METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

FINAL

REGIONAL RECYCLED WATER PROGRAM

Backbone Conveyance System | Feasibility Level Design Report

Volume I of III

June 2020

Black & Veatch
Project No. 191628

BLACK & VEATCH

IN ASSOCIATION WITH
CDM Smith

FINAL

REGIONAL RECYCLED WATER PROGRAM

Backbone Conveyance System

Feasibility-Level Design Report

Volume 1

BLACK & VEATCH PROJECT NO. 191628

PREPARED FOR

Metropolitan Water District of Southern California

30 JUNE 2020

In association with

Regional Recycled Water Program
Black & Veatch Project 191628

Backbone Conveyance System Feasibility-Level Design Report
June 2020

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ACRONYM AND ABBREVIATIONS LIST

The following abbreviations or acronyms are used in this document.

AACE	Association for the Advancement of Cost Engineering
ARVV	air-release and vacuum valve
AWT	advanced water treatment
Black & Veatch	Black & Veatch Corporation
BEP	best-efficiency point
CalOSHA	California Occupational Safety and Health Administration
Caltrans	California Department of Transportation
CEQA	California Environmental Quality Act
cf	cubic feet
CGS	California Geologic Survey
CM	construction method
CNDDB	California Natural Diversity Database
DPR	direct potable reuse
EPBM	earth pressure balance tunnel boring machine
FEWWTP	F.E. Weymouth Water Treatment Plant
ft	feet
FLDR	Feasibility-Level Design Report
fps	feet per second
GAC	granular activated carbon
GeoPentech	GeoPentech Inc
GIS	geographic information system
gpm	gallons per minute
HDD	horizontal directional drilling
HGL	hydraulic grade line
HI	Hydraulic Institute
HP	horsepower
ID	inside diameter
in	inches
IPR	indirect potable reuse
IRRP	Indirect Reuse Replenishment Project
IPR	indirect potable reuse
JWPCP	Joint Water Pollution Control Plant
kWh	kilowatt hour
LA	Los Angeles
LACDPW	Los Angeles County Department of Public Works

LACFCD	Los Angeles County Flood Control District
LACSD	Sanitation Districts of Los Angeles County
LADWP	Los Angeles Department of Water and Power
LUFT	leaking underground storage tank
MCAA	Mechanical Contractors Association of America
MCCs	motor control centers
Metropolitan	Metropolitan Water District of Southern California
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
Minagar	Minagar & Associates, Inc.
MJA	McMillan Jacobs Associates
MT	microtunneling
M_W	moment magnitude scale
NECA	National Electrical Contractors Association
OC	Orange County
OC Reach	optional branch to the Orange County Spreading Grounds
OCSD	Orange County Sanitation District
OCWD	Orange County Water District
OD	outside diameter
O&M	operations and maintenance
OPCC	opinion of probable construction cost
Project	design of the conveyance facilities of the Regional Recycled Water Program
PS	pump station
PS-1	Pump Station 1
PS-2	Pump Station 2
PS-3	Pump Station 3
RPM	revolutions per minute
RRWP	Regional Recycled Water Program
RVs	recreational vehicles
SCE	Southern California Edison
SFSG	Santa Fe Spreading Grounds
SG	San Gabriel
SWRCB	State Water Resources Control Board
TBM	tunnel boring machine
TCE	trichloroethylene
USGMWD	Upper San Gabriel Municipal Water District
VFD	variable frequency drive

WBS	work breakdown structures
WRD	Water Replenishment District of Southern California
WSE	water surface elevation

Executive Summary

PROJECT OVERVIEW

In order to improve water supply reliability in Southern California, the Metropolitan Water District of Southern California (Metropolitan) is studying the feasibility of a Regional Recycled Water Program (RRWP). The RRWP would utilize advanced water treatment (AWT) processes to purify secondary treated effluent from the Sanitation Districts of Los Angeles County's (LACSD) Joint Water Pollution Control Plant (JWPCP) in Carson, California, and then pump the advanced treated water to select locations within Metropolitan's service area for beneficial reuse. The full implementation of the RRWP system would include construction of a 150 million gallons per day (mgd) AWT plant next to the JWPCP, a new regional conveyance system, pump stations, and various additional appurtenant facilities as required to convey advanced treated water to the delivery points. Additional smaller diameter piping would be required for laterals and connections to discharge locations, which could include the Santa Fe Spreading Grounds (SFSG), the West Coast Basin Injection Wells, Long Beach Injection Wells, Rio Hondo Spreading Grounds, Montebello Forebay Injection Wells, Orange County (OC) Spreading Grounds, and harbor area industrial users.

The primary objective of the RRWP is to develop a local and sustainable water supply for the region, with an initial focus on providing water to replenish groundwater basins for indirect potable reuse (IPR). In the future as appropriate regulations are promulgated, the RRWP water may transition to direct potable reuse (DPR).

Metropolitan, in conjunction with LACSD, has been conducting planning level studies for the RRWP for more than ten years, which provided the basis for conducting more detailed, feasibility level analyses. Metropolitan separated the feasibility level planning of the RRWP into two components:

- The AWT plant, which in addition to feasibility level analyses for a full-scale treatment plant, included the design and construction of a 0.5 mgd demonstration and piloting project at the JWPCP.
- The conveyance system, which includes the pipeline, pump stations, and associated appurtenant facilities.

The feasibility level study of the conveyance system is the focus of this report. Metropolitan retained the team of Black & Veatch Corporation (Black & Veatch) and CDM Smith to provide the feasibility-level professional engineering services for the alternatives analysis of the conveyance system. The services performed included feasibility-level engineering evaluations to identify, compare, and rank alternatives that best meet the overall project objectives.

This Feasibility-Level Design Report (FLDR) comprehensively documents the conveyance system evaluations completed by the Black & Veatch/CDM Smith team and Metropolitan to date. It also provides the planning basis for the next phases of the RRWP. These next phases of work are expected to include the following studies, which will be used to support final alignment selection:

- Conducting environmental studies and permitting processes to comply with the California Environmental Quality Act (CEQA) and, if necessary, the National Environmental Policy Act.

While this FLDR typically references CEQA, the information in this report can also be used to support the National Environmental Policy Act processes, if required.

- Performing more detailed technical analyses, including field subsurface geotechnical and hydrogeologic investigations, river scour analyses, utility location investigations, and trenchless installation technical studies to advance the pipeline alignment and construction techniques definition and selection.
- Continuing right-of-way acquisition efforts and financial analyses.

PROJECT BACKGROUND

This FLDR is the culmination of several years of effort on the part of Metropolitan's staff, on-going input from and collaboration with stakeholders, and contribution from Metropolitan's consultants, including the Black & Veatch and CDM Smith team. These efforts resulted in several study reports, all of which are embodied in this FLDR and its appendices.

Figure ES-1 presents a timeline summarizing the efforts and reports contributing to the development of this FLDR. Details are summarized below.

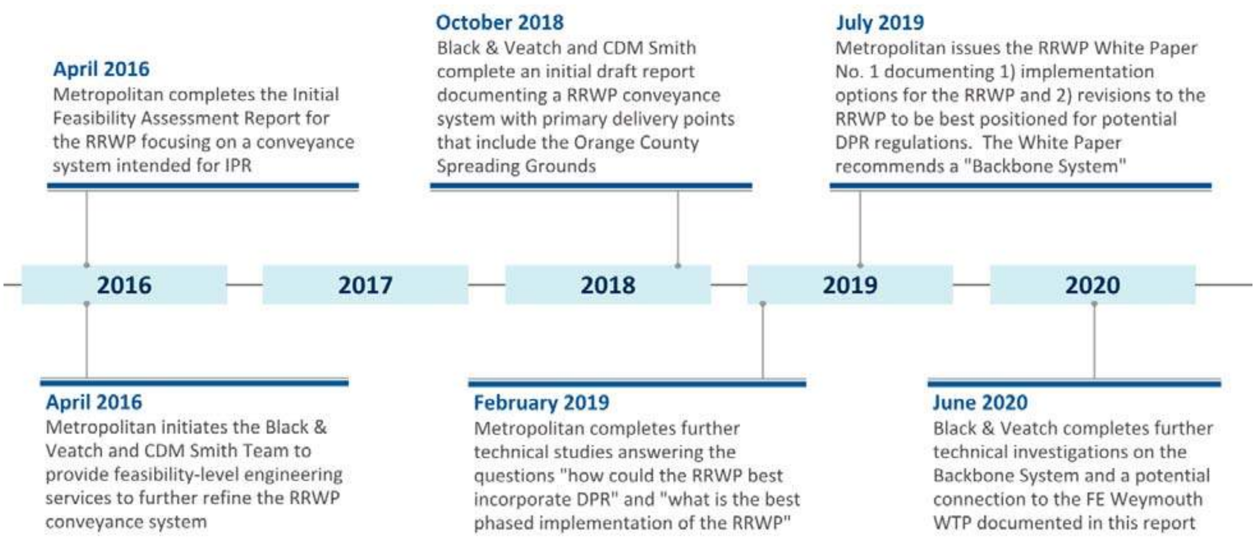

Figure ES-1 Timeline of Major Events Pertaining to the Development of this FLDR

Conveyance System Feasibility Assessment. In April 2016, Metropolitan completed a planning study for the RRWP conveyance system, which was documented in the report entitled "Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment." At the time, the RRWP was envisioned to convey the advanced treated water from the AWT plant to various spreading basins and injection wells sites within Metropolitan's service area for groundwater recharge. Upon reaching the discharge locations, the advanced treated water would be recharged into the ground, either through surface infiltration at existing spreading basins or through injection wells. After being stored in the groundwater basin for at least the minimum required retention time, the water would be available for extraction by partnering member agencies, treated, and sold for potable water distribution.

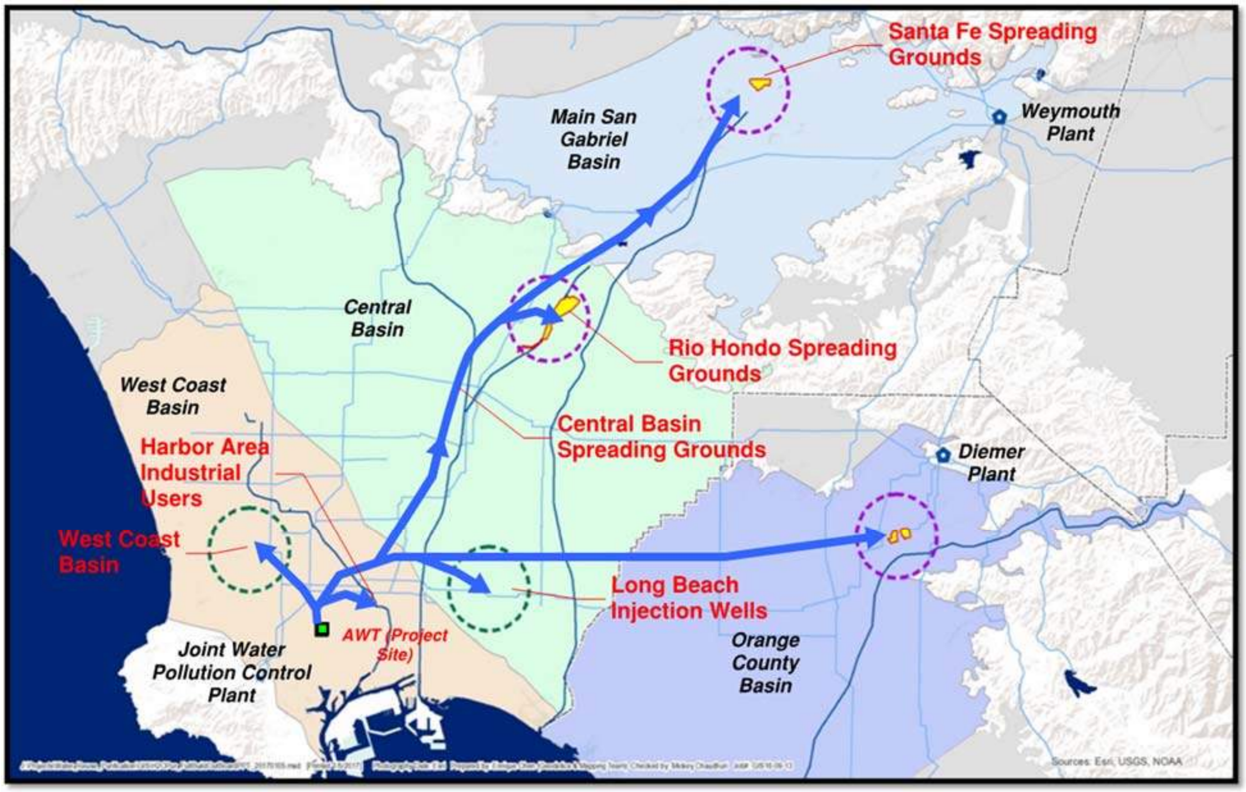

Figure ES-2 RRWP Conceptual Plan as Presented in Metropolitan's April 2016 Assessment

2018 Draft FLDR. In April 2016, Metropolitan initiated the Black & Veatch and CDM Smith team to further refine and evaluate the conveyance system alternatives described in Metropolitan's April 2016 report to help Metropolitan select a preferred alignment and system configuration. Toward that end, Black & Veatch and CDM Smith conducted a robust and collaborative evaluation process with Metropolitan to identify, compare, and assess feasible alignment alternatives to construct a large diameter conveyance pipeline system to deliver advanced treated water under the same system configuration described in Metropolitan's April 2016 Report. A thorough review of the study area resulted in the assessment of 89 separate pipeline segments, collectively covering nearly 200 miles of potential pipeline routes.

An extensive evaluation process was developed to score and rank the various alternatives and sub-alternatives. The evaluation process considered a host of factors to address the feasibility of construction, as well as minimization of potential community and biological impacts. The evaluation process, including the scoring system, application of weighting/importance factors, and sensitivity analyses, were all developed collaboratively with stakeholders across the Metropolitan organization.

The evaluation and screening process resulted in three overall alignment alternatives for more detailed consideration. One alternative generally follows the San Gabriel (SG) River, one alternative generally follows the Los Angeles (LA) River, and the third alternative utilizes a combination of existing public streets rights-of-way. These three alternatives were subsequently assessed, compared, and ranked based on the project configuration at that time. The results of this analysis were documented in a draft FLDR in October 2018 (referred to as "2018 Draft Report" in this

FLDR). The 2018 Draft Report presented the findings and conclusions of the preliminary technical investigations completed to date, including the recommendations of a preferred conveyance system that would deliver the advanced treated water to multiple spreading grounds and injection well locations, the farthest of which were the SFSG and the OC Spreading Grounds. At that time, the conveyance system was envisioned to split the flows with up to 80 mgd being conveyed to the SFSG and up to 60 mgd being conveyed to the OC Spreading Grounds. The remaining flows would be taken by potential customers along the way, such as the West Coast Basin, the City of Long Beach at injection wells, harbor area industrial users, and the Central Basin (at the Rio Hondo Spreading Grounds).

Conceptual Planning Studies Report. In February of 2019, Metropolitan issued the Conceptual Planning Studies Report presenting the results of further technical studies related to the RRWP conducted by Metropolitan and their consultants, which incorporated the results of the 2018 Draft Report. The studies presented in the Conceptual Planning Studies Report evaluate, among other things, program phasing and the potential for the program to accommodate raw water augmentation for DPR. The report recommended that Metropolitan should "proceed with the environmental review process" for the RRWP.

RRWP White Paper No. 1. In July of 2019, Metropolitan issued the RRWP White Paper No. 1 – Program Implementation and Delivery. In this document, Metropolitan examines two items in detail: 1) what are the implementation options to accelerate the program to construct conveyance facilities and/or make initial deliveries of purified water and 2) how would Metropolitan proceed in developing raw water augmentation opportunities if DPR regulations become promulgated.

Through the studies mentioned above, a proposed implementation strategy emerged that would provide the flexibility to adapt the initial system for future DPR, allow phasing opportunities to accelerate some, or all, of the program, and facilitate phasing of treatment capacity at the AWT plant. The proposed approach included an AWT plant sized to meet existing near-term and planned future demands and a "backbone conveyance system" (Backbone System) that is sized to convey the full 150 mgd from the AWT plant in Carson to the SFSG through an 84-inch pipeline. Under this scenario, a pipeline and pumping stations could be installed to convey the water from the SFSG to the existing F.E. Weymouth Water Treatment Plant (FEWWTP) for additional treatment and incorporation into Metropolitan's existing treated water distribution system for DPR.

Figure ES-3 presents a schematic of the Backbone Alignment conveyance system.

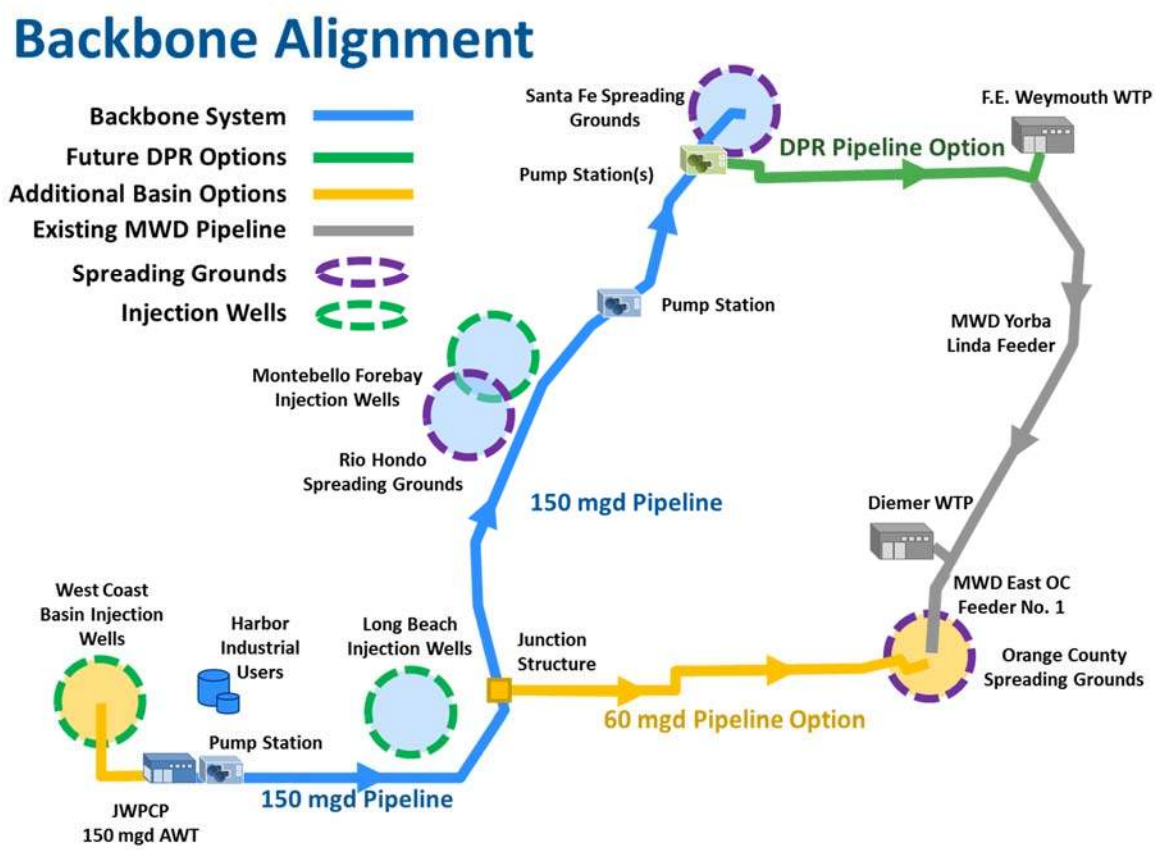

Figure ES-3 Proposed Regional Recycled Water Program Backbone System

2020 Final FLDR. As noted above, this FLDR is the culmination of the above described efforts, as well as additional studies conducted since that time. This FLDR and its appendices include all the studies and research conducted to date related to the RRWP conveyance system. It is an update of the 2018 Draft FLDR. Whereas the 2018 Draft FLDR was developed based on the system configuration described in Metropolitan's Conveyance System Feasibility Report, which was focused on delivering advanced treated water exclusively for groundwater augmentation, the 2020 Final FLDR includes the subsequent evaluations completed to assess the system configuration derived from Metropolitan's Conceptual Planning Studies Report and RRWP White Paper No. 1. Specifically, both documents recommend a Backbone System configured to allow for future implementation of DPR, as shown on Figure ES-3.

The 2020 Final FLDR included two key additional studies:

- ***Impact on Alignment Selection of OC Reach Removal.*** As shown in Figure ES-3, the pipeline reach extending to the OC Spreading Grounds in Anaheim is shown as optional. This is because 1) the current focus of the RRWP is to implement the Backbone System (which provides the flexibility to most easily incorporate raw water augmentation for DPR should regulations get promulgated), and 2) there is uncertainty as to whether the OC Spreading Grounds will ultimately be a key delivery point for IPR use. Since the 2018 Draft

Report included the branch to the OC Spreading Grounds as a critical point of delivery and not an optional future phase, a revisit of the detailed alignment evaluation was warranted to determine what impacts removing this branch would have on the selection of a “preferred” alignment for the Backbone System. Metropolitan authorized Black & Veatch to revisit the alignment study to determine what impact removing the OC Reach would have on the selection of a preferred alignment for the Backbone System. This follow up task was primarily focused between the intersection of the LA River with Sepulveda Boulevard and near the Whittier Narrows Dam, as the alternatives share a common alignment before and after these points.

- ***High Level Evaluation of DPR Alignment Options***. The 2018 Draft Report also ended with a delivery point at the SFSG, with no connection to the FEWWTP having been identified at that point. Towards that end, Metropolitan tasked Black & Veatch with conducting a high-level alignment evaluation for the potential pipeline that would connect the SFSG to the FEWWTP for the purposes of raw water augmentation for DPR.

FLDR PURPOSE

The purpose of this FLDR is to 1) document the robust evaluation process completed to compare and assess an extensive list of alignment alternatives in order to identify the preferred conveyance system, 2) provide detailed descriptions of proposed facilities to support the initiation of subsequent environmental studies and permitting processes to comply with CEQA, and 3) establish the basis for pre-design of the proposed facilities.

An evaluation process was followed to identify the preferred alignments and pump station configurations and locations such that they provide the following attributes:

- Most cost effective to construct
- Optimized operation and maintenance costs
- Minimized impacts on community
- Minimized impacts to the environment

The FLDR considered factors associated with the conveyance system including: potential alignments, feasibility-level pipe design, feasibility-level pump station design, system hydraulics, desktop geologic and seismic hazard analyses, geotechnical considerations, environmental concerns, traffic impacts, Project stakeholder requirements, construction duration, and estimated construction cost to be used as the basis for establishing construction budgets. Extensive review and input from stakeholders across the Metropolitan organizations, including Real Property Group, External Affairs Group, Environmental Planning Section, Engineering Services Group (specifically Design Section and Infrastructure Reliability Section), and Water System Operations was included in the assessments throughout the study.

BACKBONE SYSTEM ALIGNMENT ALTERNATIVES

As a result of the analyses completed, two alternatives appeared favorable as compared to their peers: the SG River Alignment and the LA River Alignment. These two alternatives are recommended to be carried forward into the environmental studies necessary to comply with

CEQA and are described in greater detail herein. Subsurface investigations and detailed environmental studies were not performed as part of this Project and will be completed during subsequent phases of work and will be used to help refine and differentiate between the two options.

While these two alternatives appear most favorable based on the analysis completed to date, the third "street right-of-way" alternative described in Chapter 4 is also feasible. Although not carried forward to the same level of detail as the others, the information presented in this FLDR for the street right-of-way alternative can be used to support CEQA analyses as well, if so desired by Metropolitan. By virtue of the compiled information presented within the main FLDR report and its appendices, this FLDR also identifies and describes additional feasible alignments and subalignment alternatives that could be carried forward if obstacles are encountered during future phases of work that impact the viability of any part of an alternative, such as unforeseen environmental impacts, technical infeasibility found via future detailed subsurface geotechnical and utility investigations, community or municipal objections, or the inability to acquire right-of-way.

This section describes the two alignment alternatives that are recommended for more detailed technical and environmental study: the SG River Alignment and the LA River Alignment.

San Gabriel River Alignment

The SG River Alignment is comprised of three reaches (Reach 1, Reach 3, and Reach 4), as described below, and is presented on Figure ES-4. The SG River Alignment is similar in concept to the "Initial Base Case" identified in an earlier phase of the RRWP, which was the route selected by Metropolitan as the most promising prior to the start of this Project.

The "Initial Base Case" was split into four reaches, with each reach beginning at a proposed pump station or control structure and ending at the wet well of the next pump station, a discharge basin, or control structure. While the Backbone System that is currently proposed does not include the branch to the OC Spreading Grounds (Reach 2) in the initial implementation phases, this FLDR has maintained the same breakdown of reaches for the SG River Alignment in the event that the branch to the OC Spreading Grounds moves forward at a later date. It may be warranted to revise the breakdown of reaches for the Backbone System during the next phase of work.

- Reach 1 – Reach 1 would be approximately 13 miles in length and would begin at the AWT plant and terminate at the former junction to the OC Spreading Grounds adjacent to the SG River. From west to east, this reach would pass through the City of Carson, unincorporated LA County, City of Los Angeles, City of Long Beach, City of Lakewood, and City of Cerritos. A majority of this reach would be within existing public street right-of-way with a short stretch along the San Gabriel River. This pipeline section would convey up to 150 mgd.
- Reach 2 – Reach 2 consists of the alignments proposed to reach the OC Spreading Grounds from the Initial Base Case and would, if further considered in the future, convey up to 60 mgd. It is not part of the Backbone System.

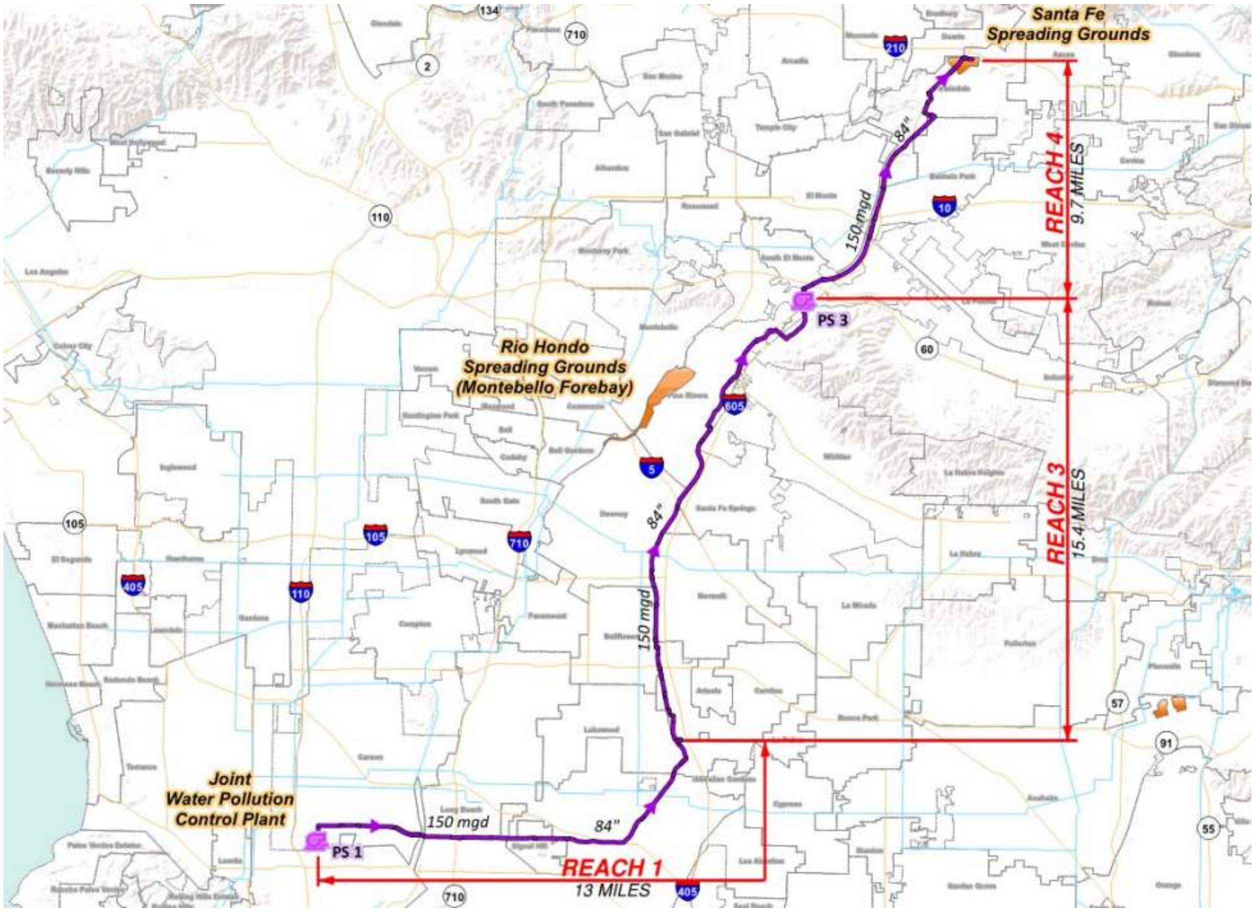

Figure ES-4 SG River Alignment Overview and Reach Extents

- Reach 3 – Reach 3 would be approximately 15.4 miles in length and begin at the former junction to the OC Spreading Grounds and terminate at the proposed site of Pump Station 3 (PS-3), north of Whittier Narrows Dam. From south to north, the alignment would pass through the Cities of Cerritos, Bellflower, Downey, and Pico Rivera. The majority of the alignment would fall within Southern California Edison (SCE) right-of-way paralleling the San Gabriel River. Due to the narrow SCE corridor and environmentally-sensitive nature areas along the San Gabriel River, the pipeline may have to be placed alternatively within the river bed itself, as well as within public street rights-of-way for portions of the alignment. It is anticipated that the pipeline would convey up to 150 mgd.
- Reach 4 – Reach 4 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG in the City of Irwindale. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A majority of the alignment would fall within SCE and LA County Flood Control District (LACFCD) right-of-way with a small stretch in public street rights-of-way. It is anticipated that the pipeline would convey up to 150 mgd.

Table ES-1 summarizes key information about each reach.

Table ES-1 Key Characteristics of SG River Alignment Reaches

REACH	BEGINNING/ENDING LOCATION	STATIONING (MILES)	LIFT (FEET)
1	Pump Station 1 (PS-1) to optional connection for Reach 2	0.0 – 14.0	350
2	Reach1 to OC Spreading Grounds (optional) (Note 2)	N/A	N/A
3	End of Reach 1 to PS-3	14.0 – 28.4	Note 1
4	PS-3 to SFSG	28.4 – 38.1	336

Notes:
1. PS-1 provides the lift for Reach 3, as well as for Reach 2 with a flow control structure should it be further evaluated.
2. Pump Station 2 (PS-2) was eliminated as part of the Backbone System.

Los Angeles River Alignment

The LA River Alignment is comprised of two reaches (Reach 1 and Reach 2), as presented on Figure ES-5. The LA River Alignment generally aligns with the Los Angeles River. The LA River Alignment is slightly shorter than the SG River Alignment and is located further west, which affords a shorter connection to any potential partnership opportunities with the City of LA. It should be noted that Reach 2 is the same as Reach 4 for the SG River Alignment.

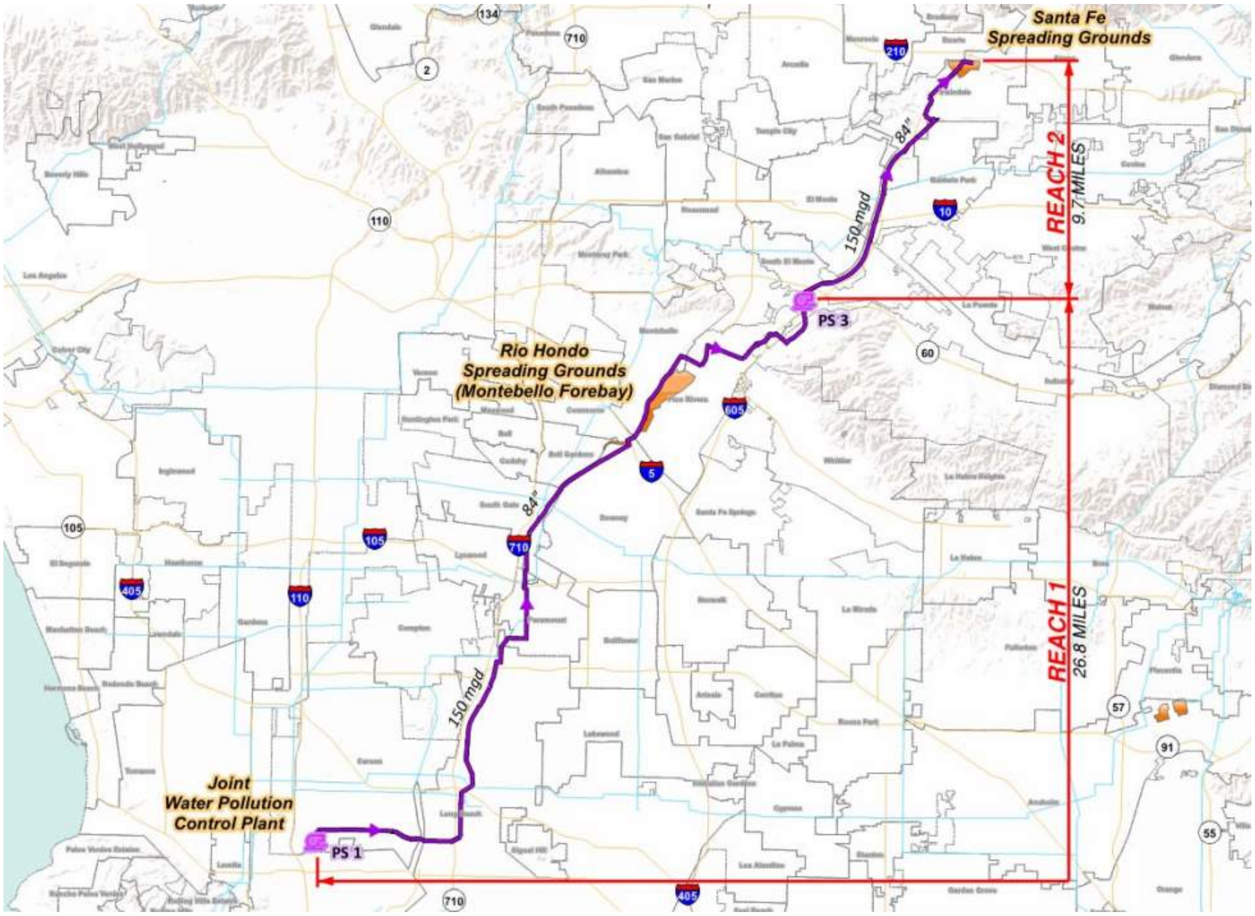

Figure ES-5 LA River Alignment Overview and Reach Extents

The LA River Alignment was developed and evaluated for the Backbone System and does not include the OC Reach, as the analysis completed shows that the SG River Alignment would be the preferred conveyance system with the OC Reach. Therefore, the LA River Alignment was separated into two reaches.

- Reach 1 – Reach 1 would be approximately 26.8 miles in length and would begin at the AWT plant and terminate at the proposed site of PS-3, north of Whittier Narrows Dam. From south to north, this reach would pass through unincorporated L.A. County and the Cities of Long Beach, Paramount, South Gate, Downey, Commerce, Pico Rivera, Montebello, and Industry. A majority of this reach would be within SCE and LACFCD right-of-way paralleling the LA River and then the Rio Hondo Channel. To avoid locations where a sufficient corridor does not exist, the pipeline would leave the river to be within public street rights-of-way for portions of the alignment. At Whittier Boulevard, the alignment would leave the Rio Hondo Channel and head east in existing public rights-of-way to the SG River. From here, the alignment would be mostly within SCE right-of-way parallel to the SG River. This pipeline section would convey up to 150 mgd.
- Reach 2 – Reach 2 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A

majority of the alignment would fall within SCE and LACFCD right-of-way with a small stretch in public street rigs-of-way. It is anticipated that the pipeline would convey up to 150 mgd.

Table ES-2 summarizes key information about each reach.

Table ES-2 Key Characteristics of LA River Alignment Reaches

REACH	BEGINNING/ENDING LOCATION	STATIONING (MILES)	LIFT (FET)
1	PS-1 to PS-3	0.0 – 26.8	341
2	PS-3 to SFSG	26.8 – 36.5	336
Note 1: Reach 2 is the same as Reach 4 for the SG River Alignment.			

PUMP STATIONS

The preferred pump station configuration for the Backbone System includes two pump stations to overcome the changes in elevation and system head losses along the alignment: The first pump station would be at the AWT plant, known as PS-1, and the second, known as PS-3, would be at the end of Reach 3 for the SG River Alignment and Reach 1 for the LA River Alignment. Prior to the identification of the Backbone System as the preferred implementation strategy, another pump station, known as PS-2, was considered where the branch to the OC Spreading Grounds would have been located. While the Backbone System that is currently proposed does not include the branch to the OC Spreading Grounds, nor PS-2, the FLDR retained the naming convention for consistency. It may be warranted to rename the proposed pump stations during the next phase of work.

Table ES-3 presents key design criteria for each of the pump stations being considered for the Backbone System. These pump stations form the basis for the cost opinions prepared for the Project. PS-1 is currently envisioned to have two separate discharge pipelines operating at different hydraulic grades. Therefore, to provide the most efficient system, two sets of pumps (Set A and Set B) would be provided: Set A would pump to injections wells for West Basin and Set B would pump to PS-3. PS-3 would only have one set of pumps pumping to the SFSG.

Under the concept outlined in Table ES-3, PS-1 would pump directly to the wet well of PS-3 and PS-3 would pump to the SFSG. Flow control would be achieved by modulating the variable frequency drive (VFD) driven pumps or flow control valves to meet the flow set point. The flow set point would be modified, or trimmed, based on the level in the upstream storage tank/forebay. The pump stations would be interlocked to keep the stations operating within designated parameters.

At this stage of study, it was determined that the hydraulics of the SG and LA River Alignments were similar enough that a common layout and general siting could be assumed as equally applicable for both alternatives.

Table ES-3 Summary of Key Pump Station Design Characteristics

ITEM	PUMP STATION 1	PUMP STATION 3
Pumps to	Set A: West Basin Injection Wells Set B: PS-3 Forebay	SFSG
Number of Pumps	Set A: 2 duty, 1 standby Set B: 4 duty, 1 standby	4 duty, 1 standby
Pump Type	Vertical turbine, VFDs	Vertical turbine, VFDs
Firm Capacity, per station	Set A: 15 mgd Set B: 150 mgd	150 mgd (SFSG)
Rated Point for Pump Selection, per pump	Set A: 7.5 mgd at 165 ft Set B: 37.5 mgd at 352 ft	37.5 mgd at 352 ft
Rated Horsepower (hp), each pump	Set A: 300 to 350 hp Set B: 4,500 to 5,000 hp	4,500 to 5,000 hp
Site Layout	Within AWT plant site	Approximately 350 ft by 450 ft
Approximate Ground Elevation, feet above mean sea level	42 ft	220 ft
General Location	Located on the northeast corner of the AWT plant	Near Whittier Narrows Dam

Note 1: Reach 2 is the same as Reach 4 for the SG River Alignment.

FEASIBILITY-LEVEL DESIGN OF THE PIPELINES

Black & Veatch completed the feasibility-level design of the pipelines associated with the Backbone System for the SG and LA River Alignments. Based on a constant design flow rate of 150 mgd and the operating pressures resulting from the lifts provided at each pump station, the design team optimized the pipeline's characteristics. Higher design velocities translate to higher hydraulic losses in the pipeline and, subsequently, higher pumping costs. Higher velocities in the pipeline would also increase the surge potential and intensity during any unplanned stoppage of the pumps (i.e., a pump trip), which would lead to larger footprints required for surge mitigation as compared to lower velocities in the pipelines. Higher velocities can also require more expensive lining methods and could lead to higher maintenance costs. Conversely, lower design velocities require larger pipe diameters which correlates to higher capital costs to construct. The optimization compared these factors and recommended a pipe diameter of 84 inches. As the capacity required for the Backbone System is constant from the AWT plant to the SFSG, the recommended pipe size is unchanged throughout. The pipe material would be welded steel pipe in accordance with Metropolitan standards.

Preliminary steel plate thickness calculations were completed for the SG River Alignment based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads included both internal and external conditions. In addition, a minimum plate thickness due to handling and installation was considered. The evaluation was limited to a reach by reach analysis to support cost estimating. It is assumed that more detailed, site specific calculations will be completed during preliminary design. The required steel plate thickness was 0.5 inches for all reaches. Since the LA River Alignment has the same, or slightly less, lift required at each pump station (since the alignment is slightly shorter), the plate thicknesses calculated for the SG River Alignment were also used for the LA River Alignment for purposes of planning and cost estimating.

Pipeline appurtenances would be required for the proper operation and maintenance of the RRWP conveyance system. Appurtenances would include combination air-release and vacuum valves (ARVV), blow-offs, access manways, isolation valves, discharge connections, pumping wells, and other miscellaneous appurtenances. Metropolitan's standard drawings would be used to develop typical details for these appurtenances.

As part of the preliminary design, a study should be performed to determine potential locations of blow-offs and ARVVs along the alignment. Locations where blow-offs could be connected to storm drains, existing channels, or drainage courses would also be identified during preliminary design. In general, blow-offs would be located at low points along the pipeline and ARVVs would be located at high points. Since the pipeline would convey advanced treated water, care in planning and design would be needed to assure compliance with regulatory requirements. All facilities will be designed in accordance with Metropolitan's standards and guidelines, which includes cross contamination prevention at air valve sites.

POTENTIAL CONNECTION FROM THE SFSG TO THE FEWWTP FOR DPR

An evaluation was performed to determine the preferred conveyance alignment for the future connection from the SFSG to the FEWWTP. While the flow rate for the conveyance system connection to the FEWWTP has not yet been determined, it is currently envisioned to be up to the full 150 mgd. The evaluation compared alignment alternatives for the purposes of achieving a ranking to recommend a preferred alignment; the evaluation did not include scope for additional facility descriptions or hydraulic evaluations. Additional evaluations would be required to determine the details of the pump station, or stations.

The preferred conveyance alignment connecting the SFSG to the FEWWTP would consist of a new pipeline connecting to Metropolitan's existing Glendora Tunnel (15'6" tunnel per as-built records) and then pumping water east to the FEWWTP, reverse of its current operation. The Glendora Tunnel is currently used to convey raw water from the Rialto Pipeline and / or the Upper Feeder to the USG-3 service connection for discharge to San Gabriel Canyon and ultimately to spreading basins for groundwater recharge. With the implementation of the RRWP, the Upper San Gabriel Municipal Water District (USGMWD) could receive their replenishment water via the RRWP at the SFSG in lieu of from USG-3. Therefore, the Glendora Tunnel could be available for this new use.

To reach the Glendora Tunnel, the pipeline alignment would follow Arrow Highway and then turn north at Irwindale Avenue. At Gladstone Street, the alignment would turn east before turning north in Azusa Avenue / SR 39. From there, the corridor would traverse north in Azusa Avenue and then north on Ranch Road. From Ranch Road, a new tunnel connecting to the terminus of the Glendora Tunnel would be constructed.

The alignment then follows the Glendora Tunnel east to the La Verne Pipeline. The La Verne Pipeline connects the east portal of the Glendora Tunnel to the Upper Feeder Junction Structure, approximately two miles to the south. The Upper Feeder Junction Structure has the ability to blend the advanced treated water with Colorado River water and State Water Project water before discharging into the FEWWTP's inlet conduit. The Upper Feeder Junction Structure allows for flow to be diverted to the Diemer Water Treatment Plant via the Yorba Linda Feeder.

Metropolitan conducted a preliminary hydraulic analysis and determined that the hydraulic grade line required to pump water east through the Glendora Tunnel is less than the design hydraulic grade for the tunnel. Therefore, this FLDR assumes that no structural improvements to the tunnel are required. This assumption should be confirmed during subsequent evaluations.

Since Metropolitan currently provides replenishment water to the USGMWD via USG-3, which is located at the westerly end of the Glendora Tunnel, approximately 14,000 feet (ft) of the Backbone Alignment associated with discharging to the SFSG could be substituted. Instead, the advanced treated water could be discharged to the San Gabriel River at, or near, USG-3 (or at another location north of the SFSG) which the Los Angeles County Department of Public Works (LACDPW) has indicated is preferred to the SFSG.

This FLDR recognizes that construction of a large diameter pipeline within Azusa Avenue would have significant impacts on the community. Azusa Avenue is one of the most heavily traveled surface streets in the area and is a popular through street from the 10 Freeway in the south to the 210 Freeway in the north. North of the 210 Freeway, Azusa Avenue is home to downtown Azusa, an improved, walkable downtown district with shops, wide sidewalks, and narrow streets.

Towards that end, this Project identified, but did not fully evaluate, two alternate alignments from Arrow Highway to the Glendora Tunnel, as shown on Figure ES-6. These alternatives should be further evaluated should the SFSG to FEWWTP concept move forward.

Hydraulic Considerations

Although a detailed hydraulic evaluation and pump station siting study for the connection from the SFSG to the FEWWTP was outside the scope of this evaluation, a quick review of the topography shows that there is a ~550-ft difference in grade (480 ft at the SFSG compared to 1,030 ft invert elevation at the terminus of the Glendora Tunnel) plus hydraulic losses along the way. Metropolitan prefers to limit the lift at any single pump station to between 300 and 400 ft when possible. Therefore, it appears that at least two additional pump stations would be required.

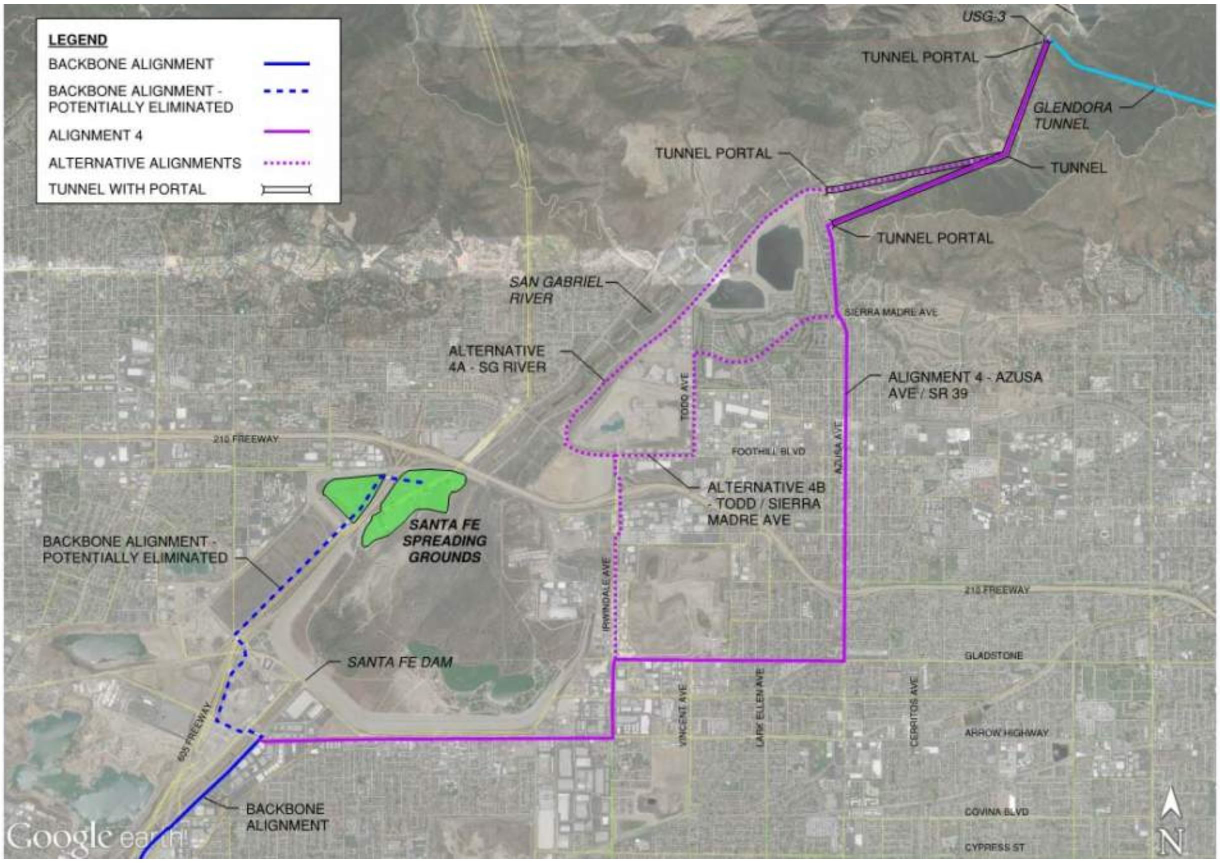

Figure ES-6 Preferred Connection from SFSG to the FEWWTP and Alternatives

EVALUATION OF LONG TUNNELS TO AVOID AREAS OF CONCERN

A preliminary review was performed comparing and assessing two long tunnels to avoid areas of particular concern for the Project.

The first area of concern was the approximately 4.5-mile-long portion of the alignment within the City of Carson. To avoid anticipated City of Carson concerns on traffic and community impact, Metropolitan considered tunneling within the City of Carson. This section has many active and abandoned utilities already in the same corridor due to the historic oil refineries in the area, as well as large sewer trunk lines flowing to the JWPCP. By tunneling this section, the Project could avoid both of these potential obstacles.

The second area of concern was the approximately 4.6-mile-long section of the SG River Alignment that is proposed within the earthen bottom of the SG River. This section extends from Imperial Highway to Washington Boulevard, where available corridors adjacent to the river channel are temporarily unavailable.

After conversations with Metropolitan's project management team, the FLDR incorporated the following approach:

- Further evaluations are required to determine the preferred construction method for these sections during the next phase of work.
- For the purposes of this FLDR, it was assumed that both sections are installed with cut-and-cover methods. However, the cost opinion for the SG River bed was developed using the cost of a tunnel such that this section would have a conservative budget. This assumption was considered in evaluation scoring and did not change the outcomes.

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

Table ES-4 provides the Engineer's opinion of probable construction cost (OPCC) for the conveyance portion of the RRWP Backbone System. This includes the pipelines and pump stations from the AWT plant to the SFSG.

The following parameters apply to the Engineer's OPCC:

- All prices were escalated to and are presented in April 2020 dollars.
- The Engineer's OPCC is Class 4 from the Association for the Advancement of Cost Engineering (AACE) with an accuracy range of -30% to +50%.
- The Engineer's OPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team.
- Prices include 22% to cover contractor overhead, profit, bonding, and insurance.
- The following costs are not included in the Engineer's OPCC:
  - Injection wells
  - Laterals to Project customers, including service connections and injection wells
  - Improvements to spreading basins
  - Permits
  - Right of way or easement acquisition
  - Property acquisition
  - Professional services, including engineering
  - Metropolitan staff time, including construction management
  - Design fieldwork, including potholing, geotechnical or environmental fieldwork
  - Contingency for potential tariffs
  - Removal, remediation, and/or disposal of potentially contaminated soils identified as a result of future environmental fieldwork

Table ES-4 Summary of Construction Costs for the Conveyance Facilities (Backbone System)

ITEM	SG RIVER ALIGNMENT TOTAL CONSTRUCTION COST	LA RIVER ALIGNMENT TOTAL CONSTRUCTION COST
Pipeline	$796,300,000	$727,600,000
Pump Stations		
PS-1	$51,200,000	$51,200,000
PS-3	$51,200,000	$51,200,000
RRWP Conveyance System Total	**$898,700,000**	**$830,000,000**

Per Table ES-4, the cost opinions for the SG and LA River Alignments are within ten percent of each other. At this feasibility level of study and estimating, this is within the level of accuracy of the estimates. Other factors outside of the construction cost opinion impact the overall feasibility and cost of each alignment, such as the property acquisition costs, design costs, and environmental mitigation costs. These are not included in the numbers presented in Table ES-4.

A cost opinion was also prepared for the pipelines associated with the connection from the SFSG to the FEWWTP. The cost opinion was based upon Alignment 4 connecting to the Glendora Tunnel, as described previously. The pump stations and any modifications, improvements, or repairs to Metropolitan's existing facilities – such as the Glendora Tunnel, La Verne Pipeline, or Upper Feeder Junction Structure – that would be required to form a complete and functioning system, are outside of the scope of this Project and are not included in this cost opinion. The OPCC for the pipelines that would be required to connect the SFSG to the FEWWTP for DPR would be:

- $214,600,000

As noted above, a cost opinion has not been prepared for the pump stations necessary to convey water from the SFSG to the Glendora Tunnel, and ultimately on to the FEWWTP. However, for budgeting purposes until these facilities can be further evaluated, Metropolitan has indicated that two pump stations of similar size and cost as PS-3 should be used as a place holder. The combined cost for two PS-3's would be:

- $102,400,000

The OPCC for the connection from the SFSG to the FEWWTP for DPR was based upon the quantities presented in Table ES-5

Table ES-5 Quantity Take Off – Connection from SFSG to FEWWTP for DPR

ITEM	QUANTITY
84-inch welded steel pipe in roadways, feet	40,200
Tunnel, feet	10,500
Pump Stations, each	2

CONCLUSION AND RECOMMENDATIONS

It appears that both the LA River and the SG River Alignments are feasible and carry similar levels of impacts and risks based on the information available for this Project. Therefore, it is recommended that both alignments be carried forward for more detailed environmental studies and technical analysis. Chapters 6 and 7 provide detailed descriptions of the proposed facilities for both alignments to support the initiation of environmental studies to comply with CEQA.

While these two alternatives appear most favorable based on the analysis completed to date, the third “street right-of-way” alternative described in Chapter 4 is also feasible. Although not carried forward to the same level of detail as the others, the information presented in this FLDR for the street right-of-way alternative can be used to support CEQA analyses as well, if so desired by Metropolitan.

It is recommended that the future connection from the Backbone System to the FEWWTP utilize the Glendora Tunnel. Additional evaluations that include coordination with the local jurisdictions should be completed during the next phase of work to determine the preferred alignment to reach the terminus of the Glendora Tunnel, as well as the number and location of the pump stations required. This evaluation should also consider if any improvements are required to Metropolitan’s existing facilities to utilize the Glendora Tunnel in this manner, such as repairs to the Glendora Tunnel’s lining, service connections (i.e., PM-26 or USG-3), or the functionality of the Upper Feeder Junction Structure.

This FLDR documents technical analysis completed to date supporting the development of the RRWP conveyance system and provides a basis as the RRWP transitions to the next phase of design. The next phase of design will continue to refine the RRWP conveyance system and will consist of more detailed engineering studies, as well as the initiation of more detailed environmental studies to comply with CEQA.

1.0 Introduction

In order to improve water supply reliability in Southern California, the Metropolitan Water District of Southern California (Metropolitan) is studying the feasibility of a Regional Recycled Water Program (RRWP). The RRWP would utilize advanced water treatment (AWT) processes to purify secondary treated effluent from the Sanitation Districts of Los Angeles County's (LACSD) Joint Water Pollution Control Plant (JWPCP) in Carson, California and then pump the advanced treated water to select locations in Metropolitan's service area for beneficial reuse.

In March 2016, Metropolitan retained the Black & Veatch Corporation (Black & Veatch) and CDM Smith team to complete feasibility level engineering and technical investigations to support the feasibility-level design of the conveyance system facilities for the RRWP. At the time, the RRWP was envisioned to provide advanced treated water to select locations within Metropolitan's service area for groundwater recharge, including the Santa Fe Spreading Grounds (SFSG). Towards that end, Black & Veatch and CDM Smith conducted a robust and collaborative evaluation process with Metropolitan to identify, compare, and assess feasible corridors in which to construct a large diameter conveyance pipeline system. A thorough review of the study area resulted in 89 separate pipeline segments, covering nearly 200 miles collectively, being considered. The results of this analysis was documented in a draft Feasibility-Level Design Report (FLDR) in October 2018 (referred to as "2018 Draft Report" in this FLDR), which presented the findings and conclusions of the preliminary technical investigations, including the recommendations of a preferred conveyance system focusing on indirect potable reuse (IPR) based on the best information available at the time. Throughout the process, workshops were held with Metropolitan stakeholders to gain feedback at every step of the evaluation.

As expected during the planning stages of a large-scale program that would provide regional benefits, the RRWP has continued to evolve since that time due to ongoing collaboration amongst interested potential partners and additional technical investigations, including the following key elements:

- How could the program accommodate future direct potable reuse (DPR) opportunities?
- Are there beneficial partnerships with other regional entities the program could leverage?
- What happens if an optional delivery point is removed from the analysis?

Based on the evolution of the Project, the technical evaluations completed prior to October 2018 were revisited. However, due to additional funding for this Project being reserved for future phases of work, a limit on time, and the uncertainties with the future regulations regarding DPR, some of the technical evaluations were performed only at a high level or were deferred to future phases.

This FLDR presents the revised findings and conclusions supporting the upcoming design and construction of the RRWP. In this FLDR, it is noted where technical evaluations need to be revisited for confirmation during the next phase of work.

1.1 PROJECT OVERVIEW

The RRWP would include construction of an AWT plant and a new regional conveyance system, including pump stations, pipelines, and various additional appurtenant facilities to convey the advanced treated water to select locations in Metropolitan's service area for beneficial reuse, including groundwater recharge. Additional smaller diameter distribution piping would be required for the laterals and connections to discharge points. It is anticipated that the program would consist of multiple implementation phases with an ultimate build-out system capacity of 150 million gallons per day (mgd) of highly treated recycled water. This new water supply would reduce dependency on imported water, while increasing overall flexibility and reliability for the region. Metropolitan separated the planning of the RRWP into two components.

- The AWT plant, which includes the full-scale treatment plant, as well as the design and construction of a 0.5 mgd demonstration project at the JWPCP. The purpose of the demonstration project is to:
    - Demonstrate proof of concept while identifying viable treatment technologies
    - Establish performance parameters for preliminary and final design
    - Provide information for projecting capital, operation and maintenance costs
- The conveyance system, which includes the pipeline, pump stations, and associated appurtenant facilities.

This FLDR documents the feasibility-level design for the conveyance system facilities of the RRWP (known as the "Project"). Work associated with the AWT plant is outside the scope of this report.

1.2 PROJECT BACKGROUND

This FLDR is the culmination of several years of effort on the part of Metropolitan's staff, on-going input from and collaboration with stakeholders, and contribution from Metropolitan's consultants, including the Black & Veatch and CDM Smith team. These efforts resulted in several study reports, all of which are embodied in this FLDR and its appendices.

Figure 1-1 presents a timeline summarizing the efforts and reports contributing to the development of this FLDR. Details are summarized below.

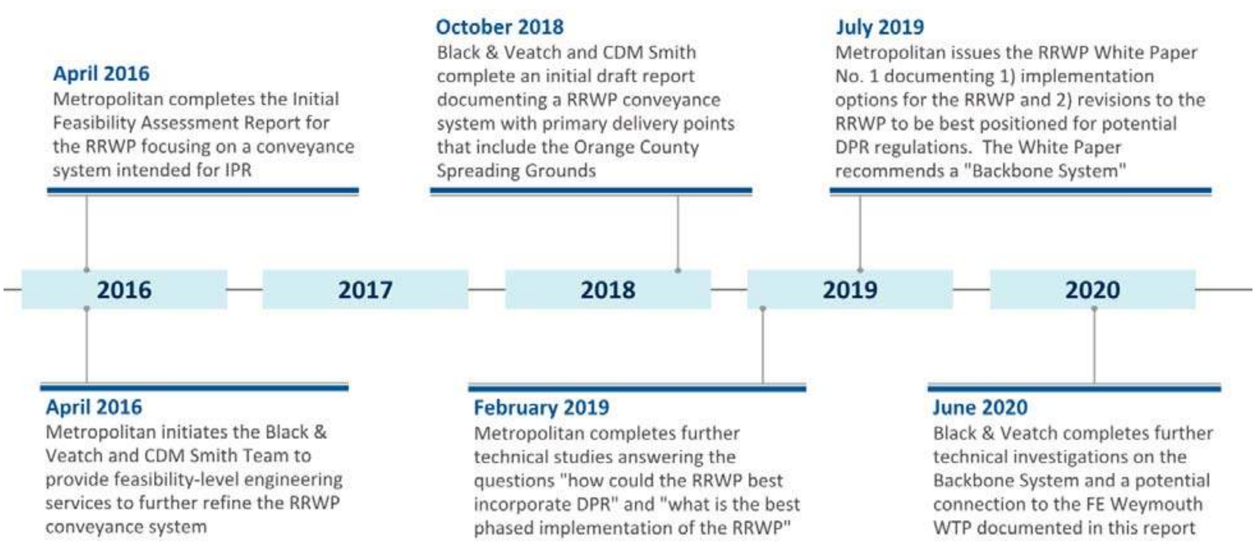

Figure 1-1 Timeline of Major Events Pertaining to the Development of this FLDR

Conveyance System Feasibility Assessment. In April 2016, Metropolitan completed a planning study for the RRWP conveyance system, which was documented in the report entitled "Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment". At the time, the RRWP was envisioned to convey the advanced treated water from the AWT plant to various spreading basins and injection wells sites within Metropolitan's service area for groundwater recharge. Upon reaching the discharge locations, the advanced treated water would be recharged into the ground, either through surface infiltration at existing spreading basins or through injection wells. After being stored in the groundwater basin for at least the minimum required retention time, the water would be available for extraction by partnering member agencies, treated, and sold for potable water distribution.

Figure 1-2, prepared by Metropolitan in 2016, presents a conceptual plan of the RRWP conveyance system including potential discharge locations as envisioned at the time.

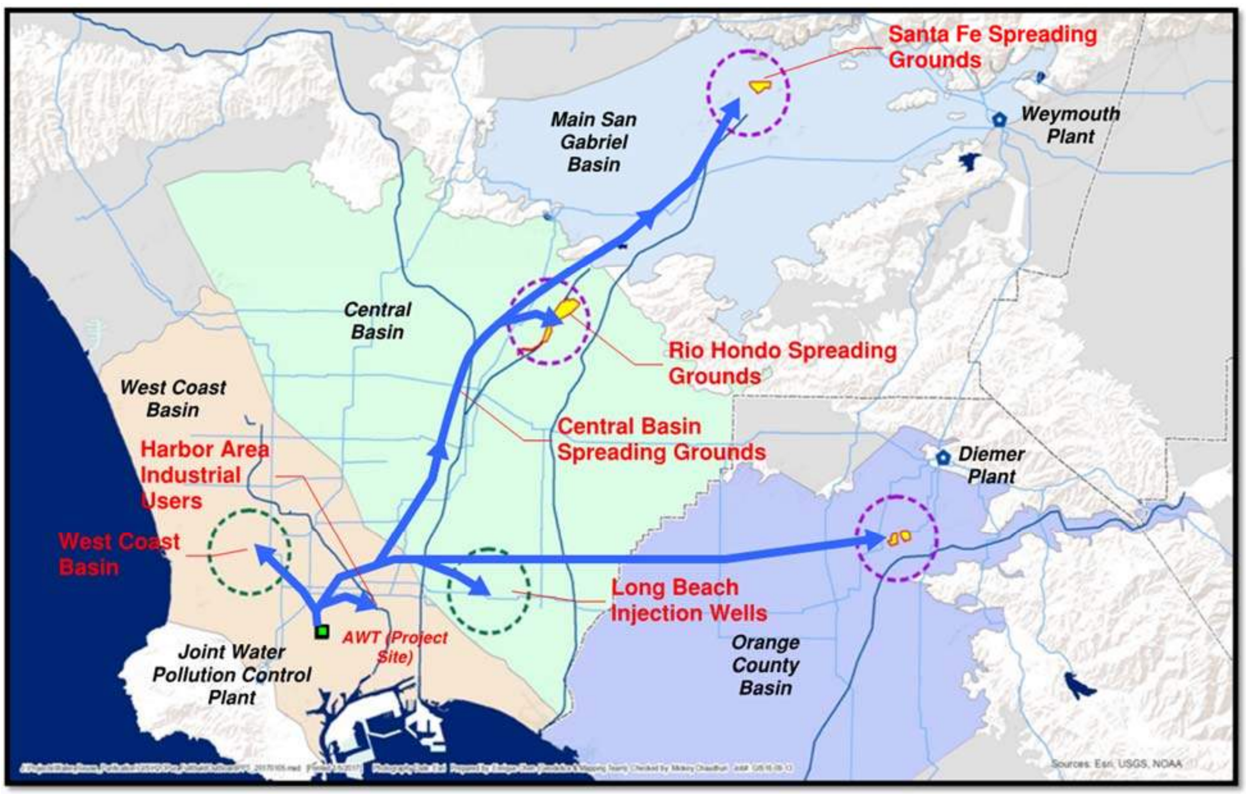

Figure 1-2 RRWP Conceptual Plan as Presented in Metropolitan's April 2016 Assessment

2018 Draft FLDR. In April 2016, Metropolitan initiated the Black & Veatch and CDM Smith team to further refine and evaluate the conveyance system alternatives described in Metropolitan's April 2016 report in an effort to help Metropolitan select a preferred alignment and system configuration. Toward that end, Black & Veatch and CDM Smith conducted a robust and collaborative evaluation process with Metropolitan to identify, compare, and assess feasible alignment alternatives to construct a large diameter conveyance pipeline system to deliver advanced treated water under the same system configuration described in Metropolitan's April 2016 Report. A thorough review of the study area resulted in the assessment of 89 separate pipeline segments, covering nearly 200 miles of potential pipeline routes, collectively.

