THE METROPOLITAN WATER DISTRICT
OF SOUTHERN CALIFORNIA

Regional Recycled Water Program
Conceptual Planning Studies Report

Executive Summary

Report No. 1618

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Chapter 1

Executive Summary

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1.0 EXECUTIVE SUMMARY

The Conceptual Planning Studies Report presents the results of further technical studies and analyses related to the Regional Recycled Water Program (RRWP) being considered by the Metropolitan Water District of Southern California (Metropolitan/MWD) and the Sanitation Districts of Los Angeles County (Sanitation Districts). These conceptual planning studies build upon the initial analyses presented in the November 2016 “Potential Regional Recycled Water Program Feasibility Study – Report No. 1530” (Feasibility Study). This report was presented to Metropolitan’s Board in January 2017 as well as the Sanitation Districts’ Board. While the Feasibility Study established that the indirect potable reuse (IPR) program described in the RRWP is feasible given the assumptions used, this report addresses specific issues regarding its potential path to implementation and anticipated performance. In broad terms, the studies presented here evaluate the opportunities for program phasing; further delineate and refine the major program elements; present additional groundwater modeling evaluations associated with introducing purified water into the groundwater basins; and examine the potential for the program to accommodate direct potable reuse (DPR) opportunities in the future.

The RRWP provides an opportunity to develop a local and sustainable water supply for the region with the objective of providing water to replenish groundwater basins. 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 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.

Metropolitan delivers imported water for groundwater replenishment; however, 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 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. The RRWP can provide stable year-to-year deliveries of a new supply for groundwater replenishment to improve the supply reliability conditions for the region. 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 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.

1.1 Program Concept

As configured in the Feasibility Study, the RRWP would produce up to 150 million gallons per day (mgd) or 168 thousand acre-feet per year (TAFY) of purified water in partnership with the Sanitation Districts. A new advanced water treatment facility would be located at the Sanitation Districts' Joint Water Pollution Control Plant (JWPCP) in Carson and a new regional conveyance system would deliver a reliable source of IPR water to recharge four regional groundwater basins: Central, West Coast, Main San Gabriel, and Orange County. An overview of the IPR concept is shown in Figure 1.1.

Figure 1.1: Program Overview

Actions to Date

For more than 8 years, Metropolitan and the Sanitation Districts have been evaluating a regional collaboration to jointly develop recycled water. From June 2010 through July 2012, pilot-scale 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 these studies determined that advanced treatment of JWPCP secondary effluent for producing water suitable for 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. Both organizations 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 nonbinding; however, they set forth key conditions anticipated to be in a future full-scale agreement. Building upon these initial terms, subsequent discussions with the Sanitation Districts in 2016, and future finalized California Environmental Quality Act (CEQA) documentation, staff would develop, for approval by the two boards of directors, a final binding agreement between Metropolitan and the Sanitation Districts for a full-scale project.

In addition, at its November 2015 meeting, the Metropolitan Board authorized staff to design a demonstration facility that would allow Metropolitan to optimize an advanced water treatment (AWT) process for 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 are undertaking a demonstration project to refine, demonstrate, and receive regulatory approval for an alternative treatment process train that 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 regulatory approvals. The demonstration facility also provides a means for Metropolitan and the Sanitation Districts to evaluate the envisioned treatment process, coordinate operations, and serve as an effective venue for public outreach. Construction of the demonstration facility is complete, and operations are expected to begin in early 2019.

Metropolitan and the Sanitation Districts are coordinating with the State Water Resources Control Board (SWRCB) through the Division of Drinking Water (DDW) and the individual Regional Water Quality Control Boards (RWQCBs) for the Los Angeles and Santa Ana regions on the testing and monitoring plan for the demonstration project. Metropolitan is working to receive final approval by the agencies prior to initiating demonstration testing in March 2019.

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. In November 2017, a subcommittee of the panel was convened to review the evaluation of alternative nitrogen management process trains. The subcommittee completed the work of the panel with its review of the Nitrogen Management Report included in Appendix C.

In April 2018, a new independent scientific advisory panel was established to provide review of the scientific, technical, and regulatory aspects of the demonstration project.

Metropolitan staff continues to meet periodically with the member agencies and groundwater management agencies that would be directly affected by the program. The discussions provide opportunities to explore how this water resource could be incorporated into the region's water supply portfolio given each basin's unique operating regime and requirements. The meetings also include conceptual discussions on potential arrangements for delivery and use of the water, including potential arrangements with member agencies, groundwater management agencies, and groundwater pumpers.

Metropolitan and the Sanitation Districts meet at an executive level on a bi-monthly basis to discuss key programmatic issues, develop and coordinate planning strategies, and review progress on various project components.

As recommended in the Feasibility Study, further consultations with member agencies, groundwater management agencies, and other potential program participants (e.g., Los Angeles County Department of Public Works, United States Army Corps of Engineers) are planned. Discussions will focus on the development of mutually agreed-upon terms and conditions that would accompany implementation if the program proceeds. The results of these efforts will be reported on separately.

In addition to this report, several other activities identified and recommended in the Feasibility Study have also been initiated: (1) development of institutional and financial arrangements for the management and operations of the program, and (2) development of a public outreach plan associated with the demonstration facility. The results of these additional activities will be reported on separately and are not included in the Conceptual Planning Studies Report.

1.2 Program Implementation and Cost Estimate

The Feasibility Study assumed that the 150-mgd program would be implemented in a single phase. One of the primary goals of the conceptual planning studies is to evaluate implementation phasing alternatives. Generally, program phasing can be advantageous when (1) there are uncertainties regarding the ultimate demands, availability of source water supply, or needed capacity of a program; (2) potential benefits can be achieved by bringing portions of a program online as quickly as possible (e.g., addressing urgent needs and early creation of revenues); (3) the program has sufficient modularity to be functional in discrete stages; (4) time is needed to evaluate potential future opportunities (e.g., incorporation of a DPR option); and (5) additional benefits may accrue from the acquisition of operational and technology experience.

From an infrastructure perspective, the primary questions examined involve (1) appropriate sizing of the AWT plant and process train(s) used; (2) the distance, capacity, and expected deliveries of the conveyance system; (3) the certainty of expected demands at various delivery points; and (4) the opportunities for future flexibility to integrate DPR (in addition to IPR) if desired. The evaluation process included the following steps:

1. Establish objectives, evaluation criteria, and performance metrics for potential phasing of the program.
2. Assess potential water demands and certainty for replenishment and consumptive uses.
3. Configure simplified, logical program phasing alternatives for preliminary evaluation.
4. Develop capital, operating, and finance costs for each simplified alternative.
5. Eliminate inferior alternatives deemed less likely to achieve objectives.
6. Identify additional potential benefits and options that could enhance the remaining alternatives.
7. Develop a proposed implementation strategy that (a) achieves program goals, (b) minimizes demand uncertainties, (c) reduces the risk of stranded investments, (d) is cost effective, and (e) preserves future flexibility.

Phasing Alternatives and Cost Estimate

The initial step in the development of phasing scenarios was the establishment of overall phasing objectives for the potential program. Each phase of every alternative was developed to achieve the following objectives:

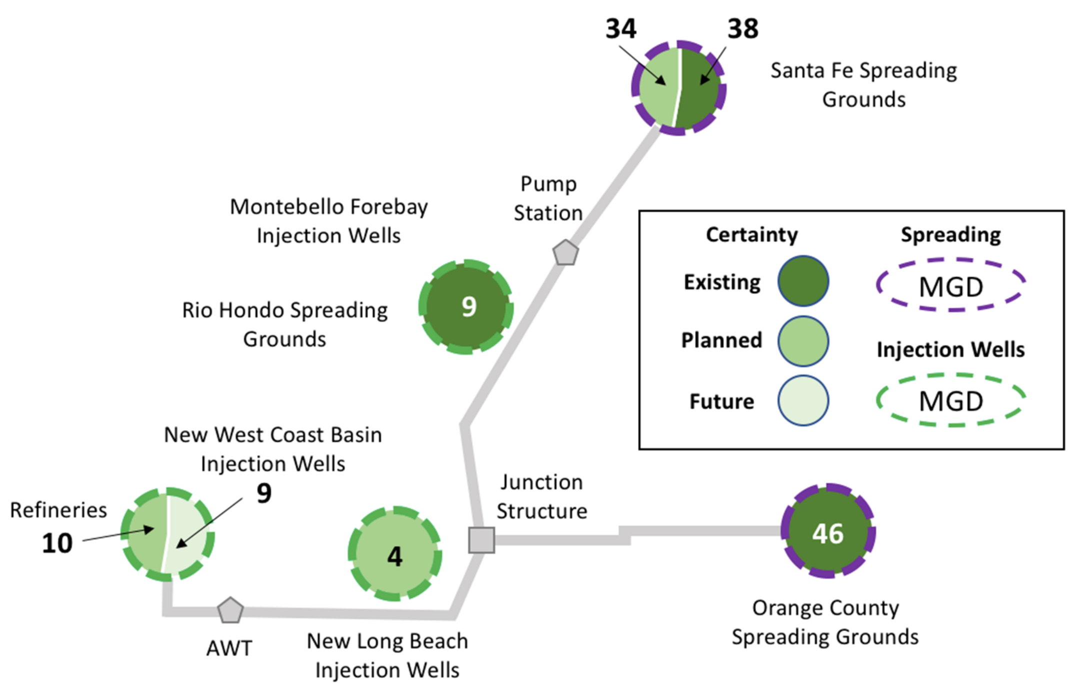
1. Perform as a fully functional and cost-effective stand-alone project.
2. Provide a significant addition to regional recycled water supply.

