Engineering (AACE) for a Class 4 cost estimate. The estimate has an accuracy level ranging between -20% to +40%.
9	Appendix D, OPCC for the Full-scale AWT Facility with MF	Page 9, bottom of table Notes below Grand Total	*Text deleted*
9	Appendix D, OPCC for the Full-scale AWT Facility without MF	Page 9, bottom of table Notes below Grand Total	*Text deleted*

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