An extensive evaluation process was developed to score and rank the various alternatives and sub-alternatives. The evaluation process considered a host of factors to address the feasibility of construction as well as minimization of potential community and biological impacts. The evaluation process, including the scoring system, application of weighting/importance factors, and sensitivity analyses were all developed collaboratively with stakeholders across the Metropolitan organization.

The evaluation and screening process resulted in three overall alignment alternatives for more detailed consideration. One alternative generally follows the San Gabriel (SG) River, one alternative generally follows the Los Angeles (LA) River, and the third alternative utilizes a combination of existing public streets rights-of-way. These three alternatives were subsequently assessed, compared, and ranked based on the project configuration at that time. The results of this analysis were documented in a draft FLDR in October 2018 (referred to as "2018 Draft Report" in this FLDR). The 2018 Draft Report presented the findings and conclusions of the preliminary technical investigations completed to date, including the recommendations of a preferred conveyance system that would deliver the advanced treated water to multiple spreading grounds and injection well locations, the farthest of which were the SFSG and the OC Spreading Grounds. At that time, the conveyance system was envisioned to split the flow with up to 80 mgd being conveyed to the SFSG and up to 60 mgd being conveyed to the OC Spreading Grounds. The remaining flows would be taken by potential customers along the way, such as the West Coast Basin, the City of Long Beach at injection wells, harbor area industrial users, and the Central Basin (at the Rio Hondo Spreading Grounds).

Conceptual Planning Studies Report. In February of 2019, Metropolitan issued the Conceptual Planning Studies Report presenting the results of further technical studies related to the RRWP conducted by Metropolitan and their consultants, which incorporated the results of the 2018 Draft Report. The studies presented in the Conceptual Planning Studies Report evaluate, among other things, program phasing and the potential for the program to accommodate raw water augmentation for DPR. The report recommended that Metropolitan should "proceed with the environmental review process" for the RRWP.

RRWP White Paper No. 1. In July of 2019, Metropolitan issued the RRWP White Paper No. 1 – Program Implementation and Delivery. In this document, Metropolitan examines two items in detail: 1) what are the implementation options to accelerate the program to construct conveyance facilities and/or make initial deliveries of purified water and 2) how would Metropolitan proceed in developing raw water augmentation opportunities if DPR regulations become promulgated.

Through the studies mentioned above, a proposed implementation strategy emerged that would provide the flexibility to adapt the initial system for future DPR, allow phasing opportunities to accelerate some, or all, of the program, and facilitate phasing of treatment capacity at the AWT plant. The proposed approach included an AWT plant sized to meet existing near-term and planned future demands and a "backbone conveyance system" (Backbone System) that is sized to convey the full 150 mgd from the AWT plant in Carson to the SFSG through an 84-inch pipeline. Under this scenario, a pipeline and pumping stations could be installed to convey the water from the SFSG to the existing F.E. Weymouth Water Treatment Plant (FEWWTP) for additional treatment and incorporation into Metropolitan's existing treated water distribution system for DPR.

Another benefit of the Backbone System is that it would allow for a potential interconnection to other purified water reuse programs. Note that the details of other water reuse programs remain uncertain. So, while the Backbone System concept may provide the aforementioned potential benefit, the Backbone System concept has not been developed to accommodate any interconnecting systems nor has the alignment selection analysis attempted to take potential points of connection into account. Additional coordination and studies will be necessary should such partnerships become better defined.

Figure 1-3 presents a schematic of the Backbone Alignment conveyance system.

2020 Final FLDR. As noted above, this FLDR is the culmination of the above described efforts, as well as additional studies conducted since that time. This FLDR and its appendices include all the studies and research conducted to date related to the RRWP conveyance system. It is an update of the 2018 Draft FLDR. Whereas the 2018 Draft FLDR was developed based on the system configuration described in Metropolitan's Conveyance System Feasibility Report which was focused on delivering advanced treated water exclusively for groundwater augmentation, the 2020 Final FLDR includes the subsequent evaluations completed considering the system configuration derived from Metropolitan's Conceptual Planning Studies Report and RRWP White Paper No. 1. Specifically, both documents recommend a Backbone System configured to allow for future implementation of DPR, as shown in Figure 1-3.

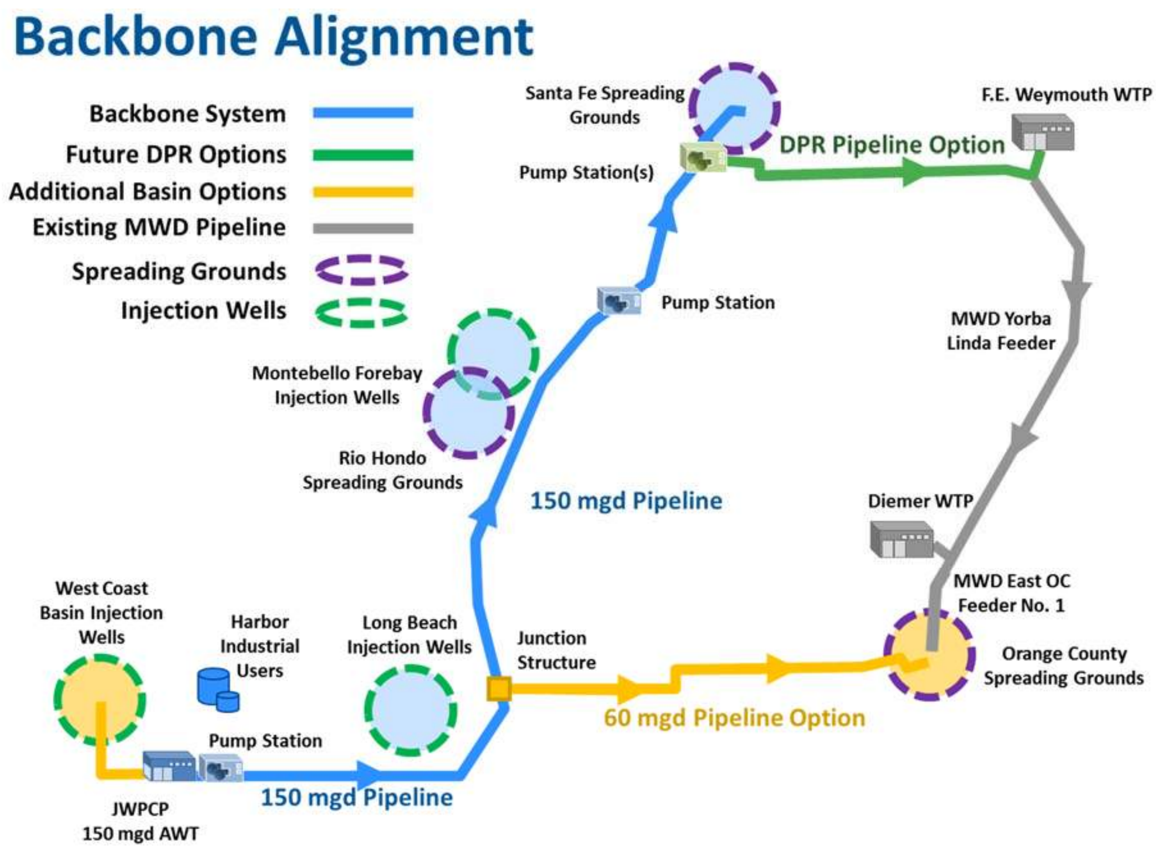

Figure 1-3 Proposed Regional Recycled Water Program Backbone System

The 2020 Final FLDR therefore included two key studies:

- ***Impact on Alignment Selection of OC Reach Removal.*** As shown in Figure 1-3, the pipeline reach extending to the Orange County Spreading Grounds in Anaheim is shown as optional. This is because 1) the current focus of the RRWP is to implement the Backbone System (which provides the flexibility to most easily incorporate raw water augmentation for DPR should regulations get promulgated) and 2) there is uncertainty as to whether the OC Spreading Grounds will ultimately be a key delivery point for IPR use. Since the 2018 Draft Report included the branch to the OC Spreading Grounds as a critical point of delivery and not an optional future phase, it was warranted to revisit the detailed alignment evaluation to determine what impacts removing this branch would have on the selection of a "preferred" alignment for the Backbone System. Metropolitan authorized Black & Veatch to revisit the alignment study to determine what impact removing the OC Reach would have on the selection of a preferred alignment for the Backbone System. This follow up task was primarily focused between the intersection of the LA River with Sepulveda Boulevard and near the Whittier Narrows Dam, as the alternatives share a common alignment before and after these points.
- ***High Level Evaluation of DPR Alignment Options***. The 2018 Draft Report also ended with a delivery point at the SFSG, with no connection to the FEWWTP having been identified at that point. Towards that end, Metropolitan tasked Black & Veatch with conducting a high-level alignment evaluation for the potential pipeline that would connect the SFSG to the FEWWTP for the purposes of raw water augmentation for DPR.

This FLDR documents the efforts described above and the resulting descriptions, including:

- The technical investigations evaluating a potential conveyance system intended for IPR
- The re-evaluation of pipeline alignments for the Backbone System
- The evaluation of pipeline alignments from the Backbone System to FEWWTP
- The resulting Project alternatives recommended for further evaluation

1.3 FLDR PURPOSE

The purpose of this FLDR is to 1) document the robust evaluation process completed to compare and assess an extensive list of alignment alternatives in order to identify the preferred conveyance system, 2) provide detailed descriptions of proposed facilities to support the initiation of subsequent environmental studies to comply with the California Environmental Quality Act (CEQA), and 3) establish the basis for pre-design of the proposed facilities. While this FLDR typically references CEQA, the information in this report can also be used to support the National Environmental Policy Act processes, if required.

An evaluation process was followed to identify the preferred alignments and pump station configurations and locations such that they provide the following attributes:

- Most cost effective to construct
- Optimized operation and maintenance costs

- Minimized impacts on community
- Minimized impacts to the environment

The FLDR considered factors associated with the conveyance system including: potential alignments, feasibility-level pipe design, feasibility-level pump station design, system hydraulics, geologic and seismic hazards analysis, desktop geotechnical considerations, environmental concerns, traffic impacts, Project stakeholder requirements, construction duration, and estimated construction cost to be used as the basis for establishing construction budgets. Extensive review and input from stakeholders across the Metropolitan organization, including Public Affairs, Environmental, Geotechnical, Water System Operations, Engineering, and so on was included in the assessments throughout the FLDR development. Subsurface investigations and detailed environmental studies were not performed as part of this Project and should be completed during subsequent phases of work.

By virtue of the compiled information presented within the main FLDR report and its appendices, this FLDR also identifies and describes additional feasible alignments and subalignment alternatives that could be carried forward if obstacles are encountered during future phases of work that impact the viability of any part of an alternative, such as unforeseen environmental impacts, technical infeasibility found via future detailed subsurface geotechnical and utility investigations, community or municipal objections, or the inability to acquire right-of-way.

1.4 PRIOR STUDIES

This section discusses other studies completed on the RRWP and provides additional background information on the Project.

1.4.1 Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment

Prior to retaining Black & Veatch and CDM Smith, Metropolitan performed an initial identification of potential alignments for the RRWP conveyance system intended to deliver water to the SFSG and the OC Spreading Grounds – along with other points along the way – in the report entitled “Potential Regional Recycled Water Supply Program – Conveyance System Feasibility Assessment,” dated April 2016. In the study, Metropolitan evaluated multiple alignments and identified the most promising to serve as the starting point for this FLDR.

The assessment separated the alternatives into 59 separate pipeline segments. Each segment started and ended at a junction with another segment and could be combined to form various alignments from the AWT plant to the discharge locations. These segments, numbered numerically (i.e., Segment 1, 2, etc.), could then be evaluated to determine which combination of segments form the alignment that meets the Project’s goals.

Figure 1-4 was obtained from Metropolitan’s April 2016 assessment and presents the 59 pipeline segments identified by Metropolitan.

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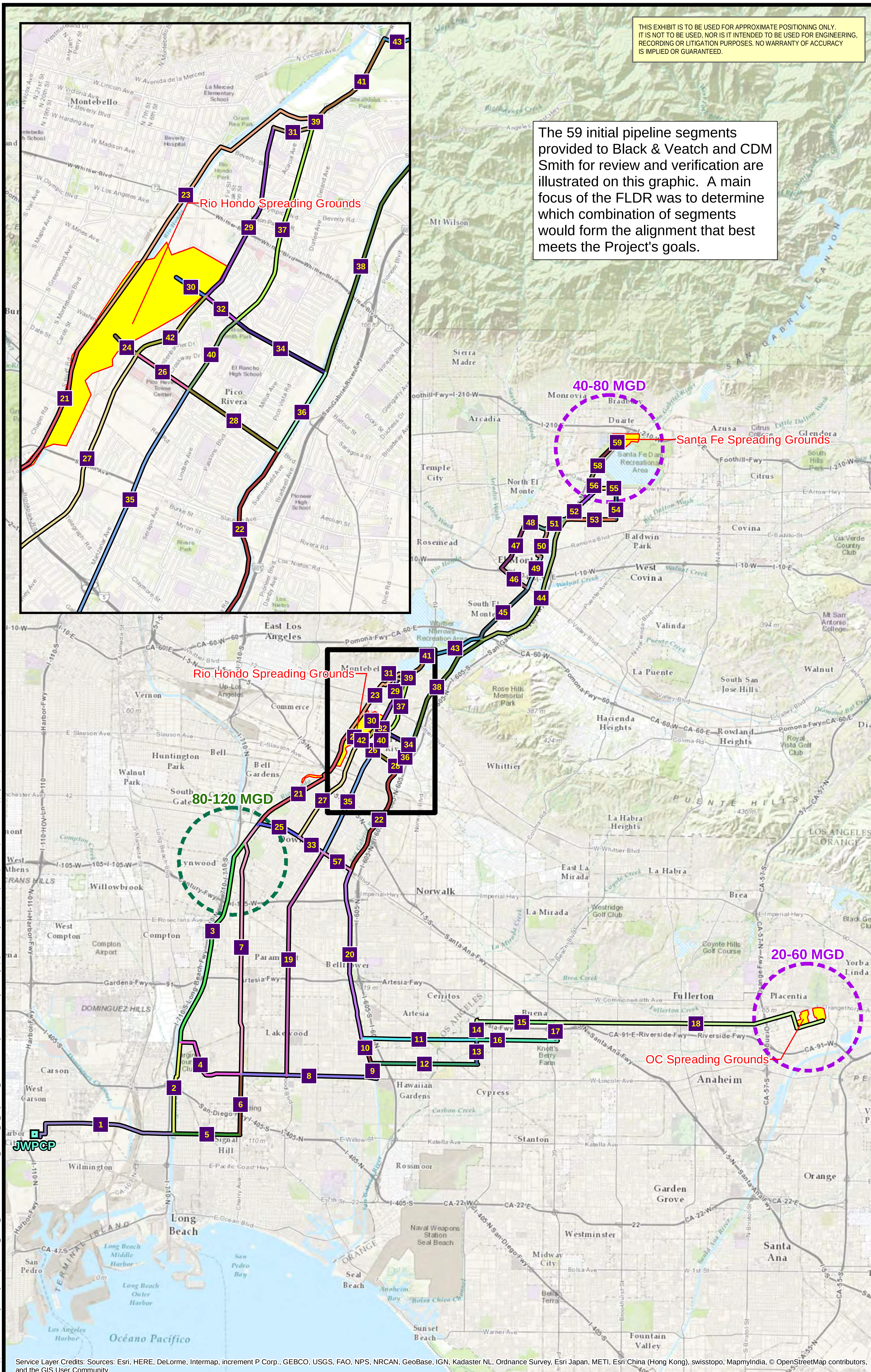

The Metropolitan Water District of Southern California
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Figure 1-4: 59 Initial Pipeline Segments Identified in Metropolitan's April 2016 Assessment

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1.4.1.1 Initial Base Case

Metropolitan's April 2016 assessment discussed all the alignment segments, and an initial identification of the most feasible alignment was made (Initial Base Case). For simplicity, the Initial Base Case alignment was broken into four reaches (Reach 1-4). Each reach would consist of pipeline sections beginning at a pump station or diversion structure and ending at the wet well of the next pump station, discharge basin, or diversion structure, as described below:

- Reach 1 – Reach 1 would be approximately 16 miles in length and begin at the AWT plant and terminate at the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River. From west to east, this reach would pass through the City of Carson, unincorporated LA County, City of LA, City of Long Beach, City of Lakewood, and City of Cerritos. A majority of this reach would be within public street right-of-way with stretches along both the Los Angeles River and the San Gabriel River.
- Reach 2 – Reach 2 would be approximately 16 miles in length and begin at the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River in the City of Cerritos and terminate at the OC Spreading Basins at Anaheim Lakes in the City of Anaheim. From west to east, the alignment would pass through the Cities of Cerritos, La Palma, Buena Park, Fullerton, Placentia, and Anaheim. Approximately six miles of the alignment would lie within Southern California Edison (SCE) right-of-way while the remaining 10 miles would fall within public street right-of-way.
- Reach 3 – Reach 3 would be approximately 14 miles in length and begin at the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River in the City of Cerritos and terminate near Whittier Narrows Dam. From south to north, the alignment would pass through the cities of Cerritos, Bellflower, Downey, and Pico Rivera. Most of the alignment would fall within SCE right-of-way paralleling the San Gabriel River. Due to the narrow SCE corridor and environmentally-sensitive areas along the San Gabriel River, the pipeline may have to be placed alternatively within the river bed itself and within public street rights-of-way for portions of the alignment.
- Reach 4 – Reach 4 would be approximately 10 miles in length and start near Whittier Narrows Dam and end at the Santa Fe Spreading Basins in the City of Irwindale. The alignment would fall within both public street right-of-way and SCE and Los Angeles County Flood Control District (LACFCD) right-of-way.

The Initial Base Case alignment segments are presented in Table 1-1 and shown on Figure 1-5. Figure 1-5 was obtained from Metropolitan's April 2016 assessment.

Table 1-1 Initial Base Case Segments

REACH	SEGMENT NOS.
1	1, 2, 4, 8, 9, 10
2	11, 16, 17, 18
3	20, 22, 28, 26, 24, 36, 38
4	44, 52, 56, 58, 59

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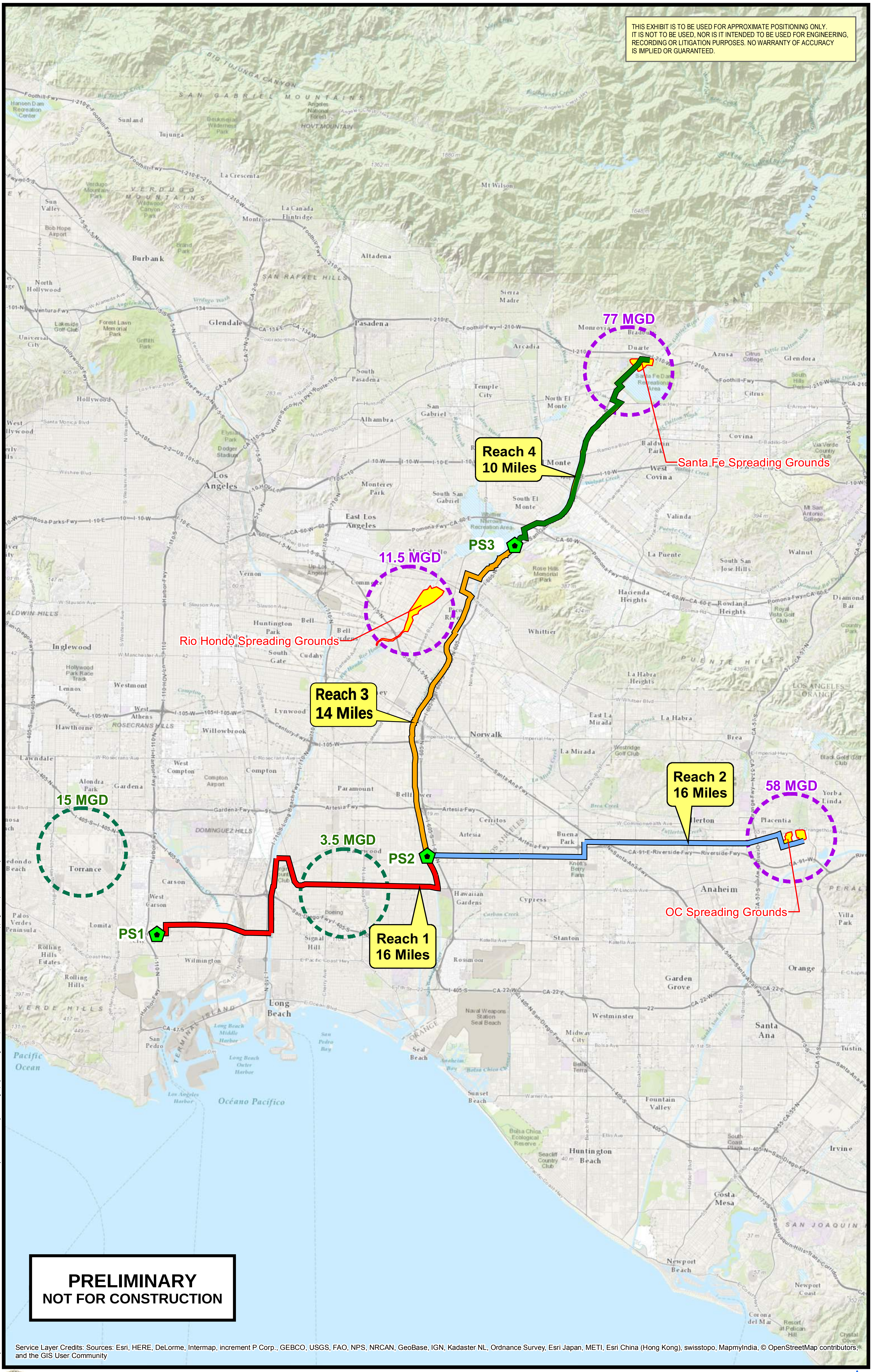

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Figure 1-5: Initial Base Case Conveyance Map

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1.4.1.1 Pump Stations

At the time, Metropolitan envisioned the RRWP would require three pump stations based on hydraulic effects, pipeline elevations, required pipe diameters, pumping costs, and pump station construction and maintenance costs.

Table 1-2 lists the pump stations identified by Metropolitan and provided to Black & Veatch and CDM Smith. Their general locations are shown on Figure 1-5. The number and location of pump stations was further evaluated during the preparation of this FLDR, as described in Chapter 5. Specific details on the pump stations, including siting, are provided in Chapter 8.

Table 1-2 Initial RRWP Pump Stations

PUMP STATION	GENERAL LOCATION	PUMPS TO
Pump Station 1 (PS-1)	JWPCP, Carson	Set A: Potential Future User Set B: PS-2 Forebay
Pump Station 2 (PS-2)	Adjacent to San Gabriel River near Del Amo Street	Set A: OC Spreading Basin Set B: PS-3 Forebay
Pump Station 3 (PS-3)	Near Whittier Narrows Dam	Santa Fe Spreading Basin

PS-1 and PS-2 would have two separate discharge pipelines operating at different hydraulic grades. Therefore, to provide the most efficient system, two sets of pumps (Set A and Set B) would be provided at PS-1 and PS-2. PS-3 only has one discharge location so only one set of pumps would be provided.

1.4.2 Business Case Report

In parallel with the initial efforts of this FLDR, Metropolitan developed a Business Case report that was presented to the Board of Directors in October of 2016. With support from data developed for this FLDR, the Business Case report included preliminary capital and operating cost estimates for the Base Case conveyance system. Those costs were combined with costs for the RRWP treatment system and other associated RRWP costs to support an evaluation of the potential economic viability of the overall RRWP.

1.5 FEASIBILITY-LEVEL ENGINEERING DEVELOPMENT APPROACH

The approach used to develop this FLDR consisted of five phases, as shown on Figure 1-6. Throughout the process, workshops were held with Metropolitan and, as appropriate, with other stakeholders to ensure consensus.

Additional discussion on each phase of FLDR development is discussed in the subsections that follow.

Phase	Phase 1 Metropolitan's Initial Evaluation	Phase 2 Alignment Verification / Initial Screening	Phase 3 Detailed Alternative Alignment Evaluation	Phase 4 Final Refinements	Phase 5 Feasibility-Level Pipeline and Pump Station Design
Tasks	• Identification of potential pipeline alignments • Identification of Initial Base Case	• Data collection • Review of Metropolitan studies • Desktop analysis • Alternate alignment development • Field investigations • Initial screening • Desktop Geotechnical Report • Traffic Analysis and Impact Report • Constructability evaluations	• Development of decision model • Evaluation criteria • Weighting of evaluation criteria • Coarse screening • Secondary screening • Final screening • Ranking of alternatives	• Incorporation of stakeholder input • Conduct supplemental evaluations	• Steel size and wall thickness • Feasibility-level pipeline plan drawings • Hydraulic analysis and profile • Special construction zones and cross-sections • Pump station siting and conceptual site and building layout • Cost development • Quantity take-off • Preliminary construction duration
Workshops		• Initial screening workshops	• Detailed evaluation workshops	• Workshops with Stakeholders • Workshops with Metropolitan's Environmental Team	• Pipeline focus meetings/ workshops • Pump station focus meetings/ workshops • Unit cost development workshops
Outcomes	• Initial Base Case alignment • Report entitled, "Potential RRWP– Conveyance System Feasibility Assessment"	• Revised Base Case alignment	• Initial Preferred Alignment	• Final Preferred Alignment	• Feasibility pipeline and pump station design • Engineer's cost opinion and Project schedule
Chapters	• Chapter 1	• Chapter 2 • Chapter 3	• Chapter 4	• Chapter 5	• Chapter 6 • Chapter 7 • Chapter 8 • Chapter 9

Figure 1-6 Feasibility-Level Engineering Development Approach

1.5.1 Metropolitan's Initial Evaluation

Black & Veatch reviewed Metropolitan's April 2016 assessment, which serves as the basis of this FLDR.

1.5.2 Alignment Verification and Initial Screening

Building upon the previous evaluations completed by Metropolitan, Black & Veatch performed an independent assessment of potential pipeline alternatives.

Goals associated with the assessment of alignment and segment alternatives included:

- Identifying additional feasible alignments that could be carried forward for further review if obstacles are encountered later during Project planning and design. Obstacles could include physical obstacles that would impact constructability and Project cost, leading to the selection of a better alternative route. Obstacles could also include unforeseen community or municipal objections, inability to acquire rights-of-way from entities such as SCE or LACFCD, or environmental / regulatory constraints yet to be identified.
- Providing full consideration of alignment alternatives such that the FLDR documentation and alignment analyses would support the next stages of CEQA compliance, Project planning, and preliminary and final design.
- Performing independent data gathering that supported an initial screening of the identified alignments, including those in the Metropolitan report, others identified and considered by

Metropolitan, and additional alternatives identified by Black & Veatch by the following methods:

- Compiling and reviewing record information about potential pipeline alignments in the Project area, using a combination of printed information and data available from Geographic Information Systems (GIS) records.
- Completing a desktop-level analysis of potential pipeline alignments using the aforementioned printed and GIS record information and internet-based mapping tools.
- Performing field reconnaissance of potential pipeline alignments.
- Conducting alignment-focused workshops with Metropolitan to review the results of the records review, desktop analyses, and field reconnaissance.

- Concluding the initial screening by identifying the set of alignment alternatives to be carried forward for additional analysis.

Using the information provided by Metropolitan and additional data obtained by Black & Veatch, an initial screening was performed to eliminate alignments not meeting Metropolitan's Project goals. At the end of the initial screening, a Revised Base Case alignment was identified which was used as the basis for Metropolitan's development of the Business Case Report and the development of a detailed Engineer's Opinion of Probable Construction Cost (OPCC) for the Business Case Report. Additionally, the initial screening identified the alignments to be carried forward to the detailed alternative alignment evaluation.

1.5.3 Detailed Alternative Alignment Evaluation

The alignments carried forward from the initial screening underwent a detailed alternative alignment evaluation to achieve a ranking of alternative alignments. The highest ranked alignment from this evaluation was known as the Initial Preferred Alignment. This evaluation was focused on a conveyance system for IPR and included alignments to reach the SFSG and the OC Spreading Grounds, along with other delivery points to potential customers such as refineries, etc. along the way.

1.5.4 Final Refinements

Additional technical evaluations were conducted to build upon and further refine the analysis completed. These technical evaluations covered two main areas. The first covered a more in depth evaluation to address specific areas of concern. As a result of the technical analysis completed, revisions were made to the Initial Preferred Alignment towards refining its constructability, financial feasibility, and social and environmental acceptability.

Second, several major changes to Project goals occurred that warranted being reflected in the alignment evaluation, including 1) the potential for DPR to become regulated, 2) the potential for partnership opportunities with other regional entities, and 3) the potential change in delivery points. As a result of these changes, two alignment alternatives emerged as favored and warranting of more detailed analysis in order to select a preferred alignment. Both alignments are recommended for further environmental studies. As noted previously, while two alternatives appear favorable, the third street right-of-way alternative has been described and evaluated in sufficient detail to be considered for CEQA, if so desired by Metropolitan.

1.5.5 Feasibility-Level Pipeline and Pump Station Design

Feasibility-level designs were completed on the two alignment alternatives resulting from the Final Refinements, including pump stations. These feasibility-level descriptions of facilities serve as the basis for the development of an Engineer's OPCC and feasibility-level construction duration. This FLDR was prepared documenting the work that had been completed.

1.6 REPORT ORGANIZATION

The FLDR documents the development of a preferred alignment and pump station configuration and recommended design decisions for the Project elements in support of environmental studies, permitting processes, and pre-design. Table 1-3 summarizes the organization of the FLDR.

Table 1-3 Organization of Report

CHAPTER/TITLE	DESCRIPTION
Executive Summary	Provides a general description of the RRWP conveyance system and summarizes the overall FLDR organization.
1.0 Introduction	Presents an overview of the RRWP and the background on the Project's evolution, discusses previous related studies, outlines the purpose of the FLDR, summarizes the feasibility-level engineering development approach and describes the organization of the FLDR.
2.0 Alignment Verification and Initial Screening	Briefly describes the data collection and initial screening process, including desktop evaluations of possible pipeline alignments, field verification of desktop evaluation findings, and results of workshops with Metropolitan's staff. Summarizes the initial screening process and identifies pipeline segments carried forward for additional analysis.
3.0 Supporting Technical Evaluations	Summarizes three supporting technical evaluations completed during FLDR development: traffic analysis and impacts evaluation, desktop geotechnical evaluation, and construction evaluation. The latter discussion incudes a preliminary description of trenchless and cut-and-cover construction methods.
4.0 Detailed Alternative Alignment Evaluations	Focuses on the pipeline segments identified in Chapter 2 to achieve a ranking of alignment alternatives. Describes evaluation goals, decision model, evaluation criteria, weighting of evaluation factors, and the evaluation screening. The results of this evaluation, as well as the Initial Preferred Alignment that was identified, was based on the inclusion of the reach to the OC Spreading Grounds.
5.0 Final Refinements	Describes the evolution of the Project after the initial alignment evaluation including the subsequent evaluations that resulted from changes in the Project's objectives. Included in this chapter are 1) progressive refinements to the Initial Preferred Alignment, 2) further alignment evaluations on the Backbone System, and 3) evaluation of alignments connecting the Backbone System to the FEWWTP.

CHAPTER/TITLE	DESCRIPTION
6.0 Feasibility-Level Design of the San Gabriel (SG) River Alignment	Documents the development of a feasibility-level design for the SG River Alignment with a focus on providing information to support the next phase of technical analysis, environmental studies and permitting processes. Additionally, develops feasibility-level engineering details for the pipeline to provide the basis for pre-design of the proposed facilities.
7.0 Feasibility-Level Design of the LA River Alignment	Documents the development of a feasibility-level design for the LA River Alignment with a focus on providing information to support the next phase of technical analysis, environmental studies and permitting processes. Additionally, develops feasibility-level engineering details for the pipeline to provide the basis for pre-design of the proposed facilities.
8.0 Pump Station Analysis	Focuses on developing a feasibility-level design for the pump stations required for the RRWP. Pump stations were developed for the IPR conveyance system originally envisioned that included the OC Reach. Changes that would be required for the Backbone System were noted, where applicable. The additional pump stations that would be required to convey water from the Backbone System to FEWWTP were not evaluated as part of this Project and need to be defined in subsequent phases of work. This chapter describes the following: pump station overview, conceptual operating strategy, pump station hydraulics, building requirements, surge control strategies, storage facilities, yard piping, power supply and electrical requirements, site investigations, and architectural theme.
9.0 Project Duration and Cost Opinion	Describes the development of the construction duration and the engineer’s opinion of probable construction cost for the LA and SG River Alignments’ conveyance system, including unit cost development and quantity take-off.
10.0 Conclusions and Recommendations	Summarizes the conclusions resulting from the technical analysis documented in this report, including the recommendation to complete more detailed analysis on the SG and LA River Alignments and the summarization of the additional studies required in the next phases of work, as identified elsewhere in the report.

CHAPTER/TITLE	DESCRIPTION
Appendices	A. Field Investigation Notes B. Preliminary Traffic Control Assessment for the Metropolitan Water District of Southern California's Potential Regional Recycled Water Supply Program Feasibility Study C. Preliminary Geotechnical/Geologic Evaluation, Proposed Regional Recycled Water Supply Program D. Raw Data Tables of Segments and Subsegments E. Decision Model Results F. Additional Details on Secondary and Fine Screening G. Feasibility-Level Pipeline Plan Drawings H. Optimization of Pipe Sizes and Pumping Costs I. Steel Cylinder Design Calculations J. Preliminary Calculations and Equipment Selection for Pump Stations K. Concept Pump Performance Curves L. Concept Pump Station Site Layouts M. Unit Cost Development for Construction Methods and Adders N. Quantity Take-Off O. Pipeline Engineer's Opinion of Probable Construction Cost P. Pump Station Engineer's Opinion of Probable Construction Cost Q. Hydraulic High Point Memo R. Alignment Verification Analysis S. Backbone Alignment Decision Model Details T. Santa Fe to Weymouth WTP Alignment Evaluation Memo U. Orange County Reach Evaluation V. 2018 Draft Report Pump Station Analysis W. Conceptual Review of Three New Tunnel Alignments Draft Report

2.0 Alignment Verification and Initial Screening

As described in Chapter 1 and highlighted in Figure 2-1 below, the initial focus of this study was to build upon the extensive research and evaluations performed by Metropolitan, verify the alignment alternatives previously identified, and complete an initial screening. This chapter documents the completion of the following tasks:

- **Data Collection and Initial Screening.** Data was collected for the study area relevant to identifying risk factors for the construction of a large conveyance system. Data was collected in paper and electronic forms and was confirmed via field visits. Workshops were held with Metropolitan to validate the data collected.
- **Summary of Pipeline Segments.** This section documents the 89 potential pipeline segments that were identified after an exhaustive review of the study area. These segments could be combined to form full alignment alternatives. Workshops were held with Metropolitan to review the pipeline segments identified.
- **Initial Screening Results and Revised Base Case.** During collaborative workshops with Metropolitan, the potential pipeline segments identified were screened to remove high risk alternatives. To support Metropolitan's development of the Business Case Report, revisions to the Initial Base Case that were preferable based on the level of evaluation completed were reviewed and agreed to with Metropolitan. The refined alignment was known as the Revised Base Case. An Engineer's OPCC was developed on the Revised Base Case to support the Business Case Report.

At the completion of this chapter, 89 potential pipeline segments were identified for further evaluation and screening. Additionally, the Revised Base Case had been established and an Engineer's OPCC developed to support Metropolitan's Business Case Report.

The alignment alternatives identified by Metropolitan and verified / screened in this Chapter were focused on the delivery of water to the SFSG and the OC Spreading Grounds, as well as other locations along the way, for the purpose of groundwater recharge as that was the Project concept at the time. Although the Project concept has evolved, the analyses provided in this Chapter were sufficiently robust to provide the foundation for additional alignment analyses that resulted in the two alternatives for the Backbone System which are presented later in this FLDR: the LA River and SG River Alignments.

See Chapter 5 for the subsequent alignment alternatives connecting the Backbone System to the FEWWTP. Figure 2-1 summarizes the Project methodology as it applies to this chapter.

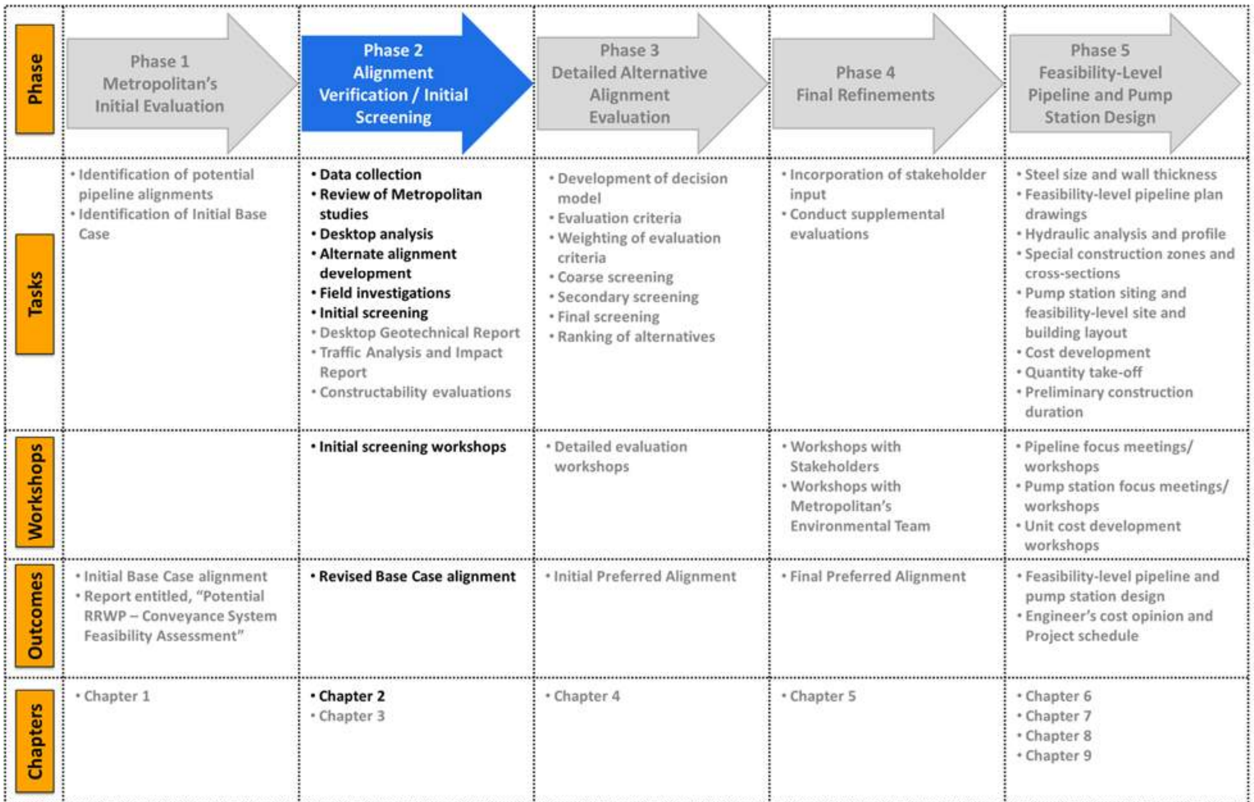


Figure 2-1 Chapter 2 Methodology

2.1 DATA COLLECTION AND INITIAL SCREENING

2.1.1 Desktop Analysis and Review of Metropolitan Studies

For the April 2016 assessment, Metropolitan collected data in both electronic and paper format from the agencies, municipalities, and utilities potentially impacted by construction of the distribution system. The available data was provided to Black & Veatch and logged into a GIS database. The GIS information was layered over aerial imagery to support the initial evaluations of existing and proposed pipeline segments.

The type of GIS information received and the agencies that provided the GIS data are listed in Table 2-1.

A map book of the segments with GIS utility layers was also prepared to assist with the field investigations.

Table 2-1 GIS Information

GIS INFORMATION RECEIVED	AGENCIES PROVIDING GIS INFORMATION	
Contour mapping	Cities	Districts
Contaminated sites	Anaheim	Metropolitan
Environmental constraints mapping	Arcadia	LACSD
Historical landfills	Bellflower	LACFCD
Jurisdictional boundaries	Buena Park	
Land use	Carson	
Park boundaries	Cypress	
Property/parcel lines	El Monte	
Rights of way/easements	Fullerton	
Streets	La Palma	
Traffic signals	Lakewood	
Utility records (includes storm drains, water, sewer, oil/gas, franchise mains, abandoned pipes)	Long Beach	
Watersheds	Los Angeles – Department of Public Works	
	Paramount	
	Placentia	
	Signal Hill	
	South Gate	

The desktop evaluations allowed for an expedited review and comparison of possible pipeline alignments, confirming that linkable corridors were available. They also allowed Black & Veatch to identify potential obstacles and screen alignments that included high risk construction areas, such as utility-congested streets and difficult freeway and utility crossing locations. Also, readily discernible were areas that presented potential community related concerns, such as schools, hospitals, regional shopping centers, and auto malls.

2.1.1.1 Existing Utilities

The existing utility information collected by Metropolitan included water, sewer, gas, storm drain, and telecommunications. Telecommunications and electrical utilities were not evaluated for the FLDR but were provided in the GIS database to be referenced in future design phases.

Table 2-2 lists the utility owners along the alternative Project alignments.

Table 2-2 List of Utility Owners

AGENCY/COMPANY	WATER	SEWER	GAS	STORM DRAIN	OIL
City of Anaheim		✓		✓	
City of Buena Park	✓	✓		✓	
City of Carson		✓			✓(1)
Dominguez Water(2)	✓				
City of Fullerton	✓	✓		✓	
LACFCD				✓	
LACSD		✓			
City of Lakewood	✓	✓		✓	✓(1)
City of Long Beach	✓	✓	✓(5)	✓	
OC Sanitation District (OCSD)(3)		✓			
Pico Co. Water District	✓				
City of Pico Rivera		✓		✓	
City of Placentia		✓		✓	
So Cal Gas(4)			✓		
City of Industry(6)					
City of Baldwin Park(6)					
City of Irwindale(6)					
Los Angeles County(6)					

Notes:
1. Existing oil utility information within the Cities of Carson and Lakewood was obtained from the Los Angeles County Road Department Permit Drawings.
2. Existing Dominguez Water utility information within the City of Carson was obtained from the Los Angeles County Road Department Permit Drawings.
3. Existing OCSD utility information within the Cities of Buena Park and Fullerton was obtained via City GIS and Sewer Atlas'.
4. Existing So Cal Gas utility information within the Cities of Carson, Lakewood, and Pico Rivera was obtained from the Los Angeles County Road Department Permit Drawings.
5. Existing gas utility information within the City of Long Beach was obtained from the City's GIS. The owners are unknown.
6. Utility information should be collected during future Project phases.

2.1.2 Alternate Alignment Development

During the desktop evaluation of Metropolitan's conceptual alignments, Black & Veatch identified 42 additional potential alignment segments that warranted consideration. These additional segments were identified to address constructability issues, property/right-of-way constraints, or municipality feedback regarding the segments already identified by Metropolitan. The additional segments are designated with a letter identifier after the segment number of the segment for which they are an alternative (i.e., 1A, 1B, etc.). The additional segments identified are shown on Figure 2-2, Figure 2-3, and Figure 2-4.

2.1.3 Field Investigations

Black & Veatch performed field reconnaissance to confirm the findings of the desktop evaluation. The reconnaissance was limited to visible at or above grade features. During the visits, actual field conditions and constructability concerns were further identified and evaluated. Attention was given to identifying high risk construction areas and finding viable solutions that could be compared based on cost and impacts to the surrounding community and environment. Visible utilities, land use restrictions, traffic flow, and environmental concerns were documented in field notes and are included in Appendix A.

2.1.4 Workshops with Metropolitan

Three separate workshops were held to discuss and compare Metropolitan's and Black & Veatch's findings about the alignments, including the initial results of the desktop evaluations, field investigations, and feasibility-level analyses. The focus of each workshop was to determine the suitability of existing and newly proposed pipeline segments. Workshop outcomes resulted in several new segments being introduced into the evaluation.

The workshops also resulted in the identification of 19 segments that were deemed unsuitable and removed from further consideration. Table 2-3 lists the segments not considered in further analyses and provides the reasons for their elimination. The locations of the eliminated segments are illustrated as the green dashed lines on Figure 2-2, Figure 2-3, and Figure 2-4.

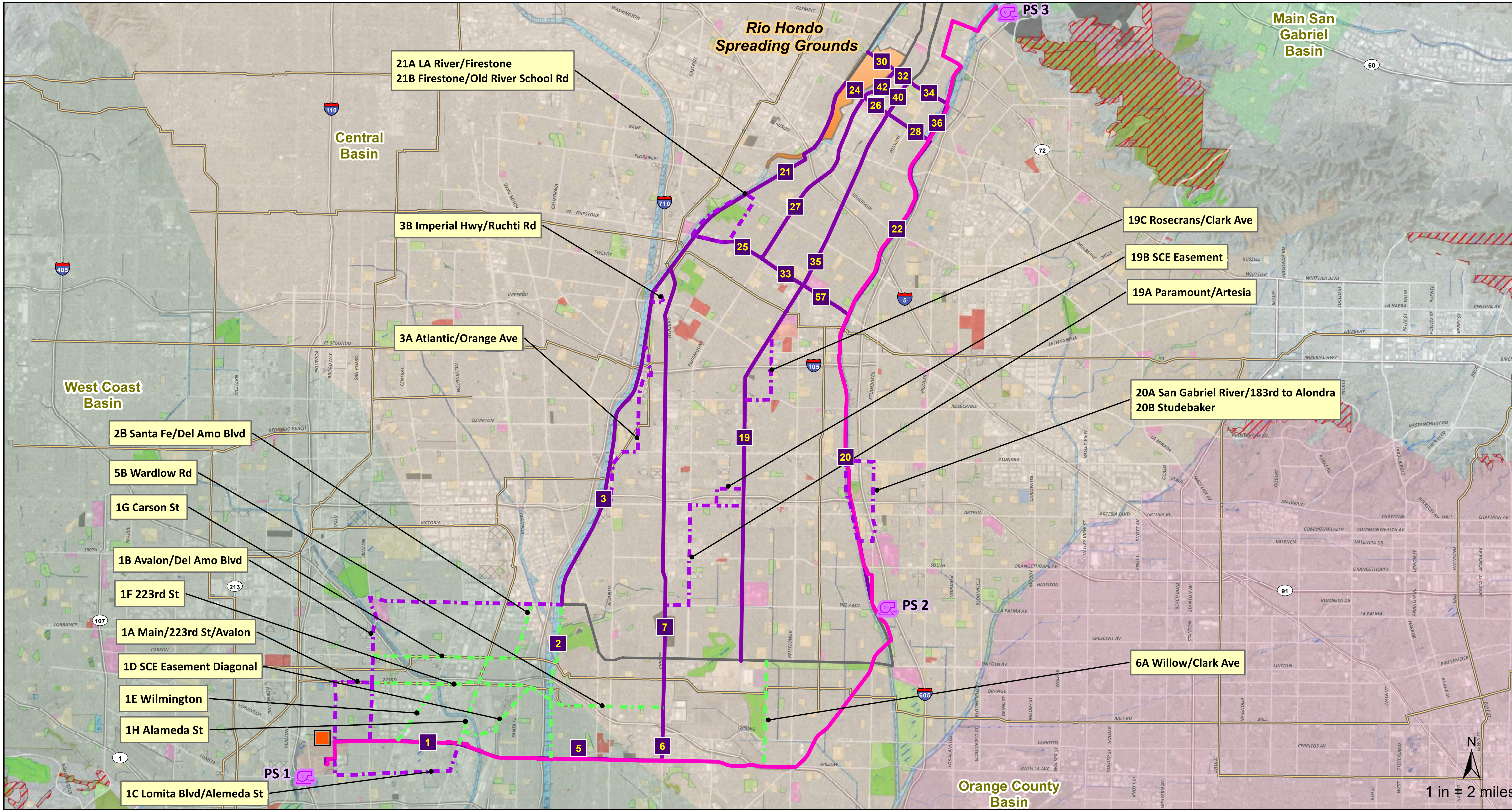
Table 2-3 Segments Eliminated

SEGMENT(S)	REASON ELIMINATED FROM FUTURE ANALYSES
1D, 1G	The proposed segments would be located in sections of Carson Street that the City of Carson indicated would not be feasible.
1E, 1F, 5B	The City of Carson stated this routing would have significant traffic and utility concerns.
1H	The proposed segment would be within a state highway which causes constructability concerns.
2B	The proposed segment would be located in streets that the City of Carson indicated would not be feasible.
6A	The proposed segment was eliminated due to community impact concerns (Long Beach City College, Long Beach Fire Station, Golf Course, Embry-Riddle Aeronautical University, and Long Beach Airport).

SEGMENT(S)	REASON ELIMINATED FROM FUTURE ANALYSES
13B	The proposed segment was eliminated to avoid Coyote Creek.
49, 50	The proposed segment would be in narrow streets that would require a full road closure. Residences would not have alternate access routes and the impact on residential community was deemed to be too great.
52D	The proposed segment was determined to not be constructible due to its location interfering with the Santa Fe Dam.

2.2 SUMMARY OF PIPELINE SEGMENTS

Following the workshops, 89 pipeline segments (57 identified by Metropolitan and 32 subsequently proposed by Black & Veatch) were carried forward for additional analysis. Figure 2-2, Figure 2-3, and Figure 2-4 illustrate the alignments carried forward for additional analyses with purple, pink and grey lines. Figure 2-2 focuses on Reaches 1 and 3, Figure 2-3 focuses on Reach 2, and Figure 2-4 focuses on Reach 4. References to critical habitats refer to California Natural Diversity Database (CNDDB) habitats. The results of the data collection for the 89 pipeline segments carried forward for detailed evaluation are presented in Appendix D.



Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-2: Alternative Alignments Carried Forward - Reach 1 and Reach 3

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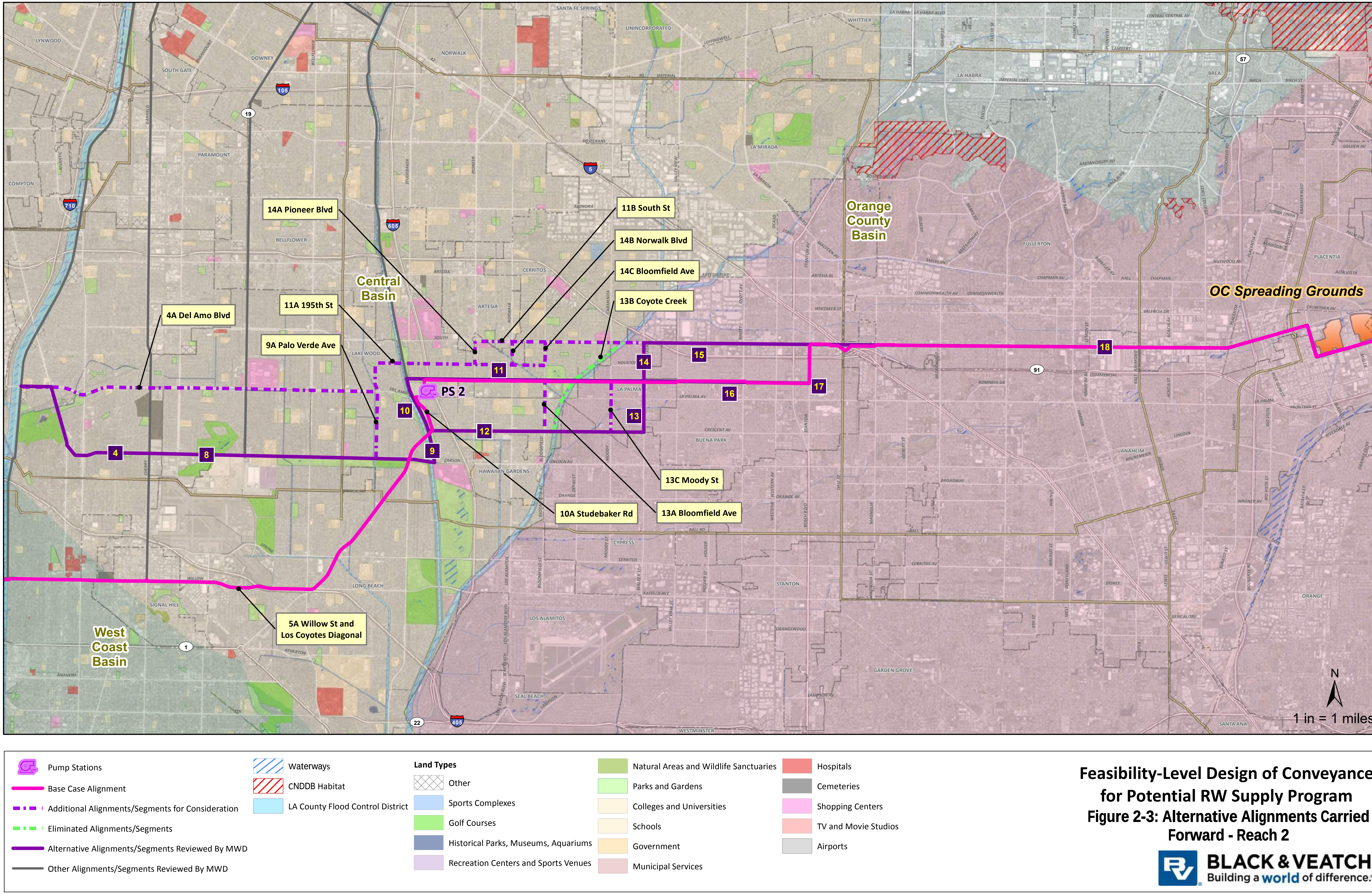

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-3: Alternative Alignments Carried Forward - Reach 2

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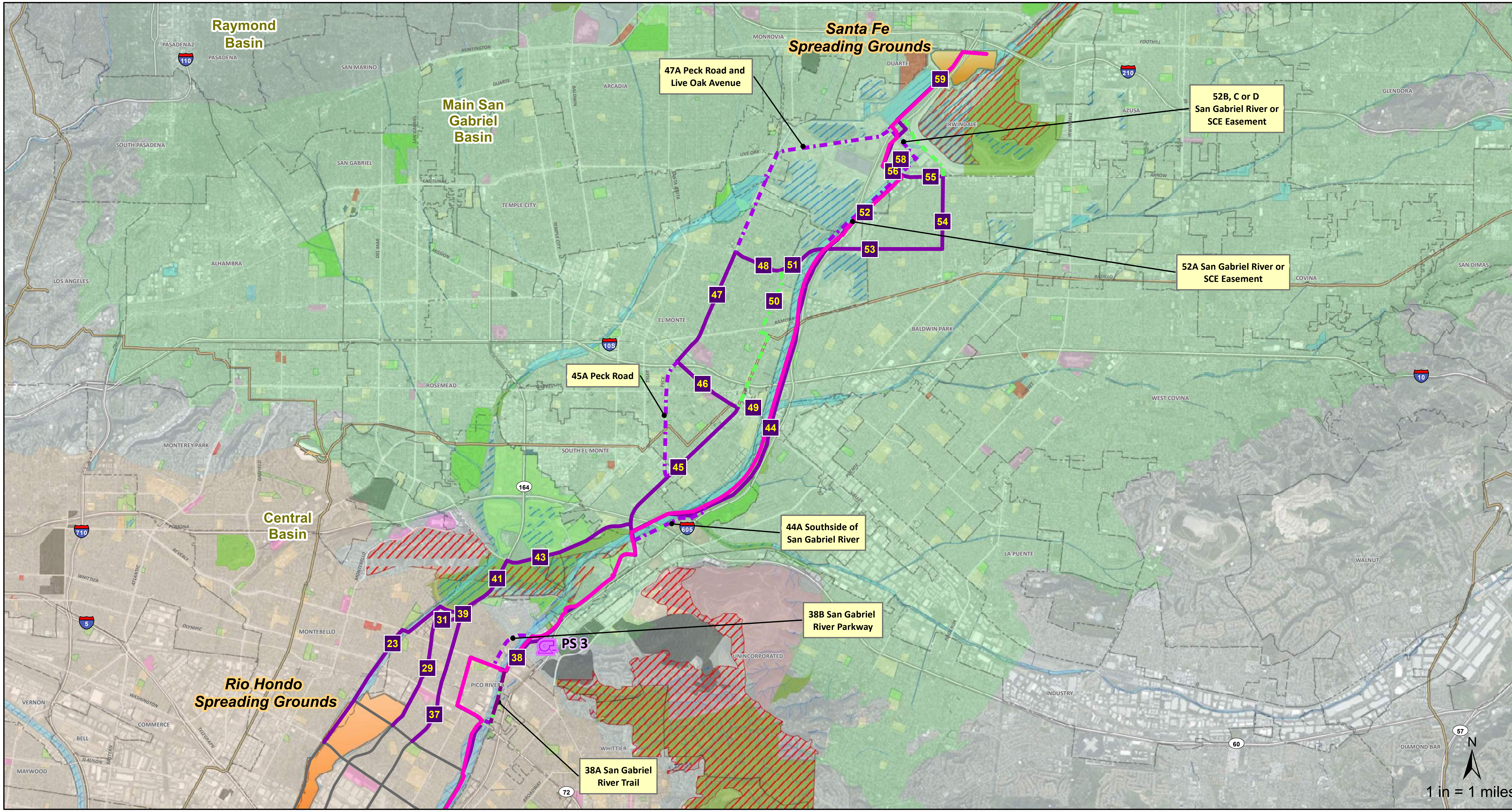

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-4: Alternative Alignments Carried Forward - Reach 4

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2.3 INITIAL SCREENING RESULTS AND REVISED BASE CASE

To support Metropolitan's development of the Business Case Report, the alternative alignment verification and initial screening process identified revisions to the Initial Base Case that were preferable based on the level of evaluation completed. The refined alignment was known as the Revised Base Case. An Engineer's OPCC was developed on the Revised Base Case to support the Business Case Report. This section of the report describes the Revised Base Case.

The revisions made to the Initial Base Case are summarized in Table 2-4.

Table 2-4 Summary of Initial Base Case Revisions

DESCRIPTION OF INITIAL BASE CASE REVISION	JUSTIFICATION FOR REVISION
• Added Segment 5 (Willow Rd). • Added a new segment (Segment 5A) to extend the alignment along Willow Rd to Los Coyotes Diagonal, and along Los Coyotes Diagonal to Carson St. • Removed Segments 4 and 8 and part of Segment 2.	• Provides a more direct route to the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River. • Avoids the Dominguez Gap restored wetlands and bike path constructed along the Los Angeles River.
• Added a new segment (Segment 10A) along Los Coyotes Diagonal between Carson St and the San Gabriel River/Centralia St., extending along Studebaker Rd between Centralia St and Del Amo Blvd. • Removed Segments 9 and 10.	• Provides a more direct route to junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River. • Avoids impacts to the Lakewood Equestrian Center and Rynerson Park facilities.

Table 2-5 lists the segments included in the Revised Base Case while Figure 2-5 presents the Revised Base Case alignment.

Table 2-5 Revised Base Case Segments

REACH	REVISED BASE CASE SEGMENT NOS.
1	1, 5, 5A, 10A
2	11, 16, 17, 18
3	20, 22, 36, 38
4	44, 52, 56, 58, 59

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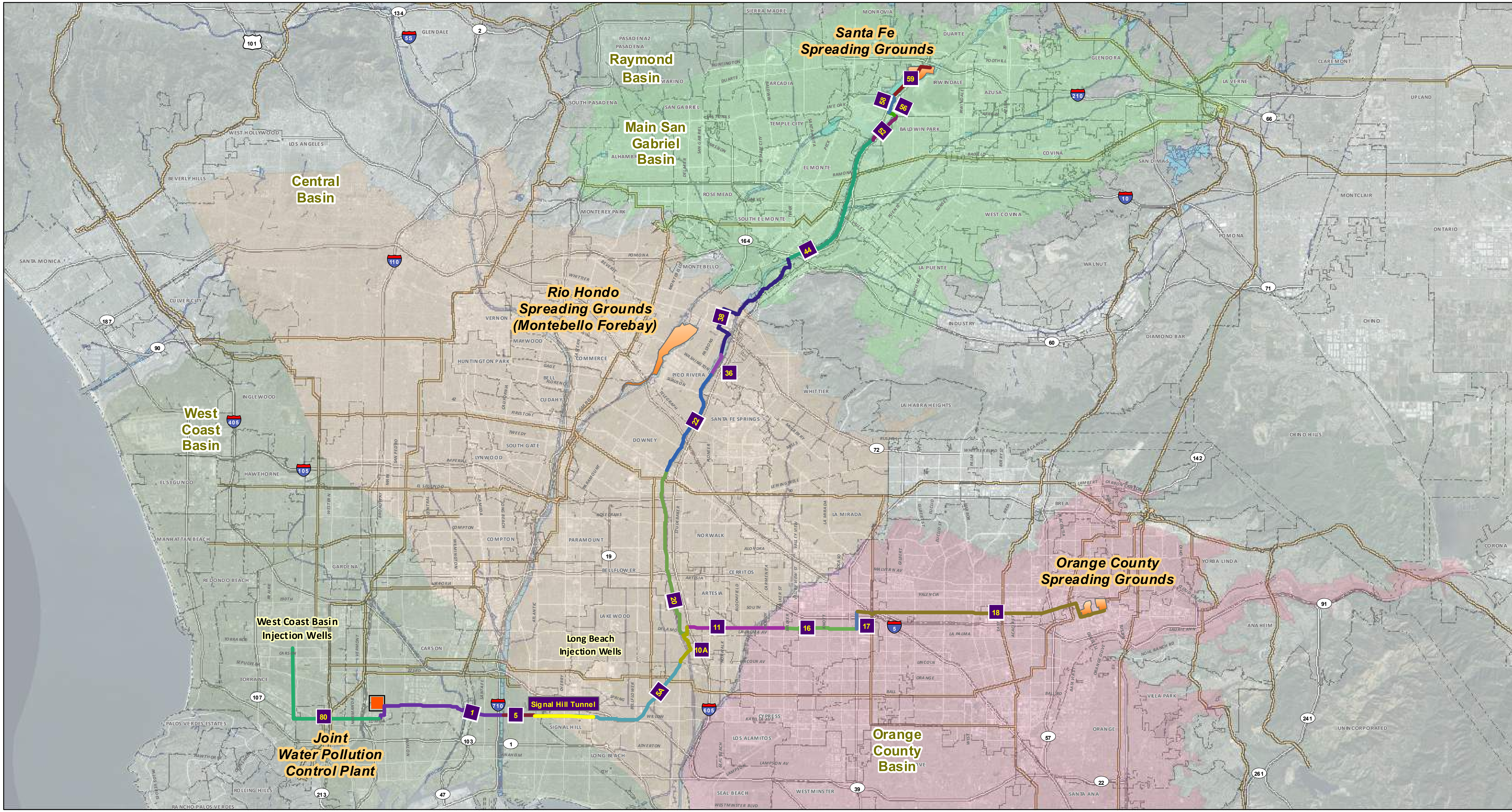

Existing MWD Distribution System
Spreading Basins

Base Case Alignments

1	17	38	58
10A	18	44	59
11	20	5	5A
16	22	52	80
	36	56	Signal Hill Tunnel

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Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 2-5: Revised Base Case Alignment

N

1 in = 3 miles

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3.0 Supporting Technical Evaluations

This chapter summarizes the three supporting technical evaluations completed during the development of the FLDR: a traffic analysis and impacts evaluation, a desktop geotechnical evaluation, and a constructability evaluation. A brief overview of the analysis documented in this chapter is as follows:

- **Traffic Analysis and Impacts Evaluation.** This section summarizes the preliminary traffic control assessment that was completed on all of the potential pipeline segments that had been identified. Covered in this assessment was Metropolitan's preliminary outreach efforts, the establishment of four conceptual traffic control configurations for pipeline construction of the RRWP in roadways, two conceptual traffic control configurations for pipeline construction through intersections, traffic control assessments for each pipeline segment, and cost opinions for traffic control. The full traffic control assessment is provided in Appendix B.
- **Desktop Geotechnical Evaluation.** A desktop geotechnical evaluation was completed on the study area using information from published literature, government agency websites, and in-house records. The evaluation summarized the mapped surficial geologic units, soil types, shallowest historic depths to groundwater, location of oil and gas fields, seismic hazards, earthquake fault zones, soil reuse, trenchless excavations, and pipeline construction in earthen river beds. The intent of the evaluation was to provide preliminary geotechnical recommendations as supporting information for Project planning and CEQA documentation. The full desktop geotechnical evaluation is provided in Appendix C.
- **Constructability Evaluations.** This section describes the trenchless and cut-and-cover construction methods that are anticipated to be required for the construction of the RRWP conveyance system. Included in the descriptions are anticipated key design criteria that serve as the basis for the cost opinion. The three trenchless construction methods evaluated were jack & bore, microtunneling (MT), and traditional tunneling. Cut-and-cover construction methods are expected for the majority of the alignment alternatives. The desktop geotechnical evaluation indicated that the soil conditions would allow for the use of either temporary shoring or temporary sloped excavation throughout the proposed alignments. Temporary shoring would likely be necessary for most of the alignment, as well as portal excavations, and has been assumed everywhere except where noted to minimize impacts to surface features, traffic flow, and adjacent utilities. Where the pipeline would be in areas with adequate space to accommodate temporary sloped excavation methods, it could be considered during future design phases.