3. Include groundwater recharge as a major portion of deliveries.
4. Provide for future expansion to the full-scale program.
5. Achieve regulatory approvals consistent with those needed for the full-scale program.
6. Offer flexibility to accommodate future opportunities such as DPR.

Based on these objectives, evaluation criteria were established to compare the relative performance of phasing alternatives. The evaluation criteria were used to develop a multi-objective decision analysis (MDA) assessing the relative performance of the first phase of each alternative under consideration. The MDA process was intended to provide both quantitative and qualitative input to the development of a proposed phased implementation approach.

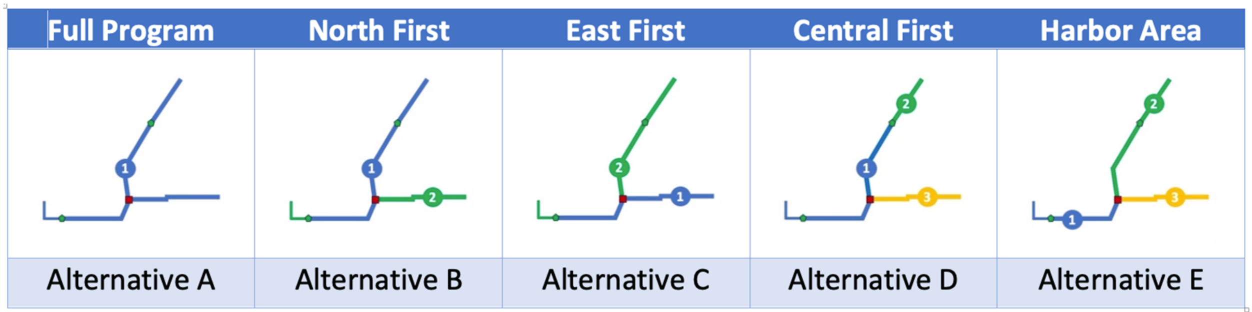
The development of various phasing alternatives proceeded from a consideration of options within the AWT plant and conveyance elements of the program. A schematic of the full RRWP is shown in Figure 1.2. The demand certainty is based on discussions with potentially affected member agencies and water masters, together with additional groundwater modeling in the Central, West Coast, Main San Gabriel, and Orange County groundwater basins. Demand certainty is characterized into three categories: **existing** (demands already served by Metropolitan); **planned** (expected demands on Metropolitan, new injection wells needed, and significant operational changes needed); and **future** (possible future demands on Metropolitan, new injection wells needed, and significant new facilities and operational changes needed).

Figure 1.2: RRWP Schematic and Demand Certainty



As illustrated in Figure 1.3 and described below, five phasing alternatives were evaluated.

Figure 1.3: Summary of Alternative Phasing Scenarios

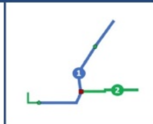


Legend: Phase 1 (Blue), Phase 2 (Green), Phase 3 (Yellow)

1. **Alternative A (Full Program):** a single-phase scenario based on the program presented in the 2016 Feasibility Study as the Base Case.
2. **Alternative B (North First):** a two-phase scenario that initially extends from the AWT plant to the Santa Fe Spreading Grounds in the first phase and subsequently reaches the Orange County Spreading Grounds and West Coast Basin in the second phase.
3. **Alternative C (East First):** a two-phase scenario that extends to the Orange County Spreading Grounds first and subsequently extends to the Santa Fe Spreading Grounds and West Coast Basin in the second phase.
4. **Alternative D (Central First):** a three-phase scenario that initially extends from the AWT plant to the West Coast Basin, Rio Hondo Spreading Grounds, and Montebello Forebay injection wells, followed by two subsequent phases to the Santa Fe Spreading Grounds and Orange County Spreading Grounds, respectively.
5. **Alternative E (Harbor Area):** a three-phase scenario that focuses initially on the demands near the AWT plant, followed by two subsequent phases to the Santa Fe Spreading Grounds and Orange County Spreading Grounds, respectively.

The alternatives are summarized in Table 1.1 with the AWT production and estimated pipeline segments installed for each phase, as well as the estimated capital costs and operations and maintenance (O&M) costs for each alternative. A detailed description and figures for each alternative are presented in Chapter 3, Program Implementation and Cost Estimate. The advantages and disadvantages of each alternative are summarized in Table 1.2.

Table 1.1: Comparison of Phasing Alternatives

Legend	Alternatives				
Phase 1 Phase 2 Phase 3					
Selected Criteria	**A**	**B**	**C**	**D**	**E**
Number of Phases	1	2	2	3	3
Description	Full Program	North First	East First	Central First	Harbor Area
AWT Production (mgd)	150	150	150	150	150
Phase 1	150	100	50	50	25
Phase 2		50	100	50	75
Phase 3				50	50
Conveyance (miles)	62	62	62	62	62
Phase 1	62	46	37	36	21
Phase 2		16	25	10	25
Phase 3				16	16
Capital Costs ($M)[1]	$3,080	$3,193	$3,292	$3,344	3,410
Phase 1	$3,080	$2,546	$1,642	$1,836	$1,177
Phase 2		$647	$1,651	$847	$1,574
Phase 3				$661	$659
Annual O&M Costs ($M)	$134	$134	$134	$134	$134
Phase 1	$134	$75	$43	$33	$15
Phase 2		$59	$91	$41	$43
Phase 3				$59	$75
Annual Financing Costs ($M)	$155	$161	$173	$176	$181
Phase 1	$155	$126	$86	$96	$62
Phase 2		$34	$87	$45	$83
Phase 3				$35	$35
Total Annual Costs ($M)	$288	$294	$307	$309	$314
Phase 1	$288	$201	$129	$129	$78
Phase 2		$93	$178	$86	$127
Phase 3				$94	$110
Total Unit Cost ($/acre-ft [AF])	$1,752	$1,788	$1,862	$1,880	$1,909
Phase 1	$1,752	$1,803	$2,345	$2,347	$2,831
Phase 2		$1,703	$1,621	$1,575	$1,540
Phase 3				$1,717	$2,000
Avg. MWD Cost Increase ($/AF)[2]	$170	$173	$180	$182	$185
Phase 1	$170	$118	$76	$76	$46
Phase 2		$55	$105	$51	$75
Phase 3				$55	$65

[1]2018 Dollars

[2]When project is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

Table 1.2: Phasing Alternatives – Advantages and Disadvantages

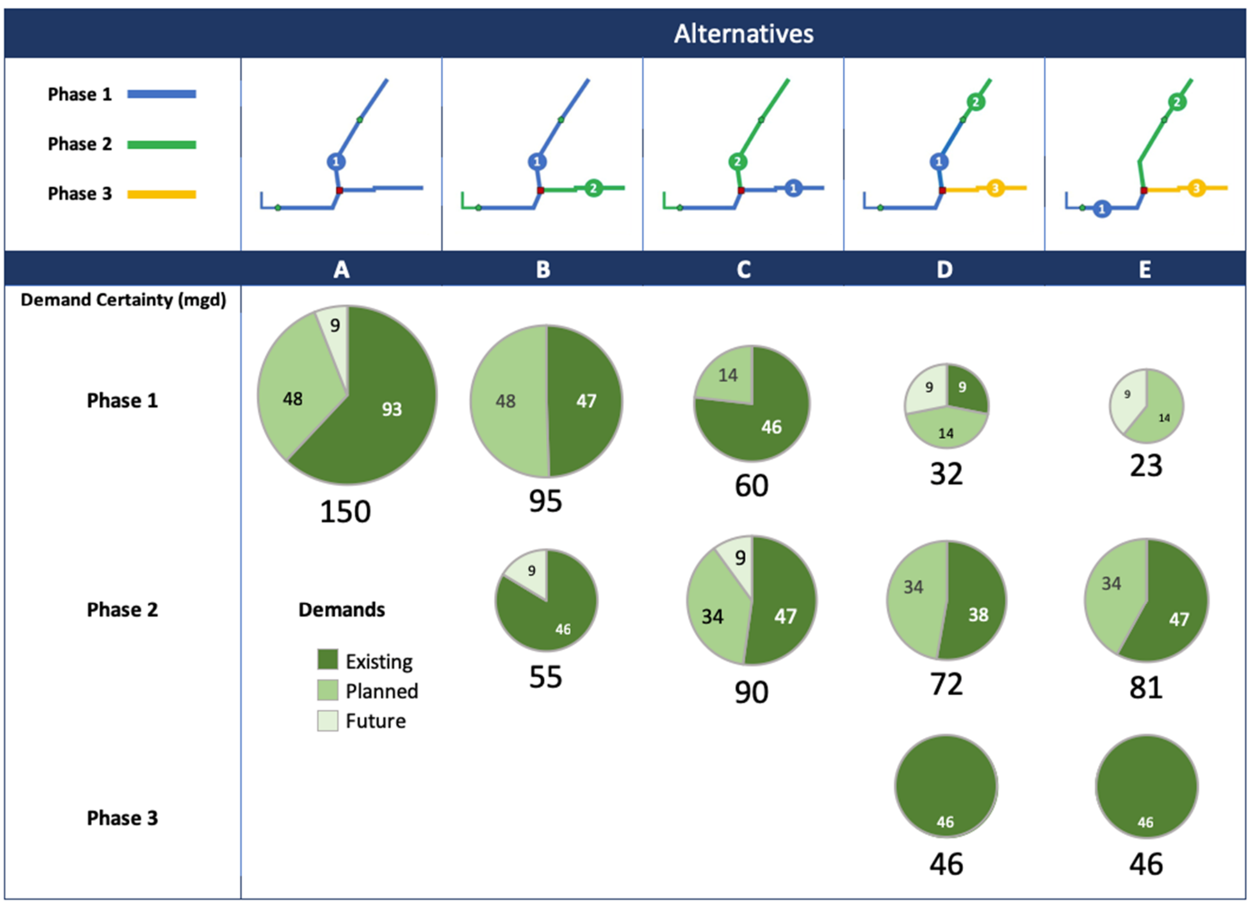
	Advantages	Disadvantages
Full Program (Alternative A) Initial Production Capacity: 150 mgd	• Most rapid completion of the overall program. • Maximum economies of scale. • Largest regional benefits to the groundwater basins and Metropolitan in its initial phase. • Less vulnerable to inflation and other cost increases.	• Largest initial commitment of funding. • Highest initial increase in MWD overall costs. • Vulnerable to changing external circumstances (recycled water demand uncertainty and future wastewater flow declines). • Commits all flows to IPR uses, reducing flexibility to incorporate DPR. • Most rapid operational learning curve.
North First (Alternative B) Initial Production Capacity: 100 mgd	• Provides the largest amount of water for replenishment in Phase 1 of the multi-phase alternatives. • Serves stressed groundwater basins with limited sources of replenishment water first. • Requires lower treatment costs during the Phase 1 to achieve basin plan nitrate limits. • Requires approvals from a single permitting agency – Los Angeles RWQCB. • Provides economies of scale. • Provides means of implementing DPR (when permitted) by extension of conveyance to both Weymouth and Diemer WTPs. • Reserves approximately 60 mgd of secondary effluent for either IPR or DPR uses.	• Highest initial capital costs of multi-phase alternatives. • Initially pumps to the highest elevation (500 ft) with the highest pumping costs. • Requires measures during Phase 1 to achieve required boron limits in the Main San Gabriel basin.
East First (Alternative C) Initial Production Capacity: 50 mgd	• Offers a lower pumping elevation (223 ft) and pumping costs in Phase 1 than northern pipeline alignment. • Utilizes full AWT plant capacity to meet demands in Phase 1. • Provides a lowest cost means of implementing DPR (when permitted) by adding an additional transmission pipeline to the Diemer WTP.	• May compete with other sources of water available for replenishment in Orange County. • Requires higher level of treatment and treatment costs in Phase 1 to meet basin plan nitrate targets. • Requires multiple RWQCB permitting approvals.
Central First (Alternative D) Initial Production Capacity: 50 mgd	• Flexibility in decision regarding implementation of additional phases. • Lower initial capital costs. • Lower impact on MWD overall cost increase in Phase 1.	• Relies heavily on consumptive demands in the Harbor Area and Central Basin. • Depends on injection wells for recharge. • Currently identified demands are insufficient to use 50 mgd AWT capacity. • Does not reach most reliable replenishment demands in Phase 1.

	Advantages	Disadvantages
Harbor Area (Alternative E) Initial Production Capacity: 25 mgd	• Lowest initial capital costs. • AWT plant initially sized to meet near-term Harbor and Central Basin needs. • Most rapid Phase 1 implementation schedule. • Most flexibility in decision regarding implementation of additional phases.	• Phase 1 relies on least certain replenishment demands. • A large percentage of production serves consumptive demands in Phase 1. • Depends on injection wells for recharge. • Does not reach most reliable replenishment demands in Phase 1. • Lacks economies of scale.

Assessment of Demand Certainty by Phase

Figure 1.4 presents a breakdown of the certainty (existing, planned, and future) in the demands expected in each phase of the five alternatives. Alternatives B and C can reach spreading basins in the first phase of implementation and avoid reliance on future replenishment demands in the West Coast Basin. The first phase of Alternatives D and E are both reliant on a high percentage of future demands and compare unfavorably to other alternatives in this regard.

Figure 1.4: Expected Demands and Assessment of Certainty by Phase



Flexibility for Future DPR Options

The Feasibility Study focused solely on a potential IPR program for groundwater replenishment. The conceptual planning studies considered the future potential of adapting the program to meet the requirements of forthcoming DPR regulations. Based on the status of DPR regulations, it appears that blending and retreatment of the AWT water at one or more of Metropolitan's existing treatment plants may become feasible in the future.

Three of the alternatives (A, B, and C) provide sufficient initial infrastructure to allow for the addition of DPR capabilities following the first phase of implementation in the form of raw water augmentation at the F.E. Weymouth Water Treatment Plant (Weymouth WTP) and the Robert B. Diemer Water Treatment Plant (Diemer WTP). The availability of a DPR option allows significant operational flexibility when used in conjunction with IPR deliveries and may significantly expand the benefits of the program.

The location of both WTPs in relation to the proposed RRWP facilities provides a unique opportunity for purified water to supplement raw water supplies to a drinking water treatment plant, once DPR regulations are approved. Regulations for the raw water augmentation form of DPR could be established by the end of 2023, based on the state of scientific and technical research at that time. In pursuing DPR options for the RRWP, several enhancements would likely be required by future regulations to compensate for the loss of the environmental buffer (i.e., groundwater basin).

Source control programs under a DPR application are expected to be more prescriptive than those required for an IPR project. Further optimization of wastewater treatment processes may also be needed to help reduce certain compounds prior to the water reaching the advanced water treatment facility. It is anticipated that higher levels of advanced water treatment will also be required by future raw water augmentation regulations. Treatment redundancy through multiple independent barriers is expected, including a greater degree of pathogen control. Responding to treatment failures becomes even more critical in a DPR treatment scheme; therefore, more rigorous monitoring and enhanced tools will be required to respond to "off-spec" events. In addition, minimum dilution requirements will likely be required by regulators when blending advanced treated recycled water with other raw waters at the Weymouth or Diemer WTPs. Initial blending requirements may be conservative until greater experience on raw water augmentation projects is gained in the future. Operational changes or investments at the Weymouth or Diemer WTPs would also need to be evaluated when considering DPR integration.