This Chapter also summarizes the development of typical construction methods. The potential pipeline segments would generally be constructed within four different situations: roadways, SCE easements, LACFCD easements, and trenchless (tunnels). A typical construction method was developed for each alignment type for the purpose of establishing a conservative budget and determining the approximate impact area for environmental analysis.

Figure 3-1 summarizes the Project methodology as it applies to this chapter. The traffic analysis and impacts evaluation and the desktop geotechnical evaluation were both completed for the development of the October 2018 Draft Report and focused on the alternatives identified to deliver water to the SFSG and the OC Spreading Grounds. While these evaluations were not updated after October 2018, they considered the entire Project study area and generally encompass the revisions that have occurred since then, including the LA River and SG River Alignments described later in this FLDR. The exception is that they do not include the alignment alternatives that would connect the SFSG to the FEWWTP.

Phase	Phase 1 Metropolitan's Initial Evaluation	**Phase 2 Alignment Verification / Initial Screening**	Phase 3 Detailed Alternative Alignment Evaluation	Phase 4 Final Refinements	Phase 5 Feasibility-Level Pipeline and Pump Station Design
Tasks	• Identification of potential pipeline alignments • Identification of Initial Base Case	• Data collection • Review of Metropolitan studies • Desktop analysis • Alternate alignment development • Field investigations • Initial screening • **Desktop Geotechnical Report** • **Traffic Analysis and Impact Report** • **Constructability evaluations**	• Development of decision model • Evaluation criteria • Weighting of evaluation criteria • Coarse screening • Secondary screening • Final screening • Ranking of alternatives	• Incorporation of stakeholder input • Conduct supplemental evaluations	• Steel size and wall thickness • Feasibility-level pipeline plan drawings • Hydraulic analysis and profile • Special construction zones and cross-sections • Pump station siting and feasibility-level site and building layout • Cost development • Quantity take-off • Preliminary construction duration
Workshops		• Initial screening workshops	• Detailed evaluation workshops	• Workshops with Stakeholders • Workshops with Metropolitan's Environmental Team	• Pipeline focus meetings/ workshops • Pump station focus meetings/ workshops • Unit cost development workshops
Outcomes	• Initial Base Case alignment • Report entitled, "Potential RRWP – Conveyance System Feasibility Assessment"	• Revised Base Case alignment	• Initial Preferred Alignment	• Final Preferred Alignment	• Feasibility-level pipeline and pump station design • Engineer's cost opinion and Project schedule
Chapters	• Chapter 1	• Chapter 2 • **Chapter 3**	• Chapter 4	• Chapter 5	• Chapter 6 • Chapter 7 • Chapter 8 • Chapter 9

Figure 3-1 Chapter 3 Methodology

3.1 TRAFFIC ANALYSIS AND IMPACTS EVALUATION

A preliminary evaluation of construction-related traffic control, community impact, and production considerations was performed by Minagar & Associates, Inc. (Minagar) and is presented in "Preliminary Traffic Control Assessment for The Metropolitan Water District of Southern California's Potential Regional Recycled Water Supply Program Feasibilities Studies", (Traffic Impact Analysis) which is provided in Appendix B. The evaluation identified construction impact to each street segment and intersection along potential alignments and recommended typical traffic control measures to mitigate these impacts.

The evaluation included the following:

- A summary of Metropolitan's preliminary outreach efforts
- Jurisdictional requirements for each agency included in Metropolitan's preliminary outreach, including:
  - City of Carson

- City of Cypress
- City of Fullerton
- City of La Palma
- City of Long Beach
- Los Angeles County

- Roadway traffic analysis and impacts
  - Four basic traffic control configurations which were conceptually developed for pipeline construction of the RRWP
  - Cost estimates for the four basic traffic control configurations
- Intersection traffic analysis and impacts
  - Two basic traffic control configurations which were conceptually developed for pipeline construction at roadway intersections of the RRWP
  - Cost estimates for the two basic traffic control configurations at intersections
- Traffic control assessments for each alternative segment
- Traffic control cost estimates at signalized intersections for all alternative segments

It should be noted that further outreach with agencies along the LA and SG River Alignments will be required during future phases of work.

3.1.1 Intersections

The Traffic Impact Analysis identified, listed, and described the signalized intersections through which the proposed pipeline alignments, segments, and alternatives would cross. A designation of either Major Intersection or Minor Intersection was then established for each intersection. In general, an intersection is defined as Major or Minor by meeting one or all the criteria defined in Table 3-1.

Table 3-1 Designation of Intersections

DESIGNATION	DEFINITION
Major Intersection	Any intersection meeting one of the following criteria: • Contains a multi-lane arterial highway or major collector roadway • Provides protected left-turn signal phasing on all four intersection approaches • Serves a designated regional truck route • Serves multiple municipal fixed bus routes
Minor Intersection	Any intersection not designated as a Major intersection

Two construction methods were considered to cross signalized (Major and Minor) intersections: shored excavation or trenchless. At this feasibility level of planning, insufficient information was available to specifically determine the preferred construction method for each location. Factors that affect the selection of the appropriate construction method include:

- Geotechnical and groundwater conditions
- Traffic impacts
- Jurisdictional requirements
- Utilities within the intersection, including their size, quantity, depth, and criticality
- Other community or environmental impacts
- Overall constructability and cost

Determination of construction methodology for each location will be evaluated during Preliminary Design.

For planning purposes, this FLDR assumed that all intersections would be crossed using shored construction unless there are known jurisdictional requirements prohibiting it (i.e., crossing rail road tracks, rivers, bridges, and California Department of Transportation (Caltrans) roads or highways). It is recognized that shored construction across signalized intersections would have a slower production rate and higher unit construction costs than shored methods elsewhere. Further, at some intersections, trenchless construction may be warranted or preferred, depending on the factors described earlier. Therefore, the FLDR has assumed a premium is applied to account for the higher cost of construction at all intersections that the Traffic Impact Analysis considered to be a Major Intersection. Additional details on the cost of intersection crossings are provided in Chapter 8.

3.1.1.1 Traffic Control at Intersections

Various traffic control approaches could be implemented for construction across the signalized intersections along the alignment. With shored excavations, three traffic control approaches were considered:

- **Full Closure of Cross Street** - With the concurrence of local jurisdictions, the work zone would continue through the intersection blocking both the upstream and downstream traffic during construction.
- **Phased Traffic Control** - Construction across larger intersections could be completed in phases such that traffic control would be established to detour the upstream and downstream traffic around the work.
- **Non-Peak Construction Hours** - Construction would be completed during non-peak traffic hours, such as at night, and the trench could be plated during the day to minimize the construction impacts.

For trenchless construction methods, the intersection would be kept clear for traffic to pass in each direction. On the primary street where the pipeline is being constructed, the work zone would extend around the launching and receiving portals and taper off on one side as it approaches the crosswalk to provide the needed space for left turns. Additional coordination should occur with the local agencies during Preliminary Design. Section 6.3.6 presents a list of the signalized intersections along the SG River Alignment that would require temporary traffic control, while Section 7.3.6 presents the same information for the LA River Alignment. See Appendix B for additional details and figures for traffic control at signalized intersections.

3.2 DESKTOP GEOTECHNICAL EVALUATION

A "desktop" geotechnical evaluation was conducted as part of the FLDR: "Preliminary Geotechnical/Geologic Evaluation, Proposed Regional Recycled Water Supply Program" (Desktop Geotechnical Evaluation). The report was prepared by GeoPentech Inc. (GeoPentech) and is included in its entirety in Appendix C. Key information is summarized below.

The purpose of the Desktop Geotechnical Evaluation was to assess the general geotechnical/geological conditions along Metropolitan's proposed conveyance alignment alternatives for the RRWP. The information used in the evaluation was from published literature, government agency websites, and in-house records. Specifically, the evaluation summarized the mapped surficial geologic units, soil types reported for borings up to 100 feet (ft) in depth, shallowest historic depths to groundwater, location of oil and gas fields, seismic hazards, earthquake fault zones, and Quaternary faults mapped along the Project area. The intent of the evaluation was to provide preliminary geotechnical recommendations as supporting information for Project planning and CEQA documentation.

3.2.1 Regional Geology

The majority of the RRWP conveyance alignment alternatives would be located within Quaternary-age alluvial and fluvial sediments that were deposited in the Los Angeles, San Gabriel, and OC basins from the foot of the San Gabriel and San Bernardino mountains to the Pacific Ocean along the Los Angeles, San Gabriel, Rio Hondo, and Santa Ana rivers and their associated tributaries. The Quaternary-age alluvial and fluvial sediments along the proposed alternatives are composed mainly of sand, gravel, and cobble at the northern end of the alignment with fine-grained sediments present at a depth less than about 20 ft; sand, silty sand and silt in the central and eastern alignment areas; and silty sand, silt, and clay in the south and southwestern portion of the conveyance Project area.

Outcrops of Pleistocene-age and older bedrock units occur in the Puente, Montebello, and Signal hills. Bedrock units in the Puente and Montebello hills are composed of shale, siltstone, sandstone, pebbly sandstone, and conglomerate of the Sespe, Topanga, Puente, and Fernando formations. Bedrock units exposed in the Signal Hill area are composed of sandy silt, sandstone, and pebbly sandstone of the Lakewood Formation, Palos Verdes Sand, and San Pedro Formation. Within the Los Angeles coastal plain, shallow groundwater less than 50 ft below the ground surface occurs perched on fine-grained alluvial deposits that range in depth from about 60 to 100 ft. See Figure 2 in Appendix C for details.

3.2.2 Quaternary Faults

The conveyance alignment alternatives would cross the Newport-Inglewood Fault Zone, the Los Alamitos Fault, and possible, though not shown, a buried fault trace that connects the Whittier and East Montebello faults. The Newport Inglewood and Los Alamitos faults have experienced surface rupture in the late Quaternary (<130,000 years before present). A summary of fault geometry and deformation characteristics is provided in the Desktop Geotechnical Evaluation in Appendix C.

The Newport Inglewood Fault is Holocene active and estimated to have probable earthquake magnitudes in the range of 6.0 to 7.4 on the moment magnitude scale (M_W) with surface rupture likely to occur above M_W 6.0. The Newport-Inglewood Fault has right-lateral displacement with an estimate of 2 meters (6.5 ft) average displacement. The Los Alamitos Fault is not known to be active in the Holocene (<11,700 years before present).

In the Puente Hills, southeast of the proposed alignment alternatives, the Whittier Fault is Holocene active and estimated to have probable earthquake magnitudes in the range of M_W 6.0 to 7.2 with surface rupture likely to occur above M_W 6.0. The Whittier Fault has right-lateral displacement with an estimate of 1.9 meters (6 ft) average displacement. See Figure 2 in Appendix C for details.

3.2.2.1 Alquist-Priolo Act Earthquake Fault Zones

The Alquist-Priolo Act established a program to produce maps of earthquake fault zones that delineate the surface trace of active faults as well as buffer zones where special studies are required to ensure structures for human occupancy do not cross the fault. It should be noted that the act does not directly address structures without human occupancy or infrastructure facilities, such as pipelines or tunnels. However, this information has been included for reference purposes.

As shown on Figure 4 in Appendix C, the Newport-Inglewood Fault Zone crosses the study area. Other identified Alquist-Priolo earthquake fault zones that are near the proposed alignment alternatives include the Whittier-Elsinore Fault Zone, East Montebello Fault Zone, and the Sierra Madre Fault Zone. The other fault that is crossed is the Los Alamitos Fault, though this fault has not been identified as a possible Holocene-active fault and, therefore, is not designated as an Alquist-Priolo Earthquake Fault Zone.

3.2.3 Groundwater Occurrence

Shallow groundwater with depths of 20 ft or less is found primarily within alluvial sediments throughout most of the proposed conveyance Project area with exceptions including the area east of the intersection of the 91 and 5 freeways in OC and north of Ramona Boulevard in the San Gabriel Valley. The shallow groundwater generally coincides with California Geologic Survey (CGS) mapped liquefaction Hazard Zones. See Figure 5 in Appendix C for details.

3.2.4 Oil and Gas Fields

The conveyance alignment alternatives would overlie oil and gas fields in the Cities of Wilmington, Long Beach, Signal Hill, Montebello, Whittier, Santa Fe Springs, Buena Park, and Placentia. Issues associated with pipeline and undercrossing tunnel construction in areas overlying oil and gas field include the potential accumulation of hazardous gasses, such as methane and hydrogen sulfide in underground excavations and tunnels, oil residuals in soil, legacy contamination associated with oil and gas production activities, and abandoned well casings.

In areas where occurrences of explosive and hazardous gases are possible, positive ventilation along with intrinsically safe and explosion-proof equipment should be used. In addition, pre-design hazardous chemical assessments should be completed to identify if legacy soil contamination exists in the Project area. A review of California's Division of Oil and Gas records should be completed in these areas to identify the possible presence of abandoned well casings, and prior to construction geophysical means should be used to clear the planned extent of excavations of buried objects. As this impacts Project cost due to utilization of specialized equipment, for the purpose of the FLDR all alignments in these areas were considered as gassy. See Figure 6 in Appendix C for details.

3.2.5 Soil Characteristics

In general, shallow (less than 20 ft depth) soils throughout the proposed conveyance Project area are composed of sandy silt and clay while the deeper (greater than 20 ft) soils tend to be coarse grained (sand, gravel, cobbles and boulders) in the northern portion of the alignment alternatives and finer grained to the south consistent with alluvial and fluvial deposition that is sourced from the mountains to the north of the Project. Deep soils within the eastern portion of the conveyance Project area (i.e., within OC) tend to be predominantly sand with some fine-grained silts and clays in the shallow zone. See Figures 7a and 7b in Appendix C for details.

3.2.6 Excavation and Soil Reuse

In general, excavation of the alluvial or fluvial materials present along most of the proposed alternative alignments would not require special equipment. Where the alignment would enter the Signal Hill area where outcropping bedrock is present heavy ripping equipment, such as a Caterpillar D-9 or D-10 dozer equipped with a ripper shank, may be necessary. Based on GeoPentech's experience, blasting would not be necessary for excavation sites in Signal Hill.

Reuse of excavated material for backfill would be evaluated on a case-by-case basis depending on the soil type present at the proposed excavation sites and the possible occurrence of contamination / hazardous substances, specifically in the areas near oil and gas fields. However, generally, non-contaminated alluvial or fluvial materials would be acceptable for reuse provided that oversized material is removed and the material is appropriately moisture conditioned and compacted.

The requirements for backfill material would depend on the anticipated use of the site and any conditions imposed by the design or the local jurisdiction. As general guidance, material with a liquid limit less than 40 and a plastic limit less than 12, or alternatively, with a sand equivalent less than 30, would likely be acceptable. Generally, this excludes clays with moderate to high plasticity, but may allow reuse of some low plasticity clays and silts. Actual requirements would depend on the soil properties, design criteria, and local jurisdictional restrictions.

In some portions of the proposed conveyance Project area, soil boring logs reviewed identified some material that would not likely be acceptable for reuse. This included particular references to material characterized as "Gumbo silt," which was noted in logs from specification No. 722 for Metropolitan's Second Lower Feeder project in the Los Alamitos area. It is not clear whether this material is only present locally and therefore was not noted in other logs, or if the particular description is a unique expression from the person(s) who documented these boreholes. GeoPentech's experience at other projects in this area suggests that fine-grained sediments would be appropriate for reuse.

3.2.7 Liquefaction

A significant portion of the proposed conveyance Project area would be located within mapped liquefaction hazard zones. Due to the deeper depth of groundwater in the portions of the conveyance alignment alternatives proposed in Signal Hill, north of Arrow Highway in the San Gabriel Valley, and between Euclid Street and Kraemer Boulevard in OC, liquefaction hazards in these sections is considered relatively low and not likely. However, liquefaction hazards are moderate to high on a regional basis for the remaining portions of the proposed conveyance alignment alternatives. Sections that would pass through mapped liquefaction hazard zones should be prioritized for evaluation, and the remaining areas should be screened to establish whether there is relatively high groundwater present and potentially susceptible soils (i.e. loose granular soils with low plasticity). Areas where these hazards are known to exist should be evaluated to estimate potential settlements or deformation for design or whether flotation of the pipeline could be a risk. See Figure 3 in Appendix C for details.

3.2.8 Seismically Induced Land Sliding

Most of the proposed alternative alignments would cross relatively flat terrain through the Los Angeles, San Gabriel and OC basins and are not near areas where seismically induced landslide zones are mapped but would be within one mile of these zones in the Montebello/Pico Rivera area.

3.2.9 Pipeline Undercrossing Excavation

The Desktop Geotechnical Evaluation evaluated the preliminary trenchless crossings required for the Project and presented four trenchless construction methods that would be feasible based on assumptions of the undercrossing design and inferred ground conditions: jack & bore, MT, traditional tunneling, and horizontal direction drilling (HDD). While HDD was initially considered, it was deemed to be unsuitable for the Project based on the diameter of the pipeline being proposed and the nature of the materials being considered (welded steel pipe). As such, HDD was not considered for any trenchless crossing for this Project.

The geotechnical criteria used to evaluate the feasibility of the alternative excavation methods considered the following:

- Pipeline design (i.e. diameter, depth and length) and applicability considering engineering constraints.
- Construction access, such as launching and receiving portals.
- Anticipated soil conditions along undercrossing such as mixed face with cobbles and boulders and potential running ground.
- Ability to control groundwater along undercrossing.

Additional discussion on each trenchless construction method is provided in Section 3.3.1.

3.2.10 Pipeline Construction in Earthen Riverbed

One of the alignment alternatives proposes constructing the pipeline linearly within the unlined portion (earthen) of the SG River bed. Construction within the unlined river bed poses many challenges, with the particular areas of concern including:

- **Scour Potential.** The depth of excavation and construction methods required to mitigate scour potential could add to the cost to construct this section. This also needs to be looked at in conjunction with any risk for flotation of the existing pipeline.
- **High probability of cobbles and boulders within the river bottom.** Cobbles and boulders slow down production rates for excavation and can impact the trenchless construction that may be required either to cross existing levees or to cross beneath existing rubber dams. They can also create challenges for the drilling and groundwater

dewatering wells. During excavation, specialized equipment may be required by the earthwork contractor.

- **Dewatering.** The river bottom is anticipated to have larger dewatering volumes, particularly if the depth of excavation is required to be deeper to avoid scour potential. Based on recharge activities conducted by LA County Public Works and the Water Replenishment District, most of the SG River is anticipated to be fully saturated most of the year. Additionally, the river bottom is anticipated to be gravelly with silt and clay lenses due to seasonal storms, which could add to dewatering difficulties.
- **Seasonal Construction Constraints.** Due to the seasonality of rainfall in Southern California, construction would likely be limited to the dry season. Off season rain events would require preventative measures, such as cofferdams, as well as the removal of construction equipment and potentially even the damage of facilities at the worksite (i.e., previously installed pipe, dewatering equipment, etc.).

No subsurface investigations or scour analysis was completed as part of this study. These tasks are recommended during future phases of work to better define the areas of concern described above.

3.3 CONSTRUCTABILITY EVALUATIONS

Installation of the RRWP conveyance system would require either trenchless or cut-and-cover construction methods. This section discusses these construction methods.

3.3.1 Trenchless Construction Method Evaluation

This section describes each trenchless method identified by GeoPentech in the Desktop Geotechnical Evaluation as being geotechnically feasible methods for the Project. Included in the descriptions are anticipated key design criteria that serve as the basis of the cost opinion.

The four trenchless construction methods evaluated were jack & bore, HDD, MT, and traditional tunneling. As described above, while HDD was initially considered, it was deemed to be unsuitable for the Project based on the diameter of the pipeline being proposed and the nature of the materials being considered and was therefore not considered for any trenchless crossing for this Project. Evaluation criteria included length, diameter, crossing type (interstate, intersection, river, etc.), groundwater levels, and anticipated geotechnical conditions. Groundwater levels and anticipated geotechnical conditions reflect the results of the Desktop Geotechnical Evaluation.

3.3.1.1 Jack & Bore (Pipe Jacking)

The primary trenchless solution considered was jack & bore, also known as pipe jacking. It provides favorable construction cost due to a less complicated technical installation, thereby allowing a larger contractor pool. Jack & bore is considered an open excavation as there is no pressurization. Jack & bore allows access to the face of the excavation facilitating removal of obstructions (boulders, cobbles, man-made structures, tree limbs, etc.). Excavation can be accomplished from within the jacked pipe with a rotating cutter head (tunnel boring machine), rotating cutter boom, backacter (digger arm), or even hand mining.

Jack & bore is generally appropriate under the following conditions:

- Less than or equal to 96 inches diameter, although larger diameters are possible
- Less than 300 ft in length if hand mining, up to 1,000 ft with mechanical methods
- Not passing beneath structures that are sensitive to dewatering (dams)
- Not a river crossing
- Not in a known oil field requiring dewatering or in other contaminated soils
- Not excavated in loose ground prone to raveling or flowing

To protect the cement mortar coating on Metropolitan's steel carrier pipes, a larger diameter casing pipe would be installed first with the steel carrier pipe inserted within. The annular space would be filled with low density cellular grout. For an 84-inch carrier pipe, the casing is assumed to be a 108" permalok pipe. For a 60-inch carrier pipe, the casing is assumed to be an 84-inch permalok pipe. For a 54-inch carrier pipe, the casing is assumed to be a 78-inch permalok pipe.

Figure 3-2 and Figure 3-3 depict examples of equipment used for large diameter jack & bore installations.

Figure 3-2 Jack & Bore Excavation Methods, Pipe Jacking Association

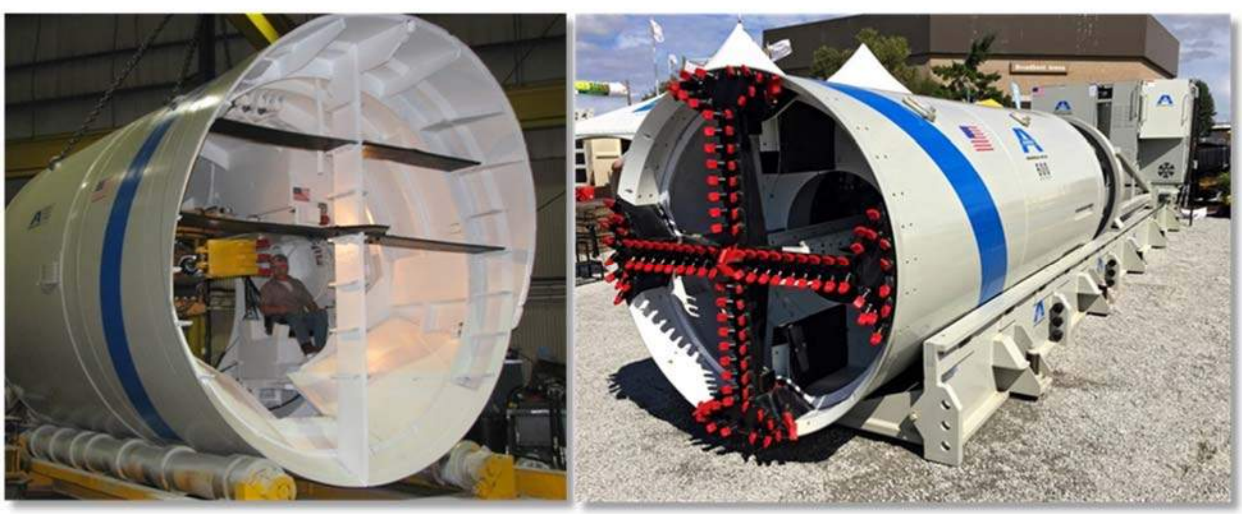


Figure 3-3 Boring/Digger Shield and Cutting Head, Akkerman

3.3.1.2 Horizontal Directional Drilling

As mentioned previously, while initially considered, HDD has since been deemed unsuitable for the Project. HDD can be a cost-effective solution for long drive lengths as it can be driven from the surface without shafts. However, HDD is not generally installed in diameters exceeding 54 inches and is most common for small diameter pipe less than 48 inches. Figure 3-4 depicts examples of equipment used for HDD installations.

HDD with steel pipe requires a bend radius of 100 times the pipe diameter due to the properties of the steel pipe. Due to the Project requirement of steel pipe and the relatively large diameter for trenchless crossings, HDD is not suitable for crossings less than 1,800 ft in length. Gravel, cobbles, and boulders cause problems with maintaining line and grade for HDD crossings. Due to the size of the pipeline being proposed and the material being considered, HDD was eliminated from consideration for the Backbone System but may be applicable for smaller diameter distribution pipelines, such as to potential injection well sites.

Figure 3-4 Large Diameter HDD Reaming Tool and Drilling Equipment

3.3.1.3 Microtunneling

MT was considered for all crossings not suitable for jack & bore. MT is more expensive than jack & bore but is a robust construction method capable of handling complex and challenging ground more effectively. In addition, MT can be done below the groundwater table without dewatering along the alignment, making it well suited for river crossings and other crossings that are difficult or expensive to dewater or where contaminated soil may be encountered (i.e. oil fields). MT does not allow access to the cutterhead from within the excavating machine. Therefore, obstructions including boulders, cobbles, or man-made structures, such as abandoned oil wells, pose a higher risk than they would for jack & bore, where the face of the excavation can be more readily accessed. MT cutter heads can be designed to crush cobbles and boulders of a certain size and frequency. However, if more frequent or larger cobbles and boulders are encountered, the tunneling excavation rate may be reduced or stopped.

Trenchless sections not using jack & bore were identified for MT unless the trenchless sections exceeded 2,000 ft, therefore require multiple jacking portals or interjack stations. Additional jacking portals or interjack stations are necessary when the jacking load on the pipe reaches a level at which damage to the pipe could occur. The maximum jacking load is a function of pipe type, thickness, pipe diameter, and ground conditions and would vary between tunnel alignments. Generally, 1,500 - 2,000 ft is considered a reasonable distance between jacking locations.

Interjack stations are installed within the tunnel between segments of pipe. They allow the jacking forces to be distributed along the pipe string allowing longer drive lengths between jacking portals.

Figure 3-5 depicts a typical jacking portal and interjack station relationship.

Figure 3-5 Interjack Stations and Jacking Portal, Pipe Jacking Association

In order to protect the lining, coating, and structural integrity of the carrier pipe during the mining and installation process, a larger diameter casing pipe would be installed into the ground first. Similar to jack and bore, the annular space would be filled with low density cellular grout. For an 84-inch carrier pipe, the casing is assumed to be 108" permalok pipe. For a 60-inch carrier pipe, the casing is assumed to be 84-inch permalok pipe. For a 54-inch carrier pipe, the casing is assumed to be 78-inch permalok pipe.

Figure 3-6 depicts a typical MT installation.

Figure 3-6 72-inch diameter Microtunneling Machine – East Chicago, Indiana

To protect the cement mortar coating on Metropolitan's steel carrier pipes, a larger diameter casing pipe would be installed first with the steel carrier pipe inserted within. The annular space would be filled with low density cellular grout.

3.3.1.4 Traditional Tunneling

Traditional tunneling allows long distances between shafts but requires an excavated diameter large enough for the man operated equipment to function. Crossings of significant length would also be 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 Project: open shielded tunnel boring machine (TBM) and earth pressure balance tunnel boring machine (EPBM).

3.3.1.4.1 Shielded Tunnel Boring Machine

A Shielded TBM protects workers from ground falls into the tunnel until initial support or tunnel lining can be safely installed. As shown on Figure 3-7, the body of the machine is enclosed in a shield marginally smaller than the excavated diameter of the tunnel. The front of the Shielded TBM is a rotating cutterhead that matches the diameter of the tunnel. As the cutterhead rotates, a ring of hydraulic cylinders provides forward thrust through "shoes" that push against the initial support or final tunnel lining. The cutterhead may be dressed with carbide picks and teeth and/or disc cutters evenly spaced across the cutterhead depending on the ground being excavated. Excavation and installation of initial support or final lining are performed sequentially. To steer, cylinders orient the articulated cutterhead in the required direction.

Figure 3-7 Open Mode Shielded TBM used on Cady Marsh Stormwater Tunnel, Griffith, Indiana

Shielded TBMs are feasible in a wide variety of ground conditions including less competent rock and soft ground. Shielded TBMs have multiple variants typically subdivided based on how the material is removed from the face of the excavation [belt conveyor (open), screw conveyor (EPBM) or pipe (slurry)]. For the purpose of the FLDR, "Shielded TBM" refers to a machine operating in open mode that removes material from the face of the excavation by belt conveyor and installs an initial support system behind the TBM. Once the tunneling is completed with the Shielded TBM, the final steel pipe would be installed and grouted in place inside the initial support system.

If groundwater is anticipated to flow into the excavation at a rate above that which can be handled with sumping, additional groundwater controls potentially including pre-excavation grouting, dewatering, permeation grouting, and/or jet grouting would be required. Pre-excavation grouting can be performed through ports in the TBM and cutterhead to reduce hydraulic conductivity ahead of the excavation. However, it is important to note that the TBM must be designed with ports for pre-excavation grouting; therefore, if anticipated, pre-excavation grouting should be specified in the contract documents.

Dewatering, permeation grouting and jet grouting all must be completed from the surface. Groundwater control through grouting is generally only cost effective if it is isolated to small portions of the alignment. If groundwater inflow is anticipated to impact large portions of the alignment tunneling, an EPBM should be considered.

3.3.1.4.2 Earth Pressure Balance Machine

EPBMs are a type of Shielded TBM specially designed for operation in soft or raveling ground conditions containing water under pressure. Figure 3-8 depicts typical EPBM equipment. EPBMs have an articulated shield that can be sealed against the pressure of ground and water inflows. EPBMs control the stability of the tunnel face and subsidence of the ground surface by monitoring and adjusting the pressure inside the cutterhead chamber to achieve a balance with the pressure in front of the cutterhead. EPBMs work best in soils with cohesion or soils that can be preconditioned to exhibit cohesion characteristics.

The working area inside the EPBM is completely sealed against the groundwater pressure outside the machine. A screw conveyor as shown in Figure 3-8 removes the fluidized muck behind the cutterhead and in front of the pressurized bulkhead. The screw conveyor's speed and discharge rate are controlled by the operator and used to control the pressure at the working face and match the muck discharge rate to the advance rate of the EPBM. Controlling inflow of water and muck through the screw can be difficult in rock and non-cohesive material, making EPBMs suited for soft ground and cohesive soils.

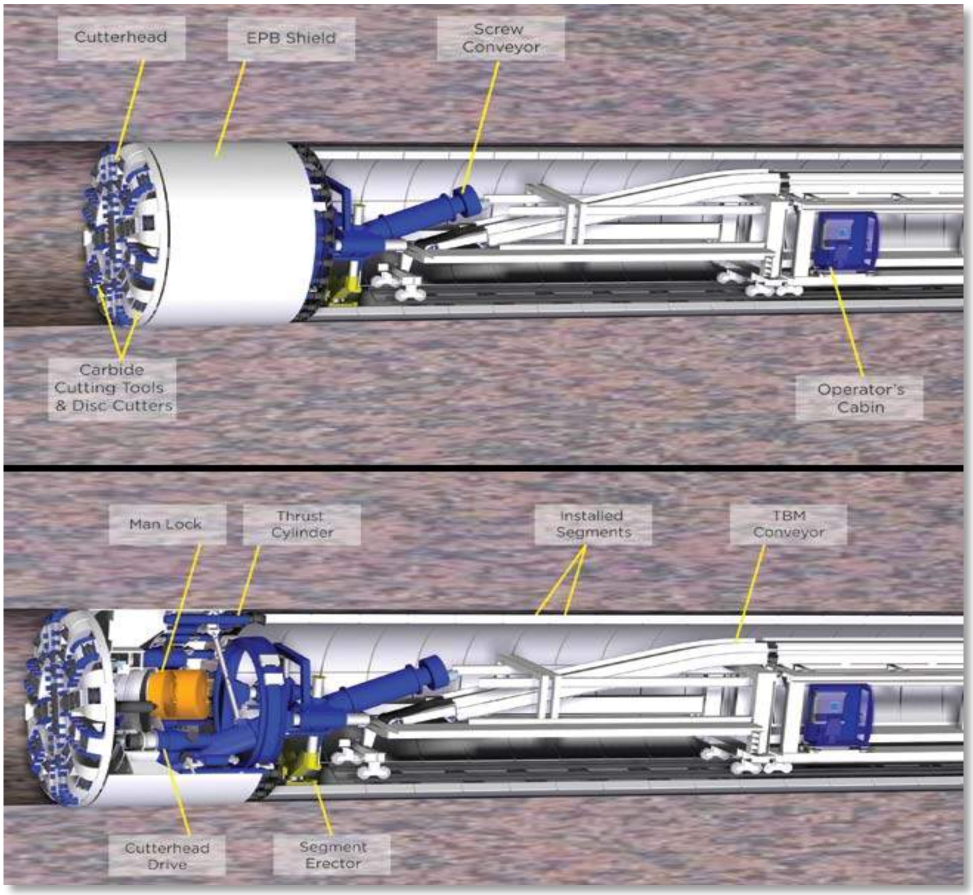


Figure 3-8 EPBM, The Robbins Company

An EPBM erects a pre-cast concrete segment tunnel final lining sequentially after each push. Specially designed high-pressure seals in the tail shield effectively seal the machine to the outside of the tunnel lining and create a barrier against groundwater. When it becomes necessary to enter the cutterhead chamber to inspect the cutterhead or change cutting tools, workers can enter through an airlock while compressed air is used to maintain a pressure balance to support the working face.

Due to equipment limitations and man access requirements into the EPBM, the minimum finished diameter possible for an EPBM is 7.5 ft, although at this diameter, machines are not readily available and would have to be special ordered. Machines are more common when at least 2.5-meter diameter (8.2 ft), and even more common when 3 meters (9.84 ft), and larger. The finished diameter consists of precast concrete segments, which are generally adequate for stormwater or wastewater conveyance. For this application, a steel pipe would be installed and grouted in place within the precast concrete segmental liner. This double liner system would allow a less robust concrete segment design as the segments are only required for initial support but would increase overall Project cost compared with a single liner system.

3.3.1.4.3 Traditional Tunneling Excavation Method Recommendation

For the FLDR, the traditional tunnel sections identified were assumed to be EPBM excavated with precast concrete segment initial support and steel pipe final lining. This is a reasonable approach given the feasibility level of analysis and lack of geotechnical field investigations. If, following a geotechnical investigation, it is determined that the soils along the alignment have low permeability that could allow shielded TBM, the tunnel cost would be lower than currently estimated. Additionally, if implementing EPBM tunneling with a secondary steel lining is cost prohibitive, the alignments could be excavated with MT equipment with intermediate jacking pits every 1,500 to 2,000 ft.

3.3.1.5 Minimum Working Spaces

In general, the larger the working space that can be provided the installation contractor, the more efficient the construction would be. Provided herein is a guideline for the minimum space that would be required at the launching and receiving shaft sites. This minimum space would provide enough area for a two to three-day supply of casing segments.

The minimum workspace for jack and bore and MG shaft sites would be as follows:

- Launching shaft minimum 105’ x 60’ or 6,300 ft^2 or 0.14 acres
- Reception shaft minimum 65’ x 60’ or 3,800 ft^2 or 0.09 acres

The minimum workspace for traditional tunneling shaft sites would be as follows:

- Launching shaft minimum 180’ x 126’ or 22,680 ft^2 or 0.52 acres
- Reception shaft minimum 108’ x 108’ or 11,664 ft^2 or 0.27 acres

For a more efficient site with a better supply of casing segments on hand, a workspace in the range of 3-5 acres is recommended.

3.3.1.6 Portals and Shafts

All trenchless methods with the exception of HDD would require portals and/or shafts to launch and retrieve the trenchless excavation equipment. In some cases, even HDD would require a launch excavation if the curve radius required is incompatible with the length of the alignment.

The pipeline alignment is relatively shallow, which would minimize the dewatering and water tight excavation methods required. In all cases, the excavation necessary for launch and retrieval would be a temporary excavation. Any permanent structure required for access or venting would have a much smaller footprint.

3.3.1.6.1 Ground Support Methods

The most common types of ground support for portals and shafts of this depth are sheet piles, soldier piles and hardwood lagging or plates, and steel ribs and hardwood lagging or steel liner plate.

Figure 3-9 depicts a typical sheet pile excavation support system.

Figure 3-9 Sheet Pile Excavation Support System, Black & Veatch

Generally, all these methods are not considered water tight although gasketed sheet piles can be installed to minimize seepage between piles. Depending on local ground conditions, dewatering could be accomplished with a sump at the bottom of the portal/shaft and a trash pump or through well point dewatering surrounding the shaft. Figure 3-10 depicts a typical steel rib with steel liner plate and hardwood lagging excavation support system.

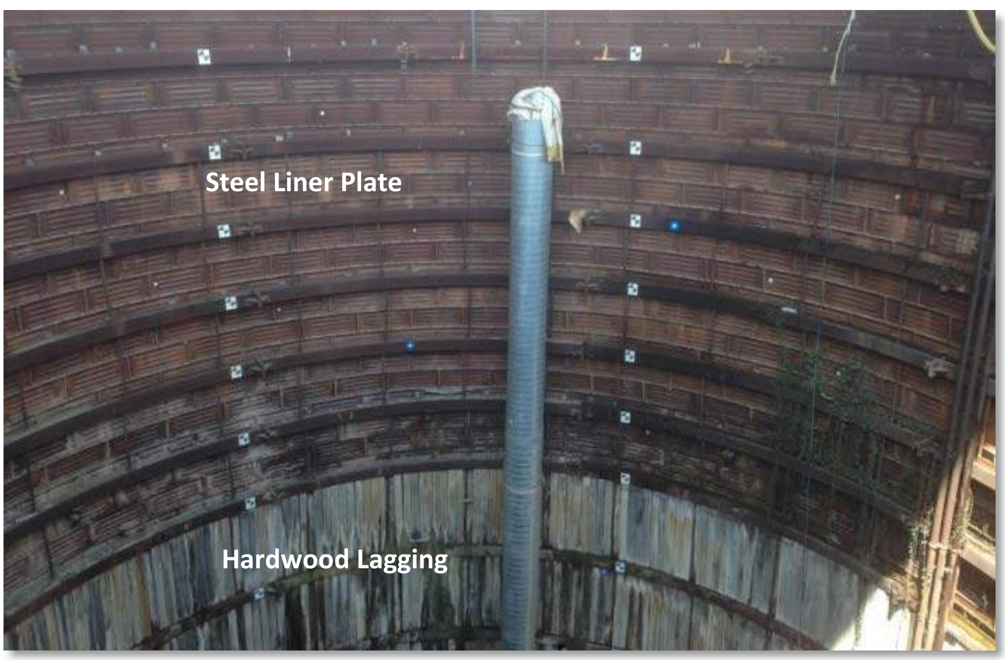


Figure 3-10 Steel Ribs with Steel Liner Plate (Top) and Hardwood Lagging (Bottom), Black & Veatch

Local geotechnical information would help develop the most appropriate support method. However, unless a certain method is required to mitigate risk, the ground support method would generally be left up to the Contractor. The Contractor would submit a work plan prior to proceeding with the activity outlining a proposed approach for the Owner's approval.

When the trenchless crossing would be below the groundwater table, water tight shaft construction methods would be anticipated. Water tight ground stabilization would likely be accomplished with secant piles, as driven sheeting may be problematic due to cobbles and boulders.

More advanced and expensive excavation support systems also would be possible, but unlikely due to the planned depths. Other excavation systems include diaphragm walls and caissons.

Figure 3-11 depicts a typical soldier pile and steel plate excavation support system.

Figure 3-11 Soldier Piles and Steel Plates, Black & Veatch

3.3.1.6.2 Portal/Shaft Sizing

Due to the depth required, rectangular portals would likely be utilized, but circular shafts would be possible for deeper sections. For circular shafts, the launch shaft diameter would generally be two to two and a half times the excavated diameter of the pipe jacking or MT machine. The retrieval shaft would generally be one and half to two times the excavated diameter. The larger diameter necessary for the launch shaft would allow space for the jacking equipment and pipe segments. For example for an 84 inch diameter steel pipe MT drive with 108 inch steel casing, the launch shaft would be between 18 and 23 ft in diameter, and the retrieval shaft would be 14 to 18 ft diameter.

Figure 3-12 depicts a circular pipe jacking shaft site.

Figure 3-12 Pipe Jacking from a Circular Shaft, Pipe Jacking Association

A circular shaft affords plenty of space around the jacking frame and inserted pipe segments, but the extra space is not efficiently utilized. Due to the linear nature of trenchless installations, a rectangular shaft would be more appropriate when possible. Circular shafts are often the only feasible geometry for deep shafts due to the efficient management of ground forces. However, for shallow installations, rectangular shafts/portals would be possible.

For the same example of an 84-inch diameter steel pipe MT drive with 108 inch casing, the rectangular launch portal would need to be at least 16 ft wide. Although a wider portal would provide more work space, a 16 ft width would be possible. Generally, a width of slightly less than two times the excavated diameter would be possible. Portal length should consider the Contractor's means and methods and the site constraints. Technically, a portal length of two to two and half times the excavated diameter would be possible, but a longer portal can improve productivity. A 36 ft long portal would allow the Contractor to place 20 ft lengths of steel pipe minimizing the time for welding between each pipe segment. The receiving shaft for the same MT boring machine would be 25 ft long by 13 ft wide.

Figure 3-13 depicts a rectangular pipe jacking shaft site.

Figure 3-13 Pipe Jacking from a Rectangular Shaft, ConstructionEquipmentGuide.com

3.3.1.6.3 Conventional Tunnel/EPBM Shaft Sizing

Shaft size guidance for conventional tunneling and EPBM tunneling would be consistent with the other trenchless technology discussed with a few exceptions.

Since conventional tunneling and EPBM tunneling could require steel pipe installed within the precast concrete segment lined EPBM tunnel or initially supported conventionally lined tunnel, the excavated diameter would be much larger than the 84-inch diameter steel pipe. The excavated diameter would consist of an outer 8 to 12-inch-thick concrete segment, followed by a 6 to 12-inch annular space filled with low density cellular concrete or structural grout, and finally the steel pipe with cement coating and lining. Therefore, for an 84-inch diameter steel pipe, the excavated diameter would likely be between 118 and 132 inches. The minimum excavated diameter required to build precast segments is generally also between 118 and 132 inches due to tunnel boring machine limitations. Therefore, smaller diameter pipes would be installed in a larger excavated tunnel. Figure 3-14 shows an example of a carrier pipe installed within a larger excavated tunnel. The finished pipe shown is approximately 48 inches; therefore, the smallest TBM available was considerably larger, resulting in additional annular space.

Figure 3-14 Carrier Pipe (Fiberglass) Installed in a Larger Excavated Tunnel, Black & Veatch

The launch and retrieval shaft sizes would need to account for this larger diameter. Due to the larger excavated diameter, the minimum width for a rectangular shaft would probably be at least 20 ft and between 20 and 25 ft for a circular shaft.

Conventional tunneling and EPBM tunneling do not require jacking of pipe so longer shaft lengths would not be required for staging pipe segments. However, conventional tunneling machines and EPBMs are considerably longer than MT and pipe jacking equipment. This equipment could be assembled segmentally in a circular shaft, but a longer rectangular portal would allow this process to proceed much quicker. A portal length exceeding 50 ft would reduce the duration of machine assembly and allow mining to commence sooner.

3.3.2 Cut-and-Cover Construction Methods

A majority of the Preferred Alignment would be expected to be constructed using cut-and-cover construction methods. The Desktop Geotechnical Evaluation indicated that the soil conditions allow the use of temporary shoring or sloped-back trenches for excavation throughout the proposed alignment. Temporary shoring would likely be necessary for most of the alignment as well as portal excavations to minimize impacts to surface features, traffic flow, and adjacent utilities. Where the pipeline would be in areas with adequate space to accommodate temporary sloped excavation methods, the excavation could be sloped back. For the purposes of this FLDR, all excavations were assumed to require temporary shoring with the exception of CM3B, as described in Section 3.4.3.

Temporary shoring such as speed shores, slide rails, trench boxes, cantilever sheet piles, soldier piles with lagging, and internal bracing could be used throughout the alignment combined with adequate dewatering where necessary. An exception is that the use of cantilever sheet piles would likely not be appropriate in areas where outcropping rock or bedrock occurs close to the ground surface as the necessary embedment may be difficult to achieve. Non-interlocking shoring would not be appropriate in areas where shallow groundwater and sandy materials are not adequately dewatered ahead of the excavation as windows between shoring may allow soil and groundwater intrusion into the excavation, potentially destabilizing it. Temporary shoring should be designed and provided based on California Division of Occupational Safety and Health Administration (CalOSHA) requirements and specified soil types.

Most of the proposed Project area appears to have relatively shallow groundwater with depths ranging from 8 ft to 20 ft below ground surface. Groundwater that is less than 20 ft below ground surface would likely require dewatering for pipeline trench construction. In areas where the groundwater level is high, cut-and-cover excavations would be difficult without adequate dewatering. Dewatering would be a viable means for controlling groundwater flow into open excavations along the majority of the alignment. In general, the sandy to cobbley deposits that occur at the northern end of the proposed Project area and the sands on the eastern end would require higher pumping rates with more wells than the finer grained deposits that occur in the south and southwestern areas of the Preferred Alignment.

3.3.3 Pipeline Separation Requirements

The proposed conveyance pipeline would be designed in accordance with the requirements of the State of California Department of Health Services, Section 64572, Title 22 of the California Administrative Code and Metropolitan's design guidelines and standards for the construction of a new pipeline conveying advanced treated recycled water. These requirements lay out the minimum separation requirements for new construction of a pipeline from existing parallel and crossing infrastructure.

Further coordination and review will be required with the California Department of Health Services and other applicable jurisdictions during design to review and approve the design documents. In locations where the basic separation standards cannot be met due to congested utility corridors, approvals will be required for alternative construction criteria from the Department of Health Services and potentially from the County of Riverside. The alternative construction criteria include specific material and design requirements.

Preliminary and final design efforts would include field verification (potholing) of existing utilities to finalize the proposed pipeline alignment and to verify separation clearances.

3.3.4 Major Utility Crossings

The proposed conveyance pipeline would cross many large diameter (major) utilities, including several of Metropolitan's existing Feeders. All major utility crossings would be in accordance with Metropolitan's design standards and follow the guidelines of Metropolitan's Substructures team.

Details would be further evaluated and defined during preliminary and final design.

3.4 DEVELOPMENT OF TYPICAL CONSTRUCTION METHODS

The routes traversed by the proposed advanced treated water pipeline were classified into four general alignment types: roadways, SCE easements, LACFCD easements, and trenchless (tunnels). A typical construction method was developed for each alignment type for the purpose of establishing a conservative budget and determining the approximate impact area for environmental analysis. These methods were intended to cover the materials and work consistently utilized for pipe installation along that alignment type. The four standard construction methods and locations where they are applied are discussed in more detail below.

3.4.1 Construction Method 1 - Roadways

Construction Method 1 (CM1) was the standard method applied in all roadway/street locations. CM1 would utilize shored construction and would be used along local, collector, or arterial roadways where the curb to curb distance is 60 ft or greater. Figure 3-15 shows the typical manner in which CM1 would be applied to construction along roadways utilizing vertical shoring.

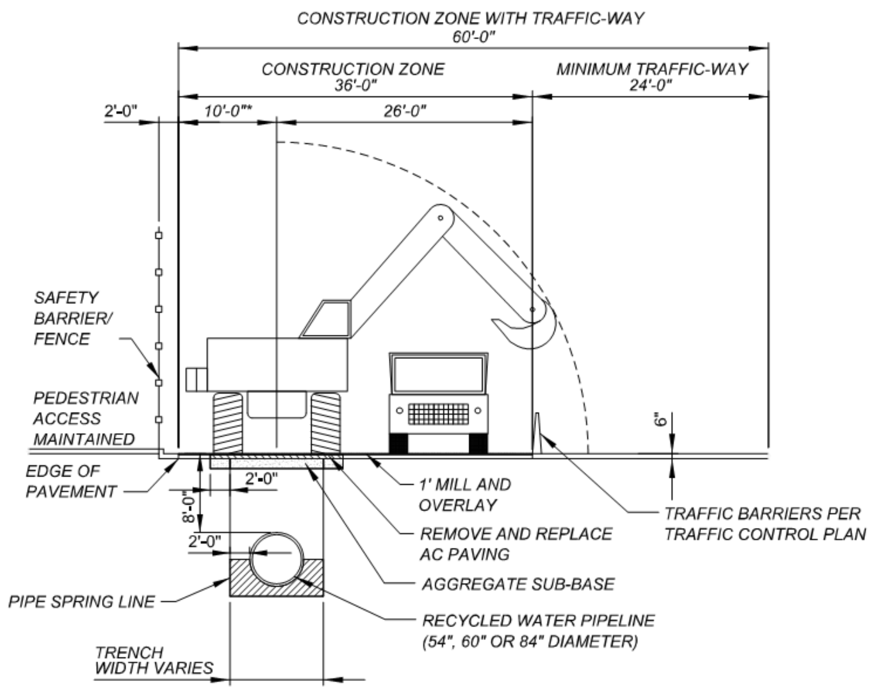


Figure 3-15 Construction Method 1 – Roadways (Shored Construction)

The minimum street width required for a 36 ft wide construction zone and two 12 ft lanes is 60 ft, in order to maintain two-way traffic and leaving the sidewalks free for pedestrian traffic and store-front access. The 36 ft wide construction zone is governed by the clearances required for operation of construction equipment of the type and size envisioned. For this feasibility-level analysis, it was assumed that the construction zone width does not vary as the trench width or pipe diameter / depth varies. Additional curb to curb width beyond 60 ft would not invalidate the configuration shown for CM1 but would permit an even wider construction zone and/or additional traffic lanes beyond the minimum. Instances with less than 60 ft curb to curb width were special cases which would require utilizing either one lane with a flagman or full closure to traffic with a detour.

3.4.2 Construction Method 2 – SCE Easements

Construction Method 2 (CM2) was the standard method applied along all SCE Easements. CM2 would utilize vertically shored excavation and a 36 ft wide construction zone plus additional clearance from transmission towers and energized lines as shown on Figure 3-16. The clearance from the towers would provide a corridor of travel for SCE to use during construction and the clearance from the energized lines (conductors) would be required to comply with the National Electric Safety Code.

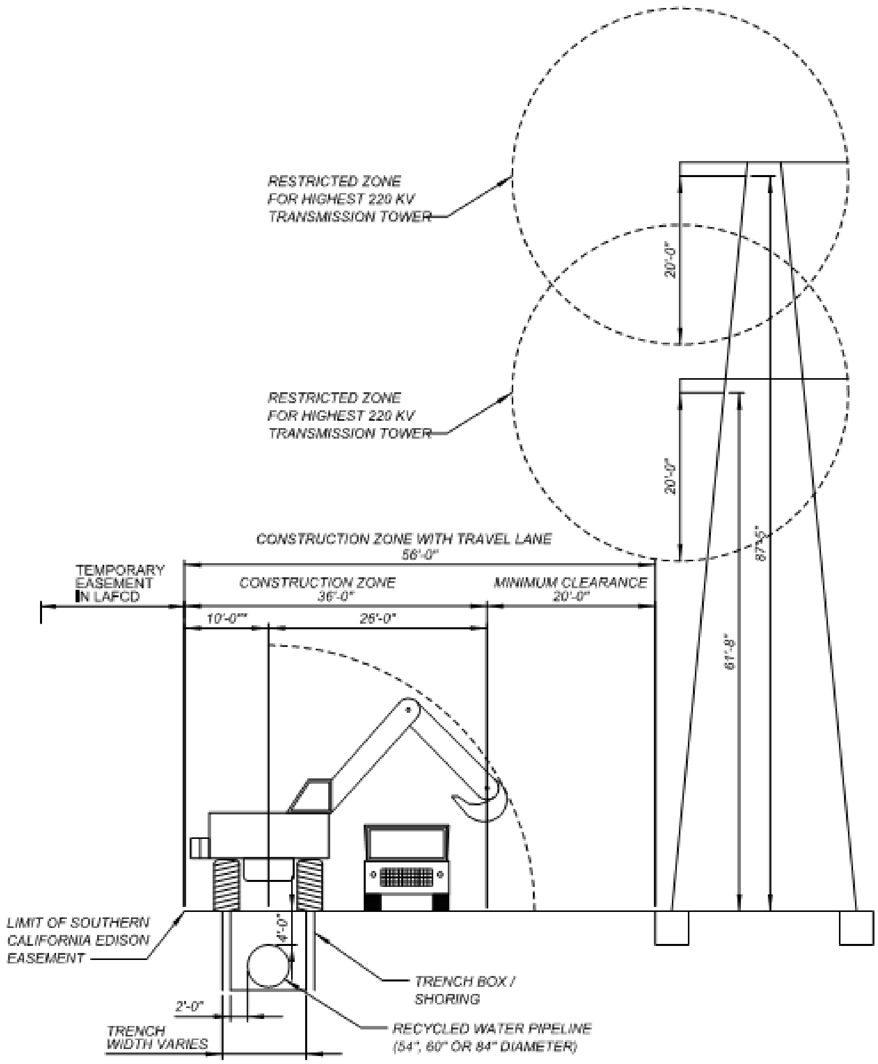


Figure 3-16 Construction Method 2 – SCE Easement (Shored Construction)

The width of the construction zone would not vary based on the diameter of the pipe because the equipment used to build the pipeline would require the 36 ft width regardless of the diameter of the pipe being installed. In certain cases, where the full 36 ft width would not be available within the interior of the SCE easement, the pipeline could still be installed within the SCE easement if a temporary easement were obtained to permit a portion of the construction zone to extend into an adjacent LACFCD corridor. Additional width available for construction activities beyond the 36 ft minimum would allow a wider construction zone and would potentially lower construction costs by increasing the speed of construction.

3.4.3 Construction Method 3 – LACFCD Easements

Construction Method 3 (CM3) would utilize cut-and-cover construction and would be the standard method applied within LACFCD easements. Figure 3-17, Figure 3-18, and Figure 3-19 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 would use shored construction where there is 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 would be for temporary sloped construction where a concrete encased pipe is installed in an earthen river bottom.
- **<u>CM3C – River Channel (Lined)</u>:** This method would be for shored construction where a concrete encased pipe is installed in a concrete lined river bottom.

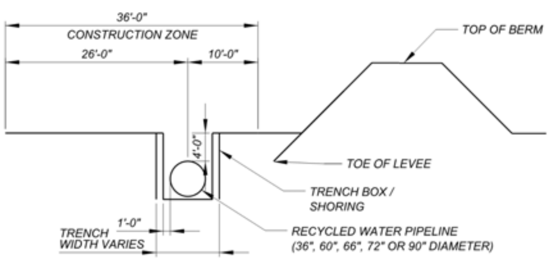


Figure 3-17 Construction Method 3A – River Bank (Shored Construction)

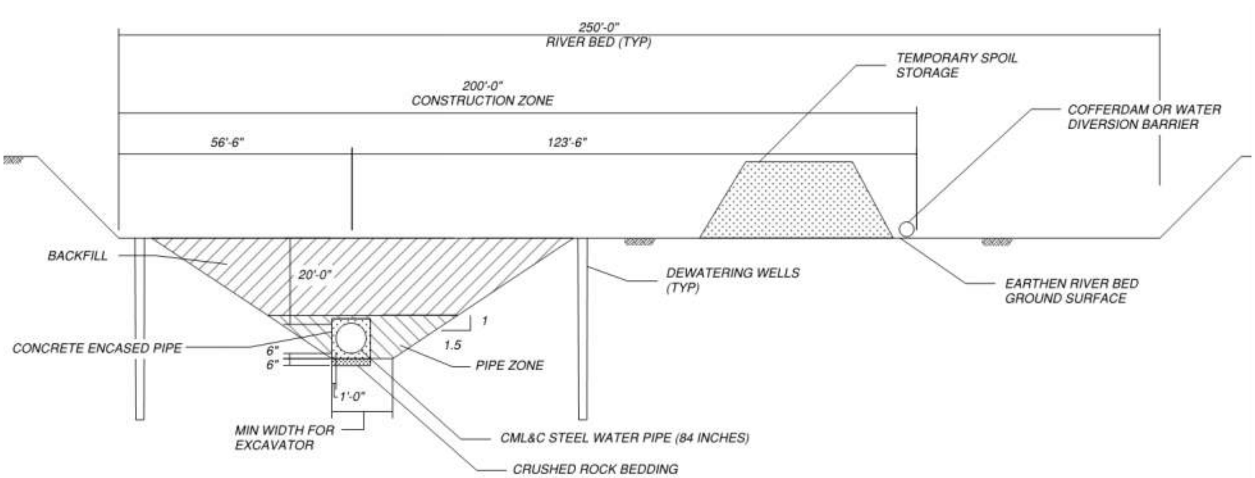


Figure 3-18 Construction Method 3B – River Channel (Unlined) (Temporary Sloped Excavation)

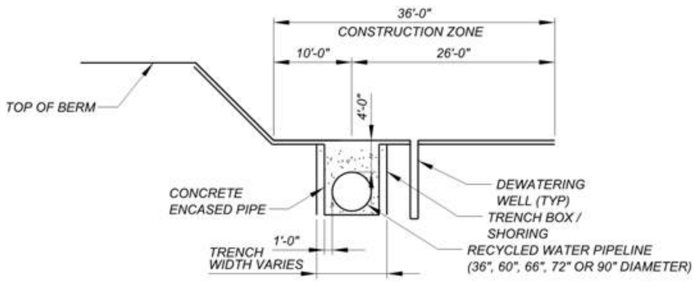


Figure 3-19 Construction Method 3C – River Channel (Lined) (Shored Construction)

As shown on the figures above, 36 ft would provide the minimum required width for pipeline installation and clearances for construction activities for CM3A and CM3C. The FLDR evaluation assumed that CM3A and CM3C would utilize a vertically shored excavation 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 ft width would not be available within the interior of the LACFCD easement, the pipeline could still be installed within the easement if a temporary easement were 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 ft minimum would permit a wider construction zone and could potentially lower construction costs.

CM3B applies if the pipeline were to be installed using temporary sloped excavation methods within an unlined river channel. As shown in Figure 3-18, this FLDR has assumed that 20 ft of cover over the pipeline and a minimum of 1 ft of concrete encasement would be required to protect the pipe from scour and prevent flotation. Pending a more detailed evaluation of scour potential, this is considered to be a reasonable planning-level assumption.

To control against groundwater, it was assumed that dewatering wells would be required at 25 ft on center for the purposes of establishing a conservative budget. Field investigations to estimate the groundwater depths and volumes have not been completed at this time and would be required prior to design. While the dewatering strategy utilized would ultimately be the responsibility of the contractor, it is anticipated that the frequency and depth of dewatering wells required would be refined for future cost estimates once this information is known.

Due to the depth of the excavation, it was assumed that the pipe trench would be laid back at a 1.5 to 1 slope instead of shoring the sides as assumed for the other construction methods. Further investigations into LACFCD's requirements on pipes installed in earthen channels and evaluations on scour and pipe flotation should be completed during subsequent design phases to confirm these planning-level assumptions.

3.4.3.1 Construction Method 4 – Trenchless

Construction Method 4 (CM4) was applied for the sections of RRWP alignment that were identified as requiring trenchless construction methods. In general, these would include crossing of rivers, major drainage channels, freeways, and railroad tracks. The Desktop Geotechnical Evaluation identified four conservative trenchless installation methods as feasible for the Project's crossings, as discussed in Section 3.2.9. After reviewing the segments of the RRWP alignment preliminarily identified for trenchless installation, the FLDR determined that HDD was not applicable for any of the Project's crossings.

The three feasible, conservative trenchless installation methods assumed for the Project's crossings were as follows:

- CM4A – Jack & Bore: This method would use a jacking system to push casing pipe (or carrier pipe) into place. A cutting head would mine the face of the excavation and a conveyor or muck car would remove spoils from inside the casing pipe. Jack & bore was selected for tunnel lengths up to 2,000 ft under appropriate conditions.
- CM4B – Microtunneling: MT also would use a jacking system to push the casing pipe (or carrier pipe) into place, but with a TBM mounted at the head of the pipe string instead of a cutter head. MT was generally selected for tunnel lengths up to 2,000 ft where the tunneling conditions were beyond those readily handled by a jack & bore system. CM4B assumed utilization of an EPBM unless more challenging conditions required the use of a slurry-faced TBM.
- CM4C – Traditional Tunneling: Traditional tunneling would 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 recycled water carrier pipe would be then skidded into the tunnel after completion. Traditional tunneling was generally selected for tunnel lengths of 2,000 ft or greater and assumed an EPBM unless more challenging conditions require use of a slurry-faced TBM.

Figure 3-20 shows the typical set-up schematically for each of the three conservative trenchless construction methods considered.