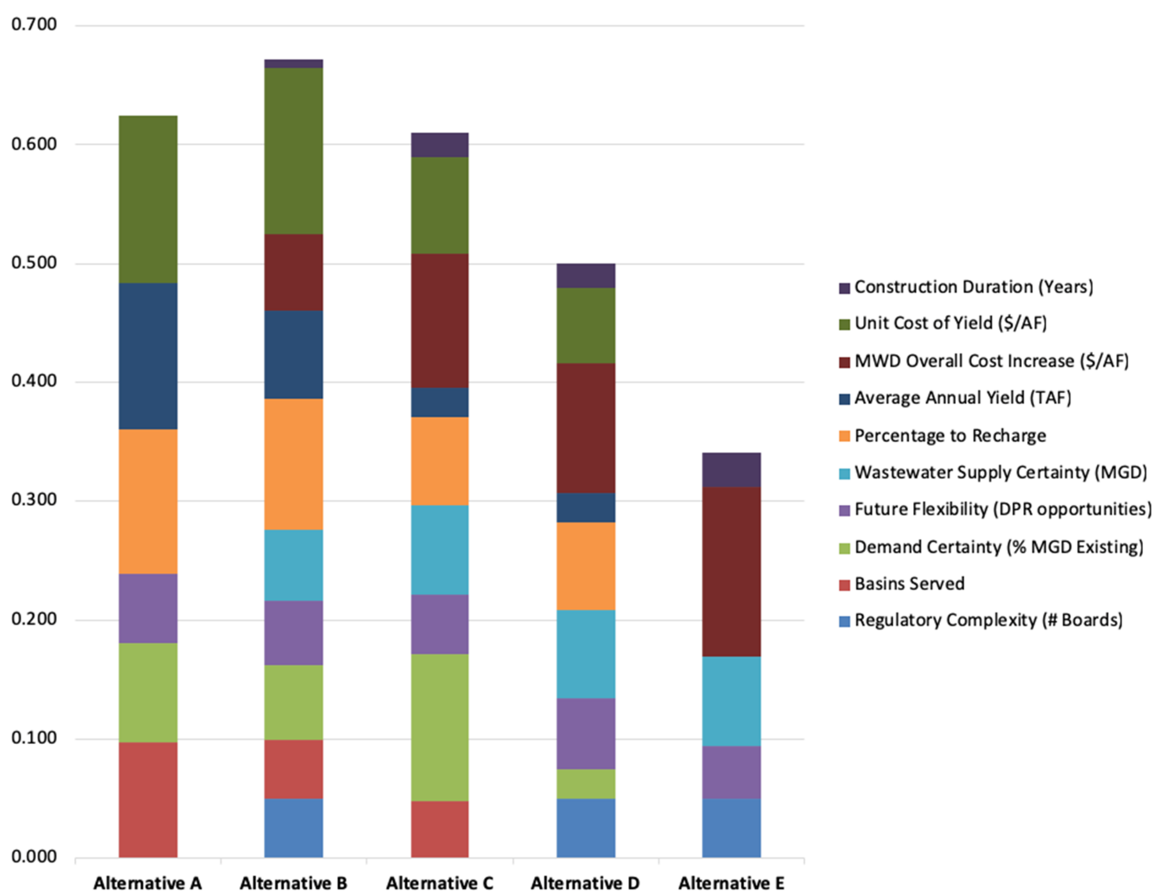
Additional conveyance facilities would be required for potential future integration of raw water augmentation for the RRWP. A connection from the Santa Fe Spreading Grounds area to the Weymouth WTP would require additional pipeline reaches and pump stations. Connecting the RRWP system to the Weymouth WTP would also allow advanced treated water to be brought to the Diemer WTP via Metropolitan's existing Yorba Linda Feeder. A connection from the RRWP system just south of the Whittier Narrows area could also be established to the Diemer WTP, requiring additional pipeline reaches and pump stations. Additional engineering studies are needed to further evaluate these conveyance options.

Raw water augmentation may be a viable future opportunity for the RRWP, but additional work is needed to fully evaluate it. Metropolitan continues to actively engage with the water industry on the regulatory development of DPR. Funding through Metropolitan's Future Supply Actions program has recently been provided to help advance several potable reuse studies and fill DPR research gaps. Metropolitan will be conducting technical evaluations through the upcoming demonstration project at the demonstration facility and developing future research programs associated with potable reuse, including raw water augmentation applications. Finally, it should be emphasized that the primary purpose of the RRWP is to provide a drought-proof supply for replenishing regional groundwater basins to meet demands on Metropolitan and maintain the long-term basin health and reliability. This long-term replenishment need would remain, with or without the potential integration of DPR in the future.

Multi-Objective Decision Analysis (MDA)

In order to develop a refined comparison of the five alternatives, a weighted MDA was developed utilizing the objectives, criteria, and performance metrics, and weightings provided by senior Metropolitan project team members. Figure 1.5 presents a bar chart comparison of the values developed through this methodology. As illustrated in the figure, Alternatives A and B are closely matched, with Alternative C slightly lower than the two highest ranking alternatives. Alternatives D and E are clearly inferior to the top 3 alternatives. Further, the analysis suggests that a multi-phase approach (Alternative B) performs as well or better than implementing the entire program in a single phase (Alternative A). Further discussion of the MDA process, along with its associated criteria and metrics, is included in Chapter 3.

Figure 1.5: Breakdown of Overall Alternative Score by Criterion



The evaluation of phasing alternatives demonstrates that the program will likely benefit from implementation in two phases, with a 100-mgd first phase project designed to extend from the JWPCP in Carson to the Santa Fe Spreading Grounds in Irwindale. The potential advantages of the proposed two-phased approach include the following:

1. Greater certainty regarding future demands sufficient to use the production from a 100-mgd AWT plant.
2. Greater certainty regarding the long-term availability of sufficient secondary effluent from the JWPCP to meet initial production needs.
3. Increased flexibility by allowing multiple pathways to serve Orange County groundwater needs and potential DPR applications in the future.
4. Lower initial capital and O&M costs reducing the initial impact on Metropolitan's overall cost increases.
5. Unit costs of production that are nearly equivalent to the unit cost estimates for the full-scale program.

Proposed Implementation Strategy (Backbone System)

Through the analysis described above, a proposed implementation strategy emerged. The proposed approach provides: (1) an AWT plant sized to meet near-term existing and planned future demands, (2) a pipeline sized to accommodate both existing and potential future uses, and (3) the flexibility to adapt the initial system for DPR once applicable regulations are established. Any DPR option would supplement the initial IPR program, not replace it. The strategy represents a modification to Alternative B (North First) and provides treatment for up to 100 mgd of purified water conveyed from the AWT plant in Carson to the Santa Fe Spreading Grounds through a pipeline appropriately sized for up to 150 mgd (the full program capacity). This reconfigured version of Alternative B has been characterized as the "backbone conveyance system" (Backbone System). Although the Backbone System serves the refinery demands adjacent to the JWPCP, it does not include the pipeline and injections wells needed for future West Coast Basin replenishment demands.

Early Delivery Opportunities

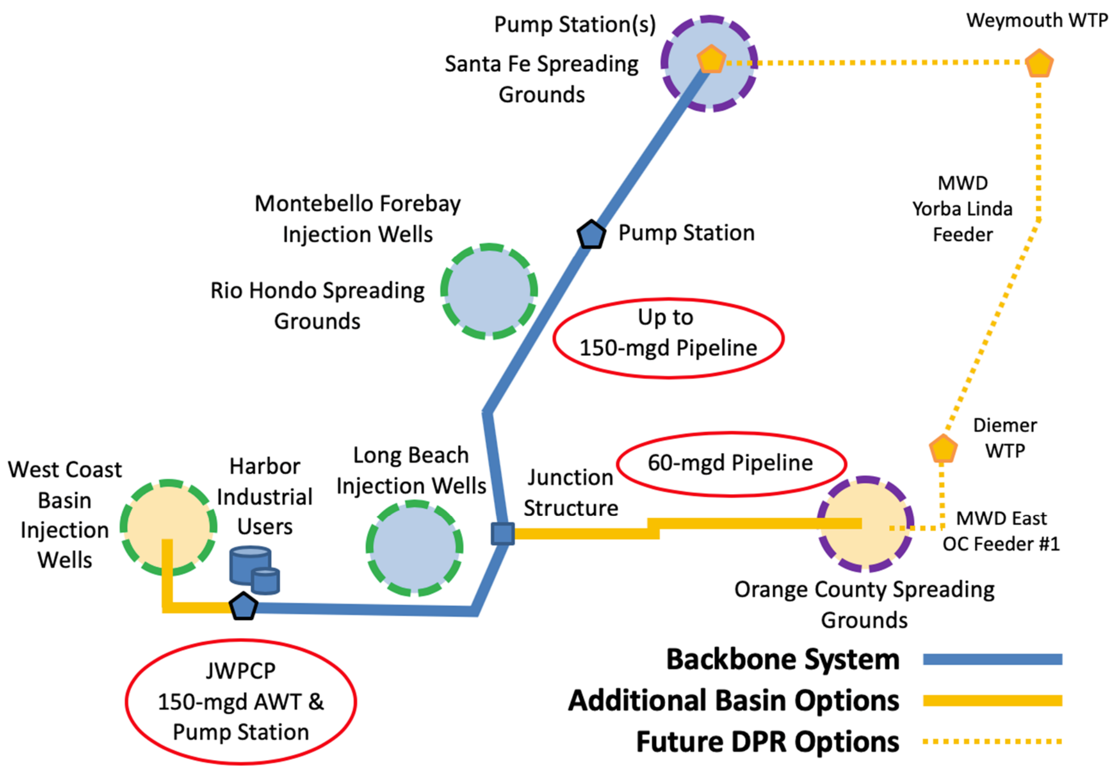
As part of the implementation strategy, it is recommended that opportunities to make early deliveries of purified water be considered during the overall Backbone System development plan. As indicated in the demand assessment earlier in this chapter, there is potentially 23 mgd of purified water demand within an 8-mile radius of the AWT plant. Documented demands include up to 10 mgd of refinery demands in the Harbor Area, 4 mgd of replenishment demand in Long Beach, and potentially 9 mgd or more of replenishment demand in the West Coast Basin. Additionally, there may be opportunities to provide purified water to industrial demands in the Long Beach Harbor area that have not yet been fully defined or quantified.

Early deliveries to these potential customers (and others along the pipeline alignment) would provide operational experience at scale, immediate supply benefits, and some initial water sales for the program. Further, the modular design of many AWT processes is conducive to progressive expansion of treatment capacity as the conveyance system is completed.

Following the environmental planning process, approximately 10 to 11 years will be needed to complete the 100-mgd Backbone System, including the construction of approximately 38 miles of pipeline from Carson to the Santa Fe Spreading Grounds. Early deliveries to customers close to the AWT plant could potentially begin within 5 to 6 years after completion of the environmental process. The timing and sequence of the planning, design, and construction of infrastructure to meet these early delivery objectives would be more fully examined during subsequent CEQA and preliminary design efforts.

Figure 1.6 presents a schematic of the overall proposed Regional Recycled Water Program, including both IPR and DPR options for the future.

Figure 1.6: Proposed Regional Recycled Water Program



The groundwater basin options (solid yellow lines) can be implemented at any time after the Backbone System is completed. The DPR options (dashed yellow) will require further regulatory developments before the technical requirements and costs can be fully evaluated. The flexibility to provide several possible pathways to 150 mgd (or even higher flows) is one of the major benefits offered by the proposed Backbone System.

Table 1.3 presents a summary comparison of the Full Program Alternative A and the different phases of the Backbone System alternative. For the purposes of this comparison, the second phase of the Backbone System alternative is assumed to be the IPR pipeline from the junction structure to the Orange County

Spreading Grounds, as described in Alternatives A through E. Given the uncertainty of future DPR requirements at this time, it does not include the cost of any of the future DPR options shown in Figure 1.6.

Table 1.3: Comparison of Full Program and Proposed Two-Phase Program

Performance Metrics	Full Program (Alternative A)	Proposed Program: Phase 1 (Backbone System)	Proposed Program: Phase 2 (OC IPR Option)	Proposed Program: Complete Program (OC IPR Option)
AWT Production Capacity (MGD)	**150**	**100**	**50**	**150**
Starting Location	Carson	Carson	Cerritos	Carson
Terminus	Complete	Santa Fe SG	Anaheim	Complete
Basins Served	All	WC, Central, Main	Orange County	All
Annual Demands (MGD)	150	86	65	150
Annual Demands (TAFY)	168	96	73	168
Miles of Conveyance in Phase (miles)	62	38	24	62
Highest Elevation (ft.)	500	500	200	500
AWT Production Capacity (MGD)	150	100	50	150
AWT Production Capacity (TAFY)	168	112	56	168
Average Yield (MGD)	147	98	49	147
Average Annual Yield (TAF)	165	110	55	165
Capital Cost of Phase ($Million)[1]	$3,080	$2,615	$782	$3,397
JWPCP Modifications	$150	$150	$0	$150
Advanced Water Treatment Plant	$570	$431	$188	$620
Conveyance Facilities	$899	$840	$190	$1,031
Well Facilities	$205	$128	$85	$213
Engineering Costs (25%)	$456	$387	$116	$503
Contingency (35%)	$798	$678	$203	$881
Annual O&M Cost of Phase ($Million)	$134	$69	$60	$129
Advanced Water Treatment	$108	$56	$52	$108
Conveyance	$24	$13	$7	$20
Well Field and Spreading Facilities	$1	$1	$1	$1
Annual Financing Costs ($Million)[2]	$155	$130	$42	$171
Total Average Annual Costs ($Million)	**$288**	**$199**	**$102**	**$301**
Unit Cost of Yield by Phase ($/AF)	$1,752	$1,813	$1,853	$1,826
Avg. MWD Cost Increase of Phase ($/AF)[3]	**$170**	**$117**	**$60**	**$177**
Construction Duration (Years)	11	10	6	16

[1] 2018 Dollars (Revised 03/15/2019)

[2] Assumes a 30 year term and 4.00% per annum interest rate.

[3] When project is fully operational and based on Metropolitan's 2017/18 Budget of 1.70 MAF.

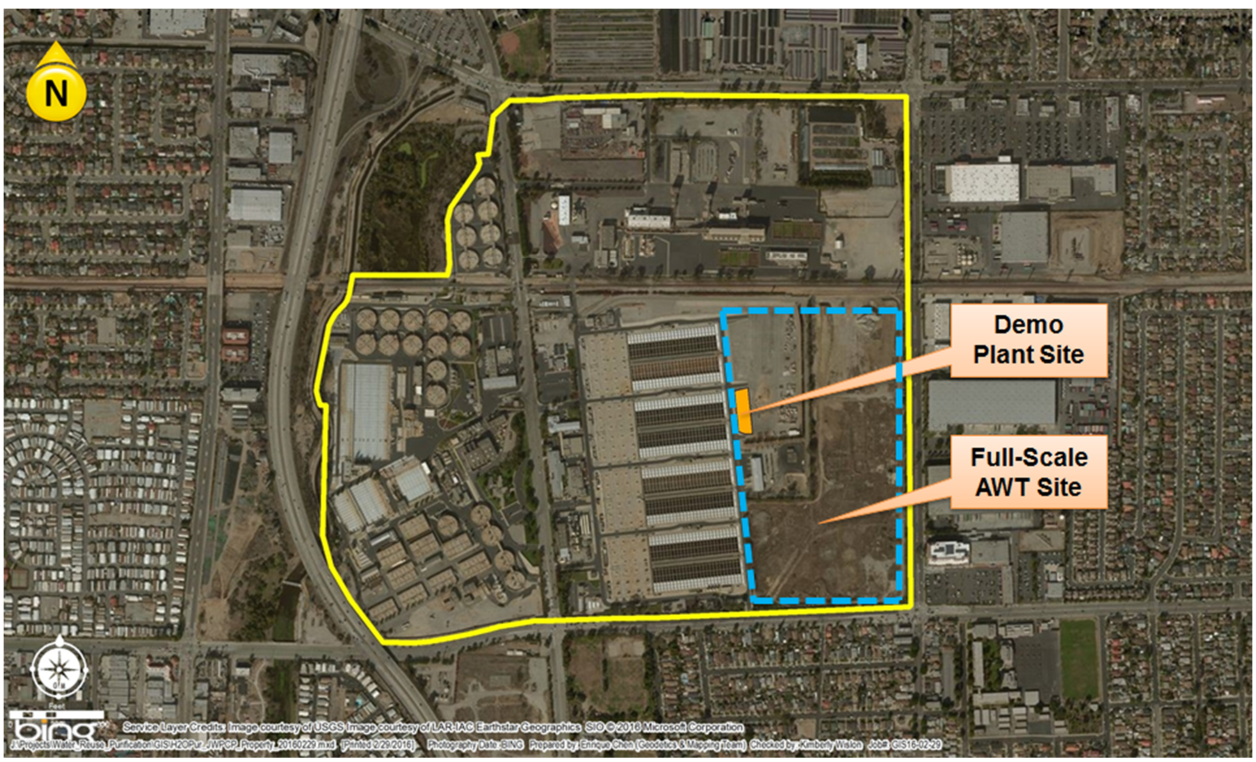
In summary, initial implementation of the proposed first phase Backbone System provides:

1. Significant new replenishment supply conveyed to the largest existing and planned groundwater recharge demands.
2. Unit production costs are competitive with the overall program (3% higher than full program implementation).
3. Lower initial impact on Metropolitan's overall cost increases resulting from lower total annual costs (31% lower than full program implementation).
4. Reduced regulatory complexity.
5. Greatest flexibility to adapt to future regulatory changes that may permit the incorporation of DPR into the program.
6. Greater certainty of secondary effluent flows needed to meet production goals.