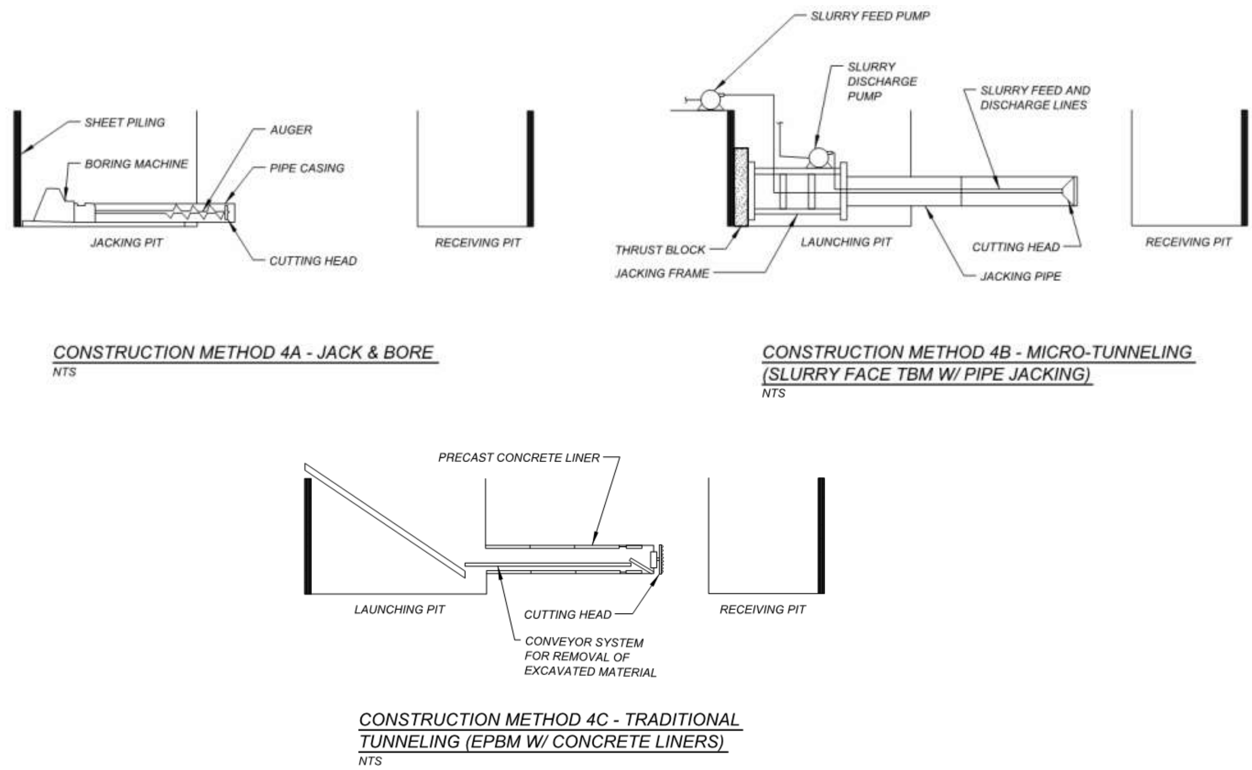


Figure 3-20 Construction Method 4 - Trenchless

4.0 Detailed Alternative Alignment Evaluation

This chapter documents two primary topics. The first is the evaluation process used to compare and assess alignments to achieve a ranking of alternatives. This evaluation process was used to assess all alignment alternatives throughout the Project and is comprised of a decision model that scores the alternatives based on a set of screening criteria and weighting factors.

The second topic documented in this chapter is the initial alignment evaluation that was completed up through the 2018 Draft Report in October 2018. At that time, the Project still envisioned delivering water to both the SFSG and the OC Spreading Grounds. The results of the evaluation, including the identification of the Initial Preferred Alignment which would deliver water to both the SFSG and the OC Spreading Grounds, are presented herein. A brief overview of the analysis documented in this chapter is as follows:

- **Goals of Detailed Alternative Alignment Evaluation.** This section presents the goals of the alignment evaluation, which includes establishing a defensible and objective process that supports upcoming environmental evaluations to comply with CEQA.
- **Decision Model.** A spreadsheet-based decision model was developed to document the alignment evaluation process. The spreadsheet-based decision model utilized the evaluation screening criteria, weighting factors, and scoring methodology established in this section to compare and rank pipeline segments. A listing of all segments and sub-segments and the corresponding raw data collected for each are presented in Appendix D. Detailed descriptions of the screening criteria are provided in Appendix F.
- **Evaluation.** This section documents the results of the alignment evaluation completed for the 2018 Draft Report. Covered in this section are the coarse, secondary, and fine screening steps. Each step evaluated progressively longer combinations of pipeline segments, until, at the fine screening step, full alignment alternatives starting at the AWT plant and ending at the SFSG and the OC Spreading Grounds were compared. Three full alignment alternatives were considered during fine screening: the SG River Alignment, the LA River Alignment, and an "All Streets" Alignment. The results of the screening evaluations are documented in Appendix D.
- **Results and Conclusions.** This section documents the results of the initial alignment evaluation completed for the 2018 Draft Report. The SG River Alignment (Route A) scored most favorably in the initial alignment evaluation, which included the reach to the OC Spreading Grounds, and is known as the "Initial Preferred Alignment".

Chapter 5 presents the subsequent investigations that considered only the Backbone System. Within those subsequent investigations, additional Metropolitan stakeholders provided input to the scoring and weighting methodology described in this chapter. The details of that input are described in Chapter 5 and were applied to the alignment evaluations described in that chapter. That feedback to this evaluation process was ultimately used to arrive at the SG River and LA River Alignments presented later in this FLDR.

Figure 4-1 summarizes the Project methodology as it applies to this chapter including many of the factors listed above.

Phase	Phase 1 Metropolitan's Initial Evaluation	Phase 2 Alignment Verification / Initial Screening	Phase 3 Detailed Alternative Alignment Evaluation	Phase 4 Final Refinements	Phase 5 Feasibility-Level Pipeline and Pump Station Design
Tasks	• Identification of potential pipeline alignments • Identification of Initial Base Case	• Data collection • Review of Metropolitan studies • Desktop analysis • Alternate alignment development • Field investigations • Initial screening • Desktop Geotechnical Report • Traffic Analysis and Impact Report • Constructability evaluations	**• Development of decision model • Evaluation criteria • Weighting of evaluation criteria • Coarse screening • Secondary screening • Final screening • Ranking of alternatives**	• Incorporation of stakeholder input • Conduct supplemental evaluations	• Steel size and wall thickness • Feasibility-level pipeline plan drawings • Hydraulic analysis and profile • Special construction zones and cross-sections • Pump station siting and feasibility-level site and building layout • Cost development • Quantity take-off • Preliminary construction duration
Workshops		• Initial screening workshops	**• Detailed evaluation workshops**	• Workshops with Stakeholders • Workshops with Metropolitan's Environmental Team	• Pipeline focus meetings/ workshops • Pump station focus meetings/ workshops • Unit cost development workshops
Outcomes	• Initial Base Case alignment • Report entitled, "Potential RRWP – Conveyance System Feasibility Assessment"	• Revised Base Case alignment	**• Initial Preferred Alignment**	• Final Preferred Alignment	• Feasibility-level pipeline and pump station design • Engineer's cost opinion and Project schedule
Chapters	• Chapter 1	• Chapter 2 • Chapter 3	**• Chapter 4**	• Chapter 5	• Chapter 6 • Chapter 7 • Chapter 8 • Chapter 9

Figure 4-1 Chapter 4 Methodology

4.1 GOALS OF DETAILED ALTERNATIVE ALIGNMENT EVALUATION

The goals of the analyses were to:

- Establish a defensible evaluation process that objectively determines a preferred conveyance system.
- Providing full consideration of alignment alternatives such that the FLDR documentation and alignment analyses would support the next stages of CEQA compliance, Project planning, and preliminary final design. Identify and rank viable alternative segments and/or overall alignments so that adjustments could be made should impediments be encountered during subsequent phases of the Project (such as the inability to acquire right-of-way, identification of fatal flaws during more detailed technical analyses, objections from regulatory agencies during permitting, etc.).
- Provide support to upcoming environmental evaluations through identification of viable segments and/or overall alignment alternatives, including a documented rationale for how the recommended alignment was selected.

As discussed previously, this process was used not only to identify the Initial Preferred Alignment in 2018 but also to evaluate the Backbone System during the later stages of the Project, as discussed in Chapter 5.

4.2 DECISION MODEL

To achieve a ranking of viable alternatives and identify a preferred alignment, a spreadsheet-based decision model was developed. The decision model was linked to the ArcGIS database to use the data compiled from record information, desktop analyses, and field observations to compare the quantitative and qualitative characteristics of individual pipe segments or combinations of pipe segments.

In the decision model, evaluation criteria, established to assess and compare the relative feasibility of each pipe segment, was scored based upon its ability to satisfy the Project objectives. A weighting factor, reflecting Metropolitan's priorities for the RRWP, was then assigned to the evaluation criteria to assess the relative contribution of each on the ranking and selection of a preferred alignment.

In certain cases, to provide sufficient resolution to make distinctions about the features and attributes of each segment (i.e., varying construction methods required for installation) within the decision model, the pipeline segments described in Chapter 2.0 were divided into new sub-segments. This was also necessary to facilitate the evaluation of alignment combinations that intersected at segment midpoints. As a result, nearly 200 separate sub-segments were included in the decision model. A listing of all segments and sub-segments and the corresponding raw data collected for each are presented in Appendix D.

The sections below describe in detail the components of the decision model, including:

- Scoring
- Evaluation criteria
- Weighting

4.2.1 Scoring

This section describes the rating system developed to compare each pipeline segment and sub-segment. Each combination of alignments or pipe segments was assigned a rating score for each criterion based upon its ability to satisfy the Project objectives using a scale of 1 to 5, as shown in Table 4-1.

Table 4-1 Screening Criteria Rating System

RATING SCORE	DEFINITION
1	Pipe segment or alignment alternative satisfies Project objectives with little to no impacts related to the evaluation criterion. The frequency with which the criterion occurs would generally be less than the average occurrence across all segments. Significant advantages may be noted.
2	Not used.
3	Pipe segment or alignment alternative satisfies the Project objectives, but with an increasing level or degree of impacts related to the evaluation criterion. The frequency with which the criterion occurs would generally fall within a range of average occurrences across all segments.

RATING SCORE	DEFINITION
4	Pipe segment or alignment alternative satisfies the Project objectives, but with a level or degree of impacts between a 3 and 5 score related to the evaluation criterion. (Used only for the ease of operations and accessibility evaluation criterion due to the four different types and/or methods of construction for the pipeline requiring different rating scores).
5	Satisfies Project objectives, but with a higher level or degree of impacts related to the evaluation criterion. The frequency with which the criterion occurs would generally be greater than the average occurrence across all segments. Significant disadvantages may be noted.

In this rating system, lower scores were favorable and higher scores were unfavorable. A low rating score (i.e., a score at or near to 1) signaled the segment, or combination of segments, compared favorably to the evaluation criteria, indicating that impacts related to the evaluation criterion either do not exist or would occur at a rate that is generally less than the average occurrence across all alternatives. Conversely, a rating score of 5 indicated the alignment alternative would not compare favorably to the evaluation criteria and the impacts related to the criterion would occur at a rate that is generally higher than average. The rating scores as applied to each of the evaluation factors are described in Section 4.2.2.

It should be noted that the evaluation was originally developed utilizing three rating scores (1, 3, and 5). However, as evaluation screening criteria were developed (as described in Section 4.2.2) it became warranted to add a fourth rating score to differentiate between alternatives. For this reason, the rating score of 4 was added strictly for the ease of operations and accessibility evaluation criterion. For all other evaluation screening criteria, the three rating scores original developed were all that were used.

4.2.2 Evaluation Criteria

This section describes the evaluation criteria used to assess and compare the various alignment and segment alternatives. The evaluation criteria were organized into three major categories: factors that would add construction risk, factors that would result in social and community impacts, and factors that would have biological impacts. The screening criteria were generally consistent with the Project description information required for preparation of CEQA review. The individual evaluation factors within each category are described in detail in Subsections 4.2.2.1 through 4.2.2.3.

4.2.2.1 Construction Risk

The construction risk category comprised factors that increase the inherent risk associated with below grade pipeline construction in urban areas. Each of the seven evaluation factors included in this category were considered to potentially affect the success of the Project by impacting the Project budget, the rate of construction progress, or the safety of working conditions. Details of the scoring for each construction risk category are presented in Table 4-2 with descriptions provided in Appendix F.

Table 4-2 Evaluation Criteria: Construction Risk

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Major Utility Crossings	Number of major utility crossings, including: • Storm Drains >30 in. • Sewer Lines/Force Mains > 24 in. • Water Transmission Mains >24 in. • Oil/Gas Pipelines >18 in.	<1 crossing per 1000 ft of trench construction	Between 1 and 2 crossings per 1,000 ft of trench construction	>2 crossings per 1,000 ft of trench construction
Trenchless Construction	Percent of pipe length that would be constructed using trenchless construction methods, such as crossing freeways, railroads, river channels, major intersections, and environmental areas	<5% of pipe length requires trenchless crossings	Between 5% and 15% of pipe length requires trenchless crossings	>15% of pipe length requires trenchless crossings
High Groundwater Conditions	Percent of pipe length that would be constructed in areas with high groundwater conditions and permeable/sandy type soils	<10% of pipe length encounters a groundwater depth <10 ft.	Between 10% and 30% of pipe length encounters a groundwater depth <10 ft	≥30% of pipe length encounters a groundwater depth <10 ft
Alignment Length[(1)]	Proposed pipe length compared to the shortest alignment	Shortest proposed alignment; or within 10% of the shortest alignment	Between 10 and 20% of the shortest alignment	Greater than 20% of the shortest alignment
Seismic Hazard	Presence of known active seismic fault crossing proposed pipe	Pipe segment does not cross a known active fault	---	Pipe segment crosses a known active fault
Soil Contamination	Number of reported contaminated soil sites within 75 ft of proposed pipe	<0.15 "hits" per 1000 ft	Between 0.15 and 0.40 "hits" per 1000 ft	>0.40 "hits" per 1000 ft

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE			
		(1)	(3)	(4)	(5)
Ease of Operations and Accessibility[(2)]	Weighted score based upon land use of the proposed segment	Utility easement	Roadway	Tunnel	River bed

Notes:
1. Additional details on the scoring of Alignment Length are provided in Appendix F.
2. Additional details on the weighted scoring of Ease of Operations and Accessibility are provided in Appendix F.

4.2.2.2 Social and Community Impacts

The evaluation factors included in the social and community impact category were used to identify and assess at a feasibility-level the potential impacts construction would have on residences and businesses located along or near to construction activities, at construction staging areas, and along designated haul routes. The Project would generate both temporary and permanent impacts on traffic circulation, the use of parks and recreation areas, and access to public facilities. Selecting pipeline routes minimizing social and community impacts would result in fewer controls and restrictions being imposed on construction activities by jurisdictional and regulatory agencies. The selection of pipeline routes minimizing these social and community impacts were also anticipated to yield less community, municipality, or regulatory body resistance, reducing the risk of delay.

Details of the scoring for each social and community impact category are presented in Table 4-3 descriptions provided in Appendix F.

Table 4-3 Evaluation Criteria: Social and Community Impacts

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Parks and Recreation Areas[1]	Would have a direct impact from construction activities within parks and recreation areas with differentiation between parks inside SCE easements	Not constructed in a park	Constructed in a park and SCE easement	Constructed in a park, no SCE easement
Public Facilities	Number of high use public facilities that would be encountered along the pipe segment, including hospitals, schools, airports, civic centers, cemeteries, and regional shopping centers	<0.35 public facilities per mile of pipe length	Between 0.35 and 0.45 public facilities per mile of pipe length	>0.45 public facilities per mile of pipe length
Traffic Impacts[2]	Length of pipe that would impact the traveled roadway during construction activities as well as the volume of traffic impacted	Not constructed in traveled roadways	Constructed in a roadway designated as a collector or local street	Constructed in a roadway designated as a minor arterial street or requiring a road closure
Street and Median Improvements	Would have a direct impact from construction activities on improved/landscaped center medians (parallel construction)	<20% of segment length	Between 20% and 30% of pipe length	≥30% of pipe length
Major Intersections	Number of major intersections that would be crossed using cut-and-cover construction (based on the Traffic Impact Analysis)	<1 major intersections per mile of pipe	Between 1 and 2 major intersections per mile of pipe	>2 major intersections per mile of pipe

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Residential and Minor Commercial	Length of pipe alignment that would impact access, traffic, and safety of residential and minor commercial areas during construction activities	<10% of segment length	Between 10% and 60% of pipe length	>60% of pipe length

Notes:
1. Additional details on the weighted scoring of Parks and Recreation Areas are provided in Appendix F.
2. Additional details on the weighted scoring of Traffic Impacts are provided in Appendix F.

4.2.2.3 Biological Impacts

Details of the scoring for each biological impact category are presented in Table 4-4 with descriptions provided in Appendix F.

Table 4-4 Evaluation Criteria: Biological Impacts

EVALUATION FACTOR	EVALUATION CRITERIA	SCORING RANGE		
		(1)	(3)	(5)
Waters of the US or State	Length of pipe alignment that would cross through Waters of the US or State	<2.5% of pipeline length	Between 2.5% and 5% of pipeline length	>5% of pipeline length
CNDDB Habitats	Pipe alignment would cross through areas of known CNDDB habitats	Pipe segment does not cross a known CNDDB habitat	---	Pipe segment crosses a known CNDDB habitat

4.2.3 Weighting of Evaluation Criteria

Weighting factors reflecting Metropolitan's priorities for the RRWP were assigned to the evaluation factors to assess the relative contribution of each criterion on the ranking and selection of preferred alternative alignments. Weighting factors were also assigned to the three evaluation categories to test the relative importance of each category and its sensitivity to adjustments of the weighting.

Workshops were held with representatives from across Metropolitan's organization to discuss the criteria and weighting to assure they reflect Metropolitan's concerns and priorities for the Project. Two weighting scenarios were developed during these workshops, presented in Table 4-5 below. Weight A placed an increased emphasis on evaluation factors related to the assessment of construction risk. Weight B emphasized evaluation factors for social and community and biological impacts.

As noted in the introduction to this chapter, stakeholder input provided after the completion of the October 2018 Draft Report resulted in a variety of different weighting scenarios which were used during evaluation and refinement of the alignment alternatives presented later in this FLDR. See Chapter 5 for details about that input.

Table 4-5 Evaluation Criteria: Weighting Factors Matrix

	WEIGHT A: EMPHASIS ON CONSTRUCTION RISK FACTORS	WEIGHT B: EMPHASIS ON COMMUNITY AND ENVIRONMENTAL FACTORS
Construction Risk	**Category Weight: 60%**	**Category Weight: 30%**
Major Utility Crossings	20%	20%
Trenchless Construction	20%	20%
High Groundwater Conditions	5%	5%
Alignment Length	25%	25%
Seismic Hazard	5%	5%
Soil Contamination	5%	5%
Ease of Operation and Accessibility	20%	20%
Subtotal	**100%**	**100%**
Social and Community	**Category Weight: 30%**	**Category Weight: 55%**
Parks and Recreation Areas	5%	5%
Public Facilities	20%	20%
Traffic Impacts	20%	20%
Street and Median Improvements	20%	20%
Major Intersections	15%	15%
Residential and Minor Commercial	20%	20%
Subtotal	**100%**	**100%**
Biological	**Category Weight: 10%**	**Category Weight: 15%**
Waters of the US and State	20%	20%
CNDDB Habitats	80%	80%
Subtotal	**100%**	**100%**

4.3 EVALUATION

This section documents the initial alignment evaluation that was completed prior to October 2018 and includes the reach to the OC Spreading Grounds.

Due to the large number of segments and sub-segments, an almost endless number of alignment iterations were possible. To make this evaluation more manageable, the following methodology was employed:

- A coarse screening focusing on relatively short, individual segments where two or more pipeline route options were available was performed to reduce the total number of alignment combinations.
- A secondary screening comparing longer combinations of segments was completed, further reducing the number of possible alignments.
- Fine screening built upon the results from the coarse and secondary screening and focused on developing and evaluating segment combinations for three basic conveyance alignments as options for the RRWP conveyance system, hereafter referred to as follows:
    - San Gabriel River Alignment – Route A
    - All Street Alignment – Route B
    - Los Angeles River Alignment – Route C

Workshops were held with Metropolitan staff during the evaluation to review the procedure, develop the evaluation criteria and weighting, and verify the results accurately represented Metropolitan's goals for the Project.

The Initial Preferred Alignment was the best scoring alignment from Routes A, B, and C and included the reach to the OC Spreading Grounds.

The focus of the evaluation process that was established was to be able identify a "preferred" alignment for the overall conveyance system that would serve as the basis for future technical/pre-design, right-of-way acquisition, and environmental, regulatory, and municipal permitting. The evaluation process was set up such that, as new information emerged during subsequent efforts, the analysis tools provided herein could be readily revisited to help identify alternatives to accommodate new or unforeseen issues with the recommended alignment. When the Project evolved as described in Chapter 5.0, these same processes, using the weighting scenarios provided by Metropolitan stakeholders, were applied to recommend a revised conveyance system. The revised weighting factors were applied to the analysis described in this chapter. and the results were unchanged.

4.3.1 Coarse Screening

The coarse screening process evaluated relatively short segments, or combination of segments, where two or more pipeline route options were available to determine the preferred route. A "path" refers to these individual evaluations of two or more pipeline routes with common starting and finishing locations, consisting of one or more combinations of segments and sub-segments. In many cases, "paths" compare routes along parallel and adjoining streets to address potential community impacts or to avoid high risk crossing areas. These paths, numbered numerically (i.e., Path 1, 2, etc.), were then evaluated to determine which segment or combination of segments met the Project's goals.

The data for each path, consistent with the evaluation criteria, was entered into the decision model spreadsheet. The coarse screening paths are presented on Figure 4-2.

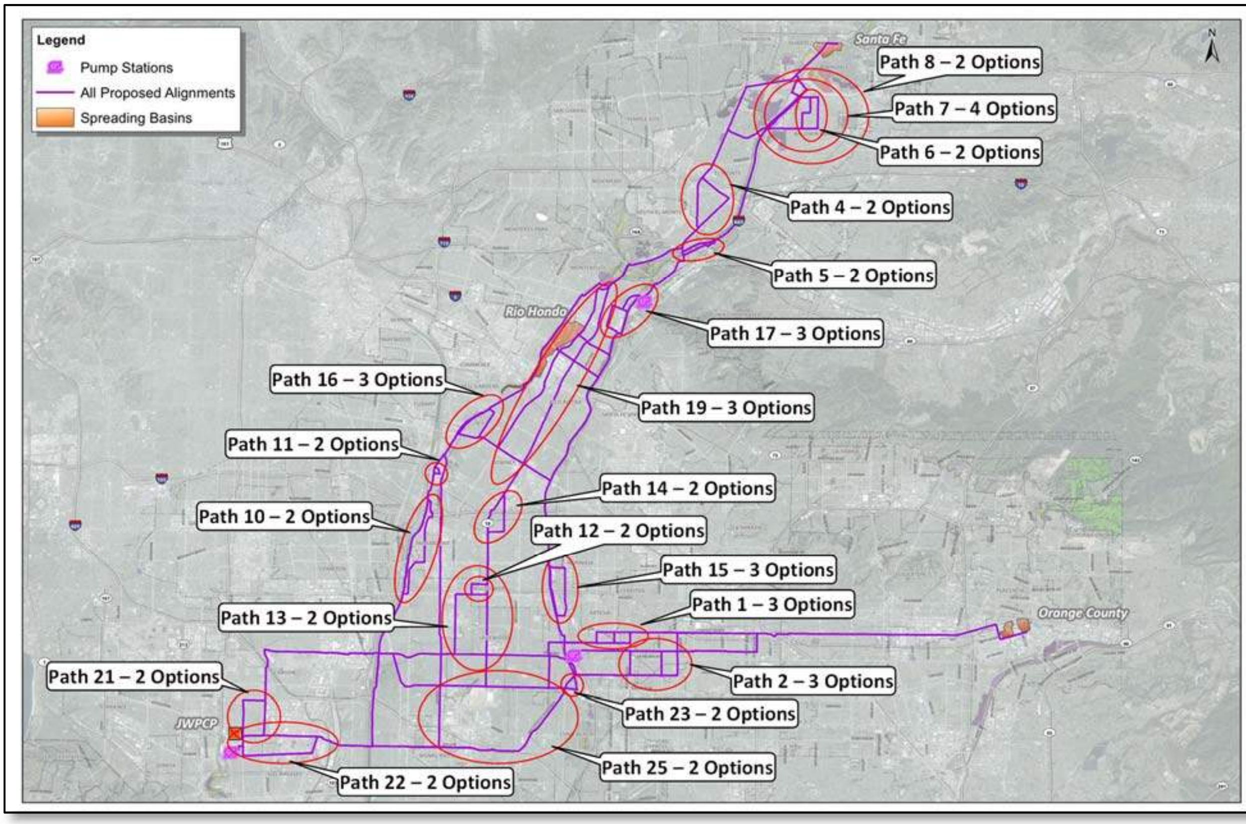


Figure 4-2 Paths Evaluated During the Coarse Screening

As described previously, outcomes from the decision model were dependent upon the evaluation criteria rating scores and category weights. To provide a more intuitive final scoring system, each total weighted score was summed for each path and then converted to a percentage (out of 100) so that the highest final score out of 100 percent was considered the preferred path for each comparison. Path scores are only applicable to the other options considered in the comparison. For instance, scores for Path 1 are only comparable to the three alignment options included in this comparison and not directly comparable to the scores for Path 2 or others.

Decision model results for the coarse screening are provided in Appendix E. The bolder black lines shown on Figure 4-3 depict the favored route for each path of the coarse screening. By performing a coarse screening, many less advantageous, localized alignments were eliminated, thereby removing these segments from further consideration. The results from the coarse screening were subsequently used to develop the longer paths and routes used for secondary screening.

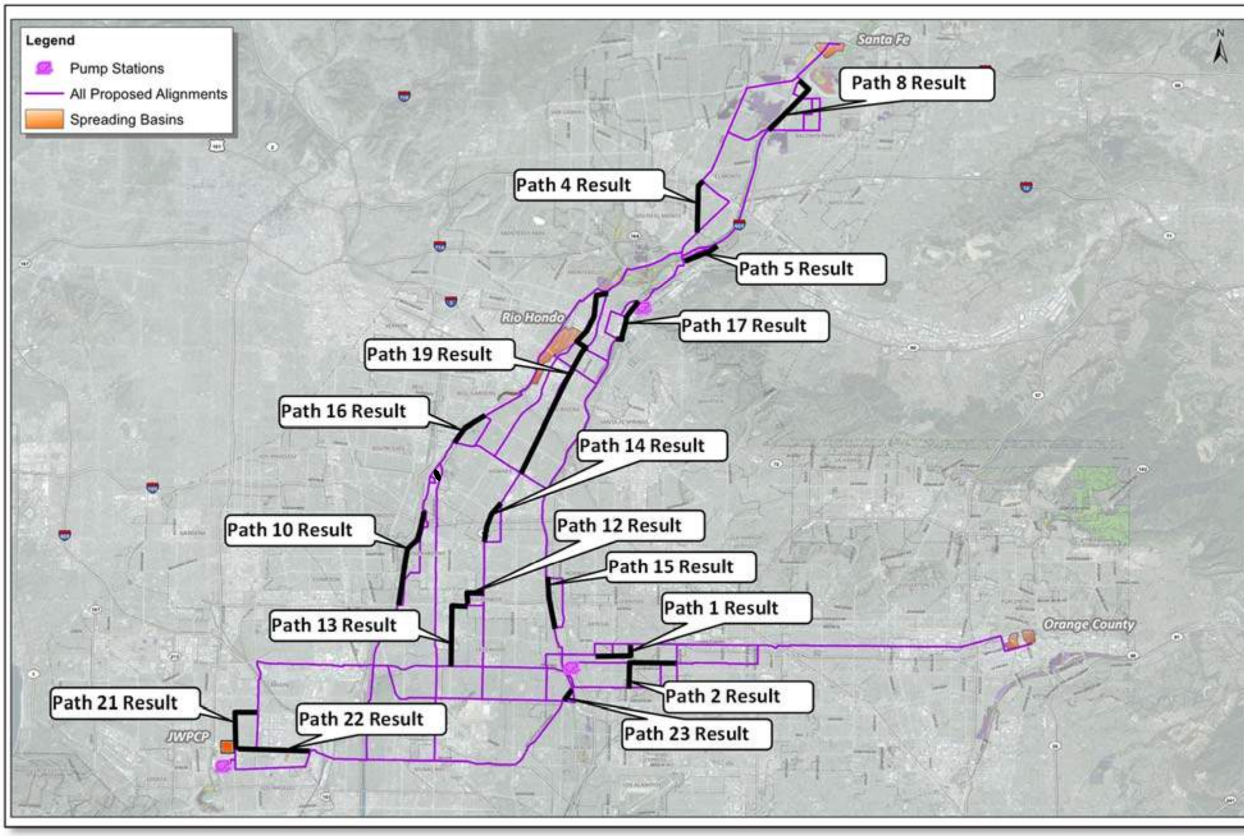


Figure 4-3 Coarse Screening Results for Weighting A

4.3.2 Secondary Screening

Secondary screening entailed developing longer segment combinations beginning at the AWT plant and ending at each of the system delivery points.

Secondary screening was divided into three areas with the goal of determining the favored alignment through each. The areas generally align with Reaches 2 thru 4 identified in Chapter 1.0 and are as follows:

- From the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River to the OC Spreading Grounds
- From the junction of the OC and Rio Hondo pipelines adjacent to San Gabriel River to PS-3/Rio Hondo Spreading Grounds
- From PS-3/Rio Hondo Spreading Grounds to the Santa Fe Spreading Grounds

Secondary screening resulted in longer alignments that were pieced together to build the “Ultimate Routes” evaluated in the fine screening.

See Appendix F for detailed discussion on the secondary screening process and key maps with paths identified.

4.3.3 Fine Screening

The three basic conveyance alignments evaluated in the fine screening are described in this section. These three "Routes" were assessed to determine the Initial Preferred Alignment for the conveyance system. Additional details on the fine screening process, including decision model results and schematics to help illustrate how the paths from the coarse and secondary screening combine to form longer alignments, is provided in Appendix F.

4.3.3.1 Route A – San Gabriel River

Route A would travel from the AWT plant to the San Gabriel River by following Sepulveda Boulevard and Willow Street to the Los Angeles River. From the Los Angeles River, the alignment would travel north and tunnel to Carson Street. The alignment would then head east on Carson Street to the Los Coyotes Diagonal before traveling along the San Gabriel River in easements to PS-2.

Continuing from PS-2, Route A would break into two branches: one branch would continue out to the OC Spreading Grounds and the other would travel north to the Santa Fe Spreading Grounds. The latter would generally follow the San Gabriel River. Also, from PS-2 Route A would head east in the SCE easement until jogging north to Orangethorpe Avenue. This would be the shortest route. Route A can be seen on Figure 4-4 in the bolder black linework.

4.3.3.2 Route B – Street Alternative

In the event that easements from SCE and/or LACFCD prove to be unavailable, Route B represents a system that would be located entirely within existing public rights-of-way to provide an optional corridor.

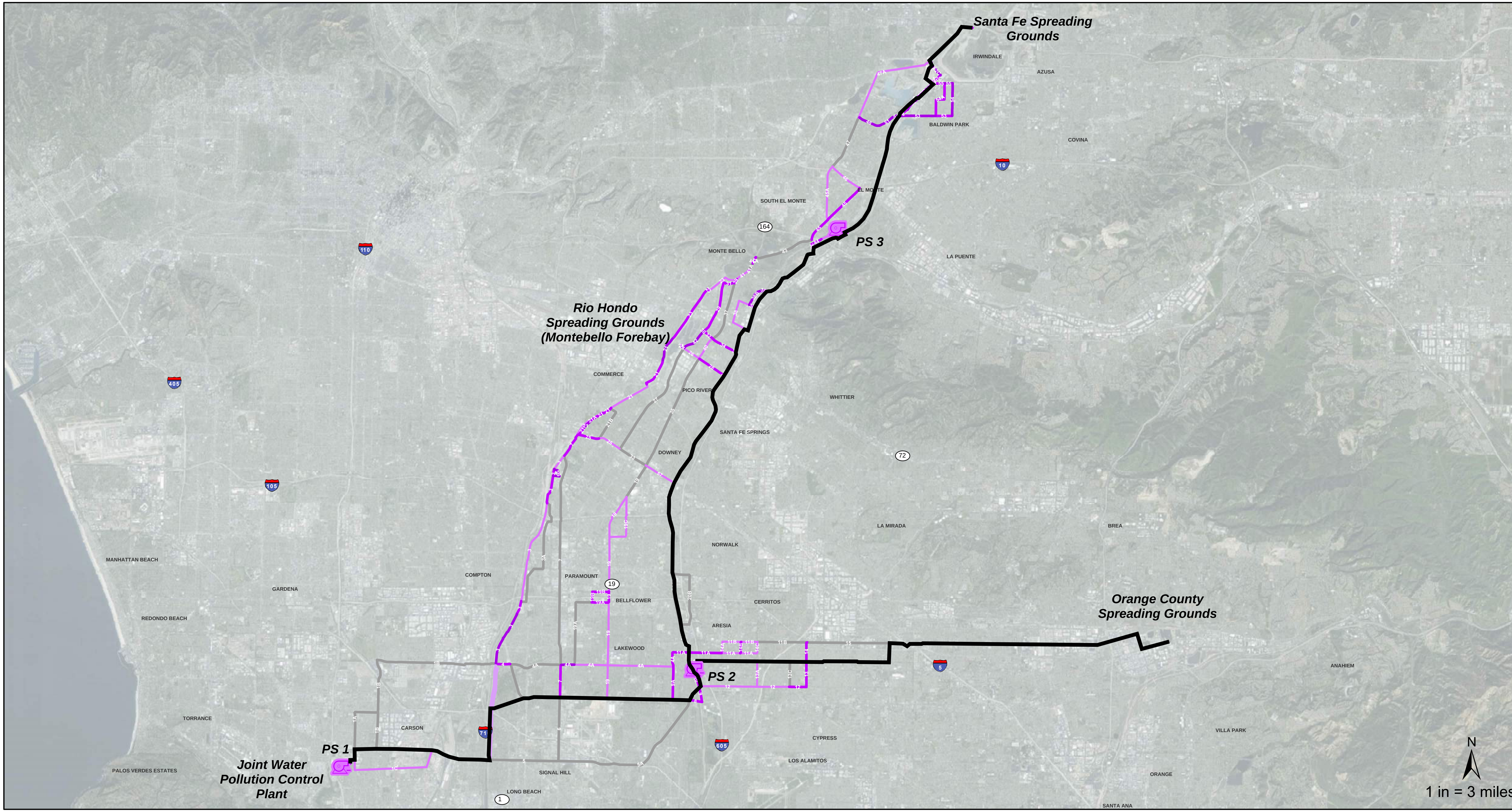
Route B would exit the AWT plant and travel north to Del Amo, then east to Paramount Boulevard before traveling north using a combination of Paramount and Lakewood Boulevards. This alignment would continue following streets from there to the Santa Fe Spreading Grounds.

To reach the OC Spreading Grounds, the alignment would travel east on Del Amo Boulevard until the San Gabriel River and would then turn south to Centralia Street and Crescent Avenue, then east before jogging north to Orangethorpe Avenue. The circuitous routing would avoid creating an expensive additional freeway crossing, would avoid Knotts Berry Farm area, and scores well in other aspects. Route B can be seen on Figure 4-5 in the bolder black linework.

4.3.3.3 Route C – Los Angeles River

Route C would require traveling from the AWT plant to the east side of the Los Angeles River and then traverse north using the best combination of streets and/or Los Angeles River easements. Similar to Route A, the alignment would follow Sepulveda/Willow Street east to the Los Angeles River, then turn north along the Los Angeles River easements. At the intersection of Durfee Avenue and Peck Avenue, the alignment would switch to follow the San Gabriel River in easements.

Again, similar to Route A, Route C would tunnel to Carson Street from the Los Angeles River, then head east to the Los Coyotes Diagonal and along the San Gabriel River in easements to PS-2, then easterly in the SCE easement until jogging north to Orangethorpe Avenue. Route C can be seen on Figure 4-6 in the bolder black linework.



Pump Stations

Figure 4-4: Route A - San Gabriel River Weighting A

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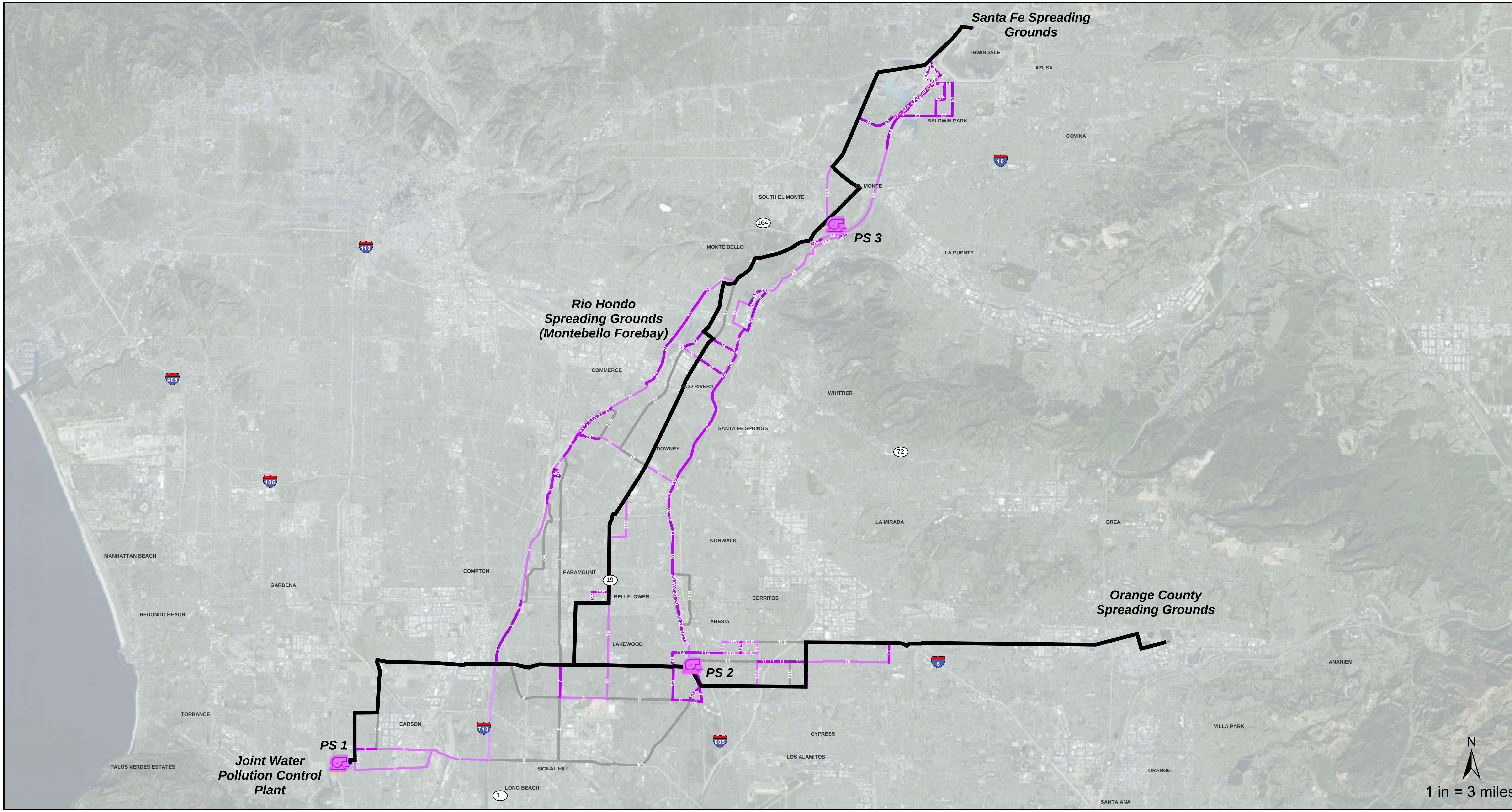

Pump Stations

Figure 4-5: Route B - Street Alternative Weighting A

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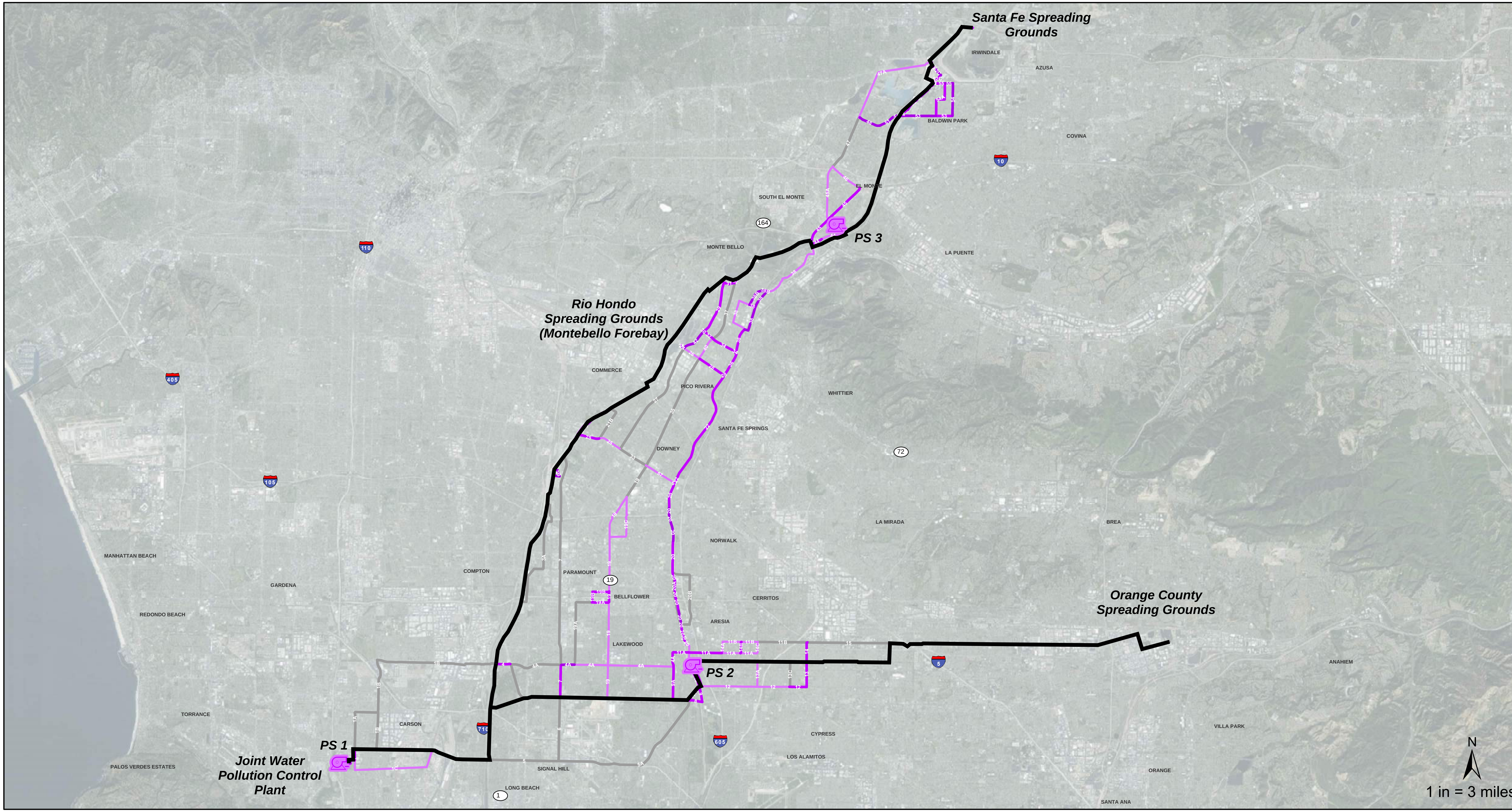

Figure 4-6: Route C - LA River Weighting A

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4.4 RESULTS AND CONCLUSIONS

4.4.1 Results

The overall results of the detailed evaluation are summarized as follows:

- **Route A** was considered the most favorable alignment because it would have:
  - The fewest major utility crossings
  - The lowest contaminated soils risk
  - The fewest public facility crossings
  - The fewest major intersection crossings
  - The shortest total alignment length
  - The fewest residential and minor commercial impacts
  - High risk of groundwater impacts
  - Most impact on waters of the US and state
- **Route C** was rated as the second most favorable alignment because it would have:
  - The most favorable ease of operations and accessibility
  - The fewest traffic impacts
  - The fewest center median impacts
  - The highest risk of groundwater impacts
  - The longest total alignment length
- **Route B** was rated as the third most favorable alignment because it would have:
  - The shortest trenchless construction length and the least impacts to parks
  - The most public facility crossings
  - The most length in streets and traffic impacts
  - The most impact to center medians
  - The most major intersection crossings
  - The most contaminated soils risk

A detailed summary of the fine screening criteria and results is presented in Table 4-7.

4.4.2 Initial Preferred Alignment

Route A scored most favorably in the initial alignment evaluation, which included the reach to the OC Spreading Grounds, and is hereafter known as the "Initial Preferred Alignment". Table 4-6 lists the segments comprising the Initial Preferred Alignment, organized based on the four reaches described in Chapter 1.0.

Table 4-6 Initial Preferred Alignment Segments by Reach

REACH	SEGMENTS
1	1, 2, 2A, 4, 8, 10A
2	11, 16, 17, 18
3	20, 22, 36, 38, 38A
4	44, 44A, 52A, 52, 56, 58, 59

Figure 4-7 presents the Initial Preferred Alignment.

As noted previously, the revised weighting factors provided by Metropolitan's internal stakeholder described in Chapter 5 were applied to the analysis described in this chapter. It was found that the new weighting factors did not affect the conclusion of the analysis.

It should be noted that some of the screening criteria were compared utilizing percentages. For example, trenchless construction was compared based upon a percentage of the alignment that was anticipated to require trenchless construction. Detailed descriptions of each screening criteria, including scoring methods, are provided in Appendix F.

Table 4-7 Summary of Overall Route Results

	MAJOR UTILITIES (EA)	TRENCHLESS CONSTRUCTION (FT)	DEPTH TO WATER (FT)	SEISMIC HAZARD (Y/N)	CONTAMINATED SOILS RISK (# HITS)	EASE OF OPERATION SUB-SCORE (WEIGHTED)	PARKS (WEIGHTED)	NON- SCE PARKS & REC AREAS (FT)	SCE PARKS & REC AREAS (FT)	PUBLIC FACILITIES (EA)	LENGTH IN STREETS (FT)	ROAD CATEGORY & TRAFFIC IMPACT (WEIGHTED)	CENTER MEDIANS (FT)	MAJOR INTERSECTIONS (EA)	RESIDENTIAL/ MINOR COMMERCIAL (FT)	TOTAL ALIGNMENT LENGTH (FT)	WATERS OF THE US AND STATE (FT)	PIPE LENGTH (FT)	TOTALS
Route A																			
Raw Count	258	29,879	102,238	Y	34.00	2.56		395	18,921	17	124,384	2.09	42,080	22	57,174	283,929	39,083	283,929	
Evaluation Criteria	0.91	10.5%	36%	Y	0.12	2.56	1.14			0.32		2.09	14.8%	0.41	20%	0%	14%		
Rating Factor	1	3	5	5	1	2.56	1.14			1		2.09	1	1	3	1	5		35
Weighted Score	12.00	36.00	15.00	15.00	3.00	30.71	1.71			6.00		12.56	6.00	4.50	18.00	15.00	10.00		193.47
																		Route A - Total “Comparable” Score	**61.31%**
Route B (Road Route)																			
Raw Count	260	23,743	72,059	N	82.00	3.01		-	-	33	262,433	3.60	127,357	74.5	113,489	296,695	6,192	296,695	
Evaluation Criteria	0.88	8.0%	24%	N	0.28	3.01	1.00			0.59		3.60	42.9%	1.33	38%	4%	2%		
Rating Factor	1	3	3	1	3	3.01	1.00			5		3.60	3	3	3	1	1		39
Weighted Score	12.00	36.00	9.00	3.00	9.00	36.11	1.50			30.00		21.60	18.00	13.50	18.00	15.00	2.00		232.71
																		Route B - Total “Comparable” Score	**53.46%**
Route C																			
Raw Count	313	40,711	111,195	Y	42.00	2.26		4,130	19,377	18	122,255	1.97	41,894	29	57,750	300,878	25,648	300,878	
Evaluation Criteria	1.04	13.5%	37%	Y	0.14	2.26	1.18			0.32		1.97	13.9%	0.51	19%	6%	9%		
Rating Factor	3	3	5	5	1	2.26	1.18			1		1.97	1	1	3	1	5		37
Weighted Score	36.00	36.00	15.00	15.00	3.00	27.11	1.78			6.00		11.81	6.00	4.50	18.00	15.00	10.00		213.19
																		Route C - Total “Comparable” Score	**57.36%**

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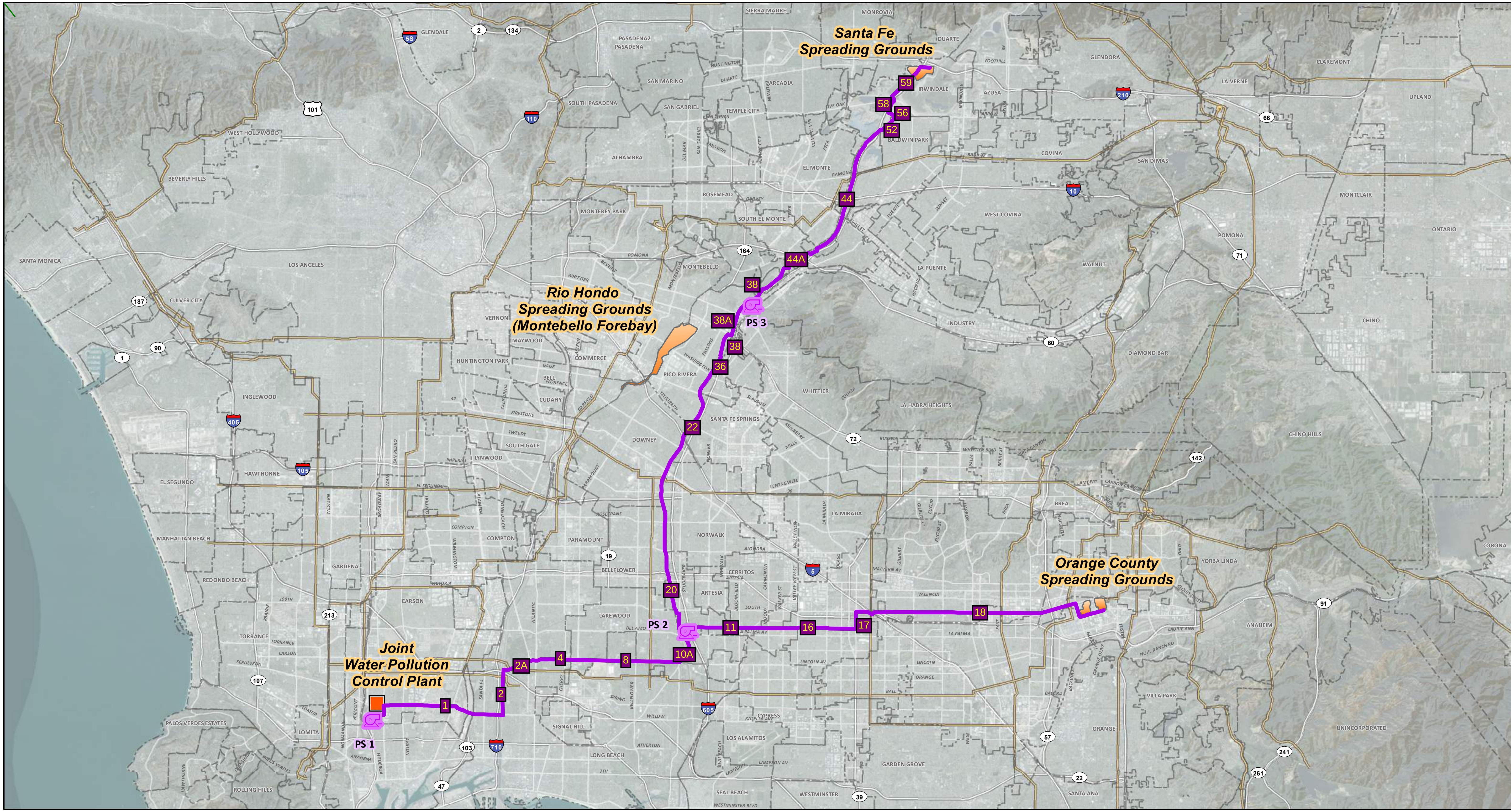

Preferred Alignment

Existing MWD Distribution System

Pump Stations

Spreading Basins

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Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 4-7: Initial Preferred Alignment

N

1 in = 3 miles

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5.0 Final Refinements

This chapter describes the additional technical studies that were completed after the identification of an Initial Preferred Alignment, as documented in Chapter 4.0. These subsequent technical studies were completed to ensure that the alignment would be constructible, financially feasible, and socially and environmentally acceptable. A brief overview of the analysis documented in this chapter is as follows:

- **Refinements Prior to the 2018 Draft Report.** The first part of this chapter describes the refinements occurring prior to the 2018 Draft Report and any refinements to the Initial Preferred Alignment that resulted from those evaluations. Additionally, it documents the analysis of the Signal Hill high point for the SG River Alignment.
- **Refinements Occurring after the 2018 Draft Report.** The second part of this chapter describes the evolution of the Project, and its goals, that occurred after the evaluations that comprised the 2018 Draft Report. Three topics were evaluated:
    - Backbone System Alignment Evaluation. As a result of the Conceptual Planning Studies Report completed by Metropolitan in February 2019 and the RRWP White Paper No. 1 completed by Metropolitan in July 2019, Metropolitan recommended the Backbone System as an implementation strategy that would provide the flexibility to adapt the initial RRWP system for DPR and allow phasing opportunities to accelerate the program. Since the Backbone System forgoes the OC Reach, Metropolitan asked Black & Veatch to re-visit the alignment evaluation to see how removing the OC reach impacts the selection of a preferred alignment for the Backbone System.
    - DPR System Alignment Evaluation. To incorporate raw water augmentation into the RRWP, a new pipeline and at least one pump station, but likely multiple, would be required to connect the Backbone System to the FEWWTP. This section documents the high-level evaluation of alignments for this connection.
    - Evaluation of Long Tunnels to Avoid Areas of Concern. McMillan Jacobs Associates (MJA) reviewed available information to determine the feasibility of tunneling select areas of concern and developed an opinion of probable construction cost for those tunnels. This was documented in a report which has been included in its entirety as Appendix W. These areas were compared to the current cut-and-cover methods to determine the preferred construction method. Further evaluations, including a subsurface geotechnical investigation, are ultimately required during the next phase of work to determine the preferred construction method for these sections. For the purposes of this FLDR, it is assumed that both sections are installed with cut-and-cover methods. However, the cost opinion for the SG River bed is developed using the costs prepared by MJA, such that a conservative budget is established for this section.

The additional studies and evolution of the Project implementation strategy resulted in both the LA River and SG River Alignments being recommended for more detailed environmental studies and technical analysis in the next phases of the Project.

Figure 5-1 summarizes the Project methodology as it applies to this chapter.

Phase	Phase 1 Metropolitan's Initial Evaluation	Phase 2 Alignment Verification / Initial Screening	Phase 3 Detailed Alternative Alignment Evaluation	**Phase 4 Final Refinements**	Phase 5 Feasibility-Level Pipeline and Pump Station Design
Tasks	• Identification of potential pipeline alignments • Identification of Initial Base Case	• Data collection • Review of Metropolitan studies • Desktop analysis • Alternate alignment development • Field investigations • Initial screening • Desktop Geotechnical Report • Traffic Analysis and Impact Report • Constructability evaluations	• Development of decision model • Evaluation criteria • Weighting of evaluation criteria • Coarse screening • Secondary screening • Final screening • Ranking of alternatives	**• Incorporation of stakeholder input** **• Conduct supplemental evaluations**	• Steel size and wall thickness • Feasibility-level pipeline plan drawings • Hydraulic analysis and profile • Special construction zones and cross-sections • Pump station siting and feasibility-level site and building layout • Cost development • Quantity take-off • Preliminary construction duration
Workshops		• Initial screening workshops	• Detailed evaluation workshops	**• Workshops with Stakeholders** **• Workshops with Metropolitan's Environmental Team**	• Pipeline focus meetings/ workshops • Pump station focus meetings/ workshops • Unit cost development workshops
Outcomes	• Initial Base Case alignment • Report entitled, "Potential RRWP – Conveyance System Feasibility Assessment"	• Revised Base Case alignment	• Initial Preferred Alignment	**• Final Preferred Alignment**	• Feasibility-level pipeline and pump station design • Engineer's cost opinion and Project schedule
Chapters	• Chapter 1	• Chapter 2 • Chapter 3	• Chapter 4	**• Chapter 5**	• Chapter 6 • Chapter 7 • Chapter 8 • Chapter 9

Figure 5-1 Chapter 5 Methodology

5.1 REFINEMENTS PRIOR TO THE 2018 DRAFT REPORT

This section presents the refinements that occurred to the Initial Preferred Alignment prior to the completion of the 2018 Draft Report. These refinements include a more detailed evaluation of specific areas along the Initial Preferred Alignment as well as an evaluation of the system hydraulics to account for the high point in the alignment located at Signal Hill.

5.1.1 Detailed Evaluation of the Initial Preferred Alignment

This section discusses the areas of concern identified during workshops with Metropolitan staff and summarizes the response to each concern.

5.1.1.1 Alignment Verification Workshops

A series of workshops were held with Metropolitan staff to review the Initial Preferred Alignment and gather input from the Project team, which included the Real Property Group, External Affairs Group, Environmental Planning Section, Engineering Services Group (specifically the Design Section and Infrastructure Reliability Section), and Water System Operations. The goal of the workshops was to receive feedback from the Project team, to confirm that the rights-of-way for the alignment could be obtained and that the costs would be financially feasible, and to identify areas requiring further investigation to alleviate concerns from the initial investigation. As shown in Table 5-1, four areas of concern were identified during the workshops. The table also summarizes the responses, which are more fully described in the following subsections.

Table 5-1 Summary of Internal Stakeholder Input

CONCERN	DESCRIPTION
Whittier Narrows Revision	Metropolitan's staff had concerns with the Initial Preferred Alignment alongside the San Gabriel River from LACSD's San Jose Creek Water Reclamation Plant north due to the increased risk of environmental hazards and the proximity to the Upper San Gabriel Valley Municipal Water District's future Indirect Reuse Replenishment Project (IRRP) pipeline. Additional alignments were identified as alternatives for this section. After further evaluation, it was agreed that the preferred route was still adjacent to the San Gabriel River.
Alternative Alignments to San Gabriel River Bed	Additional alignments were identified as an alternative to constructing pipe in the San Gabriel River bed and were evaluated against the Initial Preferred Alignment. No revision to the Initial Preferred Alignment was recommended.
Santa Fe Dam Alternatives	Alternatives were identified and evaluated to avoid crossing the Santa Fe Dam. No revision to the Initial Preferred Alignment was recommended.
Alameda Corridor/Dominguez Channel Crossing	Three methods of crossing the Alameda Corridor and Dominguez Channel were identified and presented to Metropolitan. One alternative was selected as the basis of the FLDR.

Whittier Narrows Revision. After the selection of the Initial Preferred Alignment, Metropolitan's staff became aware of the Upper San Gabriel Valley Municipal Water District's plans to construct their IRRP pipeline through the same corridor as the RRWP pipeline northward from LACSD's San Jose Creek Water Reclamation Plant. Metropolitan's staff identified an alternative route using public rights-of-way in city streets to avoid the area of concern. The revised route would be in wide streets and scored highly in many of the evaluation criteria from the detailed alignment evaluation. Black & Veatch further investigated the revised route and prepared detailed maps in GIS to document its feasibility.

Black & Veatch reviewed the revised route with Metropolitan in a series of workshops. Black & Veatch and Metropolitan agreed to leave the alignment adjacent to the San Gabriel River in a similar corridor as the IRRP pipeline. The alternative alignment using city streets would be a viable alternative to this stretch of the Revised Preferred Alignment should it become infeasible during subsequent design phases due to the construction of the IRRP pipeline or other factors.

Alternative Alignments to San Gabriel River Bed. The Initial Preferred Alignment proposed constructing pipe in the San Gabriel River bed from approximately Imperial Highway to Whittier Boulevard. Since constructing pipe in the San Gabriel River bed would introduce risk to the Project schedule and budget due to potential permitting issues and the additional interagency coordination required, Metropolitan's staff asked Black & Veatch to identify alternatives to constructing in the San Gabriel River bed as a backup plan should this concept prove to be unfeasible.

Working together, Black & Veatch and Metropolitan staff identified multiple routes that utilize public rights-of-way in city streets to avoid the San Gabriel River bed. The spreadsheet-based decision model used during the detailed alternative alignment evaluation was rerun to compare the different alternatives to the Initial Preferred Alignment. The Initial Preferred Alignment, utilizing the San Gabriel River bed, remained the favored alternative through the additional analysis. However, should an alternative route be needed, the other routes identified would be viable. The results of the analysis were presented to Metropolitan staff at a workshop on August 31, 2017, and it was agreed that no changes to the Initial Preferred Alignment should be made.

Details of the analysis, including the results of the spreadsheet-based decision model and figures, are provided in Appendix R.

Santa Fe Dam Alternatives. The Initial Preferred Alignment proposed a route on the west side of Interstate 605 to reach the Santa Fe Spreading Grounds that would require crossing a dam. Although feasible, dam crossings require additional, potentially onerous permits and engineering work, in addition to coordination with various jurisdictions. Metropolitan asked Black & Veatch to investigate alternatives that would eliminate the dam crossing.

Black & Veatch identified a route on the east side of the Santa Fe Dam to reach the Santa Fe Spreading Grounds. However, the route would be significantly longer, require difficult freeway, river, and/or dam crossings, and have greater social and community impacts. Black & Veatch presented the results of the analysis, to Metropolitan staff at the August 31 workshop. It was agreed with Metropolitan's staff to leave the Initial Preferred Alignment unaltered in this area. Details of the analysis, including figures, are provided in Appendix R.

Alameda Corridor/Dominguez Channel Crossing. The Initial Preferred Alignment would require crossing the Alameda Corridor at Sepulveda Boulevard and then, approximately 1,700 ft later, crossing the Dominguez Channel. The Alameda Corridor includes multiple railroad tracks and a state highway (Alameda Street), and trenchless construction methods would be required to cross. Crossing the Dominguez Channel also would require trenchless construction methods. However, the land adjacent to Sepulveda Boulevard at these crossings is used by oil and gas refineries and is congested with tanks, below and above grade utilities, and other manufacturing facilities. Therefore, very limited space would be available for the launching and receiving portals required for any trenchless construction method and no clear-cut route between the two crossings exists.

After discussions with Metropolitan staff, Black & Veatch developed three alternatives to construct these crossings and presented them during the August 31 workshop. All three alternatives were viable ways to construct the crossings. However, Metropolitan directed Black & Veatch to use the crossing displayed on Figure 5-2 as the basis of this FLDR as it was the most conservative alternative from a planning perspective. Further evaluation should be completed during the preliminary design phase of the Project to verify this crossing is preferred. Additional details of this crossing are discussed in Chapter 6.

Details of the analysis, including figures, are provided in Appendix R.

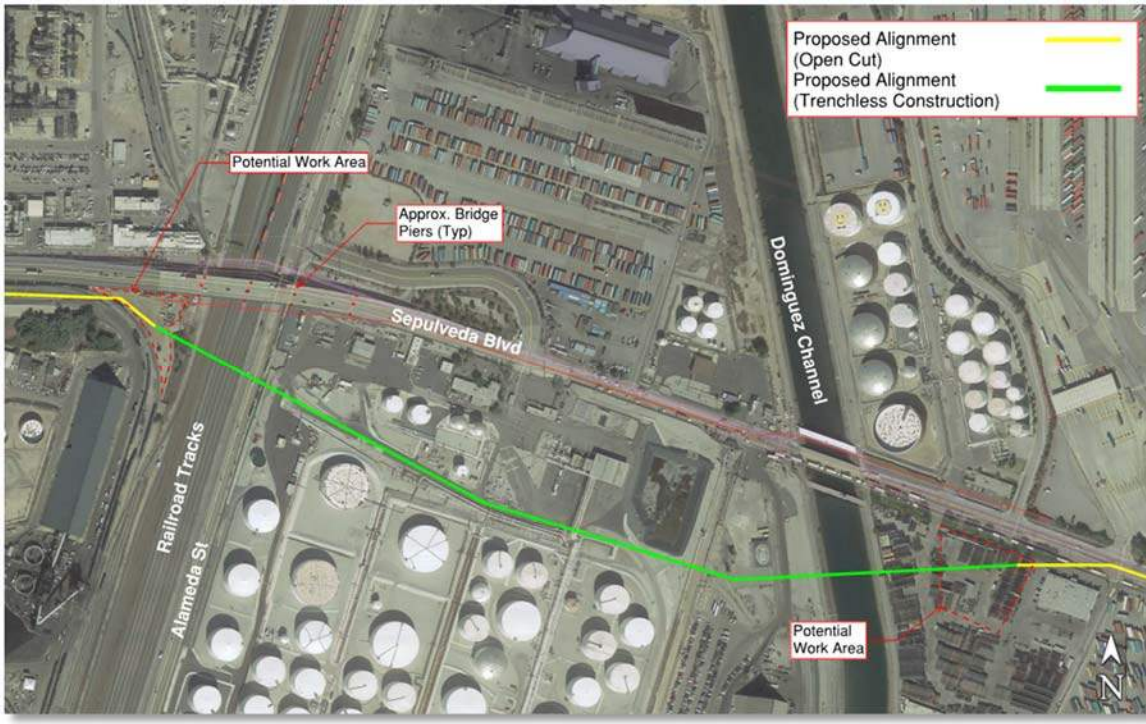

Figure 5-2 Alameda Corridor and Dominguez Channel Crossing

5.1.2 Evaluation of System Hydraulics Due to Signal Hill

This section describes the supplemental evaluations completed after the selection of the Initial Preferred Alignment to address any operational concerns with the selected alignment.

The Initial Preferred Alignment was selected based on minimizing construction risk, social and community impacts, and biological impacts during the detailed alignment evaluation completed in Chapter 4. A quick comparison of the elevation profile of the Initial Preferred Alignment's Reach 1 with the hydraulic grade line (HGL) reveals that a high point would be between PS-1 and PS-2. When the system is operated at its full 150 mgd capacity, the HGL would be above the top of the pipeline. However, the HGL would fall below the top of pipe elevation for flowrates less than approximately 140 mgd, resulting in a partially filled pipe. Since the Project could be phased in its implementation, additional analysis was conducted.

Supplemental evaluations were conducted to address the high point issue and were documented in a memorandum, entitled "Hydraulic High Point Memo", provided in its entirety in Appendix Q. The purpose of the Hydraulic High Point Memo was to provide Metropolitan with sufficient information to select a preferred method of conveying water through Reach 1.

Six concept-level alternatives were identified and evaluated by Black & Veatch and CDM Smith for conveying flows over (or around) the high point and were presented to Metropolitan staff at a coarse screening workshop on June 14th, 2017.

- Concept 1 – Initial Preferred Alignment: Pressurized and Gravity Flow
- Concept 2 – Initial Preferred Alignment: Pressurized Flow

- Concept 3 – Reroute the Preferred Alignment to Del Amo Boulevard
- Concept 4 – Relocate PS-2's Wet Well and Use Can Pumps at PS-2
- Concept 5 – Tunnel Below HGL
- Concept 6 – Eliminate PS-2

At the workshop, Metropolitan eliminated Concepts 2, 3, and 4 and requested additional analysis on the remaining three concepts. The additional analysis compared the benefits of each concept, including a feasibility-level cost estimate, and Concept 6 emerged as the preferred concept from Metropolitan's engineering perspective. Subsequently, one of the concepts originally eliminated, Concept 4, was reconsidered due to increased interest from potential Project customers located near the Carson Plant and proposed AWT plant (i.e., Los Angeles Department of Water and Power [LADWP], West Basin, and the City of Long Beach). Concept 4 adds flexibility to the Project by allowing delivery of advanced treated water to additional customers and facilitating the ability to phase the Project.

Another workshop was held with Metropolitan to present the results of the reintroduction of Concept 4. At the workshop, it was agreed that both Concept 4 and Concept 6 were viable strategies for the RRWP but that Concept 6 remained the preferred concept.

Table 5-2 summarizes the analysis of the six concept-level alternatives.

Table 5-2 Summary of Hydraulic High Point Concept-Level Alternatives

CONCEPT	PRELIMINARY REVIEW	ADDITIONAL ANALYSIS
1) Initial Preferred Alignment: Pressurized and Gravity Flow	Additional analysis requested	Eliminated
2) Initial Preferred Alignment: Pressurized Flow	Eliminated after preliminary review	N/A
3) Reroute the Initial Preferred Alignment to Del Amo Boulevard	Eliminated after preliminary review	N/A
4) Relocate PS-2's Wet Well and Use Can Pumps at PS-2	Eliminated after preliminary review	Reintroduced to analysis to provide flexibility
5) Tunnel Below HGL	Additional analysis requested	Eliminated
6) Eliminate PS-2	Additional analysis requested	Preferred concept

Concept 6 is henceforth known as Alternative A and Concept 4 is henceforth known as Alternative B. Alternatives A and B are discussed in detail below.

5.1.2.1 Alternative A - Eliminate PS-2 (Concept 6)

Under this alternative, PS-1 would be used to pump flow directly to the OC Spreading Basins and PS-3, eliminating the need for PS-2. The pumping head requirement from PS-1 would significantly increase due to the additional friction loss resulting from the longer pumping distance, and because of the higher discharge elevations of the OC Spreading Basins and PS-3. The resulting HGL of Reach 1 would be significantly over the high point.

Flow Control. To allow Metropolitan operational flexibility to adjust flow delivery to each end point, based upon the different downstream groundwater recharge needs, the Project would require one or more flow control facilities, comprising control valves and flow meters to control the splitting of flow between the two discharge locations. Flow regulation could be accomplished in one combined control facility, located at the proposed PS-2 location, or could be accomplished in a facility at any point along the alignments to at least one or both points of delivery. The flow control facilities could be located along the alignment to the points of delivery, allowing greater flexibility in site selection.

If it were certain that Metropolitan would need to deliver flows to each end user at a consistent flow rate, it would be possible to optimize such a control facility to minimize inefficiencies. However, should the flow rates vary, it would be necessary to throttle flow in one, or both, of the pipelines. For example, to reduce the water sent to OC while maintaining the amount of water to PS-3, the control facility on the OC line would need to dissipate head. This throttling operation could reduce overall system efficiency depending on the extent and duration of throttling and whether any energy recovery is included.

PS-1 Size. As mentioned earlier, eliminating PS-2 would increase the pumping head requirement at PS-1. If PS-2 were eliminated, the size of pumping equipment at PS-1 would increase significantly in order to pump to the terminal discharge points at PS-3 and OC. Essentially, the pumping power previously placed at PS-2 would be relocated and incorporated into PS-1. Although pumping head would be increased at PS-1, the overall system pumping and energy use could actually be reduced due to the associated elimination of pumping equipment at PS-2 (actual overall energy use would depend on how flow control is achieved).

Potential Reach 1 Discharge Locations. With PS-2 eliminated, the pressure in Reach 1 from PS-1 to PS-2 would increase by approximately 150 psi. If discharge locations were ultimately included in the Project along Reach 1, such as those being considered in Long Beach, this additional excess pressure would need to be dissipated, reducing the overall system efficiency.

Site Selection. If PS-2 were eliminated, it would likely be replaced with a flow control station to provide Metropolitan the ability to control the amount of flow going to both the OC Spreading Basins and PS-3. Although still of some size and complexity depending on the ultimate design criteria, it would likely have a much smaller footprint than PS-2. Additionally, and as noted above, the control facility could be located at any point along the alignments or at the points of delivery and have less stringent site criteria, allowing for greater flexibility in site selection and property acquisition. Overall, the siting challenges for a flow control station(s) are expected to be significantly reduced compared to a pump station with a large wet well or storage tank.

Additionally, with the elimination of PS-2, PS-3 would be located to minimize hydraulic inefficiencies between pumping from PS-1 to PS-3 and to the OC Spreading Grounds. Initial hydraulic calculations have been performed to optimize the location of PS-3, which is between the Whittier Narrows Dam and the San Jose Creek Water Reclamation Plant. Several potentially viable sites for PS-3 were identified in this general vicinity and are discussed in greater detail in Chapter 7. These sites are in the same general location identified as part of the Base Case system.

Alignment. The Revised Base Case alignment between PS-1 and PS-2, identified by Metropolitan and Black & Veatch as part of the development of the Business Case Report presented to Metropolitan's Board of Directors in October of 2016, was routed through Signal Hill on Willow Street (instead of Carson Street). As background, the Revised Base Case alignment was not selected as the Initial Preferred Alignment during the detailed evaluation phase of the Project in large part due to the length and depth of the tunnel required under Signal Hill to remain under the HGL. Since eliminating PS-2 would cause the pumping head requirement of PS-1 to increase so that the HGL of this reach would be significantly over the high point in Signal Hill, it was logical to consider the Revised Base Case alignment through Signal Hill. The spreadsheet-based decision model used during the detailed alternative alignment evaluation was rerun to compare the Revised Base Case alignment through Signal Hill to the Initial Preferred Alignment without PS-2 in the Project.

The results of the new model run show that the Revised Base Case alignment through Signal Hill would be superior to the Initial Preferred Alignment on Carson Street without PS-2.

Figure 5-3 presents the revisions to the Initial Preferred Alignment through Signal Hill.

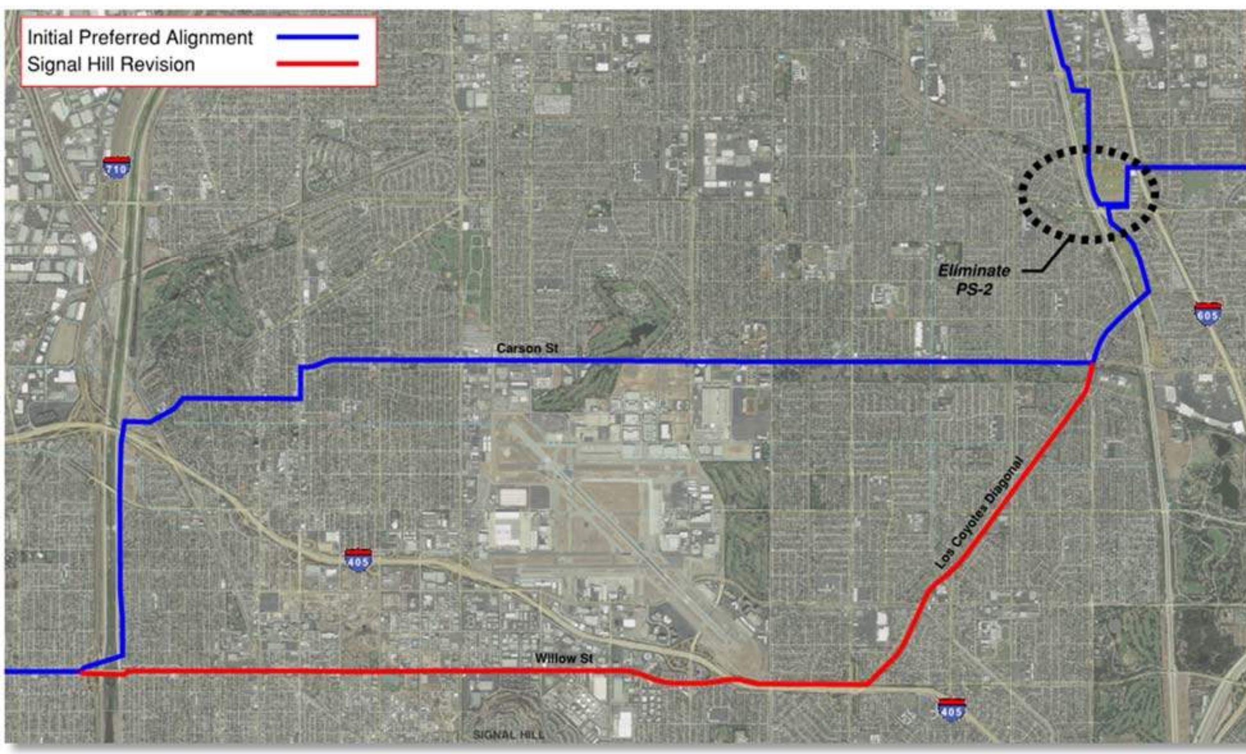

Figure 5-3 Signal Hill Revision without PS-2

5.1.2.2 Alternative B - Relocate PS-2 Wet Well and Use Can Pumps at PS-2 (Concept 4)

PS-2 would remain in the Project at its previously discussed location, but the wet well/storage tank would be relocated to the highest point of Reach 1 at a location near the alignment. Additionally, PS-

2 would be revised to an in-line pump station utilizing can pumps. PS-2 would then retain the pressure head resulting from passing over the high point to maximize system energy efficiency.

The tank at the high point would improve surge control and provide a hydraulic break in the system to aid in flow control and balancing, consistent with the original design concept. By pumping to a storage tank located at the high point of Reach 1, potential Project customers located near the Carson Plant (i.e. LADWP, West Basin, and City of Long Beach) could receive advanced treated water at a constant pressure head during all phases of the Project and not have to address the complications of receiving lower head water during the initial phases of the Project and higher head water at the ultimate Project build out.

By locating the storage tank at the top of Reach 1, the RRWP would be able to provide benefits to the entire region, regardless of individual agreements with LADWP, West Basin, City of Long Beach, or other discharge locations. Additionally, the relocated storage tank would provide benefits to the RRWP Project by improving overall system energy efficiency, increasing surge control by maintaining positive pressure, and providing balancing and control functions.

Alignment. Since relocating PS-2's wet well to the high point in Reach 1 and revising PS-2 to use can pumps would allow the pipeline to be installed through the high point without the use of trenchless construction methods (a tunnel), it was logical to re-introduce the Revised Base Case alignment through Signal Hill to the analysis as well.

The spreadsheet-based decision model used during the detailed alternative alignment evaluation was rerun to compare the Revised Base Case alignment through Signal Hill to the Initial Preferred Alignment without tunnels required to remain under the HGL. The results of the new model run show that the Revised Base Case alignment through Signal Hill, following Willow Street and Los Coyotes Diagonal, would be superior to the Initial Preferred Alignment following the Los Angeles River easements and Carson Street.

Figure 5-4 presents the revisions to the Initial Preferred Alignment through Signal Hill.

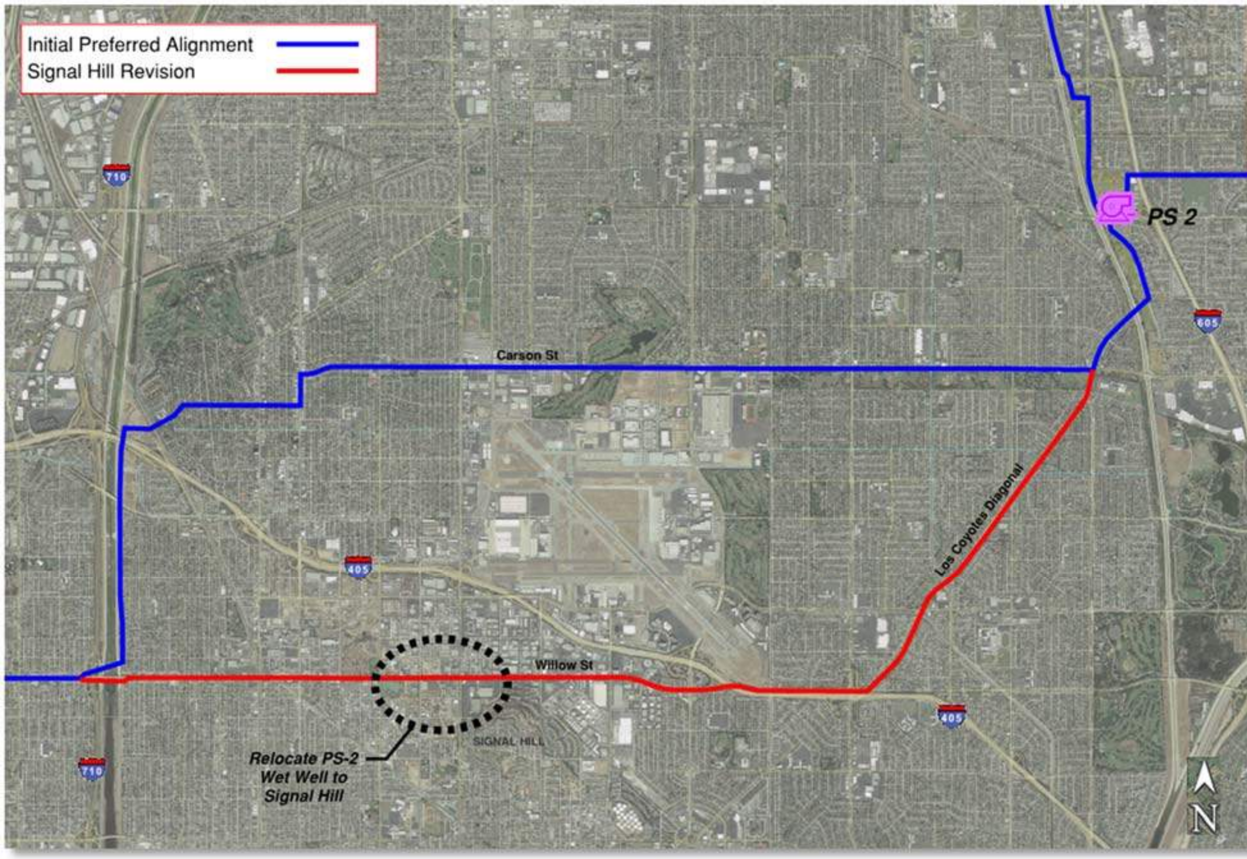

Figure 5-4 Signal Hill Revision

Storage Tank Size. The storage volume of the PS-2 wet well would be sized to improve operational control, allow coordinated and synchronized controls between stations to limit imbalances, and to minimize risk if a pump station fails to shut off. Additionally, it would be sized to provide limited surge control benefits. By moving the wet well at PS-2 to the high point of Signal Hill, the size of the storage tank could conceivably remain the same as it would have been at the same site as PS-2. However, if off-takers of the Project's advanced treated water in Reach 1, between PS-1 and PS-2, have diurnal flow demands, then the size of the storage tank would need to be revaluated and could potentially increase. Additional evaluations to determine the storage volume size should be completed once agreements with Project customers have been reached and the diurnal curves of their demands have been obtained. Details of the storage tank sizing are discussed in Chapter 7.

Storage Tank Site Identification. Several locations near the alignment at the highest point of Signal Hill were identified as potential sites for the storage tank. These sites were selected based on their proximity to the Signal Hill alignment, site access, and land use/availability. Property ownership was not evaluated during site identification. Site selection assumed 2.0 MG for the tank volume and 20 ft side water depth, resulting in a tank diameter of approximately 135 ft.

Figure 5-5 depicts potentially viable sites for the storage tank at the high point of Signal Hill. Site Nos. 2, 5, and 6, as identified on Figure 5-5, are potentially not large enough to feature a single above grade circular tank; however, other tank configurations are possible at these locations.

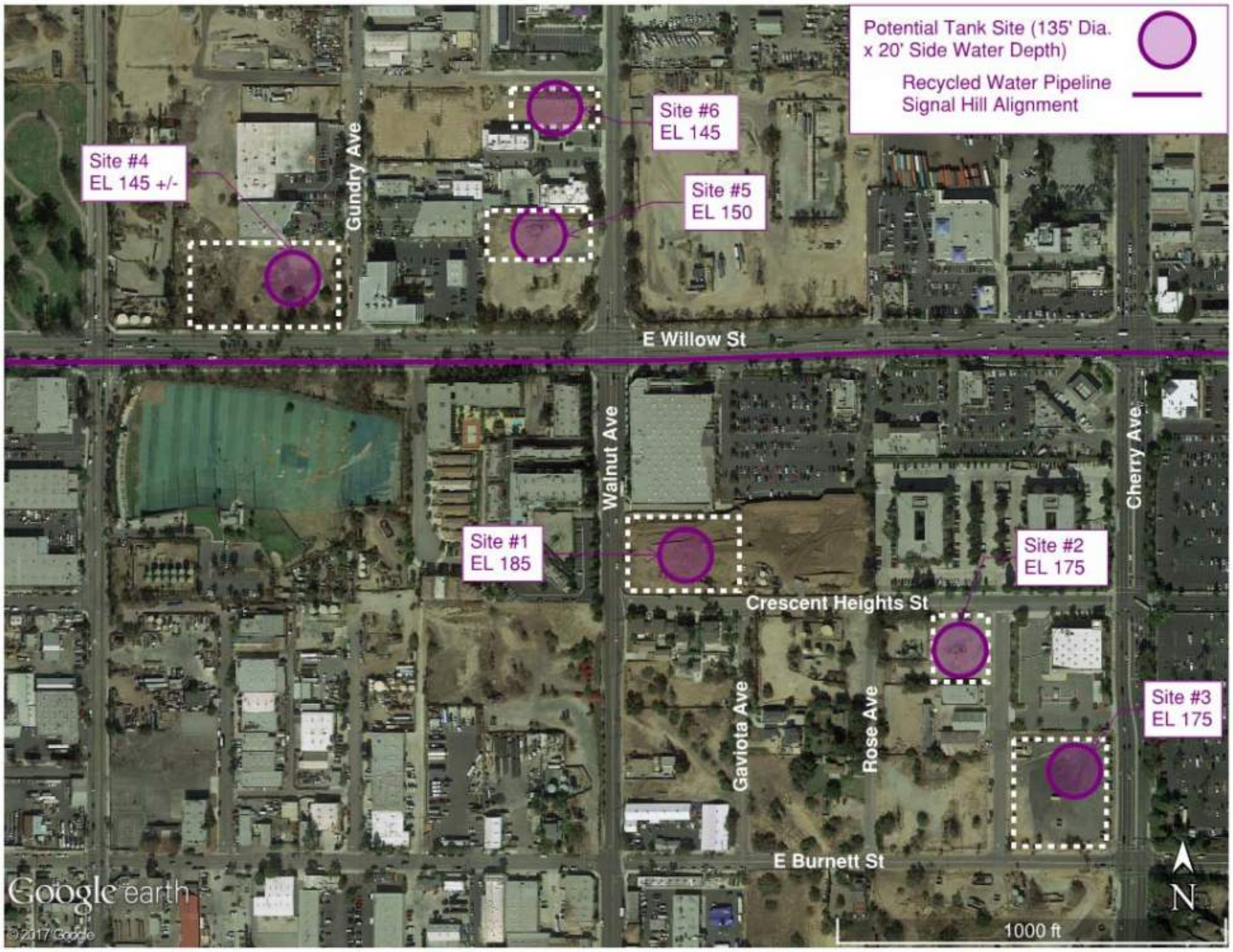

Figure 5-5 Signal Hill Tank Location Map

5.1.2.3 Hydraulic High Point Evaluation Results

The preferred hydraulic operating scenario selected was to eliminate PS-2 (Alternative A).

Alternative A includes the revised route through Signal Hill to match the Revised Base Case.

It is recognized that the Project is still at the feasibility-level planning stage. Additional planning, negotiations with potential customers, and collaboration with other Project stakeholders occurring during subsequent design phases could result in Metropolitan choosing to enact a different hydraulic operating scenario. It is recommended that the facilities required for both Alternative A and B should be included as a part of the Project for CEQA permitting purposes to provide Metropolitan flexibility to adapt the Project as it progresses.

5.1.2.4 Revised Preferred Alignment

The Revised Preferred Alignment incorporated the input received from internal and external stakeholders and was based on the information available during the preparation of the 2018 Draft Report, including:

- Input from the Metropolitan organizations for the selection and refinement of the Revised Preferred Alignment.
- Establishment, with a high degree of confidence, that the rights-of-way for the Revised Preferred Alignment can be obtained and that the costs are financially feasible.
- Results from further investigation of areas of concern from the initial investigation to determine the constructability and feasibility of the alignment.
- Additional input from municipalities and regulatory agencies.

The Revised Preferred Alignment is depicted on Figure 5-6 and is described in greater detail in Chapter 6.

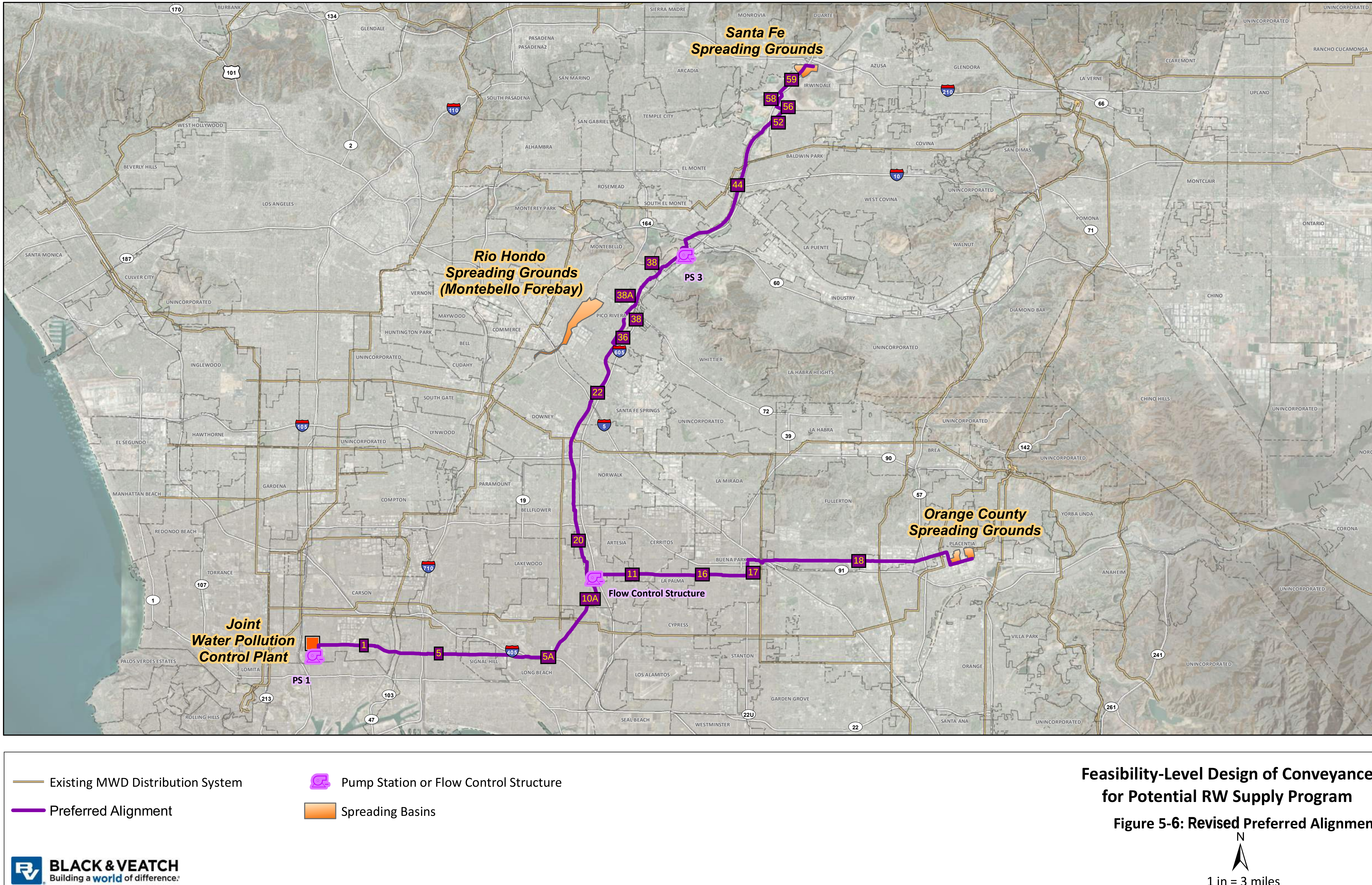

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Figure 5-6: Revised Preferred Alignment

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5.2 REFINEMENTS OCCURING AFTER THE 2018 DRAFT REPORT

In the February 2019 Conceptual Planning Studies Report and the July 2019 RRWP White Paper No. 1, Metropolitan determined that a Backbone System would be the best implementation strategy for the RRWP, as it would facilitate phasing opportunities to accelerate the program and provide the flexibility to incorporate raw water augmentation opportunities if DPR regulations get promulgated. DPR occurs when purified, recycled water is introduced directly into a potable water supply distribution system or into the raw water supply immediately upstream of a water treatment plant. At the time of this report, DPR is not permitted by the California State Water Resources Control Board's (SWRCB) regulations. Currently, the SWRCB is working to develop regulations permitting DPR. The timeline for their final approval remains uncertain but appears to be gaining traction. Two analyses were enacted specifically as a result of this latest Project concept:

- **Backbone System Alignment Evaluation**. Since the Backbone System forgoes the OC Reach, Metropolitan asked Black & Veatch to re-visit the alignment evaluation to see how removing the OC reach impacts the selection of a preferred alignment for the Backbone System.
- **DPR System Alignment Evaluation.** To incorporate raw water augmentation into the RRWP, a new pipeline and at least one pump station, but likely multiple, would be required to connect the Backbone System to the FEWWTP. Metropolitan retained Black & Veatch to complete an alignment evaluation for this proposed pipeline.

Figure 5-7 presents a schematic of the Backbone System with future options to incorporate raw water augmentation at FEWWTP. The OC Reach is shown as optional was removed from further consideration in the initial phases of the Project.

In addition to the above studies, Metropolitan also enacted a more detailed study for the potential use of long tunnels to avoid constructability risks identified for portions of the Project. The engineering evaluations that comprised these tunnels were completed by MJA.

This section documents these three evaluations: 1) the re-evaluation of the preferred alignment for the Backbone System, 2) the evaluation of alignments connecting the Backbone system to the FEWWTP, and 3) the consideration of using long tunnels to avoid areas of concern.

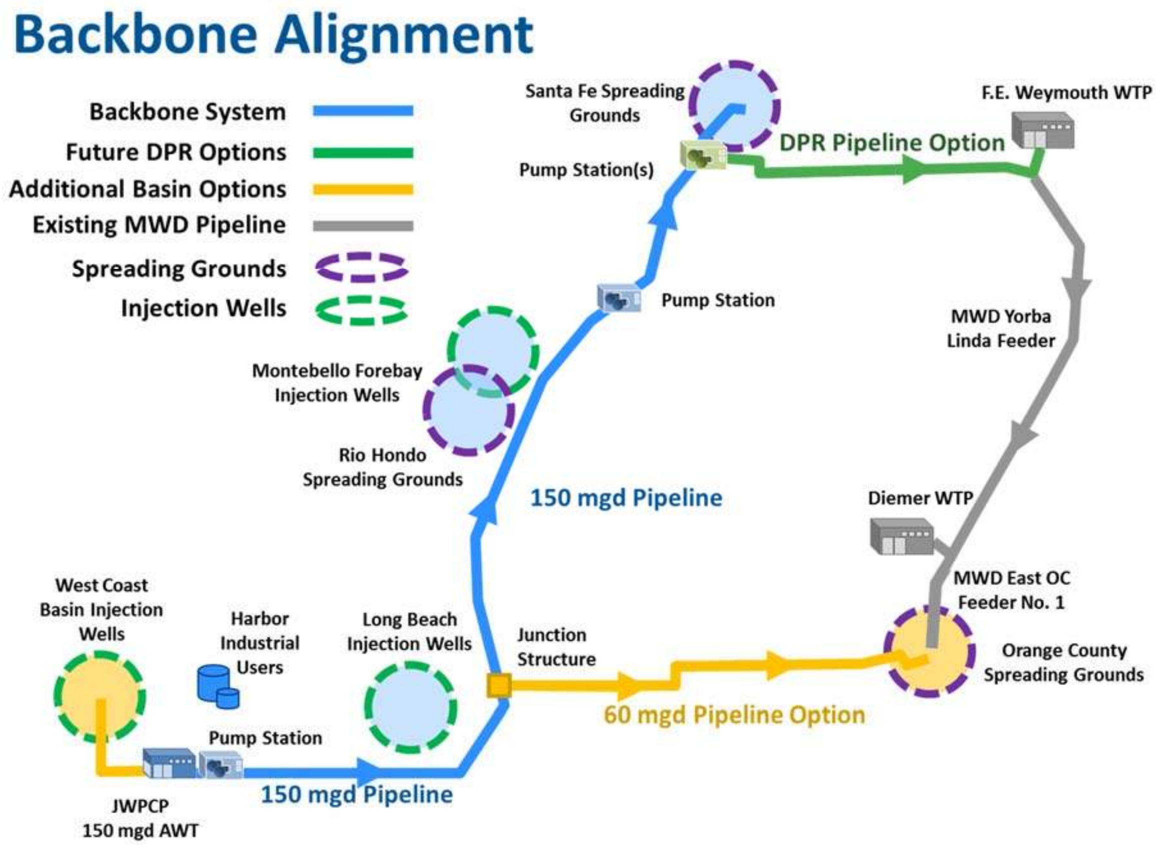


Figure 5-7 Proposed Regional Recycled Water Program Backbone System

5.2.1 Backbone System Alignment Evaluation

Through the analysis completed in Chapter 4, three full alignment alternatives were identified: the SG River Alignment, the All Street Alignment, and the LA River Alignment. Using the evaluation process established in Chapter 4, Black & Veatch was asked to rerun the analysis based on the Backbone System, with the OC Reach eliminated. As part of this effort, Black & Veatch and Metropolitan held a number of workshops with Metropolitan internal stakeholders to validate the prior evaluation process and to ensure the ongoing input from internal stakeholders was incorporated. First, the revisions to the LA River Alignment that resulted from these workshops are presented, and then following that, the evaluation itself is documented.

5.2.1.1 Revisions to the LA River Alignment

Based on the feedback from workshops with Metropolitan, the LA River Alignment was revised as follows. The alignment remains unchanged through the City of Carson and would be located within the existing public rights of way of Main Street and Sepulveda Boulevard / Willow Street. Upon crossing the LA River, the alignment would turn north and follow LACFCD's existing easement outside of the embankment adjacent to the LA River. At the 405 Freeway, the alignment would traverse to the northeast using trenchless construction methods to perpendicularly cross the Newport-Inglewood Fault Zone. The alignment would continue using trenchless methods north mostly within the existing public rights-of-way in Country Club Drive and then through the Virginia

Country Club until it is back to being adjacent to the LA River in LACFCD's existing rights-of-way / easement.

The alignment would continue parallel to the LA River until it reaches the SCE easement immediately north of the 91 Freeway where it would shift to be within the existing public rights-of-way of Atlantic Place, Hunsaker Avenue, and finally Alondra Boulevard. When Alondra Boulevard crosses the SCE easement between Garfield Avenue and Orange Avenue, the alignment would turn north again and be located within the SCE rights-of-way / easement. Initially within SCE's easement, the pipeline is envisioned to be located east of the two western transmission line towers, which is the opposite side from Metropolitan's existing Middle Feeder South. After continuing north in SCE's easement, the pipeline would shift its location as necessary to avoid obstructions.

North of Burns Avenue, the SCE easement crosses to the west side of the Rio Hondo Channel. At this point, the alignment would leave the SCE easement to continue parallel to the Rio Hondo Channel on the east side. Just south of the 5 Freeway, the alignment would cross to the north and west side of the Rio Hondo Channel and would continue adjacent to the river channel along the perimeter of the spreading basins within the LACFCD's existing rights-of-way / easements.

At Whittier Boulevard, the alignment would turn east and be located within the existing public rights-of-way. The alignment would then turn north at Paramount Boulevard and east at Beverly Boulevard until it reached the SG River. From here, the LA River Alignment would share the same route as the SG River Alignment.

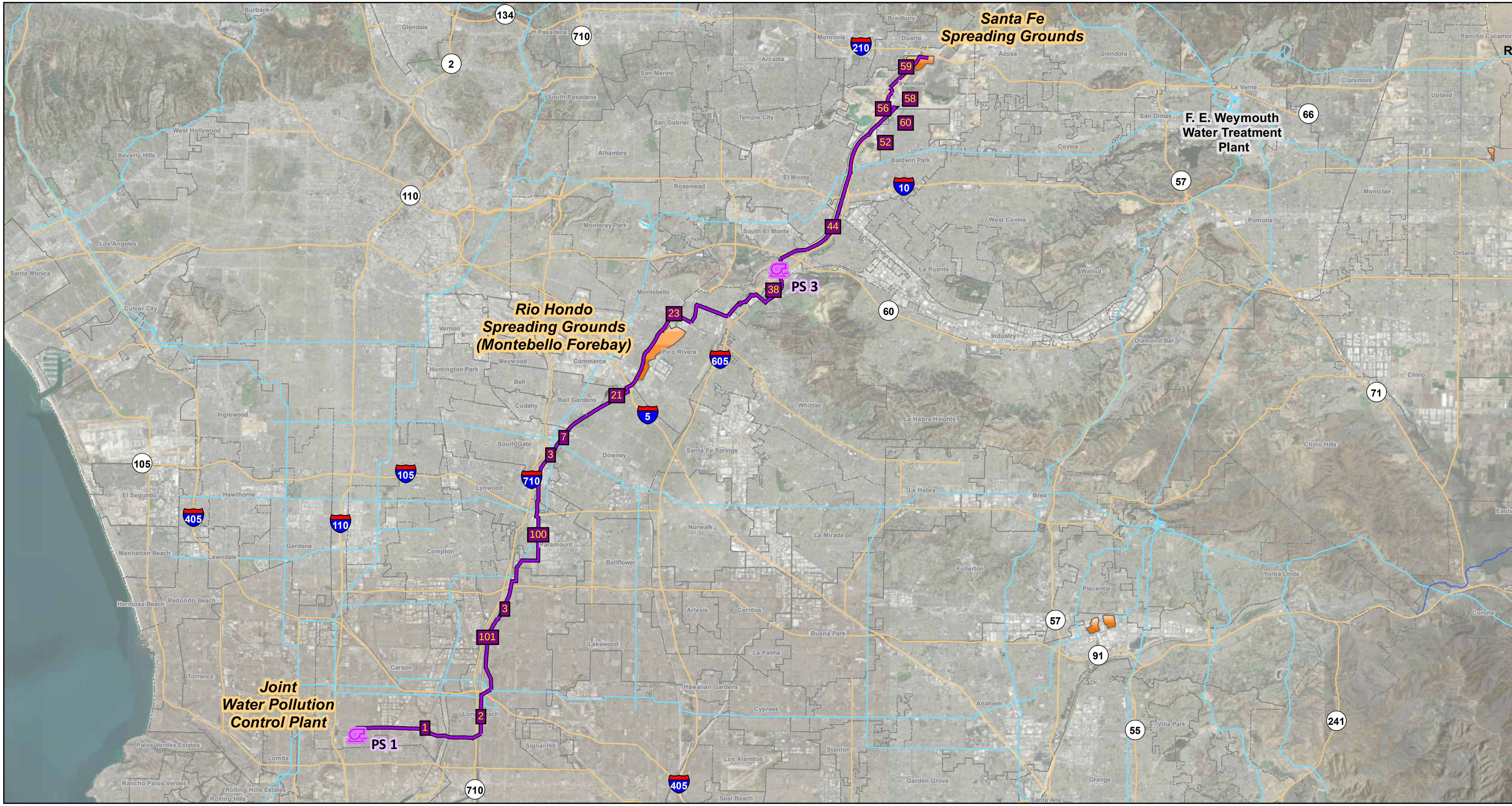
Segments 100 and 101 were added to the evaluation to document the details of the sections that were added to the evaluation per the revisions described. Details are provided in Appendix S.

Figure 5-8 presents the revised LA River Alignment.

5.2.1.2 Revisions to the Project in the Vicinity of Whittier Narrows Dam

During the workshops with Metropolitan, the crossing of the Whittier Narrows Dam, which is common to both the SG River and LA River Alignments, was evaluated further. Previously, the alignment was shown as crossing the dam itself. The United States Army Corps of Engineers (USACE) is in the planning phase for their Whittier Narrows Dam upgrade, which presents significant challenges for an alignment crossing beneath the dam. A more suitable corridor exists on the east side of the 605 Freeway that avoids crossing the dam. To some extent, the topography in this vicinity limits the availability of feasible alignments as the Puente Hills are located just to the east and the Montebello Hills and oil refineries are located to the west. Metropolitan agreed to revise the alignment as shown on Figure 5-9. Segment 60 was added to the evaluation to document the details of the new section along Workman Mill Road. Details are provided in Appendix S.

It should be noted that the revised alignment includes a high point ground elevation on Workman Mill Road of approximately 253 ft. Of the five sites identified for PS-3 during the preparation of the 2018 Draft Report, as described in Chapter 8, only Site 1 is located prior to (south of) this high point. The remaining four sites are located approximately one mile north of the high point at around elevation 230 ft. The evaluations that occurred after the preparation of the 2018 Draft Report only included scope to revise the pipeline alignments, as Metropolitan is reserving additional funding for the next phases of work which are anticipated in the near future. As such, the siting and design of PS-3 requires further evaluation during the subsequent phases of design to optimize its location and size. For planning purposes of this phase of the Project, the sites identified are sufficient for the feasibility-level Project definition and cost estimating.



Legend

Polylines

Polylines

SymbolID

0

MWD Pipelines

Rialto Pipeline

Interstate / State Highway

Date: 4/27/2020

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program

Figure 5-8: Revised LA River Alignment

0 0.75 1.5 3 4.5 Miles

N W E S

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Figure 5-9 Revised Project in the Vicinity of Whittier Narrows Dam

Figure 5-10 presents the revised SG River Alignment.

5.2.1.3 Evaluation Process

A similar evaluation process to that documented in Chapter 4 was used to compare the Backbone System alignment alternatives, with modifications as follows:

- As one of the major unknowns regarding the SG River Alignment is the depth and design required to ensure the pipeline constructed within the earthen portion of the SG River bed remains safely buried, a new evaluation criterion was added to assess scour potential. The criterion assessed the risk associated with the design and construction of a pipeline within an earthen river bottom to protect against scour, as well as pipe flotation, and was applied for portions of the alignment within an earthen river bottom. As a new evaluation criterion was added, the weighting factors had to be adjusted to account for the new criterion. See Table 5-3 below for details on the revised weighting factors.

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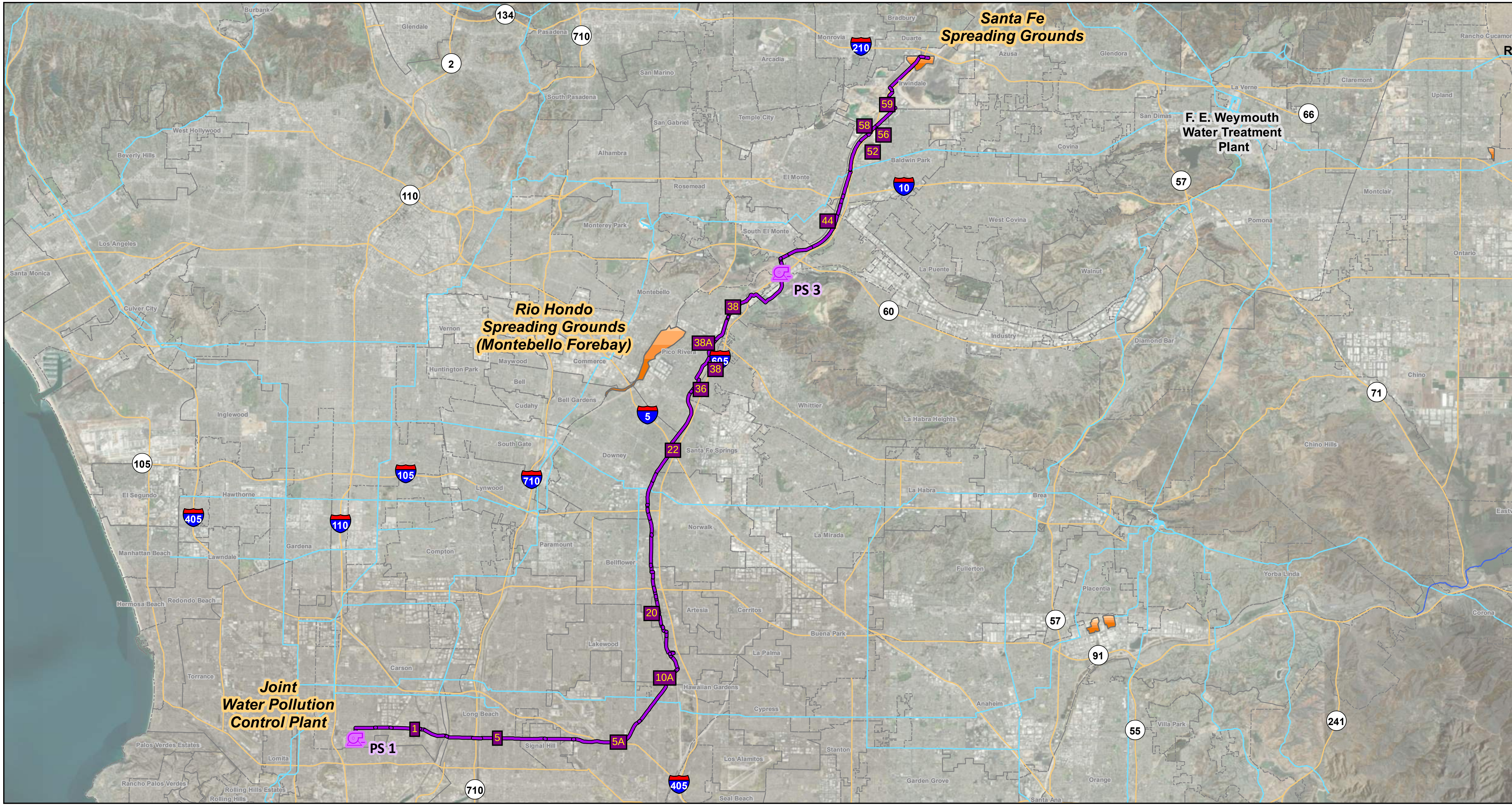

Date: 4/28/2020

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program

Figure 5-10: Revised SG River Alignment

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- Since the Project had been ongoing for nearly four years, it was warranted to review the scoring and weighting system for validation. The Project team (Environmental Planning Section, Real Property Group, and External Affairs Section) provided additional weighting scenarios to consider. The feedback was generally within the range of the two weighting scenarios developed in Chapter 4: Weighting A favoring construction risk criteria and Weighting B emphasizing the social, community, and biological criteria. Due to this, it was agreed that weighting scenarios provided by Metropolitan's internal stakeholders be used as a sensitivity analysis to check the impact the changes in weights would have on the result. Table 5-4 below presents the weighting scenarios provided by Metropolitan's internal stakeholders.

Table 5-3 Evaluation Criteria: Weighting Factors Matrix

Evaluation Factor	Scenario A (Emphasis on Construction Risk)		Scenario B (Emphasis on Community and Biological)	
Construction Risk	**Category Weight:**	**60%**	**Category Weight:**	**30%**
	Factor Weight	**Factor Score**	**Factor Weight**	**Factor Score**
Major Utility Crossings	20.0%	12.00	20.0%	6.00
Trenchless Construction	20.0%	12.00	20.0%	6.00
Groundwater Conditions	5.0%	3.00	5.0%	1.50
Alignment Length	25.0%	15.00	25.0%	7.50
Seismic Hazard	5.0%	3.00	5.0%	1.50
Soil Contamination Risk	5.0%	3.00	5.0%	1.50
Ease of Operations/ Accessibility	15.0%	9.00	15.0%	9.00
Scour	5.0%	3.00	5.0%	1.50
Social and Community	**Category Weight:**	**30%**	**Category Weight:**	**55%**
Parks/Recreation Areas	5.0%	1.50	5.0%	2.75
Public Facilities	20.0%	6.00	20.0%	11.00
Traffic Impacts	20.0%	6.00	20.0%	11.00
Street/Median Improvements	20.0%	6.00	20.0%	11.00
Major Intersections	15.0%	4.50	15.0%	8.25
Residential/Minor Commercial	20.0%	6.00	20.0%	11.00
Biological	**Category Weight:**	**10%**	**Category Weight:**	**15%**
Waters of the US and State	20.0%	2.00	20.0%	3.00
CNDDB Habitats	40.0%	4.00	40.0%	6.00

Table 5-4 Additional Weighting Scenarios Provided from Metropolitan's Project Team

Criteria	Internal Stakeholder Input					
	Environmental Planning		Real Property		External Affairs	
	A	B	A	B	A	B
Construction Risk		**30%**	**60%**	**30%**	**55%**	**30%**
Major Utilities	N/A	5%	25%	25%	20%	20%
Trenchless Construction	N/A	10%	20%	20%	20%	20%
Depth to Groundwater	N/A	25%	5%	5%	5%	5%
Total Alignment Length	N/A	0%	20%	20%	25%	25%
Seismic Hazard	N/A	5%	5%	5%	5%	5%
Contaminated Soils Risk	N/A	25%	5%	5%	5%	5%
Ease of O&M	N/A	15%	15%	15%	15%	15%
Scour Potential	N/A	15%	5%	5%	5%	5%
Social and Community		**20%**	**30%**	**60%**	**35%**	**55%**
Parks & Rec Areas	N/A	29%	5%	5%	5%	5%
Public Facilities	N/A	29%	20%	20%	15%	15%
Road Category & Traffic Impact	N/A	7%	20%	20%	30%	30%
Center Medians	N/A	7%	10%	10%	10%	10%
Major Intersections	N/A	6%	15%	15%	15%	15%
Residential/ Minor Commercial	N/A	22%	30%	30%	25%	25%
Biological		**50%**	**10%**	**10%**	**10%**	**15%**
Waters of the US and State	N/A	20%	20%	20%	20%	20%
CNDDB Habitats	N/A	80%	80%	80%	80%	80%

The spreadsheet-based decision model used during the detailed alternative alignment evaluation described in Chapter 4 was rerun to compare the three alignment alternatives, the SG River Alignment, the All Streets Alignment, and the LA River Alignment, without the OC Reach. Details on the decision model inputs and results for the Backbone System are provided in Appendix S.

5.2.1.4 Backbone System Evaluation Results

The result of the Backbone System alignment evaluation is that the LA River and the SG River Alignments both score very similarly, while the Streets Only Alignment scored poorly. Table 5-5 presents a summary of the scoring results for the LA River and the SG River Alignments.

Table 5-5 Summary of LA River and SG River Alignments Scoring

ROUTES	SAN GABRIEL RIVER ALIGNMENT				LA RIVER ALIGNMENT			
	SUM (#)	RAW SCORE	WEIGHT "A"	WEIGHT "B"	SUM (#)	RAW SCORE	WEIGHT "A"	WEIGHT "B"
Major Utilities	223	3	36	18	211	3	36	18
Trenchless Constr.	21K	3	36	18	36K	5	60	30
Depth to Water	78K	5	15	8	67K	5	15	8
Seismic Hazard	Y	5	15	8	Y	5	15	8
Contam. Soils Risk	24	3	9	5	22	3	9	5
Ease of Operation Sub-Score	3	3	23	11	2	2	17	8
Parks	1	1	2	3	1	1	2	3
Public Facilities	7	3	18	33	7	3	18	33
Road Category & Traffic Impact	2	2	12	22	2	2	11	20
Center Medians	36K	3	18	33	30K	3	18	33
Major Crossings	16	3	14	25	14	3	14	25
Residential/ Minor Commercial	30K	3	18	33	31K	3	18	33
Total Alignment Length	201K	1	15	8	193K	1	15	8
Waters of the US and State	36K	5	10	15	19K	3	6	9
CNDDB Habitats	N	1	8	12	N	1	8	12
Scour	Y	5	15	8	N	1	3	2
Weighted Score			**59%**	**61%**			**59%**	**62%**

Per Table 5-5, the LA River Alignment is anticipated to have more trenchless construction while being slightly shorter overall. The SG River Alignment would have a larger impact on biological resources and scour potential due to the length proposed in the SG River bed. Overall, the results of the analysis are that both alignments are feasible and have similar levels of impacts over the course of nearly 40 miles.

It should be noted that some of the screening criteria are scored using a weighted percentage. This is described in detail in Appendix F.

5.2.1.5 Backbone System Evaluation Conclusions

It appears that both the LA River and the SG River Alignments are feasible and carry similar levels of risk and impacts based on the information available for this Project. Therefore, it is recommended that both alignments be carried forward for more detailed environmental studies, technical analysis, and collaboration with Project stakeholders, such as regulatory agencies, municipalities, and right-of-way owners. Chapters 6 and 7 provide detailed descriptions of the proposed facilities for both alignments to support the initiation of environmental studies to comply with CEQA.

Additional studies that should be completed in order to identify the preferred Backbone System alignment include, but are not limited to, the following:

- Right-of-way and ownership evaluations
- Additional evaluation of the permitting and jurisdictional requirements
- Evaluation of impacts to environmental resources and regulatory requirements.
- Geotechnical evaluations, including dewatering testing/studies and a scour analysis

5.2.2 DPR System Alignment Evaluation

Metropolitan retained Black & Veatch to conduct an alignment evaluation on the alternatives connecting the Backbone System to the FEWWTP. The evaluation used the same approach as described in Chapter 4 and is documented in its entirety in the technical memorandum titled "Santa Fe to Weymouth WTP Alignment Evaluation" which is included as Appendix T.

The evaluation only compared alignment alternatives for the purposes of achieving a ranking to recommend a preferred alignment. Evaluations required to describe the additional facilities that would be necessary for a functioning system – such as pump stations and/or modifications to Metropolitan's existing facilities – have not been completed and are recommended during the next phase of work.

While the flow rate for the conveyance system connection to the FEWWTP has not been determined yet, it is currently envisioned to be up to the full 150 mgd.

The results of this evaluation are summarized in the following subsections.

5.2.2.1 Pipeline Corridors

Metropolitan identified various alignment alternatives to convey water from the Backbone System near the SFSG to the FEWWTP. These alignment alternatives were provided to Black & Veatch and served as the basis of this alignment evaluation.

The alignments identified by Metropolitan generally follow four east-west corridors between the SFSG and the FEWWTP. Three of these east-west corridors are generally within existing public street rights-of-way. In addition to these roadways, a potential alignment utilizing Metropolitan's existing Glendora Tunnel was considered. This corridor allows for the construction of a new transmission pipeline north in roads to the westerly end of the Glendora Tunnel. The Glendora Tunnel would be re-purposed to convey water east to the FEWWTP.

These four main east-west corridors form the basis for the pipeline segments.

- Gladstone Street
- Arrow Highway
- Cypress Street
- Glendora Tunnel

Figure 5-11 presents the segments assessed in this evaluation. Descriptions of the four main east-west corridors are provided in the sections that follow.

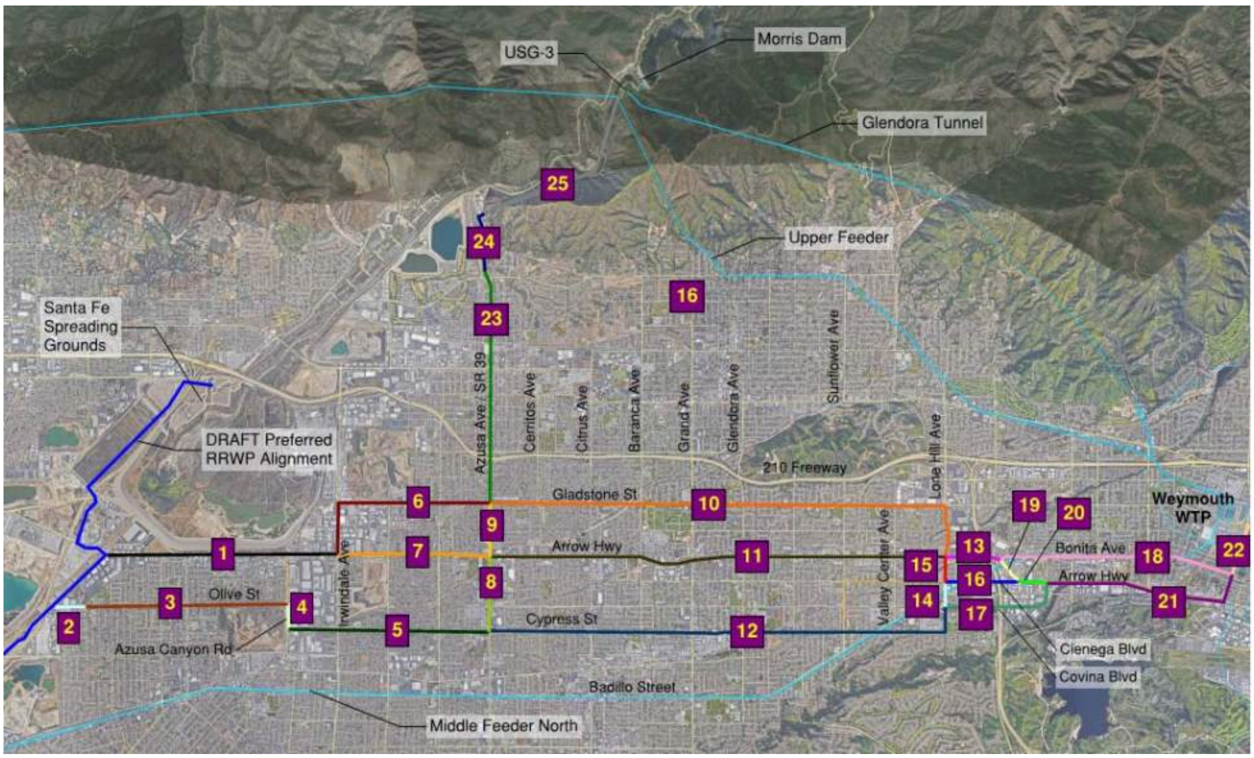

Figure 5-11 DPR Pipeline Segments

After the completion of a coarse screening to reduce the number of alternatives, the remaining segments were combined to form full alignments starting at the Backbone System and ending at the FEWWTP. The alignments within the four pipeline corridors are described as follows:

Alignment 1 – Gladstone Street. Alignment 1 would generally be located within Gladstone Street and would start in Arrow Highway heading east. At Azusa Avenue / SR 39, Alignment 1 would turn north and then east at Gladstone Street. From there, Alignment 1 is within Gladstone Street for 4.5 miles before turning south in Lone Hill Avenue, west in Arrow Highway and finally north in Wheeler Avenue. Alignment 1 is comprised of the following segments: 1, 6, 10, 13, 19, 20, 21, and 22.

Gladstone Street is a mix of industrial and residential with most residential driveways located off frontage roads or side streets with only an occasional driveway directly on Gladstone Street.

Gladstone Street is considered a collector road and is one of the primary continuous east-west roadways in the area.

Alignment 2 – Arrow Highway. Alignment 2 would generally be located within Arrow Highway and would travel east all of the way to Wheeler Avenue. Alignment 2 is comprised of the following segments: 1, 7, 11, 13, 19, 20, 21, and 22.

Alignment 2 is the most direct route from the SFSG to the FEWWTP.

Arrow Highway is mostly comprised of minor commercial and industrial land uses. Residential areas off of Arrow Highway utilize frontage roads for driveway access. Arrow Highway is considered an arterial road and is one of the primary east-west roadways in the area.

Alignment 3 – Cypress Street. Alignment 3 would generally be located within Cypress Street and would begin in a parking lot/ existing utility easement traveling east to get from the Backbone System on Rivergrade Road to Olive Street. The utility easement has existing LACFCD pipes and overhead SCE transmission lines within it and would likely require tunneling to avoid impacts to existing facilities. The alignment would then follow Olive Street to Azusa Canyon Road before turning east in Cypress Street. Alignment 3 would follow Cypress Street for 6.5 miles before turning north in Lone Hill Avenue, then East in Covina Boulevard, east again in Arrow Highway and finally north in Wheeler Avenue. Alignment 3 is comprised of the following segments: 2, 3, 4, 5, 12, 17, 21, and 22.

Cypress Street is heavily residential with driveways commonly directly on the street. Due to the residential nature of the area, overhead power lines cross the street more frequently than the other alternatives considered.

Alignment 4 – Azusa Avenue / SR 39 to Glendora Tunnel. Alignment 4 would consist of a new pipeline connecting to Metropolitan's existing Glendora Tunnel to pump water east to the FEWWTP, reverse of its current operation. The Glendora Tunnel is currently used to convey raw water from the Rialto Pipeline and / or the Upper Feeder to the USG-3 service connection for discharge to the San Gabriel Canyon and ultimately to spreading basins for groundwater recharge. With the implementation of the RRWP, the Upper San Gabriel Municipal Water District (USGMWD) would receive their replenishment water via the RRWP at the SFSG, just downstream of the USG-3 service connection, in lieu of from USG-3. Therefore, the Glendora Tunnel could be available for this new use.

To reach the Glendora Tunnel, the corridor would follow Arrow Highway and then turn north at Irwindale Avenue. At Gladstone Street the alignment would turn east before turning north in Azusa Avenue / SR 39. From there, the corridor would traverse north on Azusa Avenue and then north on Ranch Road. San Gabriel Canyon Road is another potential north-south corridor available as an alternative to Azusa Avenue, should objections to the use of Azusa Avenue arise during subsequent phases of work. Metropolitan, and their consultant McMillan Jacobs and Associates, evaluated three options to construct the pipeline from Ranch Road to the terminus of the Glendora Tunnel. The first option was to use shored excavation methods to construct the pipeline within San Gabriel Canyon Road and Old San Gabriel Canyon Road and then tunnel the final 4,400-ft. The second option involved two tunnels with 2,000-ft of shored excavation on Old San Gabriel Canyon Road between them. The third option was a single tunnel for the entire stretch.

For the purposes of this analysis, the third option, a single tunnel, was assumed for this section due to its lower overall community impact as compared to the other options. San Gabriel Canyon Road is also a portion of State Route 39 and is the primary point of access for the Mountain Cover residential development located along this corridor. Further, Old San Gabriel Road serves as access to the Azusa River Wilderness Park, a popular hiking and pedestrian trail. By tunneling this section, it minimizes the impacts to the community.

The corridor then follows the Glendora Tunnel east to the La Verne Pipeline. The La Verne Pipeline connects the east portal of the Glendora Tunnel to the Upper Feeder Junction Structure, approximately 2 miles to the south. The Upper Feeder Junction Structure has the ability to blend the advanced treated water with Colorado River water and State Water Project water before discharging into the FEWWTP's inlet conduit.

Metropolitan conducted a preliminary hydraulic analysis and determined that the hydraulic grade line required to pump water east through the Glendora Tunnel is less than the design hydraulic grade for the tunnel. Therefore, this Project assumed that no structural improvements to the tunnel are required. This assumption should be confirmed during subsequent evaluations.

Alignment 4 is comprised of the following segments: 1, 6, 23, 24, 25, and the Glendora Tunnel (known as Segment 26).

South of the 210 Freeway, Azusa Avenue is considered a primary arterial road and is one of the principal north-south trafficways with large on and off ramps to the 210 Freeway in the north and the 10 Freeway to south.

North of the 210 Freeway, Azusa Avenue transitions into heavily residential areas. Between the 210 Freeway and Fifth Street, most of the driveways in the residential areas are off frontage roads and not directly on the street. However, north of Fifth Street, Azusa Avenue travels through an improved downtown district with many driveways and commercial businesses having access directly from Azusa Avenue. Significant impacts would be anticipated for shored excavation pipeline construction through this area. Therefore, it was assumed that this section would need to be tunneled for the purposes of this evaluation. Alternate routes that avoid this localized issue, such as San Gabriel Avenue may warrant consideration in subsequent design phases.

Since Metropolitan currently provides replenishment water to the USGMWD via USG-3, which is located at the westerly end of the Glendora Tunnel, approximately 14,000 ft of the Backbone Alignment associated with discharging to the SFSG could be eliminated. Instead, the advanced treated water could be discharged to the San Gabriel River at, or near, USG-3 (or at another location north of the SFSG) which the Los Angeles County Department of Public Works (LACDPW) has indicated is preferred to the discharge location shown in the FLDR.

Figure 5-12 illustrates the eliminated section of the Backbone Alignment and the connection to USG-3 for Alignment 4 schematically. The line in red represents Alignment 4, which connects the Backbone Alignment to the Glendora Tunnel and USG-3. The blue line represents the Backbone

Alignment and the dashed blue line represents the 14,000 ft of alignment that could be eliminated if a new discharge location along Alignment 4 was implemented. The Backbone Alignment currently proposes crossing the Santa Fe Dam spillway. By eliminating this section of the Backbone Alignment, it would also eliminate the difficulty relating to the design, construction, and permitting associated with going through the spillway.