1.3 Advanced Water Treatment Plant

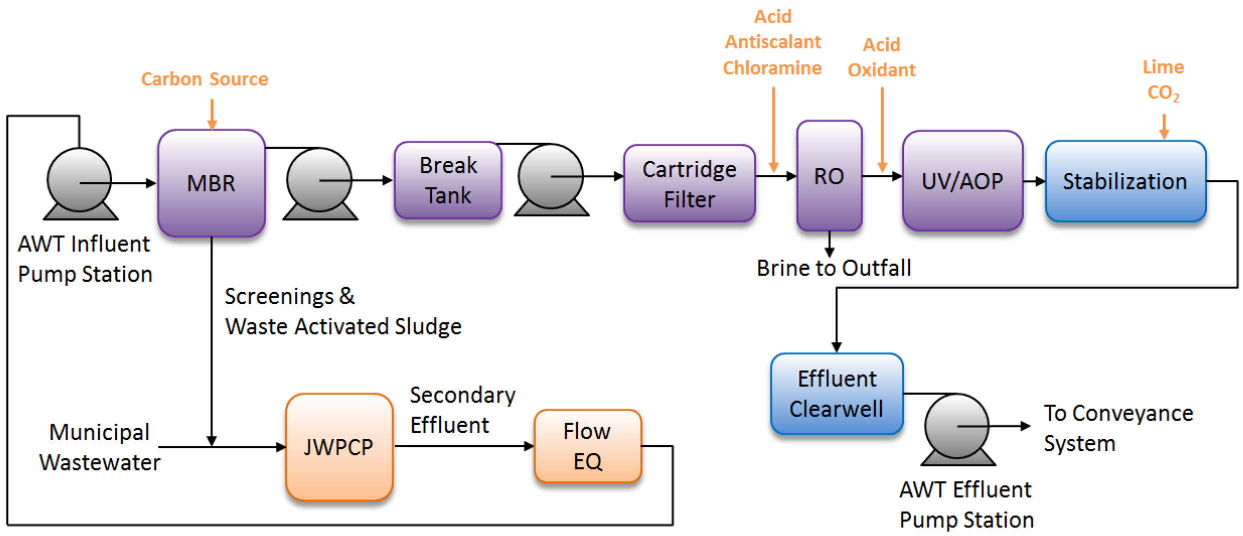
The new full-scale AWT plant would be located within the Sanitation Districts' JWPCP in Carson, as shown in Figure 1.7.

Figure 1.7: Proposed Location of AWT Facilities at JWPCP



The AWT plant would receive unchlorinated, non-nitrified secondary effluent from the adjacent wastewater treatment facilities. It would be designed to produce up to 150 mgd (168 TAFY) of high-quality water that meets the requirements for IPR through groundwater recharge. The product water quality goals would be achieved through the collaborative efforts of Metropolitan and the Sanitation Districts using source control measures and advanced water purification technologies. The AWT plant process train currently envisioned and shown in Figure 1.8 includes a tertiary membrane bioreactor (MBR) followed by reverse osmosis (RO) and ultraviolet/advanced oxidation processes (UV/AOP). The process could be modified in the future with advancements in treatment technology or changes to regulatory requirements. Due to diurnal flow patterns at the JWPCP, flow equalization will be required upstream of the AWT plant to ensure sufficient secondary effluent is available to the AWT plant at full 150-mgd capacity.

Figure 1.8: Process Flow Schematic for the Full-Scale AWT Plant



Water Quality

Regulatory oversight of water reuse projects is carried out by the SWRCB through the DDW and the individual RWQCBs. DDW and the RWQCBs regulate groundwater recharge projects under Title 22 California Code of Regulations Division 4, Chapter 3. Groundwater replenishment regulations address the protection of public health with respect to chemicals, microorganisms, and constituents of emerging concern. In addition to the Title 22 criteria, recycled water must also comply with water quality standards and objectives in applicable basin plans, salt and nutrient management plans, and other applicable regulations and policies to protect water quality and the beneficial uses of surface water and groundwater.

Los Angeles RWQCB Basin Plan objectives for the Main San Gabriel, West Coast, and Central Basins have nitrate and nitrate + nitrite limits of 10 milligrams per liter as nitrogen (mg/L-N). However, a lower nitrate limit of 3.4 mg/L-N is required by the Santa Ana RWQCB in the Orange County Basin due to basin-specific nitrate issues. Therefore, a total nitrogen (TN) water quality goal of TN $\leq$ 3.4 mg/L is established for the AWT plant product water to serve the Orange County Basin.

A primary purpose for building and operating the demonstration facility is to optimize the treatment process train for a full-scale AWT plant. One of the many water quality criteria the full-scale plant will have to comply with addresses nitrogen levels in the recycled water during and after its treatment – with both operational and public health requirements. A Nitrogen Management Committee, consisting of technical staff from both Metropolitan and the Sanitation Districts, explored cost-effective and reliable alternatives to help identify a holistic nitrogen management strategy, considering potential treatment options at both the JWPCP and new AWT plant. The committee's report is discussed in Chapter 4, Advanced Water Treatment Plant and included in Appendix C.

Boron management is also needed. JWPCP effluent boron concentration is currently about 0.9 mg/L. To protect agricultural beneficial uses, particularly for citrus crops, the California State boron notification level is 1 mg/L; the Main San Gabriel Basin Plan limit is 0.5 mg/L. Source control to reduce boron in the sewershed and additional treatment measures at the AWT plant are being considered.

1.4 Conveyance System

The conveyance system will consist of approximately 60 miles of pipeline and a series of pump stations as shown in Figure 1.9. The system will deliver up to 150 mgd of purified water as far east as the Orange County Spreading Grounds in Anaheim and as far north as the Santa Fe Spreading Grounds in Irwindale. Delivery locations along the alignment will consist of either existing groundwater spreading basins, new or existing injection wells, or industrial users in the Harbor area. For planning purposes, the pipeline alignment has been divided into five segments; the numbering is used to clarify the analysis and does not indicate any priority or construction order.

Additional analyses were completed to verify and refine the alignments presented in the Feasibility Study. The analysis revealed a topographic high point along Segment 1, near Signal Hill. Numerous concept level alternatives were identified and evaluated for conveying flows over (or around) the high point. A two-pump station system alternative was determined to be most advantageous.

Feedback was solicited from internal and external project stakeholders to ensure that the alignment to date is constructible and financially feasible, minimizes construction impacts to communities, and avoids or minimizes environmental impacts.

Proposed First Phase Backbone Conveyance System

As described above, the proposed Backbone System would include upsized conveyance that would accommodate existing and future uses and have the flexibility to accommodate DPR applications in the future once applicable regulations are established. A sensitivity analysis validated that an 84-inch diameter pipeline for Segment 1 (AWT to Junction Structure near Cerritos) is appropriate. A minimum of two pump stations will be necessary to convey up to 150 mgd from the AWT site to the vicinity of the Santa Fe Spreading Grounds. Further assessment of the hydraulics and operation of this backbone system will be conducted during preliminary design. Verification will be needed to ensure that an upsized pipeline can be constructed within the previously identified alignment.

1.5 Groundwater Modeling

The RRWP would recharge four groundwater basins as shown in Figure 1.10. These basins were selected based on their proximity to the JWPCP and their ability to accommodate up to 150 mgd (168 TAFY) of recharge water.

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. 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. As a part of the conceptual planning efforts, additional groundwater modeling, beyond that conducted for the Feasibility Study, was performed to refine anticipated replenishment demands in each basin.

Figure 1.9: Overview of the Conveyance System

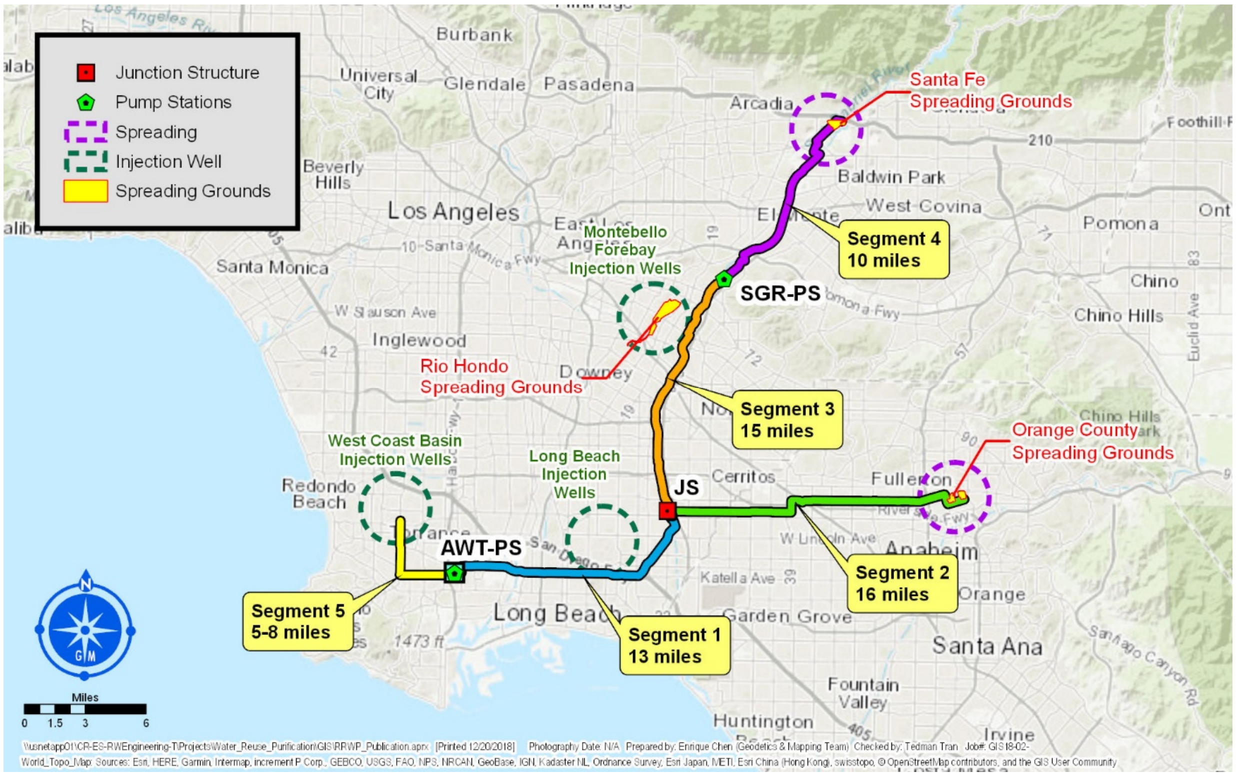
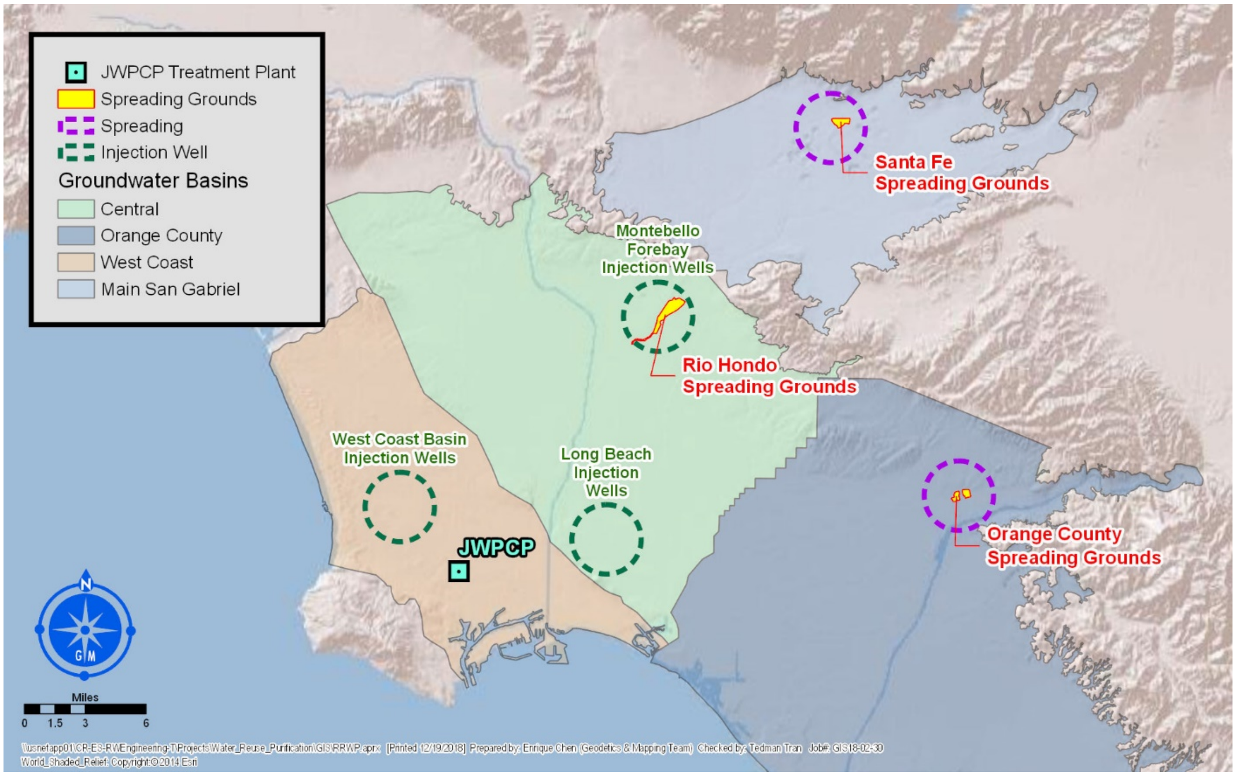


Figure 1.10: Groundwater Basins and Recharge Locations



Within the Main San Gabriel Basin, results of the groundwater modeling indicate the contamination plume associated with the United States Environmental Protection Agency (USEPA) Baldwin Park Operable Unit (BPOU) cleanup may be partially affected, particularly in the western portion of the BPOU remediation area. However, it appears that the impacts are minor and can be contained by the existing BPOU remedial systems. Key findings for the Main San Gabriel Basin are as follows:

- Without the delivery of 81 TAFY of purified water from the RRWP, water levels would be 110 feet mean sea level (MSL) (70 feet below current basin levels) assuming historical pumping and recharge activities. Because water levels drop below the threshold for maintaining well capacity in the basin, pumping capability would diminish due to these declining water levels.
- With the delivery of 81 TAFY of purified water from the RRWP, water levels would be about 70 feet above current levels (or about 250 feet MSL). Water levels peak at 303 feet MSL, which is still below the upper threshold water level at the key well.

Within the Central and West Coast Basins, groundwater modeling results suggest that in the Long Beach area, introduction of purified water from the RRWP would increase water levels by as much as 6 feet. In the Montebello Forebay area, the groundwater table is expected to rise as much as 7 feet. In the Carson area, the groundwater table would rise by a maximum of approximately 24 feet.

For the Orange County Basin, the Orange County Water District (OCWD) currently 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 (58 mgd) of imported water from Metropolitan in the future. Spreading basins owned by OCWD have the capacity to receive all 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 may be limited to 22 TAFY (20 mgd) of additional recharge from the RRWP.

Table 1.4 summarizes the levels of potential daily recharge expected approximately 85% of the year (totaling 150 mgd). During the remaining 15% of the year, total potential recharge capacity is expected to periodically decline to a low of approximately 100 mgd. This fluctuation in demands is captured in the expected yield for each of the alternatives (98% of the peak production capacity of the AWT, or 147 mgd) and is consistent with the Feasibility Study.

Table 1.4: Average Annual Replenishment Deliveries by Basin

	Annual Replenishment Deliveries	
Groundwater Basin	TAFY	mgd
Main San Gabriel	81	72
Orange County	52	46
Central	14	13
West Coast	21	19[1]
Total – All Basins	**168**	**150**

[1] West Coast Basin deliveries include 10 mgd of industrial consumptive demand.

Additional groundwater modeling was conducted for the conceptual studies to assess any impacts resulting from storing and pumping purified water in the basins and to refine the delivery flows and schedules associated with a full-scale program. The results of these evaluations are presented in Chapter 6, Groundwater Modeling.

1.6 Environmental Planning

Implementation of the RRWP will require environmental review under the 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. A Programmatic Environmental Impact Report (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, the preparation of a PEIR is recommended for the overall program with additional project-level tiered documents, which will support future phases of the program. The PEIR will allow Metropolitan to consider broad policy alternatives and program-wide mitigation measures early in the program design and will provide greater flexibility to consider design alternatives to avoid, minimize, and develop mitigation measures for identified impacts and to ensure adequate cumulative impact analysis.

1.7 Technology Acceptance and Permitting

Metropolitan and the Sanitation Districts have engaged in meetings with the regulators (DDW and Los Angeles and Santa Ana RWQCBs) since early 2016. In 2017, coordination with the regulators became focused on the testing strategy for the demonstration project. A technical memorandum, *Advanced Water Treatment Demonstration Facility Testing Strategy,* was submitted to DDW providing details on the general framework for the proposed AWT demonstration testing. The accepted framework focused on an approach for technology acceptance testing of the MBR process.

Because the JWPCP effluent has yet to be used for beneficial reuse, collecting data to establish the AWT plant'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 plant or the end use of the water.

MBRs have been widely used in nonpotable reuse applications, benefitting from its small footprint and high-quality effluent. A primary challenge facing implementation of an MBR in a potable reuse treatment train is the lack of pathogen reduction credits granted to date. A key component of the regulatory process will be to receive technology acceptance of an MBR process. Through the demonstration project, Metropolitan will be seeking pathogen log reduction credits and technology acceptance from DDW for an MBR as a key pathogen barrier in a potable reuse treatment train. Membrane filtration, an approved process train for nonpotable reuse applications, could be implemented should the technology acceptance for an MBR process not be granted by DDW. Metropolitan will also demonstrate that all the AWT processes will achieve the water quality and operational goals established for the demonstration project.