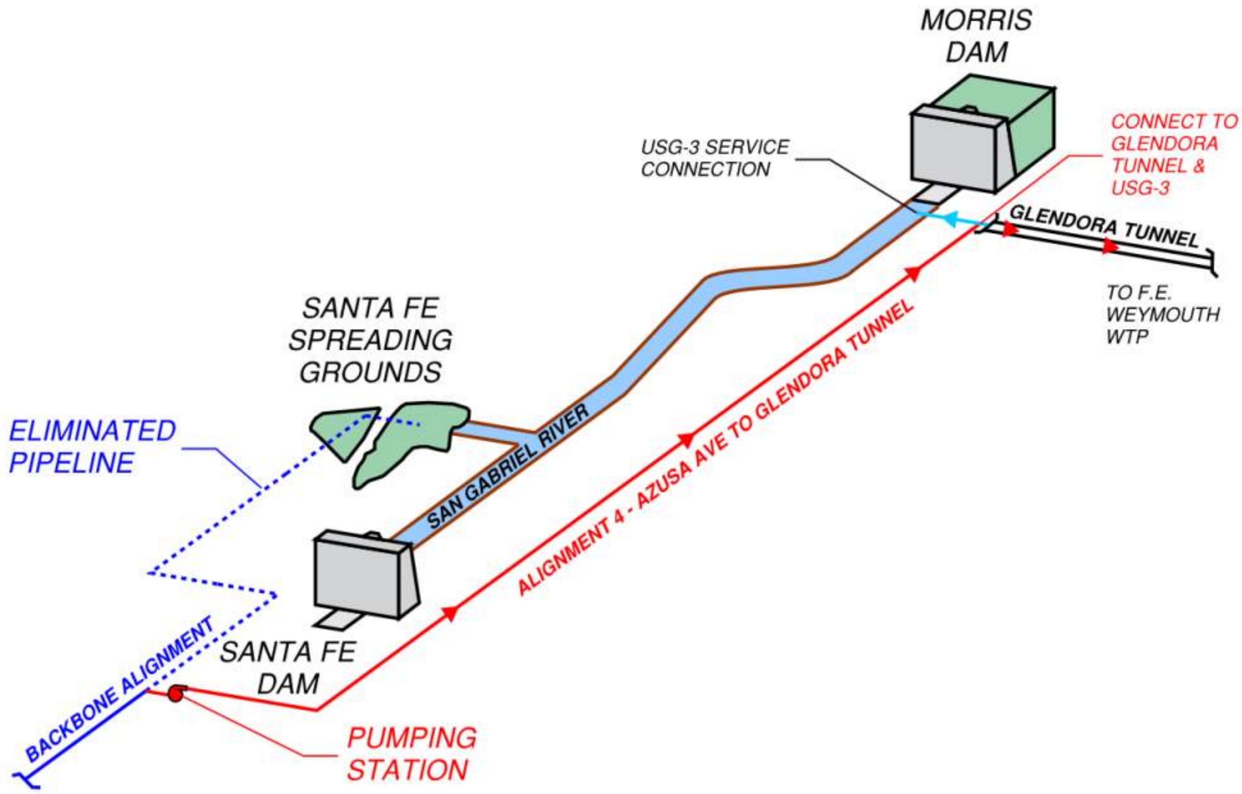

Figure 5-12 Alternative Discharge Location for Alignment 4 – Schematic View

5.2.2.2 Evaluation Results

Table 5-6 summarizes the results of the alignment evaluation.

Table 5-6 Summary of DPR System Alignment Evaluation Results

ALIGNMENT	SEGMENTS	WEIGHTING A SCORE	WEIGHTING B SCORE
Alignment 1 – Gladstone Street	1, 6, 10, 13, 19, 20, 21, and 22	51%	53%
Alignment 2 – Arrow Highway	1, 7, 11, 13, 19, 20, 21, and 22	51%	53%
Alignment 3 – Cypress Street	2, 3, 4, 5, 12, 17, 21, and 22	45%	49%
Alignment 4 – Azusa Ave / SR 39 to Glendora Tunnel	1, 6, 23, 24, 25, and 26	68%	72%

As can be seen in Table 5-6, **Alignment 4 – Azusa Avenue / SR 39 to the Glendora Tunnel** was the best scoring and most favorable alignment.

Alignment 4 offers many potential benefits, including:

- Requiring the shortest length of new pipe due to repurposing the Glendora Tunnel
- Having the fewest number of major utility crossings
- Having the fewest public facility impacts
- Having the fewest major intersection crossings

Outside of the scoring system, Alignment 4 also offers other benefits to the RRWP, such as being able to eliminate 14,000 ft of pipe associated with the Backbone Alignment and providing a more preferred discharge location for the replenishment water being supplied to the USGMWD.

Details of the decision model inputs, scoring, weighting, and results can be found in Appendix T. Figure 5-13 presents **Alignment 4 – Azusa Avenue / SR 39 to the Glendora Tunnel**.

5.2.2.3 Refinement of DPR Alignment 4

This Project recognizes that construction of a large diameter pipeline within Azusa Avenue would have significant impacts on the community. Azusa Avenue is one of the most heavily traveled surface streets in the area and is a popular through street from the 10 Freeway in the south to the 210 Freeway in the north. North of the 210 Freeway, Azusa Avenue is home to downtown Azusa, an improved, walkable downtown district with shops, wide sidewalks, and narrow streets.

Towards that end, this FLDR identified two alternate alignments to Azusa Avenue to get from Arrow Highway to the Glendora Tunnel. Both alternative alignments follow Alignment 4 from the Backbone Alignment to the intersection of Irwindale Avenue and Gladstone Street. When Alignment 4 turns east in Gladstone Street, both alternatives would continue north in Irwindale Avenue. Upon reaching Foothill Boulevard, Alternative 4A would turn west for approximately one-half mile and then head north in the open land adjacent to the San Gabriel River multi-purpose trail. The pipe would be constructed parallel to the trail outside of the influence of the levee. North of the San Gabriel Canyon Spreading Grounds, Alternative 4B would turn east. As of the time of this writing, there is a vacant parcel north of the City of Azusa's Filtration Plant that could serve as the portal for a tunnel. Alternatively, the tunnel portal could be located west of San Gabriel Canyon Road. The alignment would then tunnel east and connect back with Alignment 4.

Alternative 4A has several "pinch points" where the distance between the San Gabriel River and the adjacent railroad tracks narrows. At the time this FLDR was prepared, information was not available on the levee to determine if there would be enough space to construct a large diameter pipeline. Additional evaluations are required to confirm the feasibility of this alignment.

Alternative 4B would be located entirely within existing public rights-of-way. From Irwindale Avenue Alternative 4B would turn east in Foothill Boulevard, north in Todd Avenue, and then east in Sierra Madre Avenue back to Alignment 4. While still entirely located within existing public rights-of-way, Alternative 4B avoids Azusa Avenue and would be located on much less impactful streets.

Figure 5-13 presents Alternatives 4A and 4B. Both alternatives carry the same benefits as the base Alignment 4 located in Azusa Avenue but were developed to try to avoid the more challenging sections of the alignment.

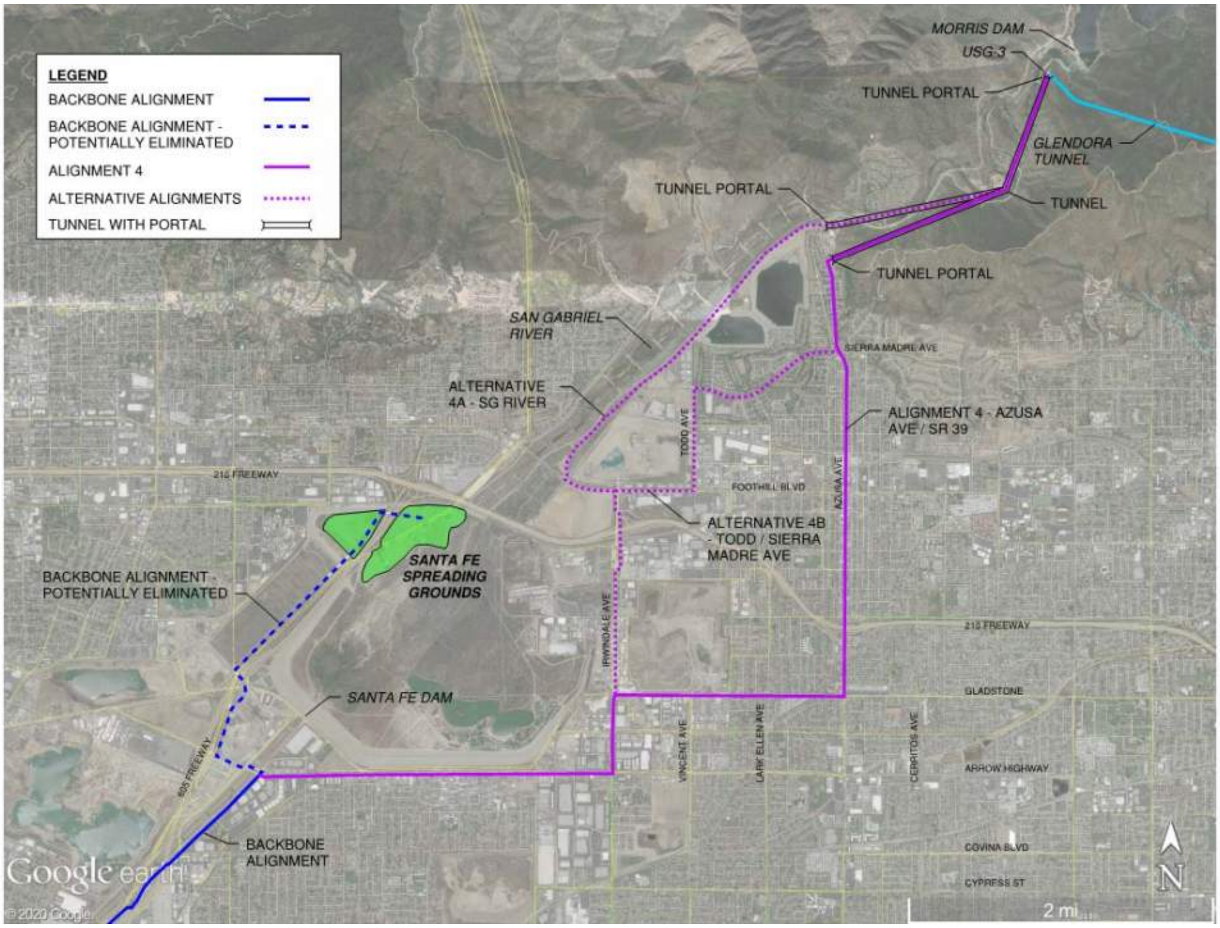

Figure 5-13 Alignment 4 – Azusa Avenue / SR 39 to Glendora Tunnel and Alternatives

5.2.2.4 Conclusions

In addition to being the preferred alignment for the DPR system in the assessment completed, Alignment 4 – Azusa Avenue / SR 39 to the Glendora Tunnel offers other qualitative benefits to the RRWP outside of those strictly considered in the screening criteria. Among these benefits are the ability to eliminate 14,000 ft of the Backbone Alignment and provide replenishment water at a more preferred location.

The use of the Glendora Tunnel is the preferred alignment to get from the SFSG to the FEWWTP. Several alternatives appear feasible to get from the Backbone Alignment near the SFSG to the Glendora Tunnel. These alternatives are recommended to be carried forward for additional evaluation in subsequent design phases to confirm their feasibility and to select the preferred route.

5.2.2.5 Hydraulic Considerations

Although a detailed hydraulic evaluation and pump station siting study was not completed, a quick review of the topography shows that there is a ~550- ft difference in grade (480 ft at the SFSG compared to 1,030 ft invert elevation at the terminus of the Glendora Tunnel) plus hydraulic losses along the way. Metropolitan prefers to limit the lift at any single pump station to between 300 and 400 ft when possible. Therefore, it appears that at least two additional pump stations would be required. FEWWTP is located at approximately elevation 1080 ft, slightly higher than Glendora Tunnel's invert elevation. A quick review of the hydraulics shows there would be minimal head loss within Glendora Tunnel for the RRWP flows. Pumping would be required to lift water from Santa Fe Spreading Grounds to the Glendora Tunnel connection and ultimately on to FEWWTP. System hydraulics should be further evaluated during subsequent evaluations.

5.2.3 Evaluation of Long Tunnels to Avoid Areas of Concern

Metropolitan retained the services of MJA, outside of the scope of this Project, to evaluate long tunnels to avoid two areas of concern. As part of their evaluation, MJA reviewed available information to determine the feasibility of tunneling these areas and developed an opinion of probable construction cost. These areas could then be compared to the current cut-and-cover methods to determine the preferred construction method.

5.2.3.1 Carson to Long Beach

The first area of concern was the beginning of the proposed conveyance system within the City of Carson. To mitigate anticipated City of Carson concerns on traffic and community impact, Metropolitan considered tunneling within the City of Carson. Further, this section of the conveyance system is proposed within the existing rights of way of Sepulveda Boulevard, which turns into Willow Street. This street has many active and abandoned utilities already in the same corridor due to the historic oil refineries in the area, in addition to the large sewer trunk lines going to the JWPCP. By tunneling this section, the Project could avoid both of these potential obstacles.

This tunnel would begin at the AWT plant and head east below an existing railroad spur line. After crossing beneath Avalon Boulevard and Wilmington Avenue, the tunnel would cross various private properties before aligning with Willow Street. The tunnel would end after crossing the 710 Interstate and the LA River.

5.2.3.2 San Gabriel River Bed

The second area of concern was the section of the SG River Alignment that is proposed within the earthen bottom of the SG River. This section extends from Imperial Highway to Washington Boulevard, where available corridors adjacent to the river channel are temporarily unavailable. While Metropolitan has had conversations with the various jurisdictions that would regulate construction within the river bottom regarding its feasibility, no scour analysis had been completed at the time of this writing. Therefore, it is uncertain how much cover the pipeline would require in order to protect against scour or flotation.

Metropolitan tasked Black & Veatch with revalidating the assumptions used to prepare costs for cut-and-cover construction of the pipeline within the earthen river bottom and then comparing that to the costs prepared by MJA. The revised assumptions within the earthen river bottom included 1) the pipe would require 20 ft of cover, 2) dewatering wells would be required at 25 ft on center, 3) a flow diverting rubber dam would be required to protect the open excavation, 4) 30% of dewatering wells would encounter cobbles and need to be re-drilled, and 5) the trench would have slopes laid back at 1.5 to 1.

Figure 5-14 presents the revised typical construction cross section for the river bed.

Black & Veatch then prepared a new opinion of probable construction cost with the revised assumptions to compare to MJA's tunnel costs.

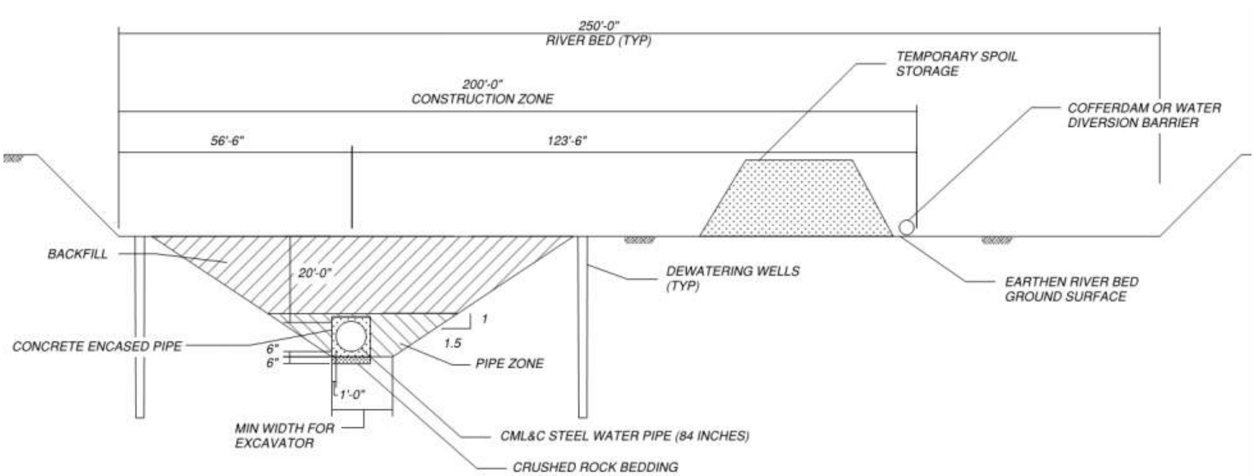

Figure 5-14 Typical Construction Cross Section in Earthen River Beds

5.2.3.3 Summary

Black & Veatch reviewed the costs prepared for tunneling these two areas of concern with the costs for constructing them with cut-and-cover methods and presented the comparison to Metropolitan. Due to uncertainties in subsurface ground conditions, a higher contingency was used for tunneling.

Table 5-7 presents this cost comparison. Black & Veatch, MJA, and Metropolitan met to discuss the cost opinions prepared. During this meeting, it was contingencies were determined for the cut and cover construction, as well as for the tunnels. In general, the level of uncertainty for the construction of tunnels is greater at this planning level and therefore warranted a higher contingency.

Table 5-7 Tunnel Costs Compared to Cut-and-Cover Costs

ITEM	CUT-AND-COVER COSTS	CUT-AND-COVER COST W/ CONTINGENCY (35%)	TUNNEL COST (MJA)	TUNNEL COST W/ CONTINGENCY (40%)	COST DELTA W/ CONTINGENCY
Carson to Long Beach	$120,200,000	$162,300,000	$168,365,200	$235,700,000	$73,400,000
SG River Bed	$139,300,000	$188,100,000	$182,844,900	$256,000,000	$67,900,000

Metropolitan reviewed the costs, along with other factors, and provided the following feedback:

- Further evaluations, including a subsurface geotechnical investigation, are required to determine the preferred construction method for these sections during the next phase of work.
- For the purposes of this FLDR, it is assumed that both sections are installed with cut-and-cover methods. However, the cost opinion for the SG River bed is developed using the costs prepared by MJA, such that a conservative budget is established for this section. The construction methodology for this reach is described in Chapter 3. The cost opinion for the Project is described in Chapter 9.

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6.0 San Gabriel River Alignment Feasibility-Level Design

This chapter describes the key facility components for the SG River Alignment required for the conveyance of advanced treated water from the AWT plant in Carson to the SFSG. Chapter 7 provides similar information for the LA River Alignment.

When this chapter was originally prepared for the 2018 Draft Report, it contained information pertaining to the OC Reach. Since the OC Reach is no longer part of the base Project description, this information has been moved to Appendix U. Table 6-1 summarizes key Project components and characteristics associated with this alignment.

Table 6-1 SG River Alignment Characteristics

CHARACTERISTIC	SG RIVER ALIGNMENT
Minimum Ground Elevation, ft above mean sea level (MSL)	5
Maximum Ground Elevation, ft above MSL	525
Total Pumping Head, ft	686
Overall Alignment Length, miles	38.1
Pump Stations, each	2

Figure 6-1 summarizes the Project methodology as it applies to this chapter.

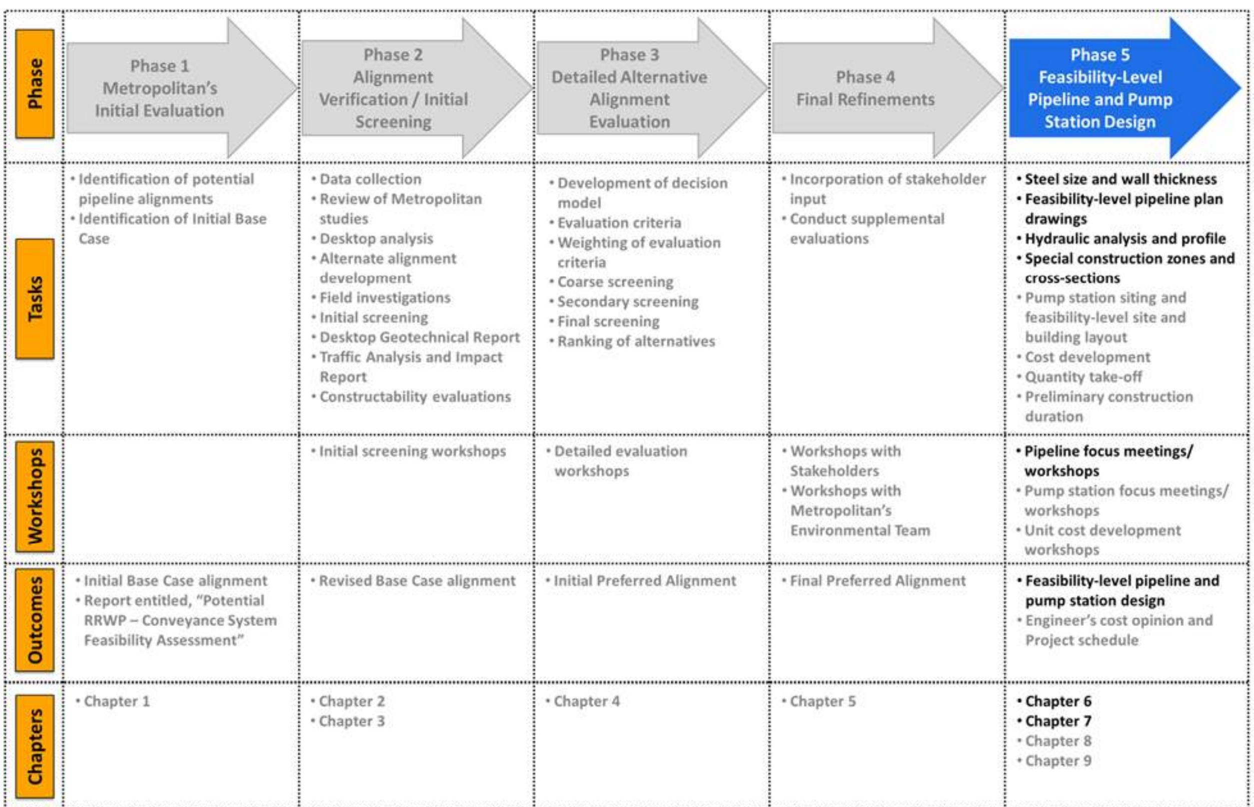

Figure 6-1 Chapter 6 Methodology

6.1 CHAPTER ORGANIZATION

Key operating parameters and Project components affecting alignment decisions for the RRWP are summarized below and discussed in the following sections:

- **SG River Alignment Overview** – This section describes the development of the SG River Alignment and presents a summary of the key attributes of the alignment, as well as areas that require further evaluation during subsequent phases of work.
- **Feasibility-Level Pipeline Plan Drawings** – This section presents the pipeline plan drawings that were developed to show the alignment at a scale large enough to display relevant surface features.
- **Feasibility-Level Pipeline Design** – This section describes the system of pressurized pipelines and tunnels for the SG River Alignment, including design criteria applicable to pipeline sizing and the development of a cost opinion. This section also describes locations that are anticipated to require trenchless construction methods to avoid surface or below grade features or obstructions and presents typical cross-sections for the alignment.

6.2 SAN GABRIEL RIVER ALIGNMENT OVERVIEW

The SG River Alignment, established in Chapter 5, was the result of feasibility-level engineering development, input from internal and external stakeholders, and the ability to procure rights-of-way and easements. 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.

Figure 6-2 presents an overview of the SG River Alignment and the three reaches it is comprised of. Table 6-2 summarizes key information about each reach.

Table 6-2 Key Characteristics of SG River Alignment Reaches

REACH	BEGINNING /ENDING LOCATION	STATIONING (MILES)	LIFT (FT)
1	PS-1 to optional connection for Reach 2	0.0 – 14.0	350
2 (optional OC Reach)	Reach 1 to OC Spreading Grounds (optional)	Not included in current Project	Not included in current Project
3	End of Reach 1 to PS-3	14.0 – 28.4	Note 1
4	PS-3 to SFSG	28.4 – 38.1	336
Note 1: PS-1 provides the lift for Reach 3.			

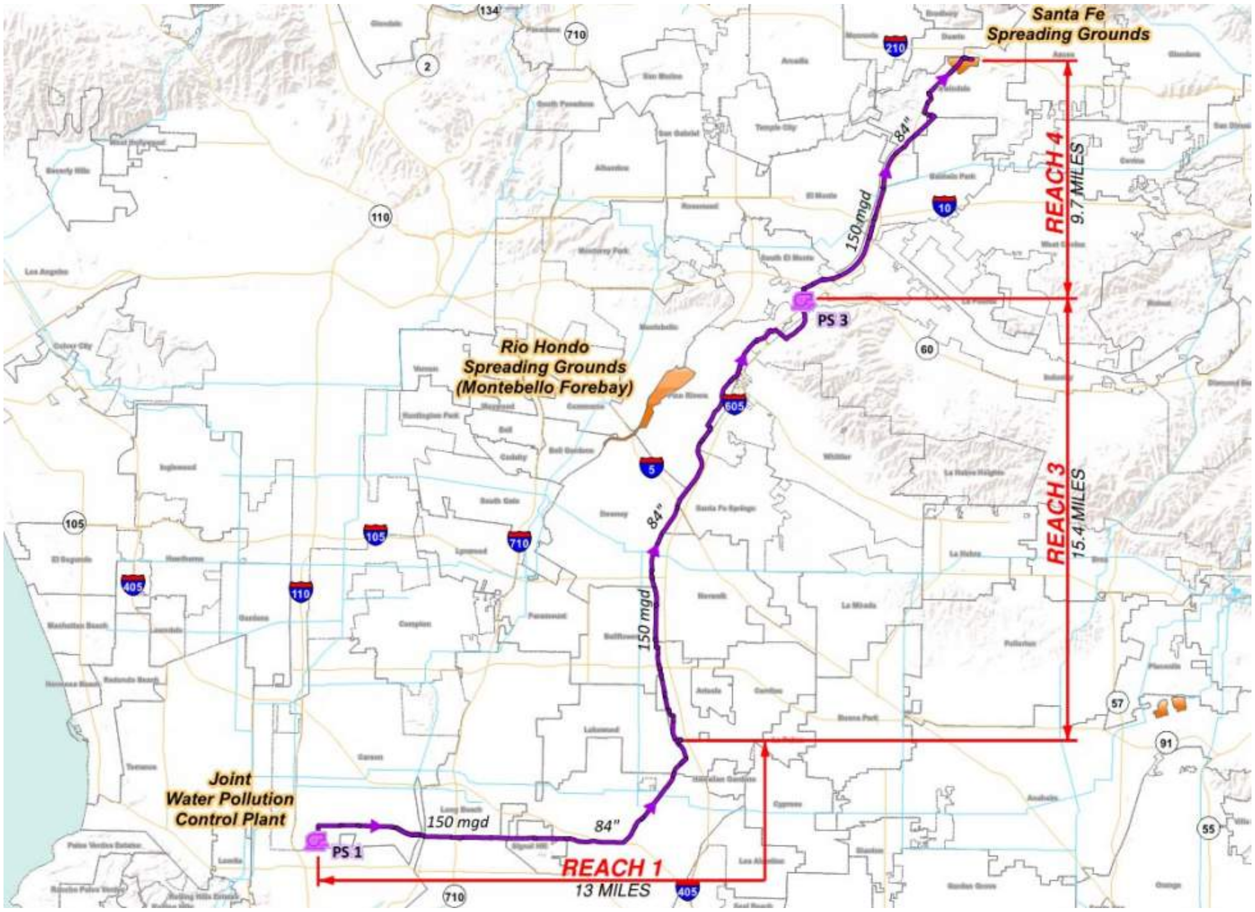

Figure 6-2 SG River Alignment Overview and Reach Extents

A description of each reach is as follows:

- Reach 1 – Reach 1 would be approximately 13 miles in length and would begin at the AWT and terminate at the former junction to the OC Spreading Grounds adjacent to the SG River. From west to east, this reach would pass through the City of Carson, unincorporated LA County, City of Los Angeles, City of Long Beach, City of Lakewood, and City of Cerritos. A majority of this reach would be within existing public street right-of-way with a short stretch along the SG River. This pipeline section would convey up to 150 mgd.
- Reach 3 – Reach 3 would be approximately 15.4 miles in length and begin at the former junction to the OC Spreading Grounds and terminate at the proposed site of PS-3, north of Whittier Narrows Dam. From south to north, the alignment would pass through the Cities of Cerritos, Bellflower, Downey, and Pico Rivera. The majority of the alignment would fall within SCE right-of-way paralleling the SG River. Due to the narrow SCE corridor and environmentally-sensitive nature areas along the SG River, the pipeline may have to be placed alternatively within the river bed itself, as well as within public street rights-of-way for portions of the alignment. It is anticipated that the pipeline would convey up to 150 mgd.

- Reach 4 – Reach 4 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG in the City of Irwindale. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A majority of the alignment would fall within SCE and LACFCD right-of-way with a small stretch in public street rights-of-way. It is anticipated that the pipeline would convey up to 150 mgd. It should be noted that much of Reach 4 parallels USGMWD's proposed IRRP Pipeline Project.

For details on Reach 2 (OC Reach), see Appendix U.

A summary of the key attributes of the SG River Alignment is presented in Table 6-3. Additionally, areas requiring specific considerations during subsequent design phases are described in Table 6-4.

6.3 FEASIBILITY-LEVEL PIPELINE PLAN DRAWINGS

Feasibility-level plan drawings depicting the SG River Alignment were developed in GIS. These plans depict the SG River Alignment at a scale large enough to display surface features that would prevent or restrict cut-and-cover construction and/or require trenchless construction methods.

The feasibility-level plan sheets are provided in Appendix G.

Table 6-3 Summary of SG River Alignment

SEGMENT	PIPE DIAMETER (IN.)	TOTAL LENGTH (FT)	TRENCHLESS CONSTRUCTION (FT)	CITIES	DESCRIPTION	STREET	STREET WIDTH (FT)	TRAFFIC LANES (NO.)	TYPICAL CONSTRUCTION METHOD ASSUMED[1]
1	84	23,957	4,948	Carson, Los Angeles, Long Beach	Roadway	Main St.	80	4 + median	CM1
						Sepulveda Blvd. (turns into Willow St)	80	4,6 + median	
5	84	11,004	222	Long Beach, Signal Hill	Roadway	Willow St.	80	6 + median	CM1
5A	84	26,649	366	Long Beach, Signal Hill	Roadway	Willow St.	80	6 + median	CM1
						Los Coyotes Diagonal	75 to 80	4 + median	
10A	84	6,871	1,006	Lakewood, Cerritos	Roadway/SCE/Private	Los Coyotes Diagonal	75	4 + center lane	CM1/CM2
						Studebaker Rd	80	4 + center lane	
						Del Amo Blvd.	80	4 + median	
20	84	32,140	2,527	Cerritos, Bellflower, Downey	SCE/LACFCD	Studebaker Rd.	75	4 + median	CM2/CM3A
22	84	20,094	422	Downey, Pico Rivera	LACFCD/River	-	-	-	CM3B/CM3C
36	84	4,651	-	Pico Rivera	LACFCD	-	-	-	CM3A
38	84	21,745	1,921	Pico Rivera, Industry, Unincorporated	SCE/LACFCD/Roadway	SG River Pkwy	100	4 + median	CM1/CM2
						Rose Hills Rd.	60	4	
						Workman Mill Rd	85	4 + median	
						Peck Rd	75	4 + median	
38A	84	4,592	3,734	Pico Rivera	LACFCD	-	-	-	CM3A/CM4C
44	84	28,748	4,575	South El Monte, Industry, Baldwin Park, Irwindale, Unincorporated	SCE/LACFCD	-	-	-	CM2/CM3A
52	84	2,292	-	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	22 to 60	2, 4 + center lane	CM1
60	84	4,884	528	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	60 to 80	4 + center lane	CM1
56	84	1,166	-	Irwindale	Roadway	Live Oak Ave.	80	4 + median	CM1
58	84	3,339	517	Irwindale	SCE/Private	-	-	-	CM2
59	84	9,028	1,723	Irwindale	LACFCD	-	-	-	CM3A
TOTALS		**201,160**	**22,489**						

Note 1: See Section 3.4 for details on typical construction methods, including definitions of abbreviations.

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Table 6-4 Areas Requiring Specific Consideration During Subsequent Design Phases

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
General	Where the SG River Alignment would cross a seismic hazard/ fault, a detailed seismic assessment which may include finite element analysis would be required in subsequent design phases to design for seismic resiliency (Segments 5, 5A, and 22).
	At this feasibility level of planning, sufficient information is not available to determine the preferred construction method, cut-and-cover or trenchless construction, at intersections crossing the Preferred Alignment. For planning purposes, this FLDR assumed that all intersections would be crossed using cut-and-cover construction unless there are known jurisdictional requirements prohibiting it (i.e., crossing railroad tracks, rivers, bridges, and Caltrans roads or highways). The FLDR applies a premium to account for the higher cost of construction at all intersections that the traffic analysis report considered to be a Major Intersection. Further evaluation will be completed during the Preliminary Design when a comprehensive investigation and mapping of buried utilities, additional traffic control analysis, and coordination with local jurisdictions would be completed.
	This FLDR assumed that when the pipeline alignment would cross beneath freeway overpasses with adequate clearance from the bridge structure to the ground for construction equipment, and no on or off-ramp access, the pipeline would be constructed using cut-and-cover methods. Based on prior experience with Caltrans District 7, this would be feasible as long as the edge of pipe is at least 10 ft from the bridge footings and abutment. Additionally, a casing is typically required, even with cut-and-cover construction methods. These crossings would be evaluated on a case by case basis. Additional coordination should be conducted with Caltrans during subsequent design phases to better understand their design requirements. No discussions with Caltrans were held at this stage of the project.
	Further investigation into designated wetlands and sensitive wildlife areas along the SG River and associated spreading grounds would be required in subsequent design phases.
1	Assumptions made for the crossing of Alameda Corridor and Dominguez Channel from Reach 1, Sta. 139+17 to Reach 1, Sta. 173+59 should be verified. Should any issues be encountered with the proposed crossing during subsequent design phases, two other viable crossings were identified and are presented in Appendix R.[1]
	Numerous underground utilities were identified along Sepulveda Boulevard and Willow Street. Additional utility research and potholing should be completed to confirm the alignment.[2]
5	None.
5A	This FLDR assumed that the crossing at Interstate 405 would be constructed using trenched construction methods due to freeway's overpass having adequate clearance from the ground to the bridge structure and no on or off-ramp access from Stanton Ave.
10A	This FLDR assumed that trenchless construction would be required to cross the LADWP transmission corridor, SG River, multi-use trails, linear parks, SCE transmission corridor, and concrete drainage channel continuously. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project stakeholders and construction staff to determine if the crossing could be made with two shorter tunnels and cut-and-cover construction through the remaining area. [1]

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
20	The proposed alignment would be constructed in equestrian areas, crowded storage yards, open space, and Ironwood Nine Golf Course from 183rd Street to Alondra Boulevard within the SCE and LACFCD easements.
22	This FLDR assumed a typical construction method to protect against scour and pipe flotation in an earthen channel. Further investigations into LACFCD's requirements on pipes installed in earthen channels and evaluations on scour and pipe flotation should be completed in subsequent design phases. [3] However, the FLDR conservatively assumed the cost for tunneling this section.
	This FLDR assumed that construction of the pipeline would be possible under the four LACDPW's rubber dam locations in the river bed. Coordination with LACDPW would need to be completed in subsequent design phases.
36	This FLDR assumed the alignment would be constructed around the perimeter of the LACFCD spreading basins from Reach 3, Sta. 1207+00 to Reach 3, Sta. 1253+80 (end of Segment 36). Additional evaluations into the impacts the pipeline construction could have on the spreading basins recharge capacities should be completed in subsequent design phases. If pipeline construction is determined not to impact the recharge capacities, a straighter alignment may be possible through the basins with LACDPW's consent.
38	This FLDR assumed that the crossing of a drainage channel that crosses SG River Parkway, just west of Interstate 605, could be constructed using trenched construction methods. During subsequent phases of design, this assumption should be further evaluated.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
38A	This FLDR assumed traditional tunneling methods would be used to construct the segment crossing the SG River and running alongside the railroad tracks from Reach 3, Sta. 1291+00 to Reach 3, Sta. 1328+79 in one continuous span. The crossing would consist of an oversized excavated tunnel with an 84-inch carrier pipe inside. The additional annular space created by the EPBM tunnel (minimum excavated diameter of 118-132 inches) would be filled with grout. Additional geotechnical information should be obtained during preliminary design to determine if other trenchless technologies would be more appropriate for the anticipated ground conditions. [1]
44	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
52	A general corridor was selected that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. However, utility information has not been received from the Cities of Baldwin Park and Irwindale. Future utility investigation should be completed during subsequent design phases and the alignment should be adjusted accordingly.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
	Due to the narrow width of Rivergrade Road (approx. 32 ft) from Reach 4, Sta. 1804+50 to Reach 4, Sta. 1825+00, a full road closure may be required.

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
60	None.
56	None.
58	Construction is required on private property from approximately Reach 4, Sta. 1888+00 to Reach 4, Sta. 1912+00.
59	The corridor selected involves crossing the Santa Fe Dam from approximately Reach 2, Sta. 1966+50 to Reach 2, Sta. 1978+50. Additional evaluations would need to be completed to determine the preferred crossing method.

Notes:
1. See Section 6.4.7 for additional details.
2. See Section 6.4.8 for typical cross-sections.
3. See Section 3.4.3 for typical section.
4. See Figure 5-10~~Figure 5-10~~ for identification of segments comprising the SG River Alignment.

6.4 FEASIBILITY-LEVEL PIPELINE DESIGN

The following section establishes the pipeline design basis, including the pipeline flow rate, hydraulic profile, diameter, material, and governing design standards.

6.4.1 Design Flow

Pipeline diameters were sized for the full program build out of 150 mgd.

6.4.2 Optimization of Pipe Sizes and Pumping Costs

A feasibility-level analysis optimizing the pipe size for the SG River Alignment to balance pumping power cost with capital construction cost was performed. The analysis compared the amortized capital costs and the annual energy consumption to determine the most cost-effective pipe diameter. A more detailed evaluation should be conducted during preliminary design to validate the results. The pipe size optimization calculation is presented in Appendix H.

The pipeline diameters selected for each reach are presented in Table 6-5. The stated diameter shall be the clear inside diameter after application of linings and the velocity shall be in feet per second (fps).

Table 6-5 Pipe Sizes

REACH	PIPE DIAMETER (IN.)	DESIGN FLOW (MGD)	PIPE VELOCITY (FPS)
1	84	150	6.0
3	84	150	6.0
4	84	150	6.0

Note: Reach 2 refers to the OC Reach, which has been excluded from the initial implementation of the Project.

6.4.3 Hydraulic Profile

Preliminary hydraulic profiles were developed for the SG River Alignment (Backbone System) and are presented on Figure 6-3 through Figure 6-5. It should be noted that tunneling under a dam is technically feasible but could lead to permitting challenges.

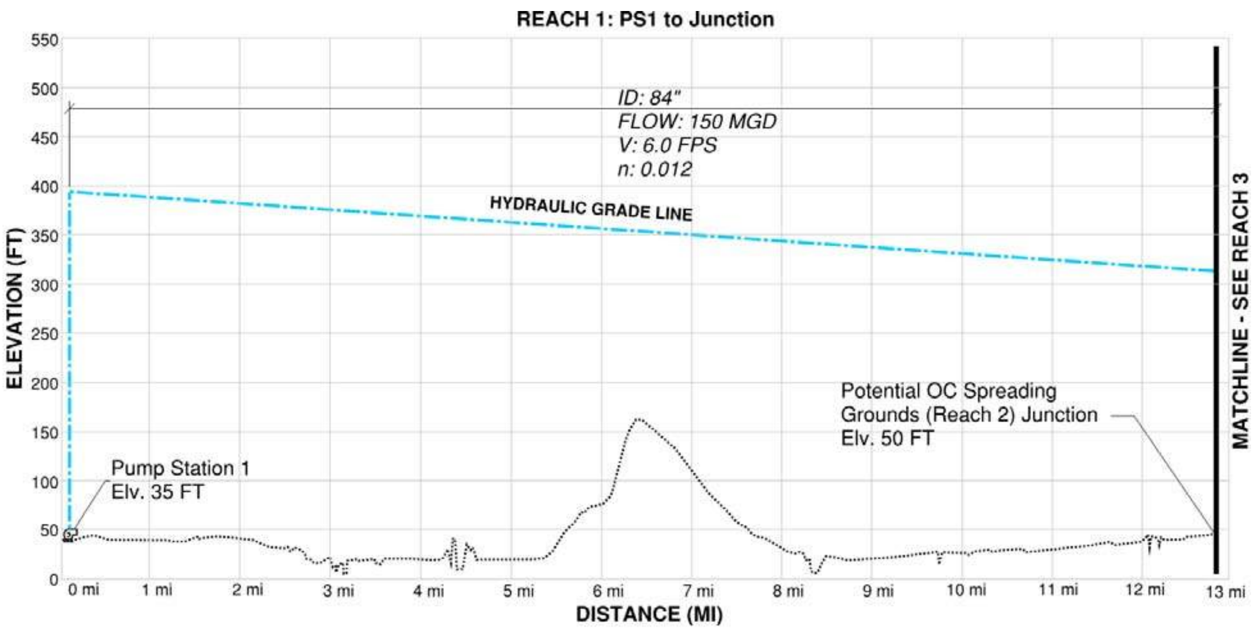

Figure 6-3 Reach 1 Hydraulic Profile (SG River Alignment)

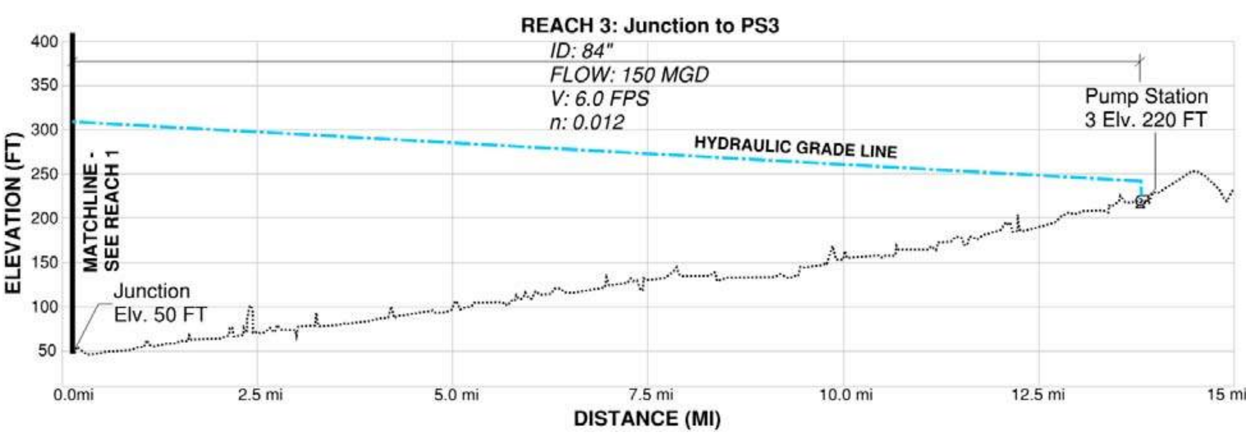

Figure 6-4 Reach 3 Hydraulic Profile (SG River Alignment)

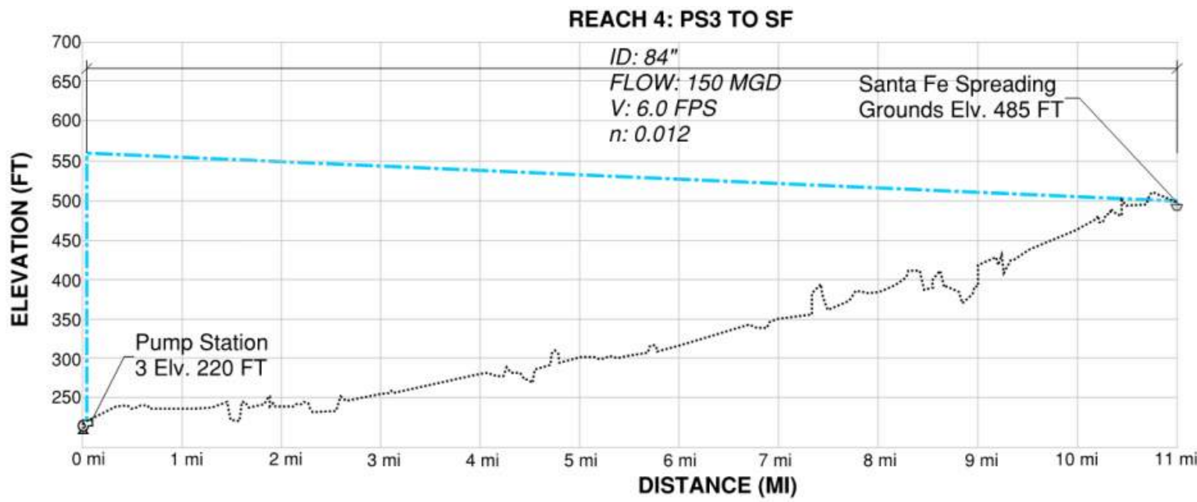

Figure 6-5 Reach 4 Hydraulic Profile (SG River Alignment)

As can be seen on Figure 6-5 above, the proposed alignment crosses the Santa Fe Dam spillway to reach the SFSG. It is currently envisioned that the alignment would cross under the dam using trenchless construction methods, which is technically feasible but could lead to permitting challenges. Additional coordination with the governing jurisdictions would be required during future phases of work to determine the preferred construction method.

6.4.4 Pipe Materials

Pipeline materials would be welded steel pipe in accordance with Metropolitan standards. Lining material selection was not evaluated as part of the study but was assumed to be cement mortar for purposes of establishing a budgetary cost. Metropolitan’s design standards will be followed with evaluating and selecting lining material during future phases of work, in conjunction with water quality data from the demonstration plant.

6.4.4.1 Steel Cylinder Design Calculations

Initial pipeline plate thickness calculations were completed for the SG River Alignment. The steel plate thickness was determined based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads included both internal and external conditions. In addition, a minimum plate thickness due to handling and installation was considered. The evaluation was limited to a basic segment by segment analysis to support cost estimating and provide an initial basis for preliminary design development. Site specific calculations should be completed during preliminary design.

The recommended steel plate thicknesses for each pipe segment are summarized in Table 6-6. Details of the initial pipeline plate thickness calculations are presented in Appendix I.

Table 6-6 Steel Cylinder Thicknesses

REACH	PLATE THICKNESS (IN.)
1	0.500
3	0.500
4	0.500

Note: Steel cylinder thickness calculations assume 42 kips per square inch steel and a minimum plate thickness of 0.375 inches per Metropolitan's standard specification Section 02662.

6.4.5 Pipeline Appurtenances

Pipeline appurtenances would be required for the proper operation and maintenance of the RRWP conveyance system. Appurtenances would include combination air-release and vacuum valves (ARVV), blow-offs, access manways, isolation valves, discharge connections, pumping wells, and other miscellaneous appurtenances. Metropolitan's standard drawings should be used to develop typical details for these appurtenances. All facilities will be designed in accordance with Metropolitan's standards and guidelines, which includes cross contamination prevention at air valve sites.

As part of the preliminary design, a study should be performed to determine potential blow-off and ARVV locations along the alignment. Locations where blow-offs could be connected to storm drains, existing channels, or drainage courses would also be identified during preliminary design.

In general, blow-offs would be located at low points along the pipeline and ARVVs would be located at high points.

6.4.6 Intersections

A list of Major and Minor Intersections, as designated by the Traffic Impact Analysis, for each Segment of the SG River Alignment is provided in Table 6-7.

Table 6-7 Summary of Intersection Designations

SEGMENT	INTERSECTION	CLASSIFICATION
1	Sepulveda Blvd. @ Dolores St.	Minor
	Sepulveda Blvd. @ Marbella Ave.	Minor
	Sepulveda Blvd. @ Panama Ave.	Minor
	Sepulveda Blvd. @ Avalon Blvd.	Major
	Sepulveda Blvd. @ Banning Blvd.	Minor
	Sepulveda Blvd. @ Wilmington Ave.	Major
	Sepulveda Blvd. @ Tesoro/Phillips 66	Minor
	Sepulveda Blvd. @ Alameda Connector	Minor
	Sepulveda Blvd. @ Intermodal Wy.	Minor
	Sepulveda Blvd. @ R/R Xing	Major
	Sepulveda Blvd. @ ICTF	Minor

SEGMENT	INTERSECTION	CLASSIFICATION
	Sepulveda Blvd. @ Middle Rd.	Minor
	Sepulveda Blvd. @ CA-103 terminus	Minor
	Sepulveda Blvd. @ Regway Ave.	Minor
	Sepulveda Blvd. @ Santa Fe Ave.	Major
	Sepulveda Blvd. @ Easy Ave.	Minor
5	Willow @ Golden Ave.	Minor
	Willow @ Magnolia Ave.	Minor
	Willow @ Pacific Ave.	Minor
	Willow @ Earl Ave.	Minor
	Willow @ Long Beach Blvd.	Major
	Willow @ Atlantic Ave.	Major
	Willow @ California Ave.	Minor
	Willow @ Orange Ave.	Minor
	Willow @ Walnut Ave.	Minor
	Willow @ Town Center	Minor
	Willow @ Cherry Ave. (alignment turn)	Major
5A	E. Willow @ Cherry Ave. — continued from 5	Major
	E. Willow @ Dawson Ave. / Town Center E.	Minor
	E. Willow @ Junipero Avenue	Minor
	E. Willow @ Temple Avenue	Minor
	E. Willow @ Redondo Avenue	Major
	E. Willow @ Grand Avenue	Minor
	E. Willow @ Lakewood Boulevard	Major
	E. Willow @ Clark Avenue	Major
	E. Willow @ Bellflower Boulevard	Major
	E. Willow @ N. Los Coyotes Diagonal (alignment turn)	Minor
	Los Coyotes Dia. @ Spring St.	Minor
	Los Coyotes Dia. @ Woodruff Ave.	Minor
	Los Coyotes Dia. @ Wardlow Rd.	Minor
	Los Coyotes Dia. @ Palo Verde Ave.	Minor
	Los Coyotes Dia. @ Studebaker Rd. / Parkcrest St.	Major
	Los Coyotes Dia. @ Carson St. — continues to 10A	Minor
10A	Los Coyotes Diagonal @ Carson — continued from 5A	Minor
	Studebaker @ Del Amo — continued from 10A	Major
20	Studebaker @ 195th Street	Minor
22	None	N/A

SEGMENT	INTERSECTION	CLASSIFICATION
36	None	N/A
38	Shepherd St. @ Rose Hills Rd.	Minor
	Rose Hills Rd. @ Workman Mill Rd.	Minor
	Workman Mill Rd. @ E Mission Mill Rd.	Minor
	Workman Mill Rd. @ Rose Hills Gate 1	Minor
	Workman Mill Rd. @ College Dr.	Minor
	Workman Mill Rd. @ Peck Rd.	Minor
	Peck Rd. @ Pellissier Rd.	Minor
	Peck Rd. @ Rooks Rd.	Major
38A	None.	N/A
44	None	N/A
52	Rivergrade @ Brooks Dr.	Minor
60	Rivergrade @ Live Oak Ave.	Minor
56	Live Oak @ Graham	Minor
58	None	N/A
59	None	N/A

6.4.7 Trenchless Construction Recommendations

In order to establish a conservative budgetary construction cost for the portions of the alignment preliminarily identified for trenchless installation, it was necessary to select a feasible trenchless construction method for each location. To do this, the engineering team reviewed the trenchless methods that were identified as applicable in the Desktop Geotechnical Evaluation and selected a feasible method for each trenchless installation site based on its location, length, pipeline size, and the foreseeable subsurface geotechnical and hydrogeologic conditions available from the desktop studies.

The next phase of the Project is expected to include site specific subsurface geotechnical explorations, comprehensive investigations, and mapping. These site-specific analyses will allow for a final selection of trenchless installation methods to be used at each location and may warrant that the trenchless methods described herein be revised.

The selected trenchless methods provided the basis for development of the feasibility level Engineer's OPCC for the Project. Figure 6-6 correlates the trenchless identification number listed in Table 6-8 (shown below) with the location of each trenchless sub-segment along the SG River Alignment. Table 6-8 summarizes the assumptions used to select the trenchless methods. The geotechnical information presented in Table 6-8 was based on the provided in the Desktop Geotechnical Evaluation.

It should be noted that a conservative depth of cover was assumed generally equal to three times the excavated diameter for the purposes of establishing a conservative budget for each trenchless crossing. Section 6.4.8 evaluates nine trenchless crossings in greater detail. At these locations, the depth of cover that was assumed to be required were further refined, which, in some cases, led to them being reduced to less than three times the excavated diameter based upon the trenchless construction method assumed, the anticipated ground conditions, and the sensitivity of facilities for which it would cross beneath.

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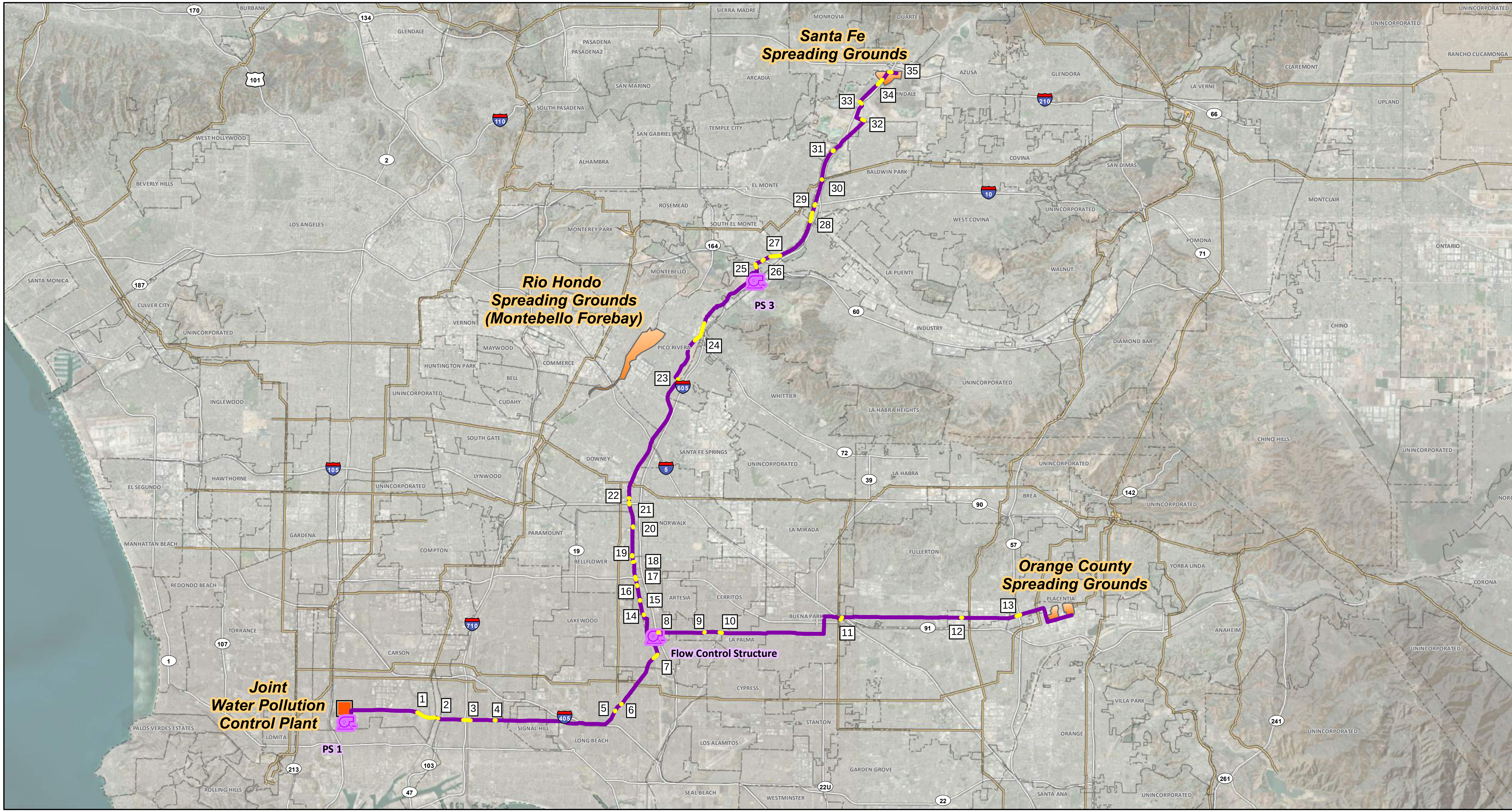

Existing MWD Distribution System

Preferred Alignment

Trenchless / Tunnel Undercrossing with ID #

Pump Station or Flow Control Structure

Spreading Basins

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Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 6-6: Final Preferred Alignment Trenchless/Tunnel ID

N

1 in = 3 miles

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Table 6-8 Assumed Trenchless Construction Methods (SG River Alignment)

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
1	3,442	Intersection / railroad / river	7	11	33	Yes	Traditional Tunneling (EPBM)	-	-	Yes	Length and curves would make MT difficult but not impossible, recommend EPBM at this time.
2	88	Railroad	7	9	27	Yes	Microtunneling	-	-	-	MT would be best suited to manage risk under railroad.
3	1,418	River	7	9	27	Yes	Microtunneling	Yes	-	-	Too large diameter for HDD, too short for conventional tunneling. Not possible to dewater and use jack & bore.
4	222	Intersection / Railroad	7	9	27	Yes	Jack & Bore	-	-	Yes	Presence of clay and short drive length make jack & bore feasible with dewatering.
5	166	River	7	9	27	Yes	Jack & Bore	-	-	-	Crossing is under a concrete lined channel which appears to generally only have minimal flow. Jack & Bore acceptable.
6	200	River	7	9	27	Yes	Jack & Bore	-	-	-	Crossing is under a concrete lined channel which appears to generally only have minimal flow. Jack & Bore acceptable.
7	1,006	River	7	9	18	Yes	Microtunneling	-	-	-	Crossing would not suitable for jack & bore as a river crossing.
8	206	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
9	167	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
10	249	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
11	580	Freeway	7	9	11	Yes	Microtunneling	-	-	-	Drive length too long for Jack & Bore.
12	270	River	7	9	11	Yes	Microtunneling	-	-	-	Drive length too long for Jack & Bore.
13	280	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	
14	205	Intersection	7	9	27	Yes	Jack & Bore	-	-	-	Presence of clay and short drive length make jack & bore feasible with dewatering.
15	468	Freeway	7	9	27	Yes	Microtunneling	-	-	-	Drive length long enough to assume MT, particularly with fine grained soils and sands and crossing critical infrastructure.
16	102	Dam	7	9	27	Yes	Jack & Bore	-	-	-	Crossing under levee. Into drainage area. Jack & Bore acceptable due to length.
17	422	River	7	9	27	Yes	Microtunneling	-	-	-	Length and lack of clay lend it to MT.
18	3,734	River/Railroad	7	11	22	Yes	Traditional Tunneling (EPBM)	-	-	-	Length and curves would make MT difficult but not impossible. However, EPBM is recommended for budgeting at this time. Further analysis would be recommended to confirm in later design stages.
19	325	Freeway	7	9	27	Yes	Jack & Bore	-	-	-	Short drive length favors jack & bore.

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
20	88	Railroad	7	9	27	Yes	Microtunneling	-	-	-	MT would be best suited to manage risk under railroad.
21	842	Freeway	7	9	27	Yes	Microtunneling	-	-	-	Length and lack of clay lend it to MT.
22	666	River	7	9	27	Yes	Microtunneling	Yes	-	-	Crossing would not be suitable for jack & bore as a river crossing.
23	381	Freeway	7	9	27	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
24	1,825	River	7	9	27	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
25	1,631	Railroad / River	7	9	18	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
26	325	Freeway	7	9	27	Yes	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
27	128	Road	7	9	27	Yes	Jack & Bore	Yes	-	-	Short drive length favors jack & bore.
28	285	Road	7	9	27	No	Jack & Bore	Yes	-	-	Short drive length favors jack & bore.
29	528	River	7	9	11	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT
30	517	Freeway	7	9	18	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
31	1,215	Dam	7	9	27	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.
32	508	Freeway	7	9	27	No	Microtunneling	Yes	-	-	Length and lack of clay lend it to MT.

Notes:

1. Tunnel identification number corresponds with Figure 6-6.
2. Depth below ground surface or river channel to top of pipe or crown of tunnel; generally equal to 3 diameters of the excavated hole.

6.4.8 Feasibility-Level Technical/Construction Details

This section discusses segments of the SG River Alignment where the typical construction methods would not be sufficient to construct the pipeline due to terrain, such as rivers, and/or physical barriers, such as freeways or railroads, or to avoid impacts to the community. A preliminary review of the SG River Alignment identified nine locations warranting feasibility-level technical / construction details. The nine feasibility-level technical / construction detail locations are identified in Table 6-9 and presented on Figure 6-7.

Descriptions for each of the nine feasibility-level technical / construction detail locations are provided in the following subsections, including details on site conditions, existing utilities, easements, and trenchless methodology. Additionally, plan and profiles have been developed for each of the nine locations. All ground elevations shown were obtained through Google Earth and are approximate. Ground surveys were not completed for this FLDR.

Table 6-9 Feasibility-Level Technical/Construction Detail Locations

NO.	STATION	DESCRIPTION
1	Reach 1, Sta. 139+17 – Reach 1, Sta. 173+59	Trenchless crossing of Alameda Street/railroad corridor and the Dominguez Chanel along Sepulveda Boulevard.
2	Reach 1, Sta. 225+38 – Reach 1, Sta. 239+57	Trenchless crossing of 710 Freeway and Los Angeles River along Sepulveda Boulevard.
3	Reach 1, Sta. 635+90 – Reach 1, Sta. 645+96	Trenchless crossing of SG River at Los Coyotes Diagonal.
4	Reach 3, Sta. 808+30 – Reach 3, Sta. 814+10	Trenchless crossing of 91 Freeway along the SG River easements.
5	Reach 3, Sta. 841+37 – Reach 3, Sta. 844+07	Trenchless crossing of the SG River south of Alondra Boulevard.
6	Reach 3, Sta. 1291+00 – Reach 3, Sta. 1328+34	Trenchless crossing of the SG River and parallel to the railroad tracks from Whittier Boulevard to Beverly Boulevard.
7	Reach 4, Sta. 1652+73 – Reach 4, Sta. 1669+04	Trenchless crossing of the Walnut Creek Wash along the SG River
8	Reach 4, Sta. 1871+00 – Reach 4, Sta. 1876+28	Trenchless crossing of the SG River along Live Oak Avenue.
9	Reach 4, Sta. 1997+81 – Reach 4, Sta. 2002+89	Trenchless crossing of the 605 Freeway.

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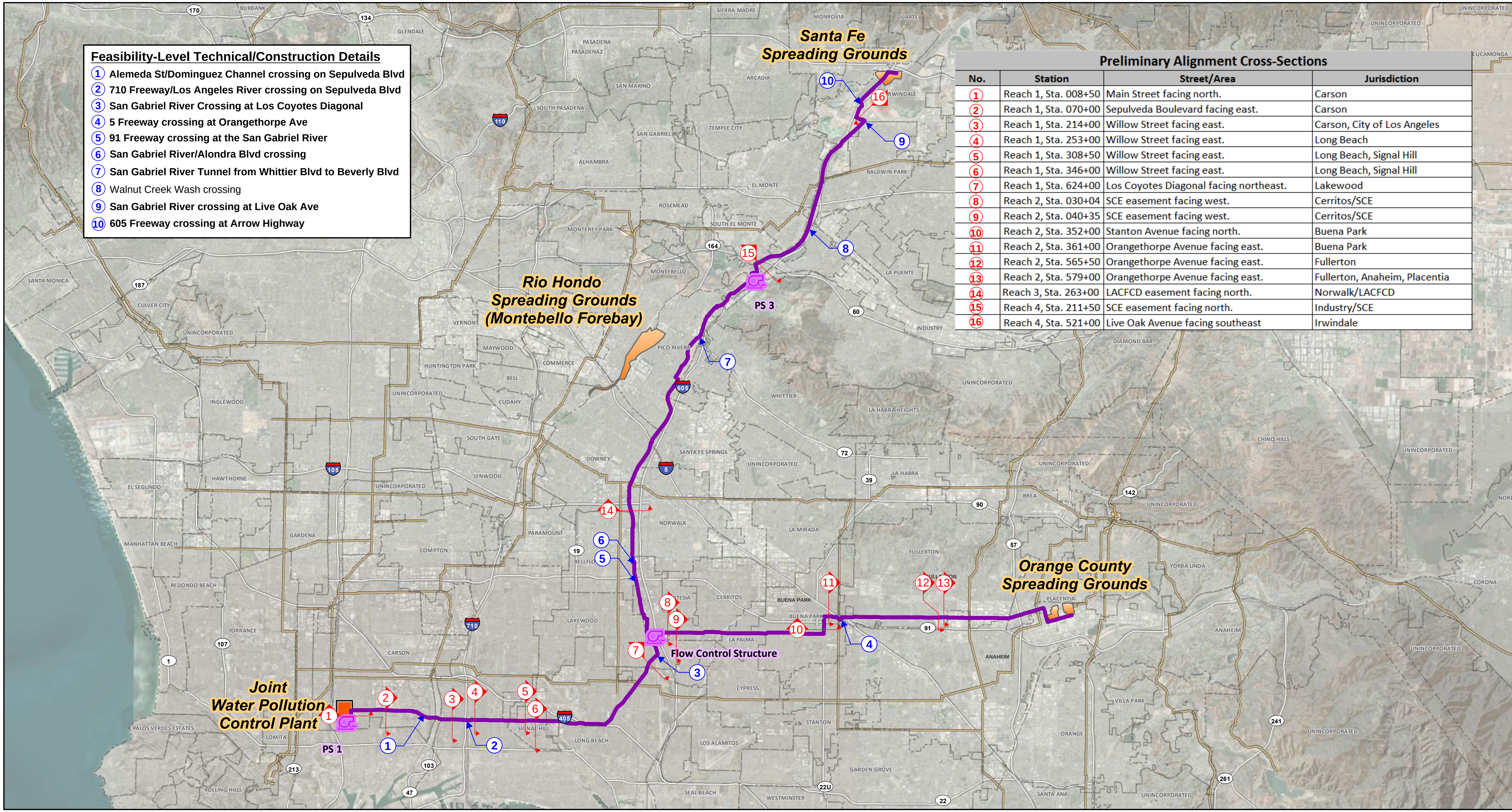

Preliminary Alignment Cross-Sections

No.	Station	Street/Area	Jurisdiction
1	Reach 1, Sta. 008+50	Main Street facing north.	Carson
2	Reach 1, Sta. 070+00	Sepulveda Boulevard facing east.	Carson
3	Reach 1, Sta. 214+00	Willow Street facing east.	Carson, City of Los Angeles
4	Reach 1, Sta. 253+00	Willow Street facing east.	Long Beach
5	Reach 1, Sta. 308+50	Willow Street facing east.	Long Beach, Signal Hill
6	Reach 1, Sta. 346+00	Willow Street facing east.	Long Beach, Signal Hill
7	Reach 1, Sta. 624+00	Los Coyotes Diagonal facing northeast.	Lakewood
8	Reach 2, Sta. 030+04	SCE easement facing west.	Cerritos/SCE
9	Reach 2, Sta. 040+35	SCE easement facing west.	Cerritos/SCE
10	Reach 2, Sta. 352+00	Stanton Avenue facing north.	Buena Park
11	Reach 2, Sta. 361+00	Orangethorpe Avenue facing east.	Buena Park
12	Reach 2, Sta. 565+50	Orangethorpe Avenue facing east.	Fullerton
13	Reach 2, Sta. 579+00	Orangethorpe Avenue facing east.	Fullerton, Anaheim, Placentia
14	Reach 3, Sta. 263+00	LACFCD easement facing north.	Norwalk/LACFCD
15	Reach 4, Sta. 211+50	SCE easement facing north.	Industry/SCE
16	Reach 4, Sta. 521+00	Live Oak Avenue facing southeast	Irwindale

Existing MWD Distribution System
Preferred Alignment
Pump Station or Flow Control Structure
Spreading Basins
Preliminary Alignment Cross-Section
Location of Concept Construction Details

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Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 6-7: Feasibility-Level Technical/ Construction Detail and Cross Section Locations

N

1 in = 3 miles

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6.4.8.1 Alameda Corridor and the Dominguez Channel Crossing (Detail Location 1)

The SG River Alignment proposes crossing the Alameda Corridor at Sepulveda Boulevard and then, approximately 1,700 ft later, crossing the Dominguez Channel. Trenchless construction methods would be required to cross either of these obstructions. Additionally, the land adjacent to Sepulveda Boulevard is used for oil and gas refineries and is congested with tanks, below and above grade utilities, and other manufacturing facilities leaving very limited space for the launching and receiving portals required for any trenchless construction method.

As discussed in Chapter 5, three alternatives were identified to construct these crossings and presented to Metropolitan during a workshop on August 31, 2017. All three alternatives are viable options for constructing through this segment. The most conservative alternative was selected for use in this FLDR. Key details of this crossing are provided in Table 6-10.

Table 6-10 Summary of Alameda Corridor / Dominguez Channel Crossing (Detail Location 1)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
3,442	Intersection / Railroad / River	7	33	Yes	EPBM Tunnel	Y	N	N	N	Y

The selected crossing, displayed on Figure 6-8, Figure 6-9, and Figure 6-10, would use EPBM tunneling methods to cross both the Alameda Corridor and the Dominguez Channel in a single tunnel from Reach 1, Sta. 139+17 to Reach 1, Sta. 173+59. Further evaluation should be completed during the preliminary design phase of the Project to verify this is the preferred crossing. The profile of the proposed crossing is shown on Figure 6-11.

Receiving is recommended from the property west of the Alameda Corridor and south of Sepulveda Boulevard based on available, undeveloped space for portal excavation and contractor staging. Access to the site would be available via the access road on the south side of Sepulveda Boulevard and from the north side of Sepulveda Boulevard via the private parking lot located under the bridge for Sepulveda Boulevard. The potential receiving location is presented on Figure 6-8. Further investigation of the property would be required to finalize portal location and availability.

The proposed pipeline would cross existing railroad tracks twice as the alignment leaves Sepulveda Boulevard to reach the proposed launching site. However, the railroad tracks are fenced off as they cross the driveway to Sepulveda Boulevard and grass has grown over the tracks indicating that the tracks may not be active. Therefore, this FLDR assumed that the pipeline would be constructed across these tracks using cut-and-cover construction methods and that the tracks would be replaced in kind afterwards. Additional investigation into the status of the tracks should be conducted during preliminary design.

The lot east of the Dominguez Channel is recommended for the launching portal. This lot has potentially available space for excavation and contractor staging. The area is currently used as storage. Further investigation of the property would be required to finalize portal location and availability. Construction and easements would have a significant impact on the property, and early real property acquisition is recommended to confirm the alignment.

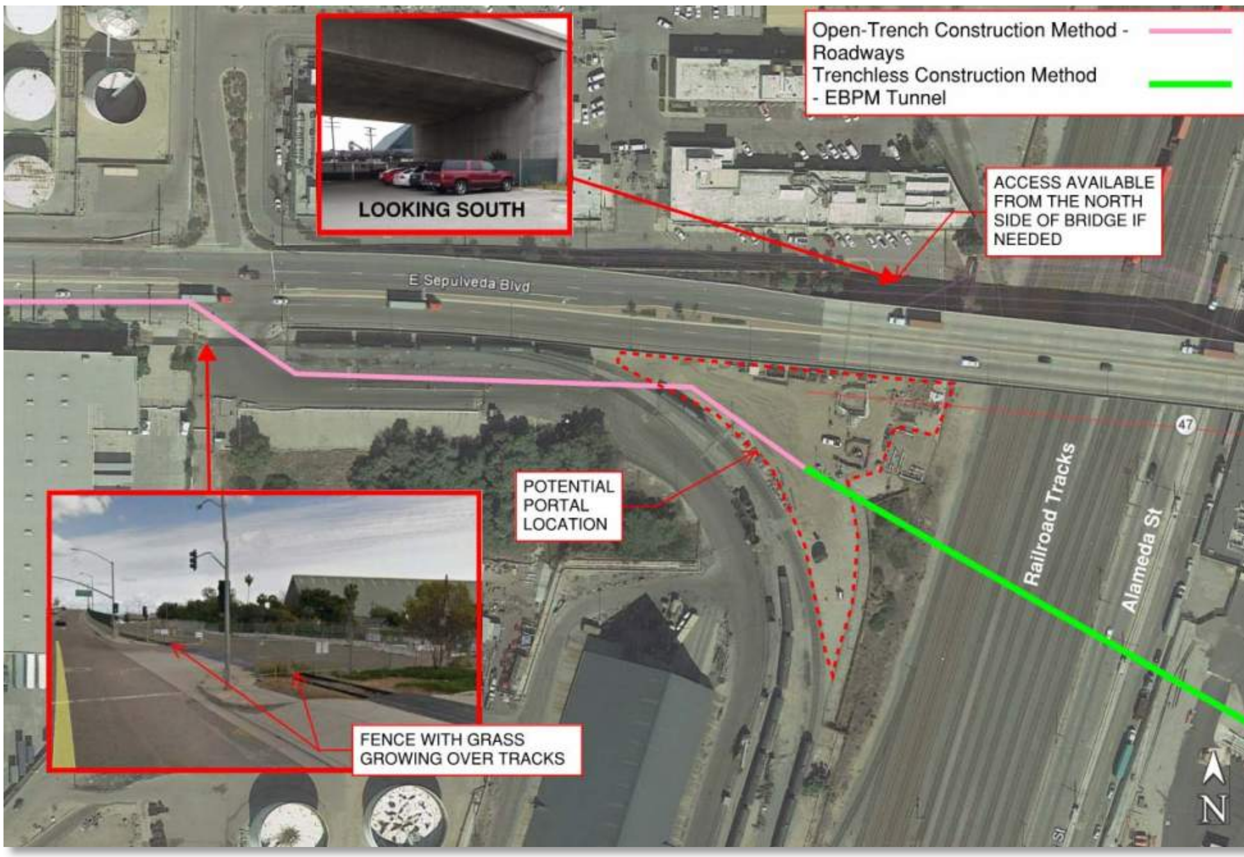
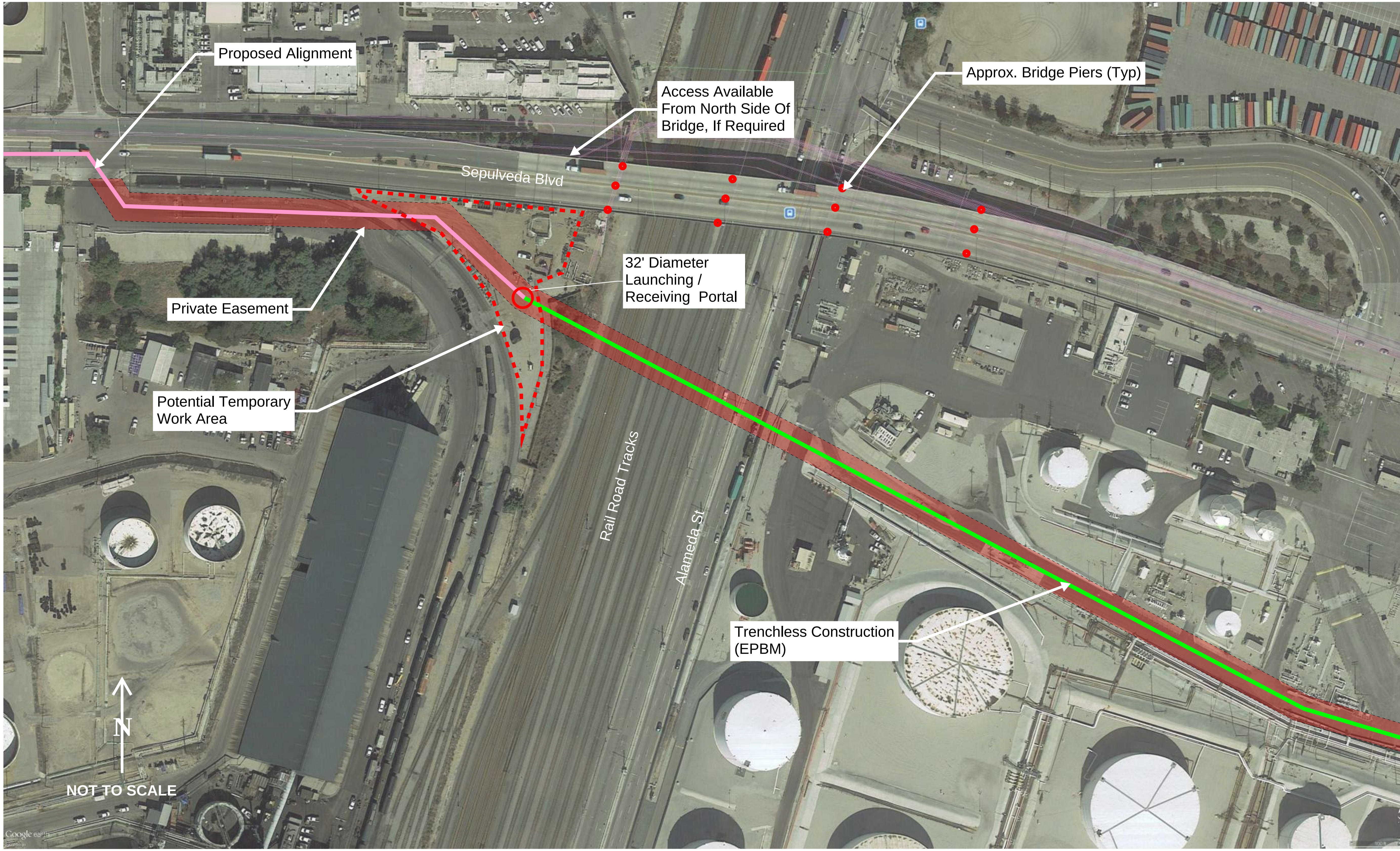


Figure 6-8 Potential Launching Portal Site for the Alameda Corridor/Dominguez Channel Crossing (Detail Location 1)

Due to the depth, both the launching and receiving portals are assumed to be circular.

The proposed receiving site is on the corner of an oil refinery that is congested with existing utilities. Potholing would be required to finalize portal location and feasibility. Additionally, Sepulveda Boulevard has many existing utilities that would need to be crossed as the pipe leaves the street to reach the launching and receiving portal locations. The excavation for the pipeline would need to be deep to avoid interferences at these crossings. Utilities anticipated include storm drain, water, telecommunications, sewer, oil, and gas pipes. Potholing to locate the utilities is recommended. Acquisition of temporary and permanent easements would be required.



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Open-Trench Construction Method - Roadways
Trenchless Construction Method - EPBM Tunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
Alameda Corridor and Dominguez Channel Crossing - Part 1

FIGURE 6-9

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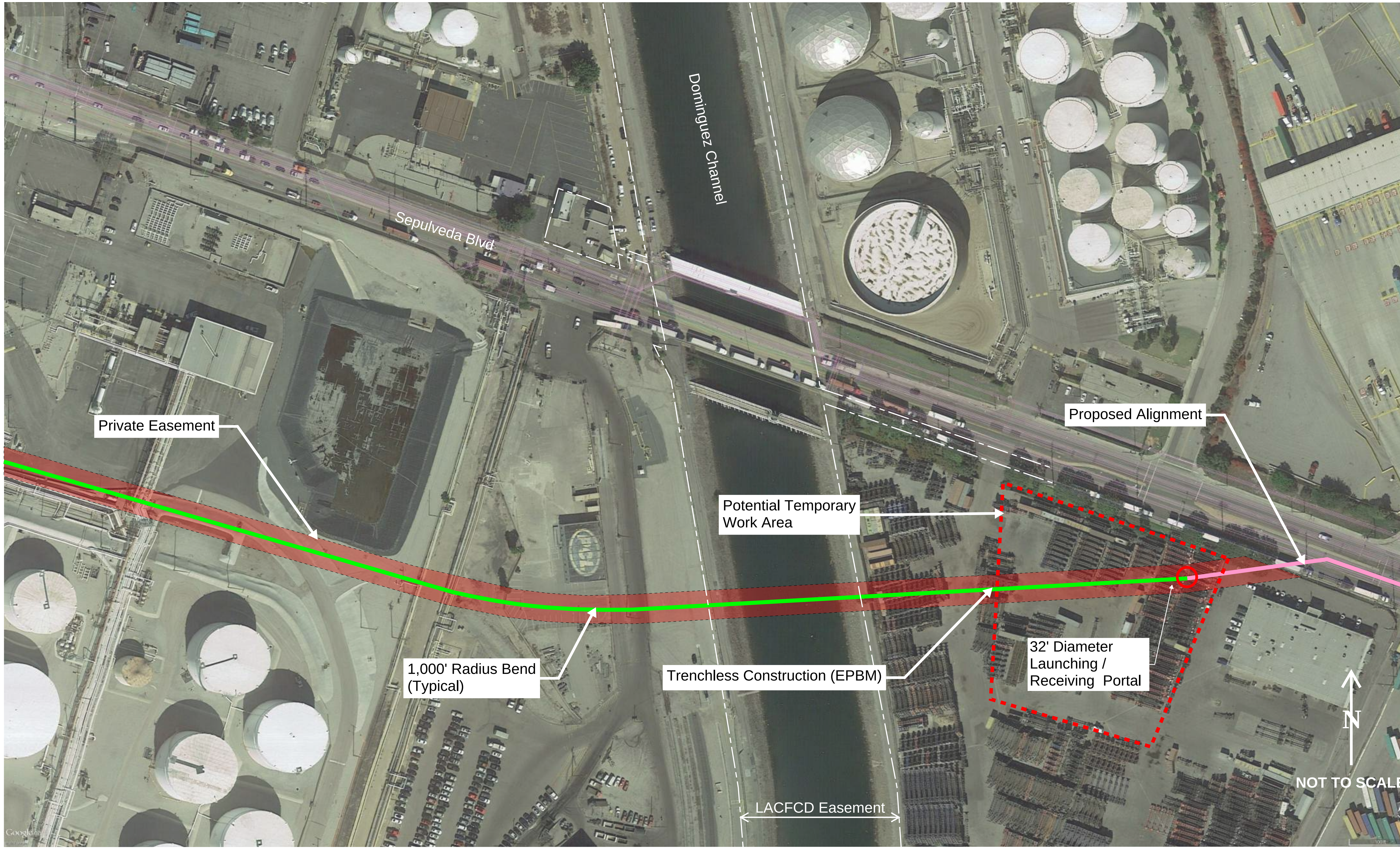

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - EBPM Tunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
Alameda Corridor and Dominguez Channel Crossing - Part 2

FIGURE 6-10

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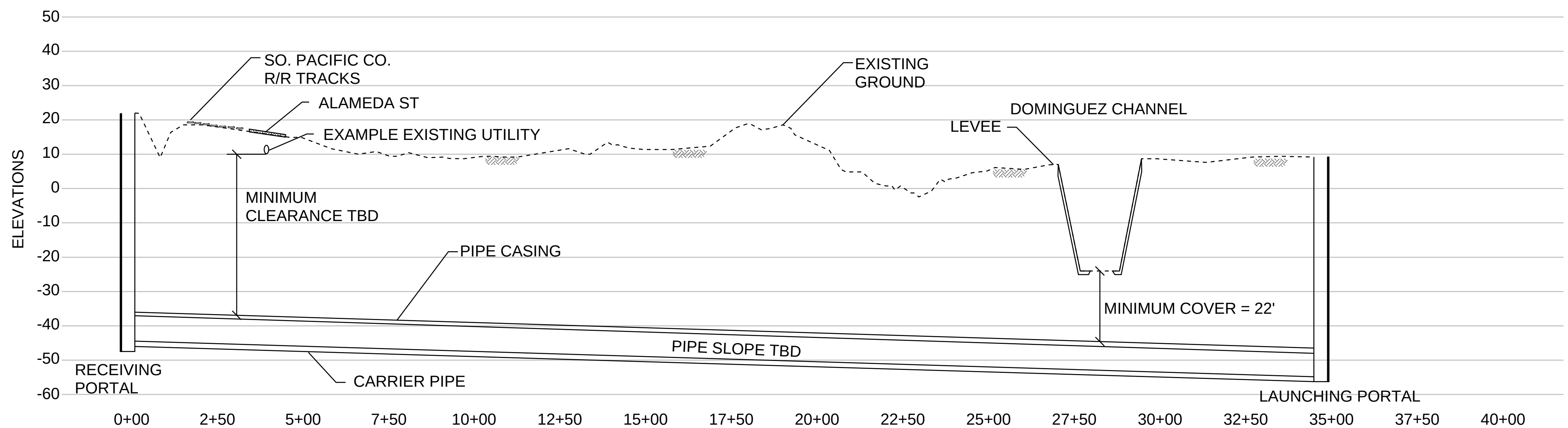

CONVENTIONAL TUNNEL (EPBM) OF ALAMEDA ST AND DOMINGUEZ CHANNEL 1

HORZ: 1" = 400'
VERT: 1" = 40'

BLACK & VEATCH

1" = 200' 0 200' 400' 600' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Alameda Corridor and Dominguez Channel Crossing

FIGURE 6-11

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6.4.8.2 710 Freeway and Los Angeles River Crossing (Detail Location 2)

The SG River Alignment proposes crossing below the 710 Freeway and the Los Angeles River on the south side of Willow St from Reach 1, Sta. 225+38 to Reach 1, Sta. 239+57. Key details of the crossing are provided in Table 6-11. The proposed crossing is shown in plan on Figure 6-12 and in profile on Figure 6-13.

Table 6-11 Summary of the 710 Freeway and Los Angeles River Crossing (Detail Location 2)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,418	River / Freeway	7	11	Yes	MT	Y	N	Y	N	N

Launching is recommended from the west side of the 710 Freeway based upon potentially available space for portal excavation and contractor staging in the vacant lot on the corner of the on/off ramp to the 710 Freeway. Further investigation of the property would be required to finalize portal location and availability. Receiving is recommended from the east side of the Los Angeles River in the area between Willow Street and W 25th Way. The property is recommended for the receiving portal due to limited available space and potential impacts to existing trees. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

This drive length may require an intermediate jacking station. Although with good continuously replenished overcut lubrication, it may be possible without one. The MT boring machine is assumed to need disc cutters to fracture any boulders encountered and the shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. While the cover under the LA River is not known at this time, it is assumed that a minimum of 11 ft would be required below the lowest point, with more cover provided along the rest of the route.

Willow Street is congested with existing utilities and the SG River Alignment may require deeper excavation to avoid interferences as it leaves the street to reach the launching and receiving site locations. These utilities include existing storm drains, water, sanitary sewer, oil and gas piping, and telecommunications. Potholing of these utilities is recommended. The vertical profile of the pipeline would rise after reaching its alignment in Willow Street. Additionally, a corridor of existing oil and gas pipes runs parallel to the Los Angeles River on the east side. Potholing of these utilities is also recommended to confirm the location of the receiving portal.

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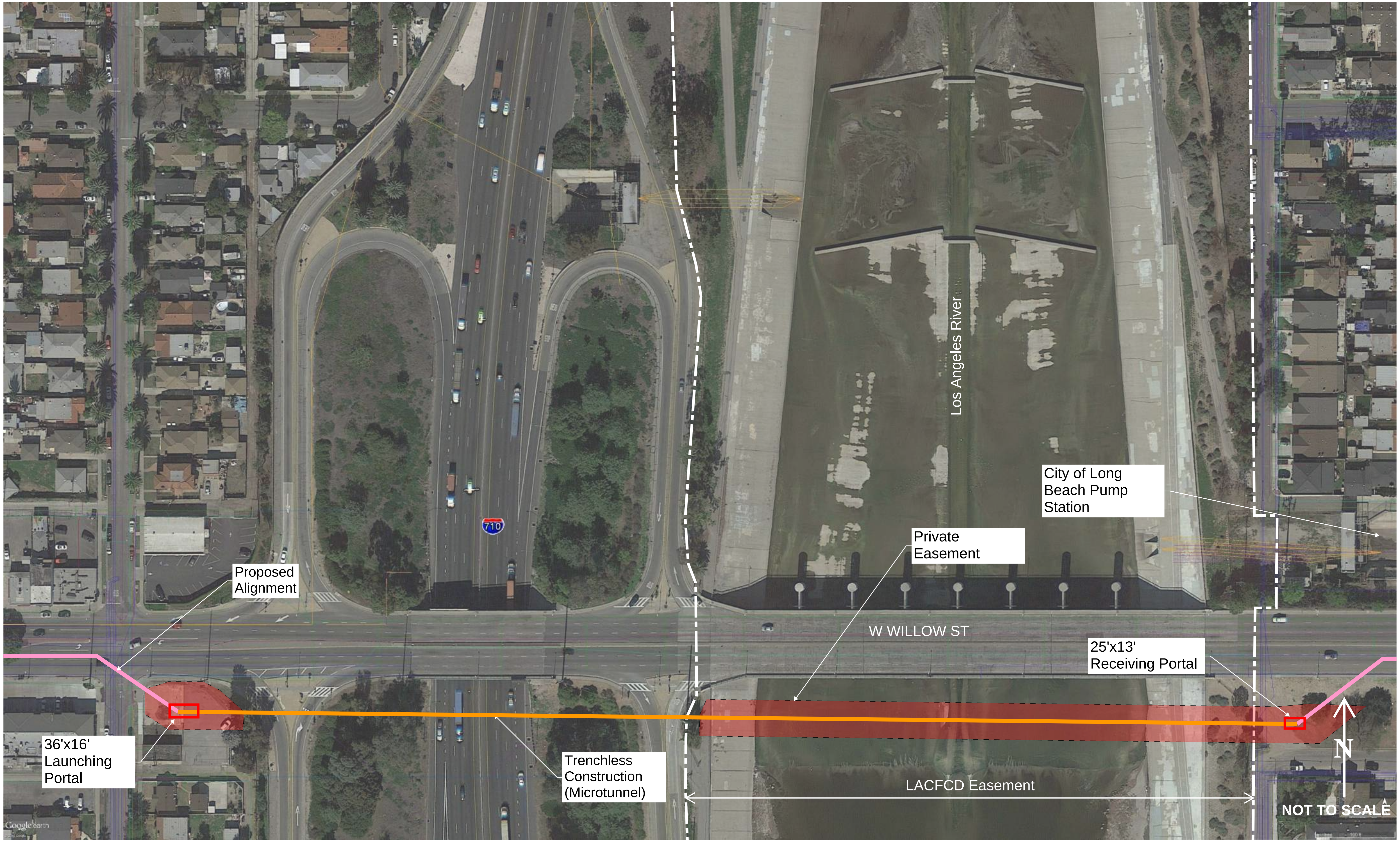

Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

710 Freeway and Los Angeles River Crossing

FIGURE 6-12

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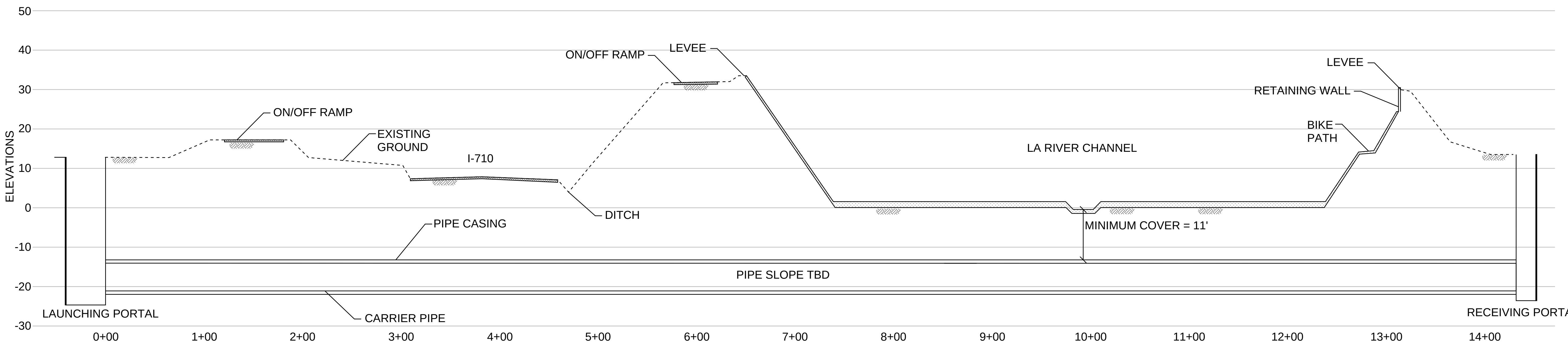

MICROTUNNEL CROSSING OF I-710 AND THE LA RIVER (2)
HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
Profile of 710 Freeway and Los Angeles River Crossing

FIGURE 6-13

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6.4.8.3 SG River Crossing – Los Coyotes Diagonal (Detail Location 3)

The SG River Alignment proposes crossing the SG River at the Los Coyotes Diagonal from Reach 1, Sta. 635+90 to Reach 1, Sta. 645+96 using trenchless construction methods. Key details of the crossing are provided in Table 6-12. The proposed crossing is shown in plan on Figure 6-14 and in profile on Figure 6-15.

Table 6-12 Summary of SG River Crossing at Los Coyotes Diagonal (Detail Location 3)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,006	River	7	18	Yes	MT	Y	N	N	N	N

Launching is recommended from the west side of the river and LADWP easement in the vacant lot at the end of the Los Coyotes Diagonal based upon available, undeveloped space for portal excavation and contractor staging. The Los Coyotes Diagonal dead-ends into the vacant lot with no driveways or other street entrances in the vicinity. Further investigation of the property would be required to finalize portal location and availability. Receiving is recommended from the east side of the river in the vacant space between the drainage channel and Centralia Street due to limited available space. Early real property acquisition is recommended to confirm the alignment and acquire access. Temporary and permanent easements are anticipated to be required.

An existing LACSD sewer line follows this same alignment to cross the SG River. Additionally, overhead LADWP and SCE transmission line corridors run parallel to the SG River. No other utilities are anticipated. Potholing of the LACSD sewer is recommended to confirm the alignment.

The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

This FLDR assumed that this crossing would span across the LADWP transmission corridor, SG River, multi-use trails, linear parks, SCE transmission corridor, and concrete drainage channel in one continuous trenchless segment with a launching and receiving portal on either end. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project stakeholders and construction staff, to determine if the crossing could be made with two shorter tunnels and cut-and-cover construction through the remaining green space.

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Los Coyotes Diagonal

FIGURE 6-14

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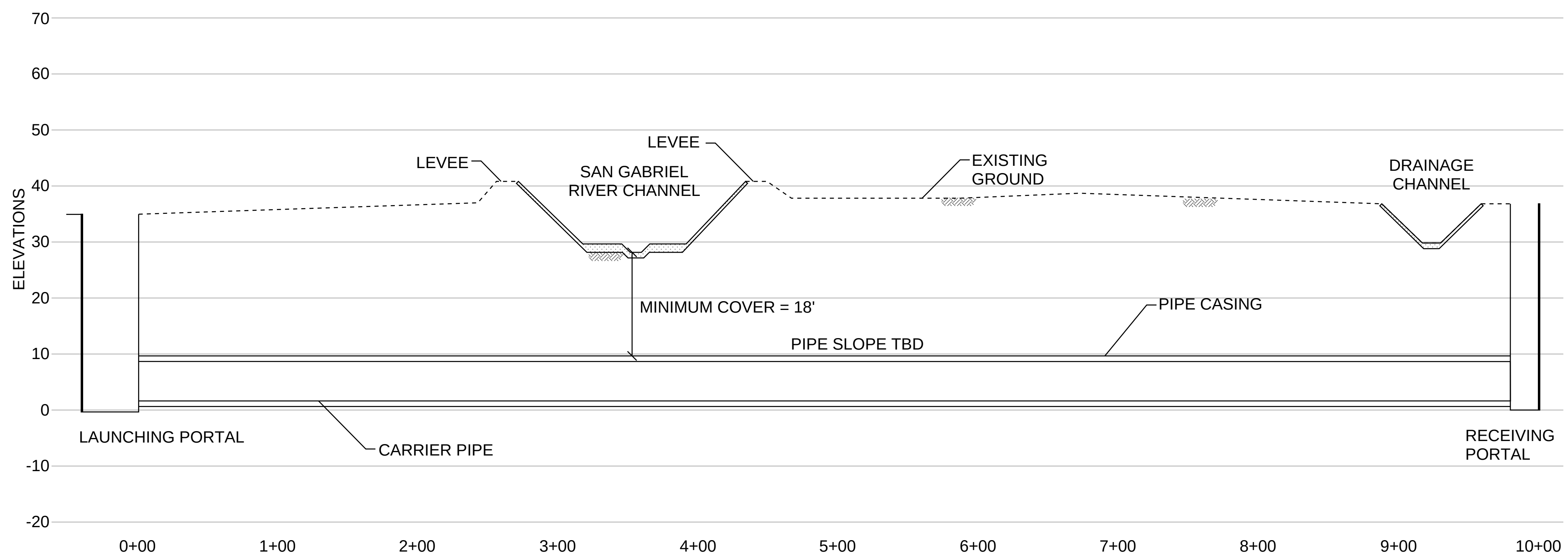

MICROTUNNEL CROSSING OF THE SAN GABRIEL RIVER AT LOS COYOTES DIAGONAL 3

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Los Coyotes Diagonal

FIGURE 6-15

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6.4.8.4 91 Freeway Crossing (Detail Location 4)

While traveling in the SCE and LACFCD easements parallel to the east side of the SG River, the SG River Alignment proposes crossing the 91 Freeway from Reach 3, Sta. 808+30 to Reach 3, Sta. 814+10 using trenchless construction methods. Key details are provided in Table 6-13. The proposed crossing is shown in plan on Figure 6-16 and in profile on Figure 6-17.

Table 6-13 Summary of 91 Freeway Crossing (Detail Location 4)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
580	Freeway	7	11	Yes	MT	Y	N	N	N	N

Launching is recommended from the north side of the freeway based upon potentially available space for portal excavation and contractor staging in the corner of the golf course located within SCE and LACFCD's easements. Construction would directly impact a minimum of one hole on the golf course and construction access could impact additional holes. Further investigation of the property would be required to finalize portal location and availability.

The receiving portal is recommended on the south side of the freeway due to limited available space between an existing long-term storage unit facility and the overhead SCE transmission lines. The recommended receiving portal location is currently used as long-term storage for recreational vehicles (RVs), trucks, and boats in the SCE easement and is directly adjacent to an existing long-term storage unit facility in the LACFCD easement. Construction and easements would have a significant impact on both the launching and receiving properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

No underground utilities would be anticipated to impact this crossing. However, the alignment is located parallel to a SCE transmission line corridor and overhead utilities could impact construction activities.

An inactive railroad corridor is located immediately south of the proposed trenchless construction segment. Additional investigations and coordination with the owner of the railroad corridor would be required in subsequent design phases to confirm this crossing.

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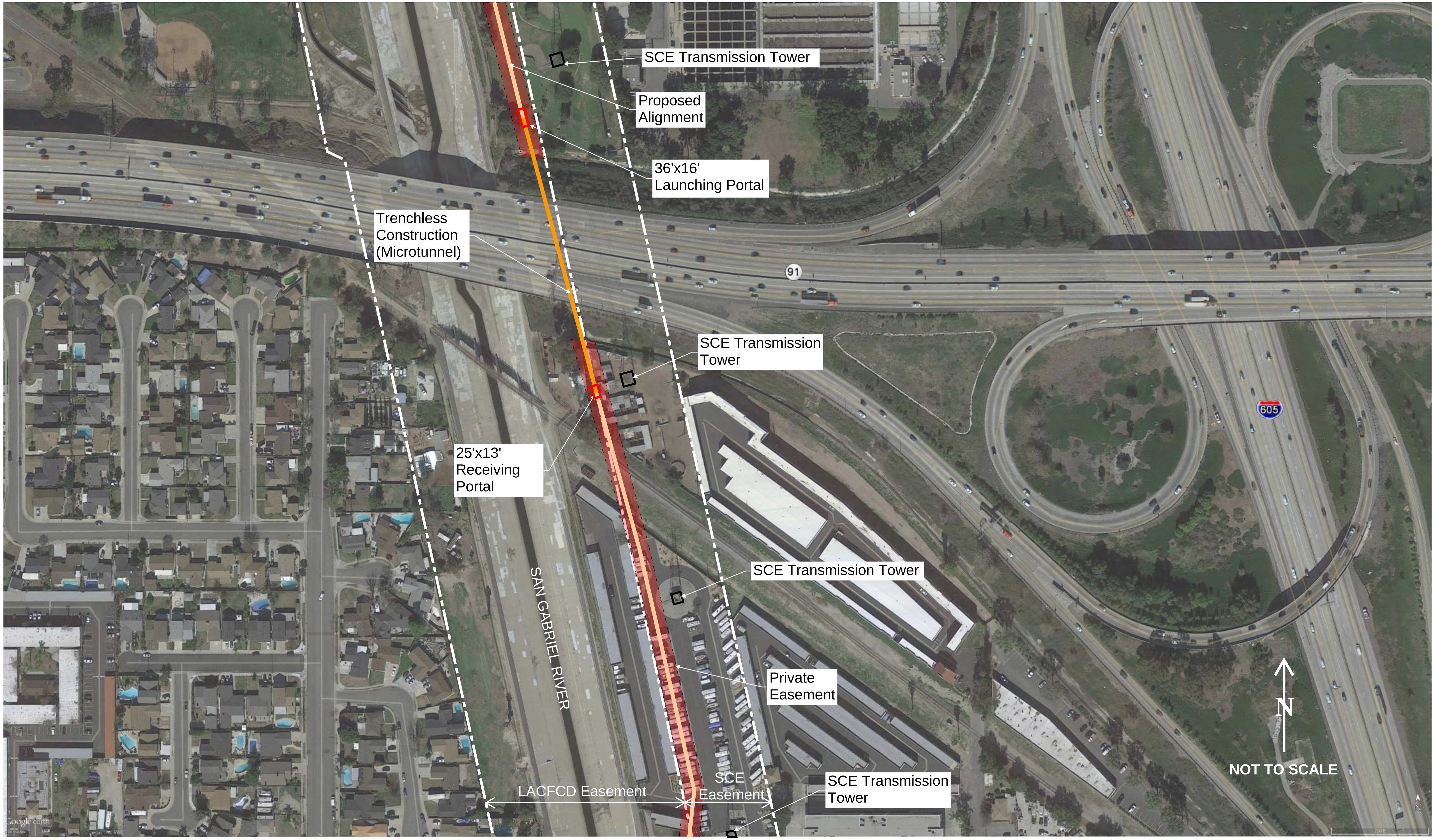

BLACK & VEATCH

Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
91 Freeway Crossing

FIGURE 6-16

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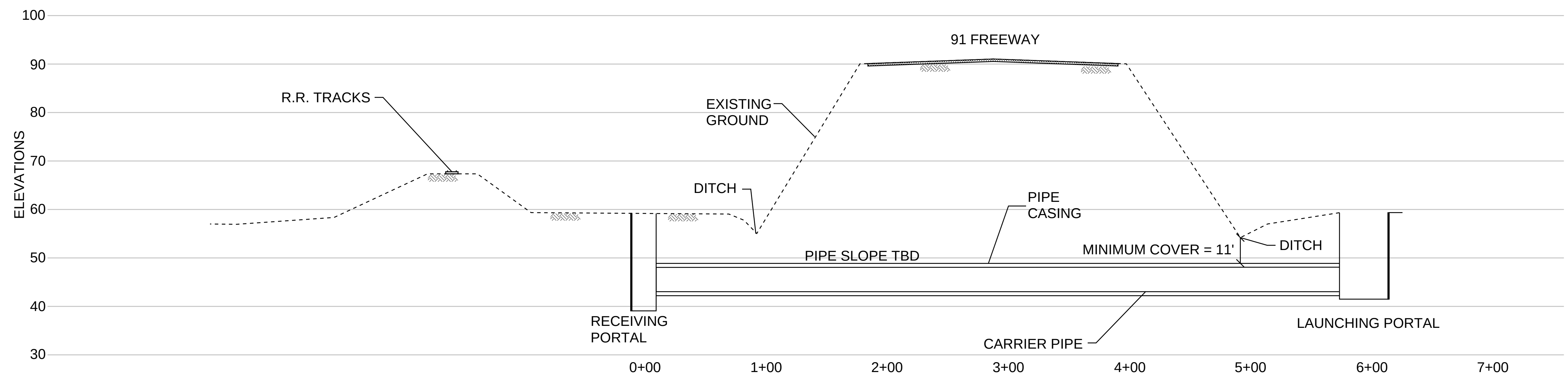

MICROTUNNEL CROSSING OF 91 FREEWAY (4)

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 91 Freeway Crossing

FIGURE 6-17

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6.4.8.5 SG River Crossing - Alondra Boulevard (Detail Location 5)

Traveling parallel to the SG River, the SG River Alignment proposes crossing from the SCE easement on the east side of the SG River to the west side from Reach 3, Sta. 841+37 to Reach 3, Sta. 844+07 using trenchless construction methods. The alignment would then cross under Alondra Boulevard in the SCE easement. Key details of the crossing are provided in Table 6-14. The proposed crossing is shown in plan on Figure 6-18 and in profile on Figure 6-19.

Table 6-14 Summary of SG River Crossing (Detail Location 5)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
270	River	7	11	Yes	MT	Y	N	N	N	N

Launching for the trenchless construction is recommended from the east side of the river based upon potentially available space for portal excavation and contractor staging. The land is used to store transportable property such as RVs, trucks, and boats. Further investigation of the property would be required to finalize portal location and availability. The receiving portal is recommended on the west side of the river due to limited available space between the SG River, a LACSD sewer pipe, and a concrete drainage channel. The area also contains a short, multi-use trail. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

An existing LACSD sewer pipe runs parallel to the SG River and the proposed alignment and crosses under Alondra Boulevard. The alignment would cross the LACSD sewer pipe just prior to crossing under Alondra. Additionally, a LACFCD storm drain connects to the drainage channel in the vicinity of the proposed receiving portal location. Potholing would be required to finalize portal and alignment locations and feasibility.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

In subsequent phases of design, should the land west of the SG River and south of Alondra Boulevard prove to be infeasible for the construction of the alignment for any reason (from property acquisition or otherwise), it would be feasible to cross under the SG River and Alondra Boulevard in one continuous tunnel. Additional details on the bridge abutment for Alondra would need to be collected.

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- Open-Trench Construction Method - SCE Easement
- Trenchless Construction Method - Microtunnel
- Private Easement
- Launching/Receiving Pit
- Trenchless Construction Method - Jack & Bore w/ Dewatering

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Alondra Boulevard

FIGURE 6-18

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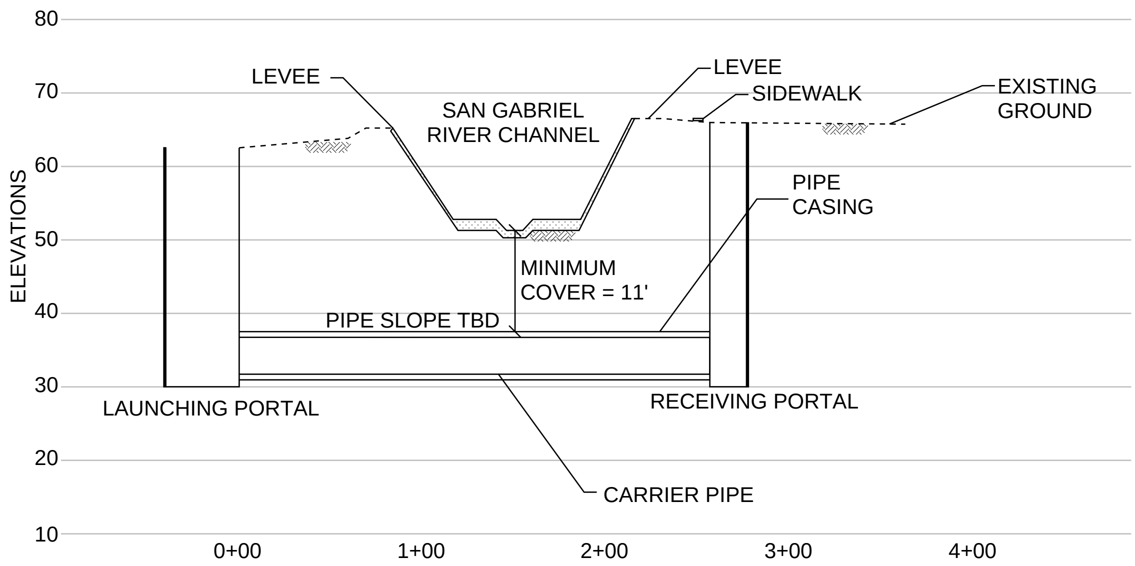

MICROTUNNEL CROSSING OF THE SAN GABRIEL RIVER AT ALONDRA BOULEVARD 5

HORZ: 1" = 50'
VERT: 1" = 12.5'

1" = 50' 0 50' 100' 150' FEET

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Alondra Boulevard

FIGURE 6-19

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6.4.8.6 SG River Crossing - Whittier Boulevard (Detail Location 6)

The SG River Alignment proposes using trenchless construction methods from Reach 3, Sta. 1291+00 to Reach 3, Sta. 1328+34 during which the pipeline would cross Whittier Boulevard, the SG River, railroad tracks, and travel parallel to the SG River in the space between the river levee and the adjacent railroad tracks. The FLDR conservatively assumed that this section would be constructed using trenchless methods due to the narrow space between the river levee and the railroad corridor for construction activities. Additionally, overhead utility poles are present for part of this segment to further limit the available construction space. Key details of the crossing are provided in Table 6-15. The proposed crossing is shown in plan on Figure 6-20 and Figure 6-21 and in profile on Figure 6-22 through Figure 6-24.

Table 6-15 Summary of SG River Tunnel and 605 Freeway Crossing (Detail Location 6)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
3,734	River / Railroad	7	22	Yes	EPBM	Y	N	N	N	N

Launching is recommended from north of the railroad tracks east of the river due to potentially available space for portal excavation and contractor staging. The area is undeveloped and appears unused in LACFCD’s easement. Additional space is potentially available for contractor staging in the existing storage lot for transportable property such as RVs, trucks, and boats in SCE’s easement adjacent to the site. Further investigation of the property would be required to finalize portal location and availability. Receiving is recommended on the west side of the river, south of Whittier Boulevard due to limited available space next to LACFCD’s recharge basins. Construction and easements could impact LACFCD operations on the west property and early real property acquisition is recommended to confirm the alignment and acquire access.

Due to the depth, the receiving portal is assumed to be circular. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. Portions of the alignment would pass close to bridges which are anticipated to have deep foundations. Detailed stress change and ground movement analysis is recommended at these locations.

The west side of the SG River has several existing LACFCD storm drains and a LACSD sewer pipe that the alignment would cross. An existing LACSD sewer pipe travels parallel to the alignment near the proposed launching site on the north end and would be crossed by the alignment twice. Potholing is recommended to confirm the alignment and portal location. Acquisition of temporary and permanent easements would be required

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BLACK & VEATCH

Open-Trench Construction Method - LACFCD Easement (River Bank)
Trenchless Construction Method - EPBM
Launching/Receiving Pit
Private Easement

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
San Gabriel River Crossing at Whittier Boulevard – Part 1

FIGURE 6-20

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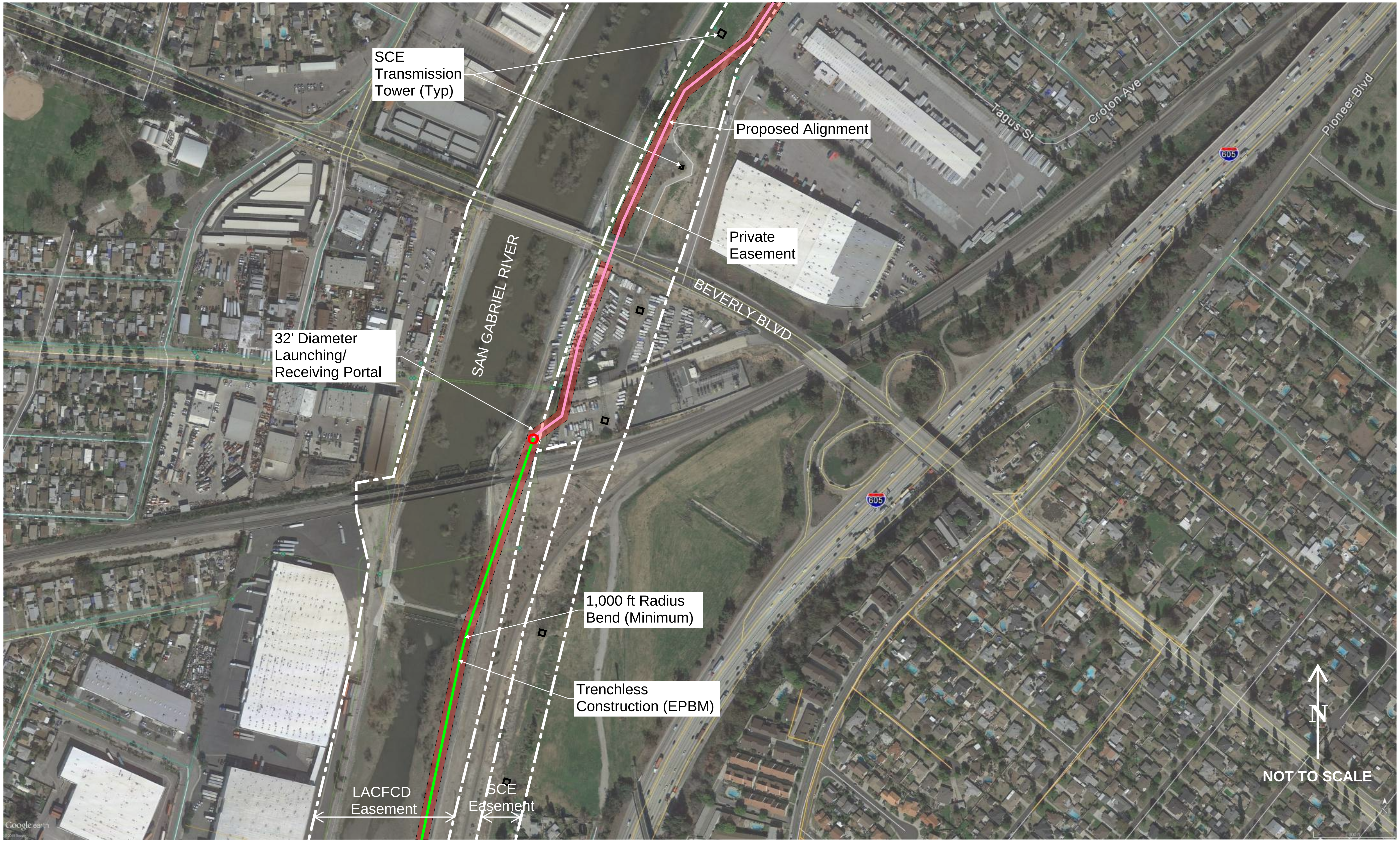

BLACK & VEATCH

Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - EPBM
Launching/Receiving Pit
Private Easement

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Whittier Boulevard – Part 2

FIGURE 6-21

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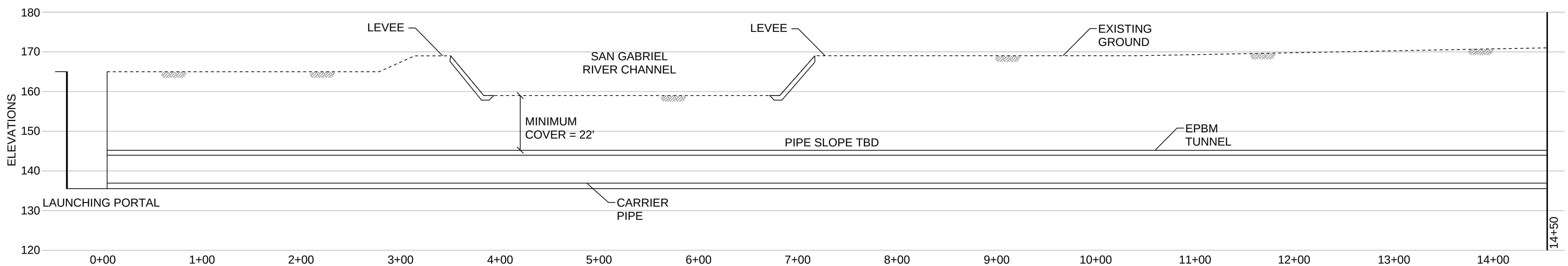

CONVENTIONAL TUNNEL (EPBM) CROSSING OF THE SAN GABRIEL RIVER AT WHITTIER BOULEVARD

6.1

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Whittier Boulevard – Part 1

FIGURE 6-22

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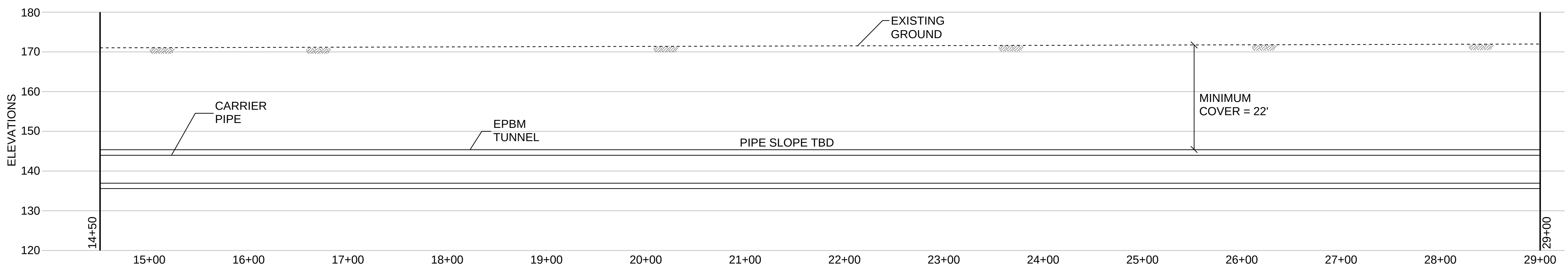

CONVENTIONAL TUNNEL (EPBM) CROSSING OF THE SAN GABRIEL RIVER AT WHITTIER BOULEVARD 6.2

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Whittier Boulevard – Part 2

FIGURE 6-23

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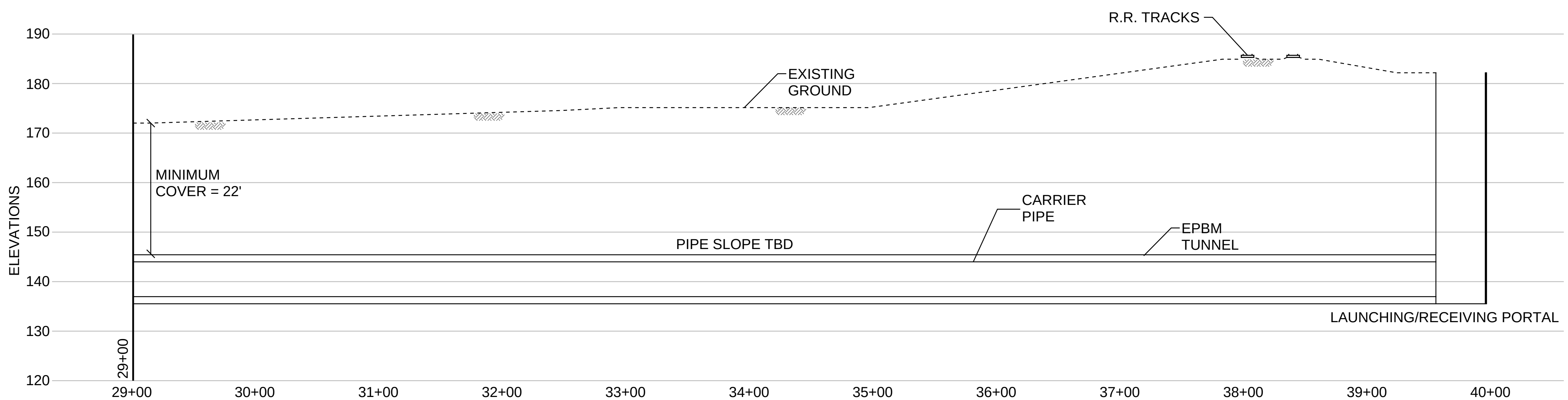

CONVENTIONAL TUNNEL (EPBM) CROSSING OF THE SAN GABRIEL RIVER AT WHITTIER BOULEVARD 6.3

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Whittier Boulevard – Part 3

FIGURE 6-24

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6.4.8.7 Walnut Creek Wash Crossing (Detail Location 7)

The SG River Alignment proposes crossing below the Walnut Creek Wash north of Valley Blvd from Reach 4, Sta. 1652+73 to Reach 4, Sta. 1669+04 using trenchless construction methods. Key details of the crossing are provided in Table 6-16. The proposed crossing is shown in plan on Figure 6-25 and in profile on Figure 6-26.

Table 6-16 Summary of Walnut Creek Wash Crossing (Detail Location 7)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,631	River	7	18	Yes	MT	Y	N	Y	N	N

Launching is recommended south of railroad tracks due to potentially available space for portal excavation and contractor staging. The trenchless construction segment would cross under Union Pacific Rail Road and Southern California Regional Rail Authority property, which would require tunnel easements. Further investigation of the property would be required to finalize portal location and availability. The receiving portal is recommended on the northern side of the river due to the proximity of over-head powerlines and transmission towers.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Portions of the alignment would pass close to bridges which are anticipated to have deep foundations. Detailed stress change and ground movement analysis is recommended at these locations.

Potholing is recommended to confirm the portal and alignment locations. Additional utility information should be gathered in this area during subsequent phases of design. Acquisition of temporary and permanent easements would be required.

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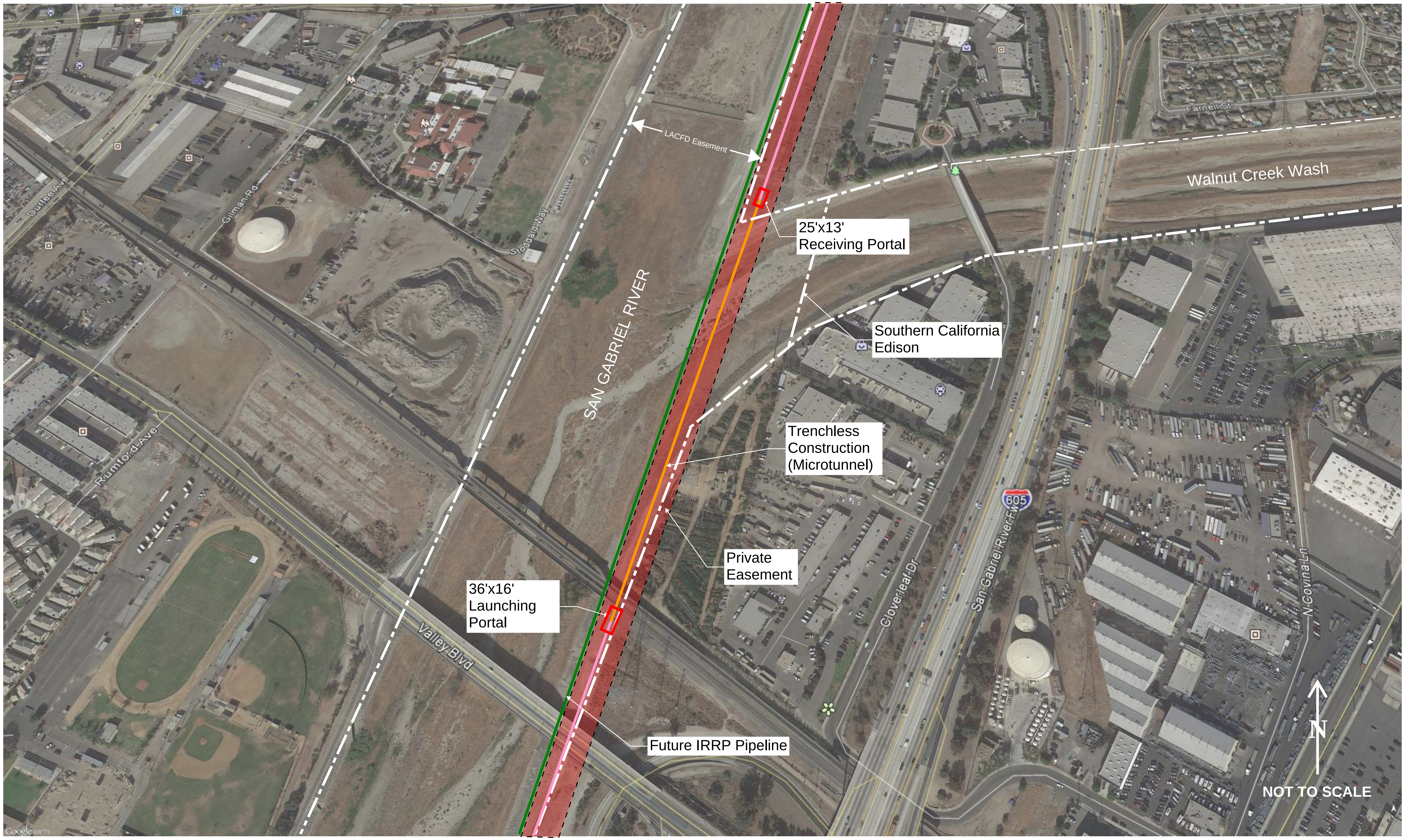

BLACK & VEATCH

- Open-Trench Construction Method - Roadways
- Trenchless Construction Method - Microtunnel
- Private Easement
- Launching/Receiving Pit
- Future IRRP Pipeline

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Walnut Creek Wash Crossing

FIGURE 6-25

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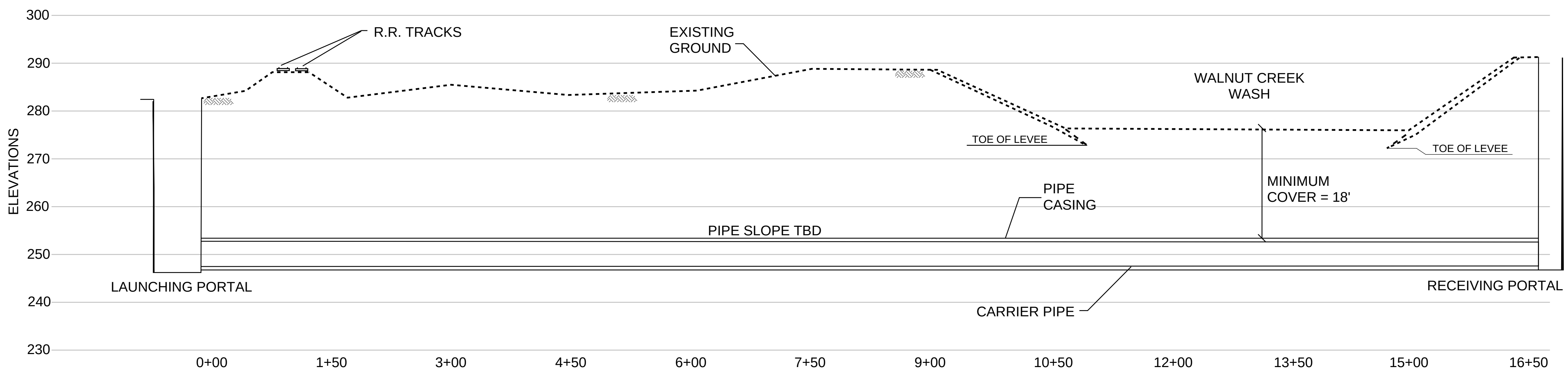

MICROTUNNEL CROSSING OF WALNUT CREEK WASH 7
HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Walnut Creek Wash Crossing

FIGURE 6-26

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6.4.8.8 SG River Crossing – Live Oak Ave (Detail Location 8)

The SG River Alignment proposes crossing below the SG River north of Live Oak Avenue from Reach 4, Sta. 1871+00 to Reach 4, Sta. 1876+28 using trenchless construction methods. Key details of the crossing are provided in Table 6-17. The proposed crossing is shown in plan on Figure 6-27 and in profile on Figure 6-28.

Table 6-17 Summary of SG River Crossing at Live Oak Ave (Detail Location 8)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
528	River	7	11	Yes	MT	Y	N	Y	N	N

This FLDR assumed launching would be accomplished from the east side of the creek due to potentially available space for portal excavation and contractor staging in the west lanes of Rivergrade Road. Should the impact to the property on the west side of the river be determined to be less during preliminary design, then the launching portal could be moved to the west side of the river. Further investigation of the property would be required to finalize portal location and availability. The receiving portal and subsequent alignment on the west side of the river would be located in the corner of the facility to reduce the impact to the property. Even with mitigation, construction and easements would still have significant impacts on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Utility information has not been collected along the alignment in this area. During subsequent phases of design additional utility information should be collected and the location of the alignment and excavation portals verified. Utilities anticipated in roads the size of Live Oak Avenue and Rivergrade Road include storm drain, water, telecommunications, sewer, and oil and gas pipes, and potholing is recommended to verify the alignment and excavation portals. However, on the east side of the crossing, the alignment would pass near visible storm drain outlets in the SG River. The underground alignment of the storm drain piping is unknown at this time and may require relocation or deeper excavation to avoid. Potholing would be required to finalize portal location and feasibility.