Metropolitan and the Sanitation Districts prepared a draft testing and monitoring plan for the demonstration facility. The plan outlines the work to be conducted in the demonstration project in three phases over a period of 15 months beginning in early 2019. Metropolitan and the Sanitation Districts presented the draft demonstration testing and monitoring plan to the independent scientific advisory panel and the regulators in August 2018, gaining key feedback. Staff is working to receive final approval by the regulatory agencies prior to initiating demonstration testing in March 2019. Use of the demonstration facility could continue following the first 15 months of operation for additional data to develop process design criteria and optimize process train operations.

1.8 Findings and Recommendations

The conceptual studies presented in this report focused on program phasing opportunities, potential DPR options, water quality related to nitrogen management and boron control, refining the configuration of the conveyance system, and further groundwater modeling and characterization of demand certainty. The following are the findings and conclusions from the analyses and technical investigations. This section concludes with recommendations for next steps.

Importance of the First Phase

Because all five alternatives ultimately achieve a 150-mgd program, the initial decision regarding program implementation is largely driven by the first phase considerations and performance metrics. The first objective of the phasing assessment called for each phase of every alternative to "perform as a fully functional and cost-effective stand-alone project." This objective reduces the risk of stranded assets if the implementation of subsequent phases is delayed or indefinitely postponed. The assessment objectives also recognized the value of flexibility to accommodate future DPR opportunities. Alternative B – with 100 mgd of production and conveyance to the Santa Fe Spreading Grounds in the first phase – offers the most balanced approach, including significant economies of scale and proximity to both the Weymouth and Diemer WTPs (similar to Alternative A) at lower overall uncertainty (similar to Alternative C). Furthermore, a multi-phase approach offers the ability to initiate program development without foreclosing on emerging opportunities for increased efficiency, effectiveness, and operational control that may result from the availability of DPR as a viable option. For these reasons, Alternative B (North First) was considered the most desirable among the five alternatives considered and served as the basis for the proposed Backbone System. The Backbone System offers the following benefits:

1. Significant new replenishment supply conveyed to the largest existing and planned groundwater recharge demands.
2. Unit production costs are competitive with the overall program (3% higher than full program implementation).
3. Lower initial impact on Metropolitan's overall cost increases resulting from lower total annual costs (31% lower than full program implementation).
4. Reduced regulatory complexity.
5. Greatest flexibility to adapt to future regulatory changes that may permit the incorporation of DPR into the program.
6. Greater certainty of secondary effluent flows needed to meet production goals.

In addition to an expansion to meet Orange County Basin replenishment demands, other potential future program components that could be implemented in conjunction with the Backbone System include (1) a future purified water tie-in from a future AWT plant at the City of Los Angeles Hyperion Water Reclamation Plant, and (2) IPR in the Raymond and Chino groundwater basins.

Direct Potable Reuse

The location of both the Weymouth and Diemer WTPs in relation to the proposed first phase Backbone facilities provides an opportunity for purified water to supplement the raw water supply to a drinking water treatment plant after DPR regulations are approved. The potential benefits of incorporating DPR in the full-scale program (once approved) are considered significant enough to warrant phasing program implementation enabling retention of future flexibility.

Nitrogen Management Options

Effective nitrogen management through the AWT process is crucial to ensuring optimum overall treatment process efficiency, as well as ensuring that the product water from the plant meets the TN and nitrate goals for the groundwater basins that will be receiving the purified water. Several process trains were selected for further detailed evaluation. Some of these potential processes can be readily examined at the demonstration facility, and modifications to the plant were made during construction to facilitate further testing and examination of nitrogen management. The Nitrogen Management Committee recommended that testing of these alternative processes be undertaken after the initial demonstration facility testing is completed.

Boron Source Control and Treatment

Boron is present in the flow streams entering the JWPCP and the boron concentration in the effluent leaving the plant is currently about 0.9 mg/L. However, the source and quantification of these flows was not previously well understood. The Sanitation Districts undertook a boron source investigation study and determined that most of the boron is entering the plant from the oil field industries in the Long Beach and Signal Hill areas. With the current basin objective in place for the Main San Gabriel Basin, this program may need additional measures to reduce boron, either through source control or with additional treatment. Treatment could potentially be provided at either the JWPCP site or at a satellite treatment facility near the Santa Fe Spreading Grounds. Methods of boron source control, including bench-scale tests, are currently being investigated by the Sanitation Districts. This work should be continued to determine the feasibility of cost-effective source control.

Refined Conveyance System Configuration

The conveyance pipeline system was refined from the configuration presented in the Feasibility Report base case system. These refinements were made to realize improved efficiencies to the overall system, as well as to address the potential for phasing of the overall program. Key refinements and improvements made include (1) establishing a hydraulic control point in Signal Hill to facilitate the implementation of a phased system, (2) considering elimination of one pump station along the alignment to reduce costs and simplify system operations, (3) reassessing the need for and configuration of trenchless crossings at critical locations to better reflect actual conditions and to refine cost estimates, (4) confirming preliminary utility and other major buried infrastructure information with impacted stakeholders to further refine potential construction impacts and costs, and (5) identifying conceptual-level pipeline alignments to convey AWT water from the current terminus of the system at the spreading basins to Metropolitan’s Weymouth and Diemer WTPs as part of a potential future DPR scenario.

Demands for Replenishment Water

Significant additional groundwater modeling efforts were undertaken in close coordination with the potentially affected member agencies and water masters. The results of this modeling were used to refine near-term and future potential replenishment demands beyond what had been previously identified in the Feasibility Study. A separate assessment characterized the relative certainty of replenishment demands in the groundwater basins. This qualitative assessment supports phasing alternatives that reach significant levels of existing demand during the first phase of the program.

Recommended Next Steps

Based on the results of the analyses completed for these conceptual planning studies, the following next steps are recommended should Metropolitan’s Board decide to move implementation of the RRWP forward:

1. **Proceed with environmental review process.** The analyses completed thus far in the Feasibility Study and Conceptual Planning Studies Reports for the RRWP allows for Metropolitan to proceed with the environmental review process at a programmatic level for the full program, including potential future IPR and DPR options. Project-level environmental review can also be

prepared for initial construction projects planned for the first phase. Because of the complexity and long lead time needed to complete the environmental permitting process, it is recommended that the environmental process proceed while further program development and evaluations continue to take place. Engineering activities will be needed to support the environmental process; the extent to which preliminary design is completed for a program element during the environmental review process can impact the overall implementation schedule.

2. **Further refine treatment options for a full-scale AWT plant.** While initial demonstration testing and monitoring for regulatory acceptance of MBR proceeds, additional testing work should be planned to help finalize a recommended treatment train for the full-scale AWT plant. This additional testing should include refinement of process design criteria for a full-scale AWT plant; further evaluation of selected process trains for nitrogen management; and further analysis of source control and treatment for boron.
3. **Further develop the conveyance system.** Metropolitan should continue to engage key stakeholders, including the United States Army Corps of Engineers (USACE), Southern California Edison, and Los Angeles County Department of Public Works, and the cities and municipalities involved to refine pipeline alignments and right-of-way requirements. The hydraulic characteristics of the system should be finalized, and infrastructure requirements needed at groundwater recharge locations evaluated. Further assessment of pipeline appurtenances as well as pipeline coatings should be conducted, and design criteria established for seismic events, fault crossings, river crossings, and major infrastructure crossings.
4. **Conduct additional groundwater analysis.** Metropolitan should work with the groundwater basin managers to perform physical tracer studies to confirm results of solute transport and particle tracking and perform water compatibility studies for the injection wells and the spreading basins to assess whether there will be any potentially adverse interactions between the purified water and the native groundwater. Based on the results, siting of the proposed injection wells and relocated production wells should be confirmed.
5. **Establish preliminary commitments.** Efforts should be undertaken to confirm the willingness of potential recipients of the purified water to commit to the delivery schedule, operational requirements, and financial needs of the overall program.
6. **Evaluate program cost recovery.** Present information to the Metropolitan Board to obtain policy direction as to preferred cost recovery methods.
7. **Ensure consistency with the IRP.** Continue evaluation of the program's regional water supply benefits in the context of Metropolitan's IRP.
8. **Adjust for current and future needs.** The RRWP should be phased to "right size" the initial investment in AWT facilities based on the established commitments of potential recipients. The infrastructure provided for conveyance should consider the availability of purified water and the needs of the full program over time. An analysis of implementation sequencing should be prepared for overall program development as well as individual projects within a given phase.
9. **Strengthen collaborative management.** Program development should include participation from all agencies needed to make the overall integration of many utility functions (a "system-of-systems") to perform reliably over time. From a high-level perspective, the RRWP is a multi-agency undertaking that requires close collaboration and coordination among Metropolitan, the Sanitation Districts, member agencies, groundwater basin managers, Los Angeles County

Department of Public Works, and others. To ensure reliable operations of the full program, a collaborative management structure should be in place during the planning, development, implementation, and ongoing operations of the system. Although this may not require the creation of a new organization, a formal acknowledgment of the program's overall mission and goals by all participants is important.

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