Acquisition of temporary and permanent easements would be required.

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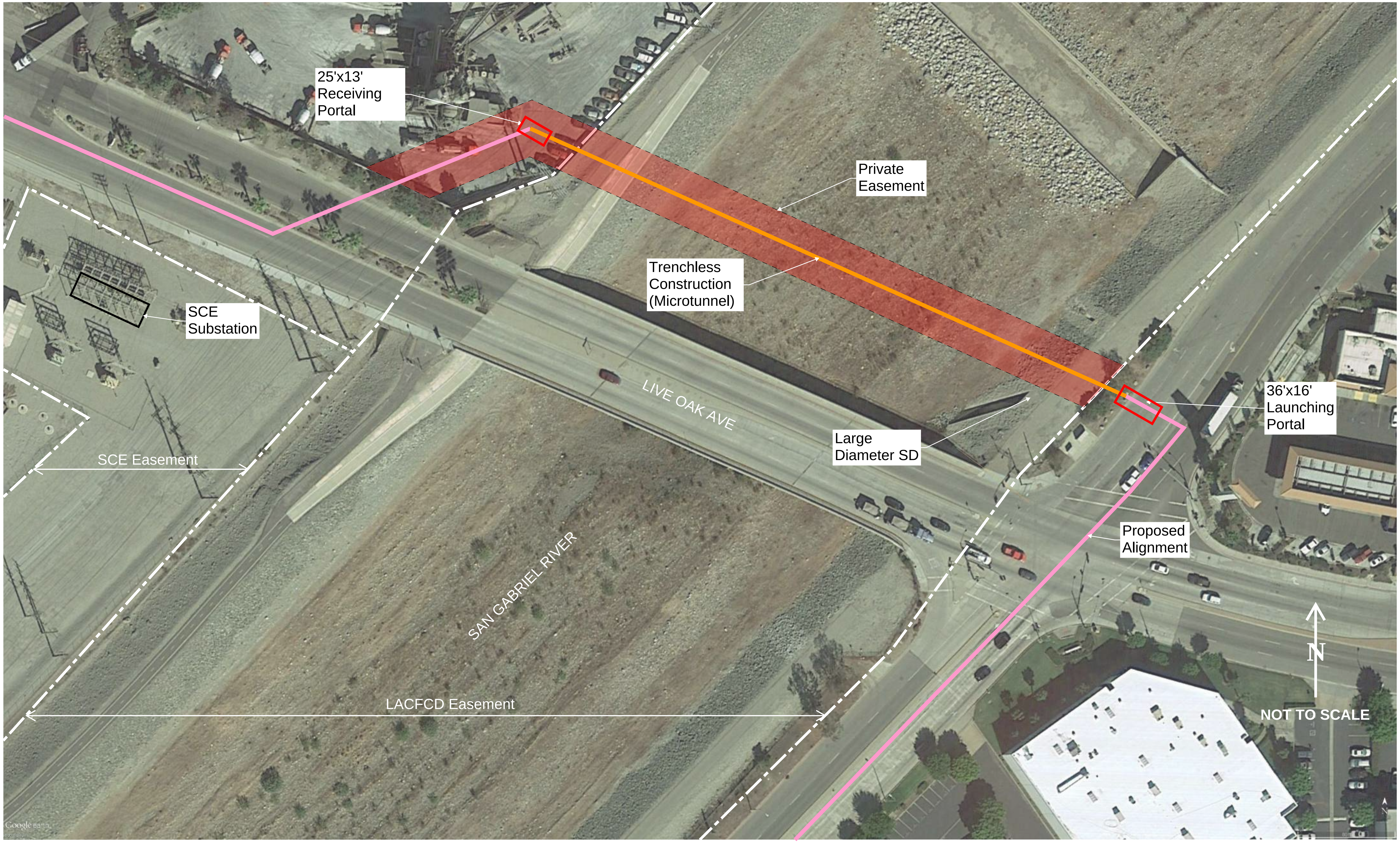

BLACK & VEATCH

Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Live Oak Ave

FIGURE 6-27

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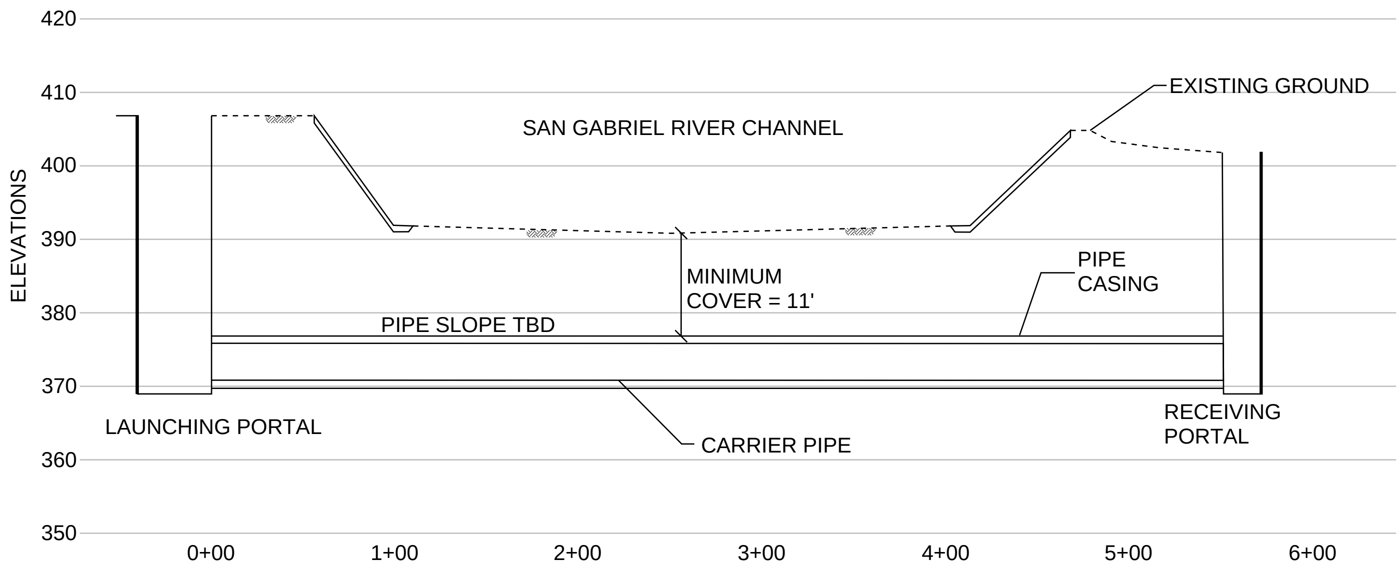

MICROTUNNEL CROSSING OF SAN GABRIEL RIVER 8

HORZ: 1" = 50'
VERT: 1" = 12.5'

1" = 50' 0 50' 100' 150' FEET

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Live Oak Ave

FIGURE 6-28

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6.4.8.9 Arrow Highway and 605 Freeway Crossing (Detail Location 9)

The SG River Alignment would cross below the 605 Freeway. Key details of the crossing are provided in Table 6-18. The proposed crossing is shown in plan on Figure 6-29 and in profile on Figure 6-30.

Table 6-18 Summary of Arrow Highway and 605 Freeway Crossing (Detail Location 9)

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
508	Freeway	7	18	No	MT	Y	N	Y	N	N

Launching is recommended from the north side of the freeway based upon available, undeveloped space for portal excavation and contractor staging. The portal is proposed on the access road on the bank of the Santa Fe Diversion Channel. Early real property acquisition is recommended to confirm the alignment and acquire access.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

The alignment would cross Arrow Highway parallel to five LACFCD culverts and cross the 605 Freeway parallel to a single large diameter culvert/tunnel in the Santa Fe Diversion Channel. No other utilities are anticipated at this crossing. Potholing would be required to finalize the alignment and portal location and feasibility. Acquisition of temporary and permanent easements would be required.

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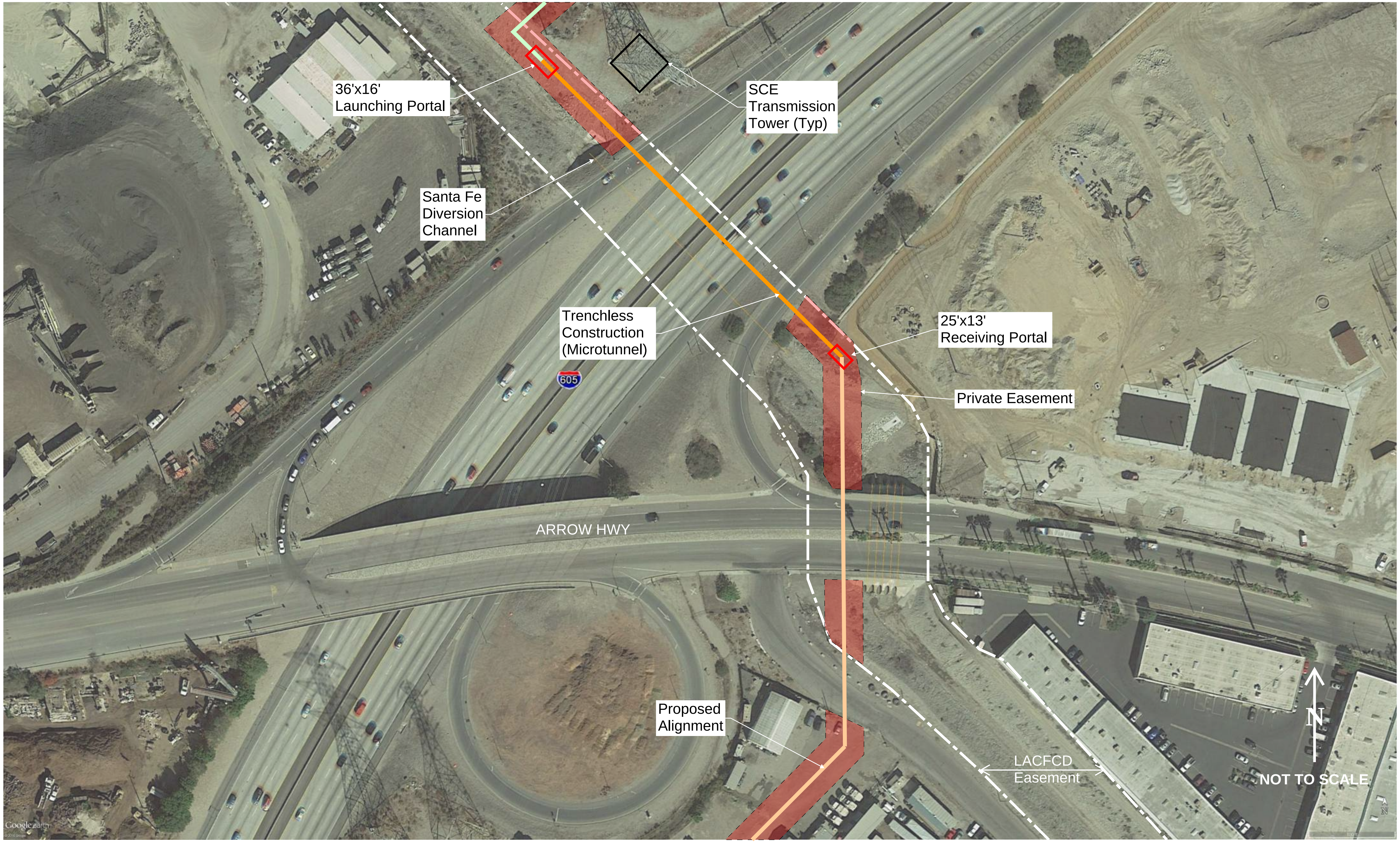

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Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit
Open-Trench Construction Method - LACFCD Easement

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Arrow Highway and 605 Freeway Crossing

FIGURE 6-29

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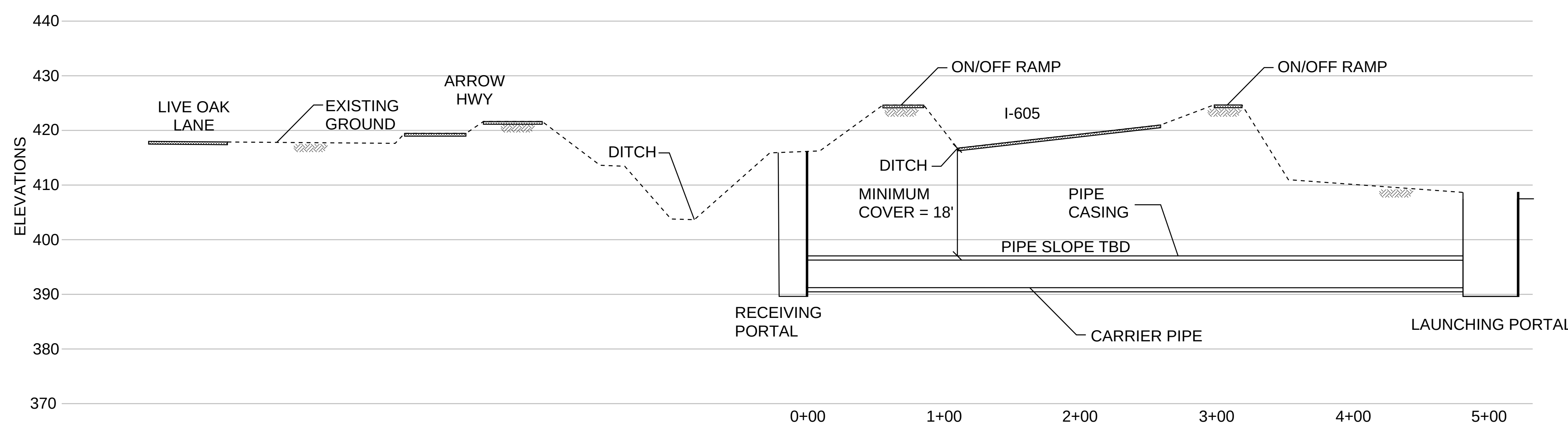

MICROTUNNEL CROSSING OF ARROW HWY AND I-605 9

HORZ: 1" = 50'
VERT: 1" = 12.5'

BLACK & VEATCH

1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Arrow Hwy and 605 Freeway Crossing

FIGURE 6-30

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6.4.9 Preliminary Alignment Cross-Sections

Utilizing GIS mapping and right-of-way information, feasibility-level alignment cross-sections were developed to depict the approximate location of the SG River Alignment relative to known major utilities and key surface features. The proposed location of the SG River Alignment was developed based on extensive research of existing utilities based on above grade features and available utility maps. The cross-sections are graphical in nature and are not intended to represent design-level detail. However, the alignment does reflect a general corridor that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. Additional utility investigations, including subsurface investigations, will be completed during subsequent design phases and the alignment is anticipated to be adjusted accordingly.

Since the SG River Alignment would traverse long stretches of existing streets with utilities varying in location, no “typical” section is provided to represent the location of the pipeline along the entire alignment. Instead, the alignment attempts to account for the presence of existing utilities and constructability concerns at each specific location. The representative cross-sections at key corridors are identified in Table 6-19 and presented on Figure 6-31 thru Figure 6-40. Figure 6-7 presents the location of each representative cross-section.

Table 6-19 Preliminary Alignment Cross-Section Locations

NO.	STATION	DESCRIPTION
1	Reach 1, Sta. 008+50	Main Street facing north.
2	Reach 1, Sta. 070+00	Sepulveda Boulevard facing east.
3	Reach 1, Sta. 214+00	Willow Street facing east.
4	Reach 1, Sta. 253+00	Willow Street facing east.
5	Reach 1, Sta. 308+50	Willow Street facing east.
6	Reach 1, Sta. 346+00	Willow Street facing east.
7	Reach 1, Sta. 624+00	Los Coyotes Diagonal facing northeast.
8	Reach 3, Sta. 946+00	LACFCD easement facing north.
9	Reach 4, Sta. 1523+00	SCE easement facing north.
10	Reach 4, Sta. 1883+00	Live Oak Avenue facing southeast.

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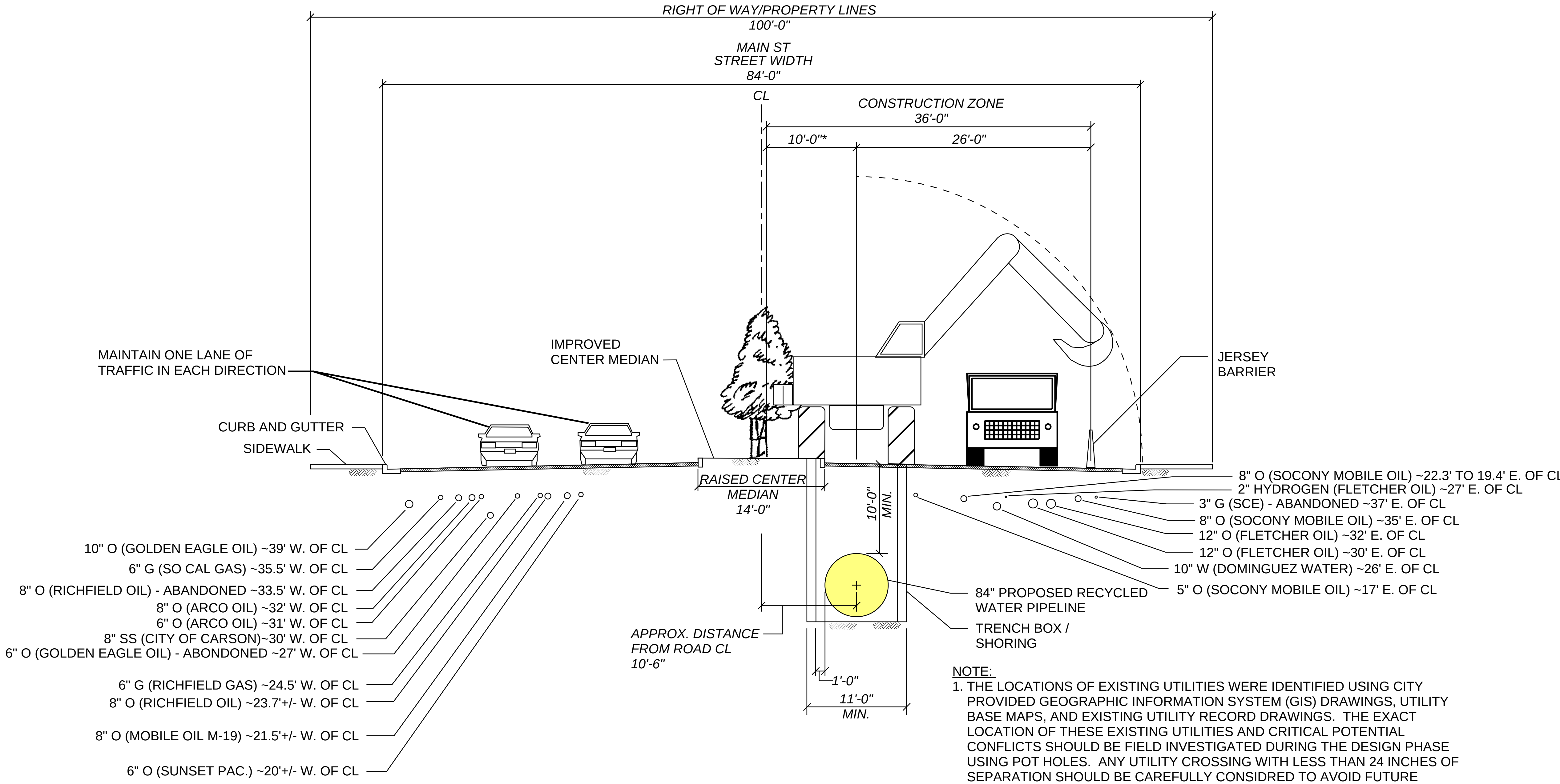

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 1 / -

NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-300

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

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0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 1 – MAIN STREET FACING NORTH (REACH 1, STA 008+50)

FIGURE 6-31

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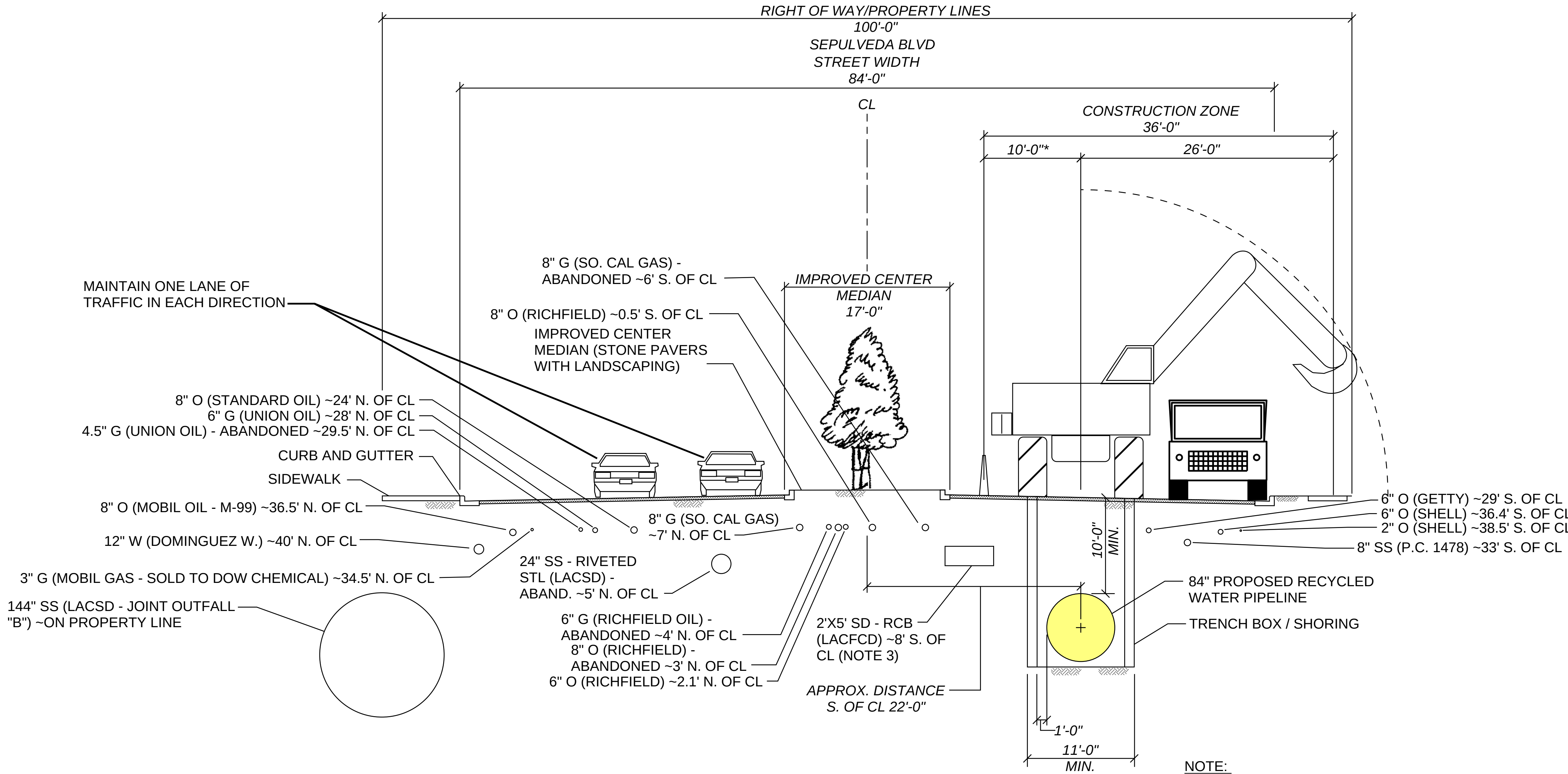

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. LOCATED IN STREET FOR APPROXIMATELY 550'.

CROSS SECTION 2 -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-291

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

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POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 2 – SEPULVEDA BLVD FACING EAST (REACH 1, STA 070+00)

FIGURE 6-32

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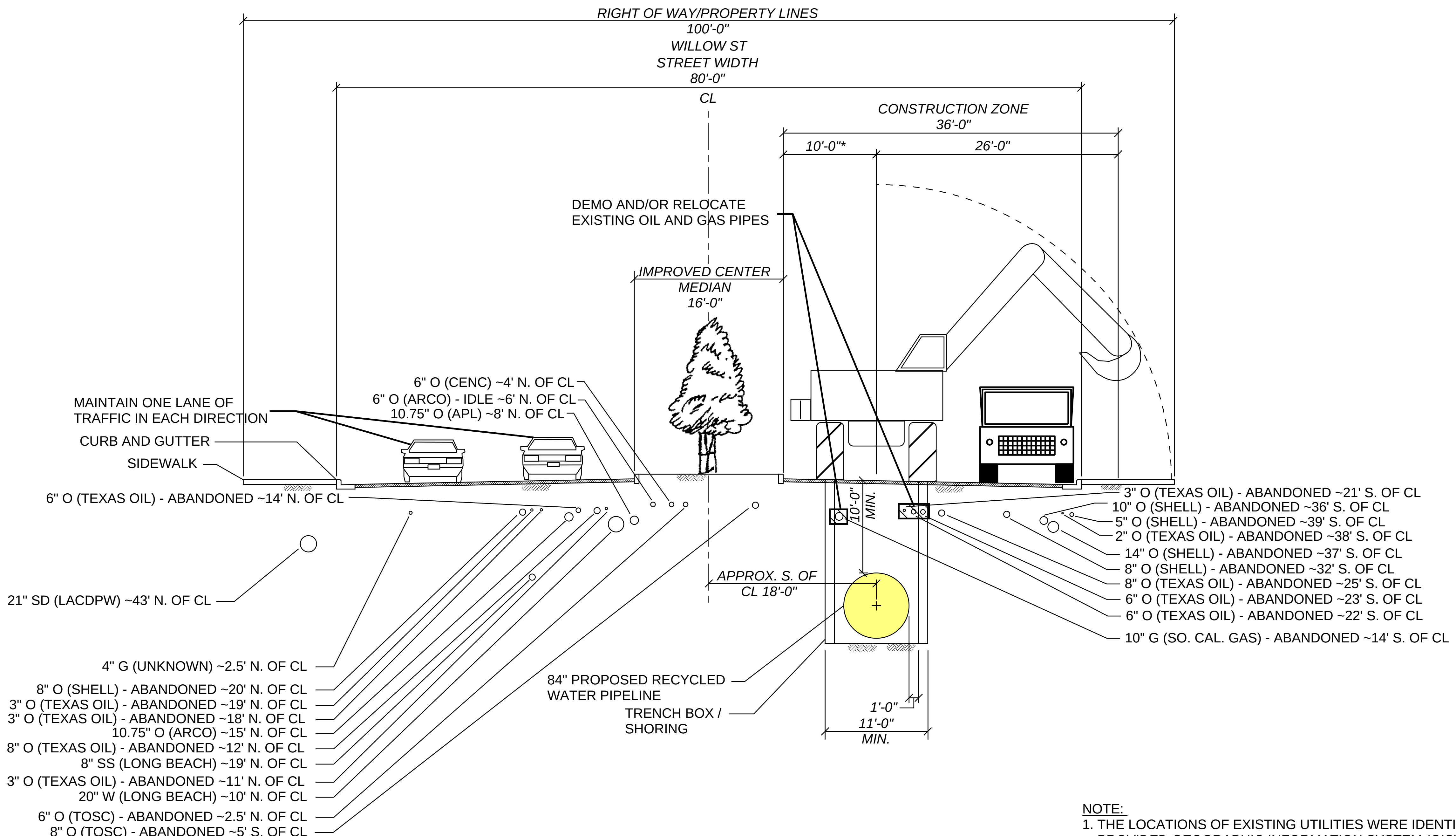

CROSS SECTION 3
-
NO SCALE

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-307
- CITY OF LONG BEACH GIS DATA

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH	0 5 10 15 FEET	**POTENTIAL REGIONAL RECYCLED WATER PROGRAM** **PRELIMINARY ALIGNMENT CROSS-SECTION 3 – WILLOW ST FACING EAST (REACH 1, STA 214+00)**	**FIGURE 6-33**

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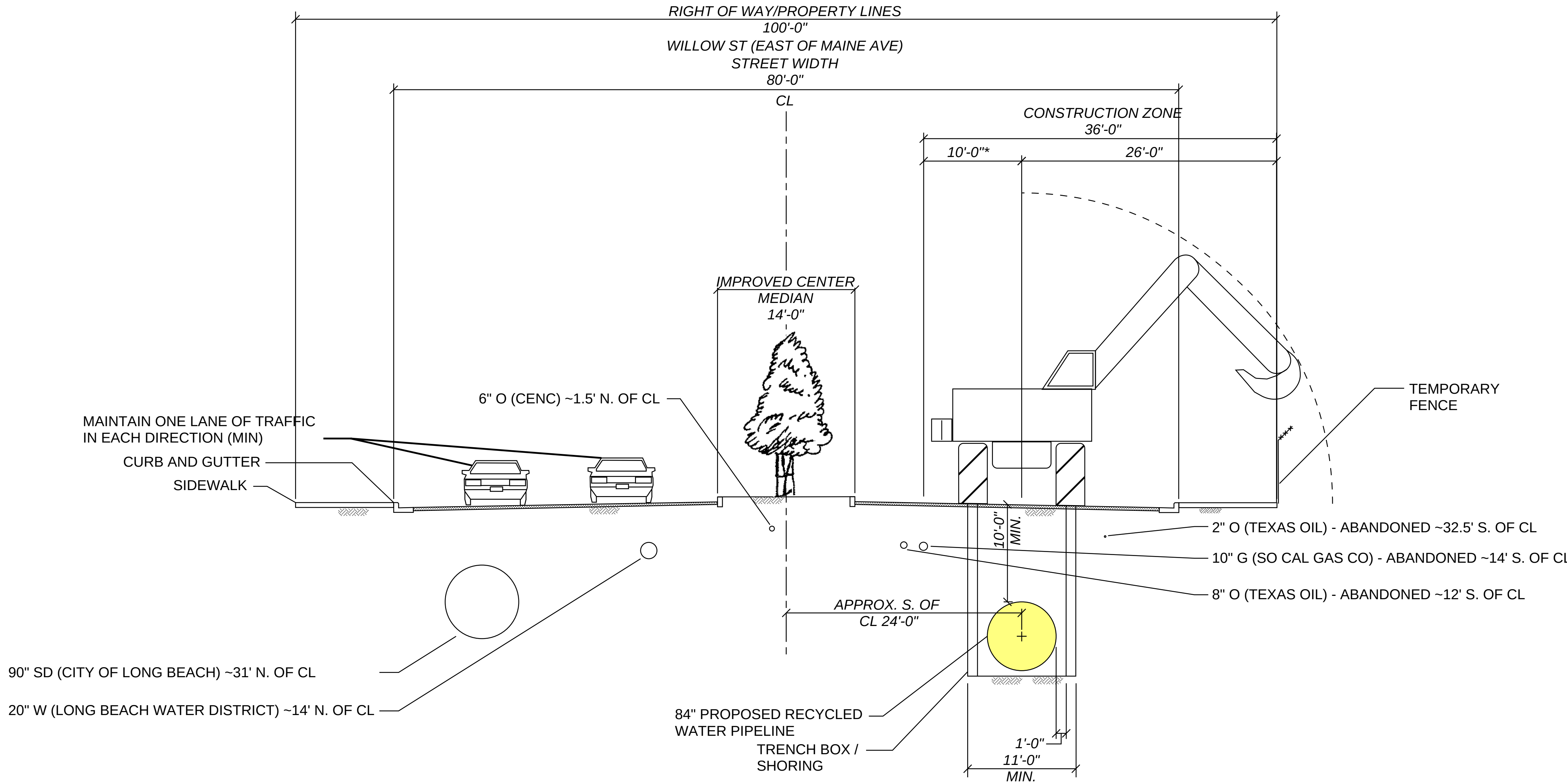

CROSS SECTION 4
-

NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG W-307
- CITY OF LONG BEACH GIS DATA

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

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POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 4 –
WILLOW ST FACING EAST (REACH 1, STA 253+00)

FIGURE 6-34

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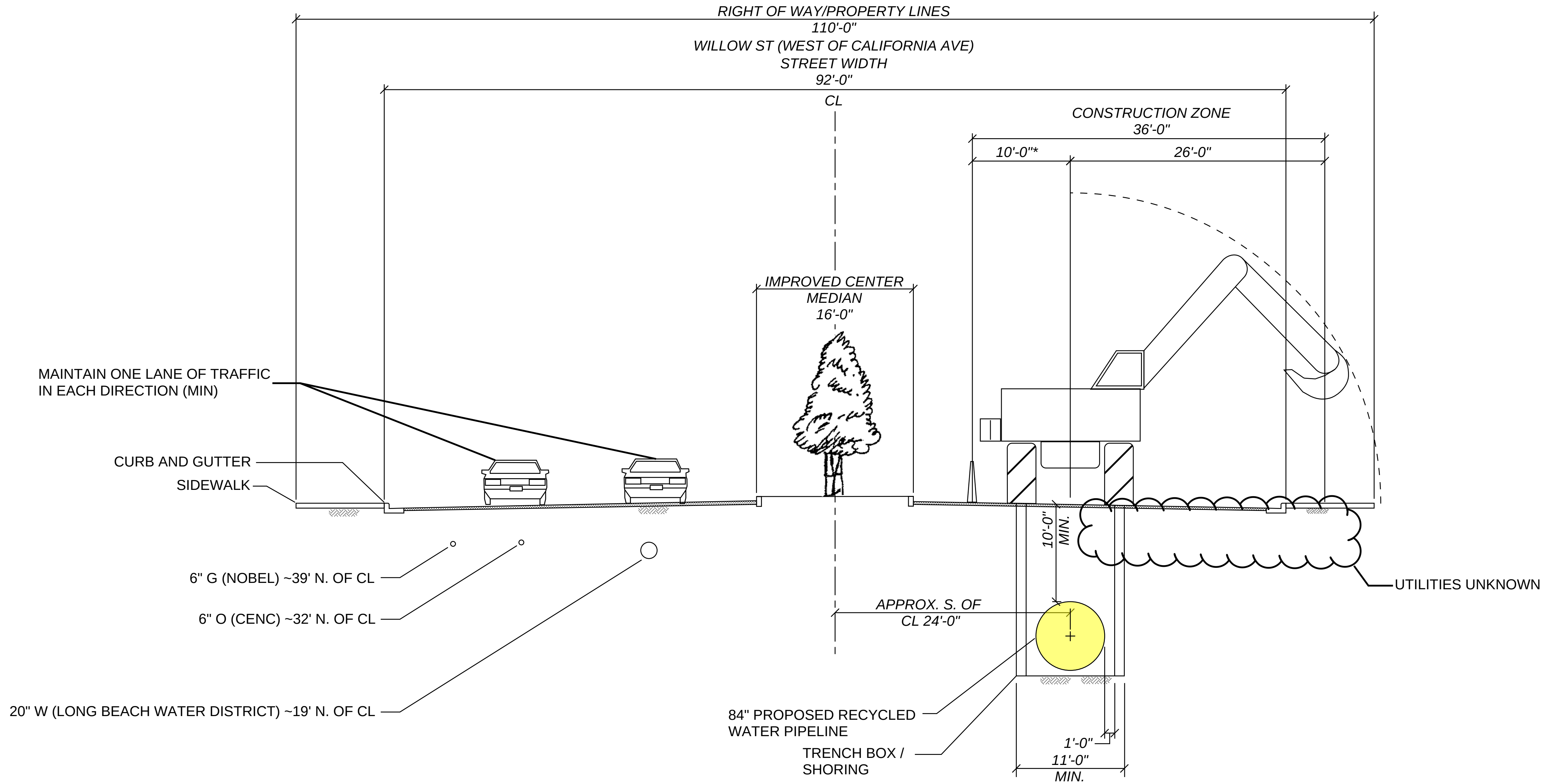

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 5
-
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- CITY OF LONG BEACH GIS DATA

NOTE:
* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 5 – WILLOW ST FACING EAST (REACH 1, STA 308+50)

FIGURE 6-35

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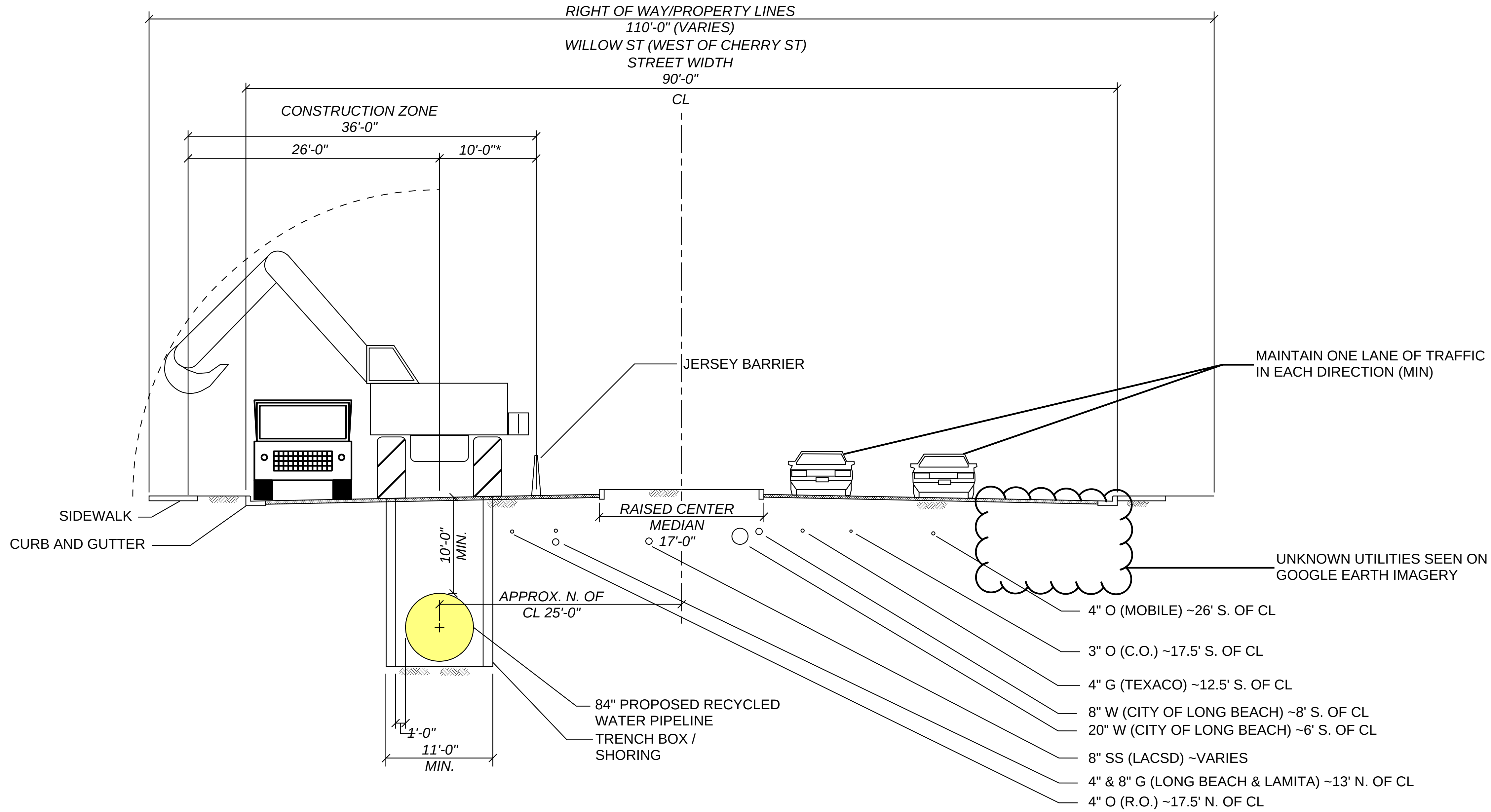

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 6 / -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- CITY OF SIGNAL HILL STREET IMPROVEMENT PLAN DWG R-1147-A (WILLOW STREET STA. 46+40.99 TO STA. 50+50.00
- CITY OF SIGNAL HILL STREET IMPROVEMENT PLAN DWG R-1148-A (WILLOW STREET STA. 50+50.00 TO STA. 56+23.69
- CITY OF LONG BEACH GIS DATA

NOTE:
** WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 6 – WILLOW ST FACING EAST (REACH 1, STA 346+00)

FIGURE 6-36

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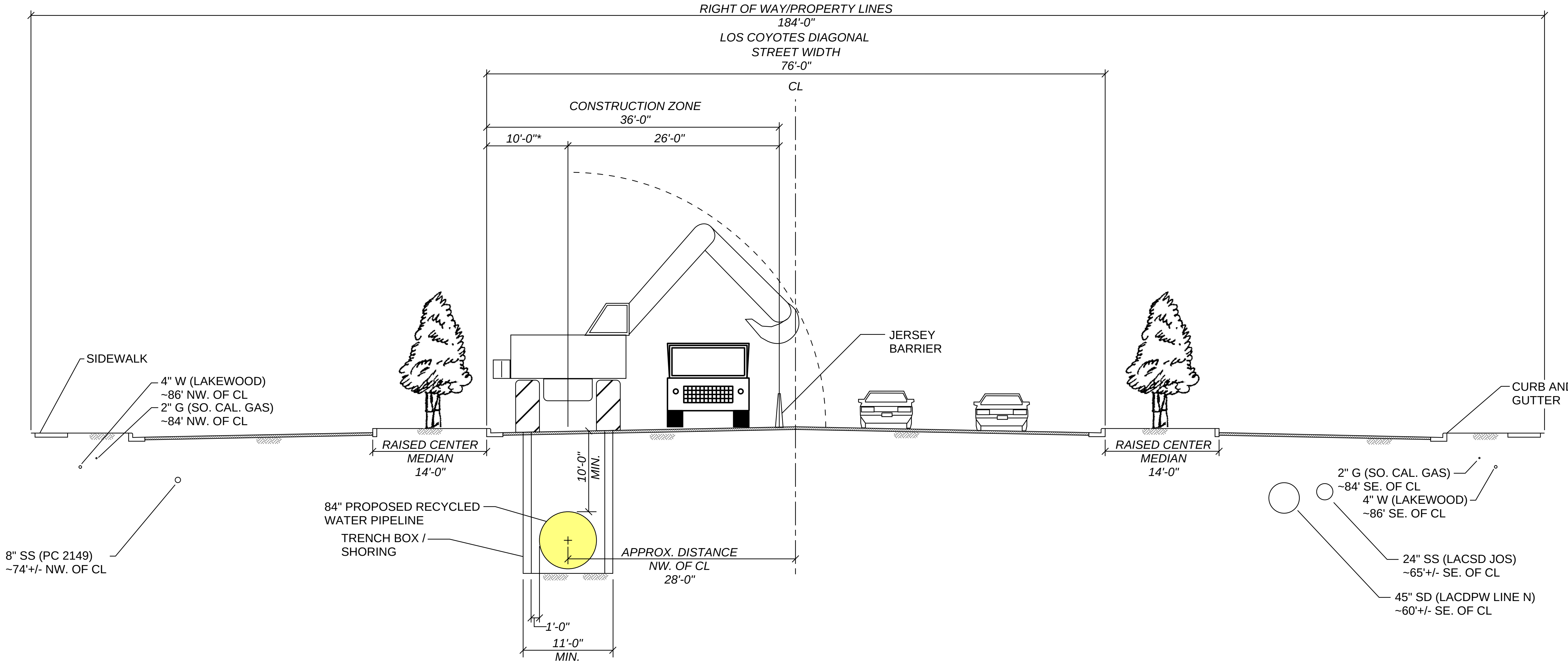

CROSS SECTION 7 / -

NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG DC-420
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG DC-433
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG DC-434

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

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0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 7 – LOS COYOTES DIAGONAL FACING NORTHEAST (REACH 1, STA 624+00)

FIGURE 6-37

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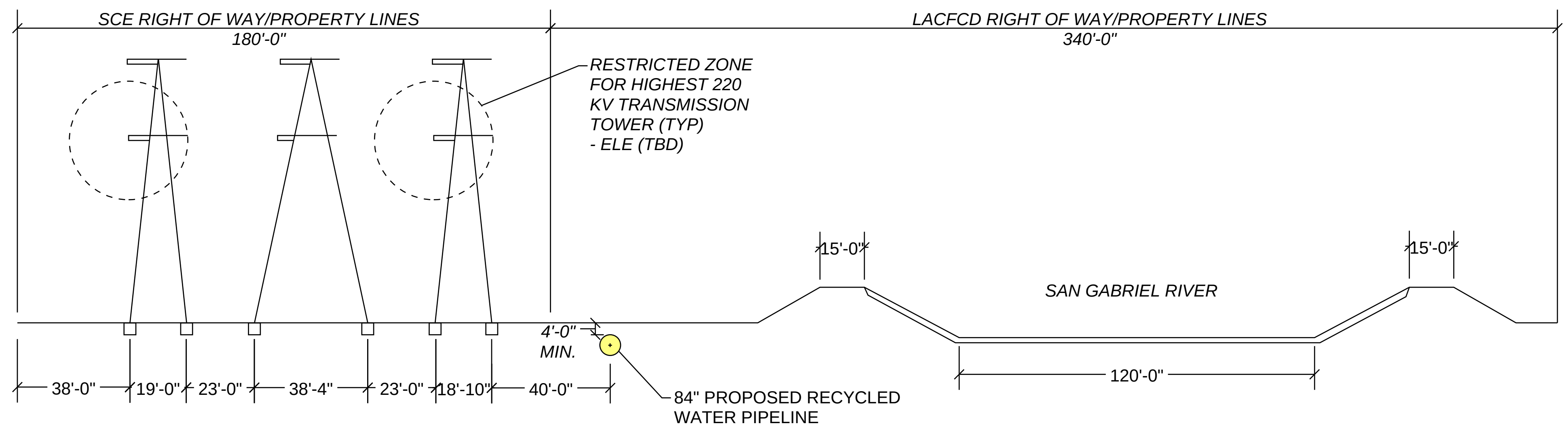

CROSS SECTION 8
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

BLACK & VEATCH		**POTENTIAL REGIONAL RECYCLED WATER PROGRAM** **PRELIMINARY ALIGNMENT CROSS-SECTION 8 – LACFCD EASEMENT FACING NORTH (REACH 3, STA 946+00)**	**FIGURE 6-38**

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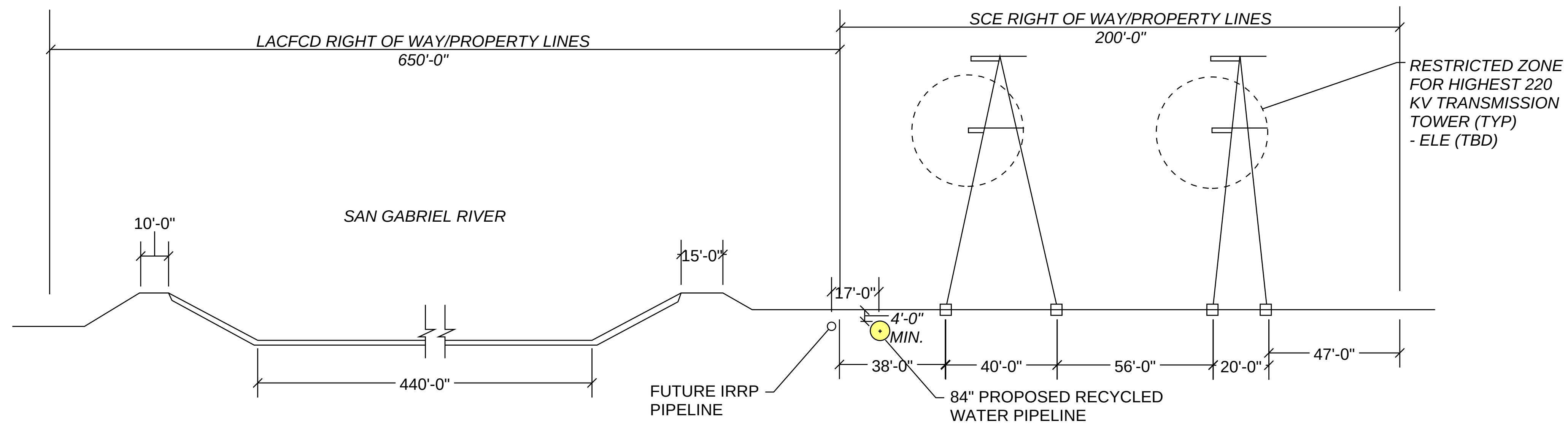

CROSS SECTION 9 / -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 9 – SCE EASEMENT FACING NORTH (REACH 4, STA 1253+00)

FIGURE 6-39

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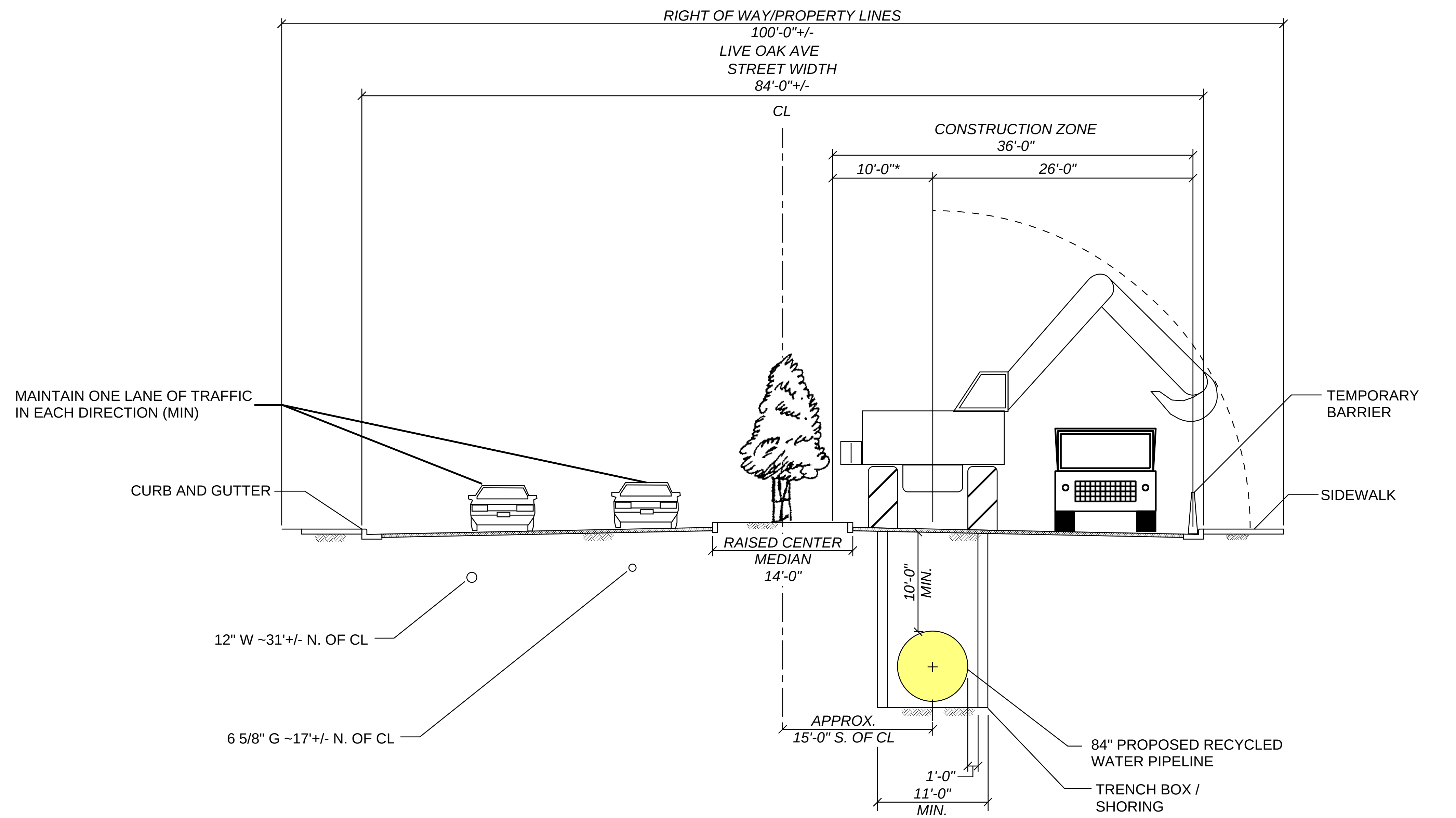

NOTE:

1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

CROSS SECTION 10 -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- CITY OF IRWINDALE STORM DRAIN IMPROVEMENT PLANS FOR TENT. PARCEL MAP NO 22505, JOB NO 89140.27, SHEET 7

NOTE:

* WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.

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0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 10 – LIVE OAK AVE FACING SOUTHEAST (REACH 4, STA 1883+00)

FIGURE 6-40

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7.0 Los Angeles River Alignment Feasibility-Level Design

This chapter describes the key facility components for the LA River Alignment required for the conveyance of advanced treated water from the AWT plant in Carson to the SFSG.

If the LA River alignment is selected as the preferred alignment during future phases of work and a pipeline to OC were ultimately required, this study identified alignments to OC as described in Chapter 4. Table 7-1 summarizes key Project components and characteristics associated with this alignment.

Table 7-1 LA River Alignment Characteristics

CHARACTERISTIC	LA RIVER ALIGNMENT
Minimum Ground Elevation, ft above MSL	7
Maximum Ground Elevation, ft above MSL	525
Total Pumping Head, ft	677
Overall Alignment Length, miles	36.5
Pump Stations, each	2

Figure 7-1 summarizes the Project methodology as it applies to this chapter.

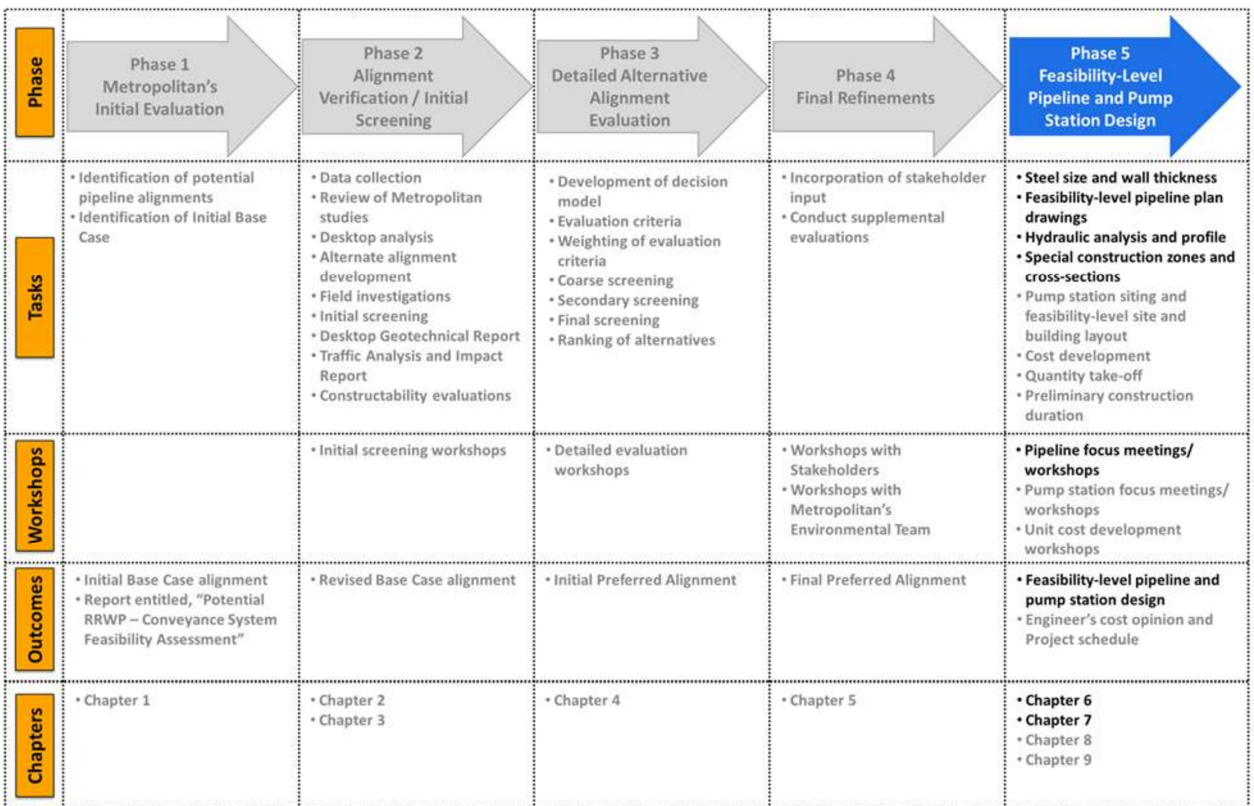

Figure 7-1 Chapter 7 Methodology

7.1 CHAPTER ORGANIZATION

Key operating parameters and Project components affecting alignment decisions for the RRWP are summarized below and discussed in the following sections:

- **LA River Alignment Overview** – This section describes the development of the LA River Alignment and presents a summary of the key attributes of the alignment, as well as areas that require further evaluation during subsequent phases of work.
- **Feasibility-Level Pipeline Plan Drawings** – This section presents the pipeline plan drawings that were developed to show the alignment at a scale large enough to display relevant surface features.
- **Feasibility-Level Pipeline Design** – This section describes the system of pressurized pipelines and tunnels for the LA River Alignment, including design criteria applicable to pipeline sizing and the development of a cost opinion. This section also describes locations that are anticipated to require trenchless construction methods to avoid surface or below grade features or obstructions and presents typical cross-sections for the alignment. Similar descriptions for the LA River Alignment are provided in Chapter 6.

7.2 LOS ANGELES RIVER ALIGNMENT OVERVIEW

The LA River Alignment, established in Chapter 5, was the result of feasibility-level engineering development, input from internal and external stakeholders, and the ability to procure rights-of-way and easements. 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.

Figure 7-2 presents an overview of the LA River Alignment and the two reaches it is comprised of. Table 7-2 summarizes key information about each reach.

Table 7-2 Key Characteristics of LA River Alignment Reaches

REACH	BEGINNING/ENDING LOCATION	STATIONING (MILES)	LIFT (FT)
1	PS-1 to PS-3	0.0 – 26.8	341
2	PS-3 to SFSG	26.8 – 36.5	336

Note 1: Reach 2 is the same as Reach 4 for the SG River Alignment.

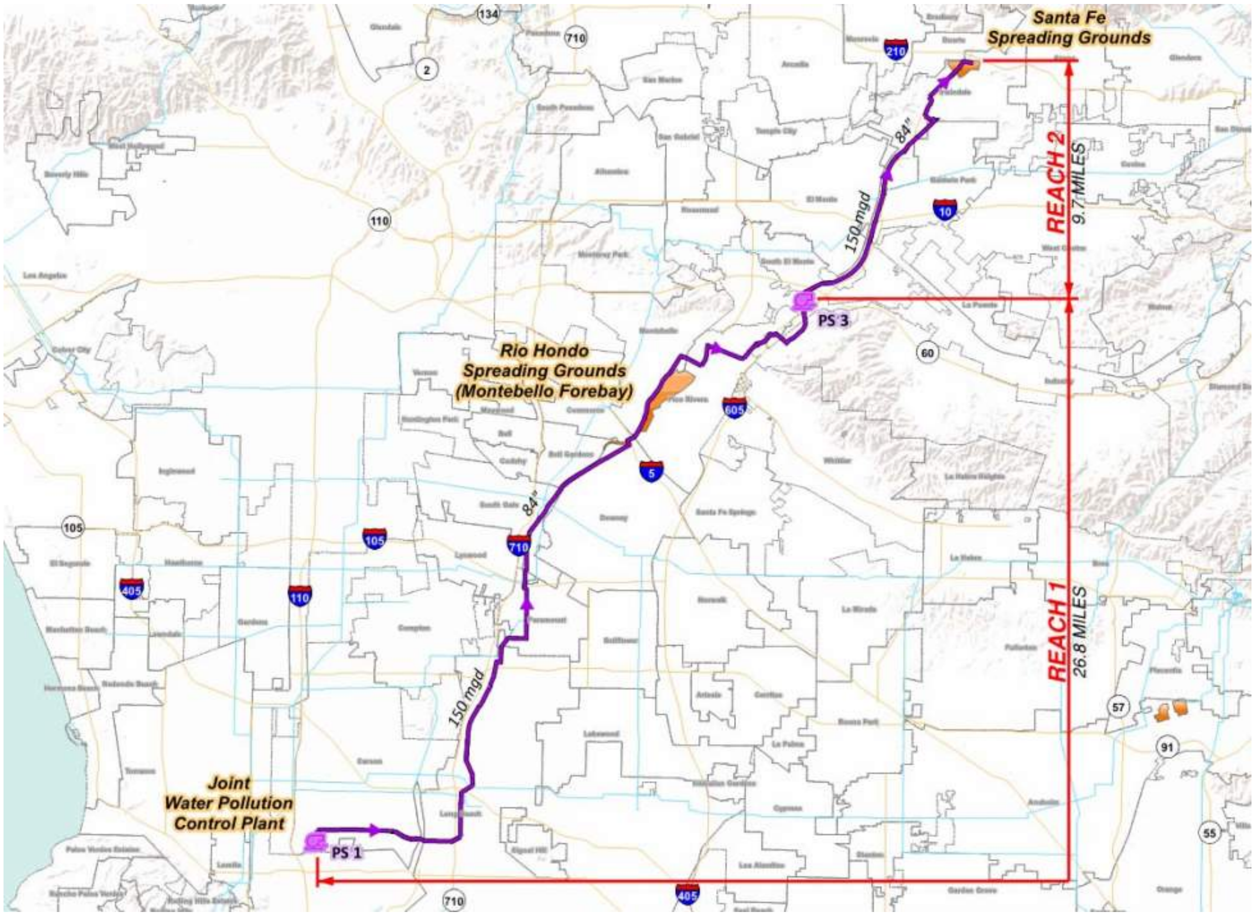

Figure 7-2 LA River Alignment Overview and Reach Extents

A description of each reach is as follows:

- Reach 1 – Reach 1 would be approximately 26.8 miles in length and would begin at the AWT plant and terminate at the proposed site of PS-3, north of Whittier Narrows Dam. From south to north, this reach would pass through unincorporated L.A. County and the Cities of Long Beach, Paramount, South Gate, Downey, Commerce, Pico Rivera, Montebello, and Industry. A majority of this reach would be within SCE and LACFCD right-of-way paralleling the LA River and then the Rio Hondo Channel. To avoid locations where a sufficient corridor does not exist, the pipeline would leave the river to be within public street rights-of-way for portions of the alignment. At Whittier Boulevard, the alignment would leave the Rio Hondo Channel and head east in existing public rights-of-way to the SG River. From here, the alignment would be mostly within SCE right-of-way parallel to the SG River. This pipeline section would convey up to 150 million gallons per day (mgd).
- Reach 2 – Reach 2 would be approximately 9.7 miles in length and begin at PS-3 and terminate at the SFSG. From south to north, this reach would pass through unincorporated LA County and the Cities of South El Monte, Industry, Baldwin Park, and Irwindale. A majority of the alignment would fall within SCE and LACFCD right-of-way with a small

stretch in public street rigs-of-way. It is anticipated that the pipeline would convey up to 150 mgd.

A summary of the key attributes of the LA River Alignment is presented in Table 7-3. Additionally, areas requiring specific considerations during subsequent design phases are described in Table 7-4.

7.3 FEASIBILITY-LEVEL PIPELINE PLAN DRAWINGS

Feasibility-level plan drawings depicting the LA River Alignment were developed in GIS. These plans depict the LA River Alignment at a scale large enough to display surface features that would prevent or restrict open-cut construction and/or require trenchless construction methods. The feasibility-level plan sheets are provided in Appendix G.

Table 7-3 Summary of LA River Alignment

SEGMENT	PIPE DIAMETER (IN.)	TOTAL LENGTH (FT)	TRENCHLESS CONSTRUCTION (FT)	CITIES	DESCRIPTION	STREET	STREET WIDTH (FT)	TRAFFIC LANES (NO.)	TYPICAL CONSTRUCTION METHOD ASSUMED[1]
1	84	24,083	5,074	Carson, Los Angeles, Long Beach	Roadway	Main St.	80	4 + median	CM1
						Sepulveda Blvd. (turns into Willow St)	80	4,6 + median	
2	84	12,826	6,365	Long Beach	LACFCD/Roadway	Country Club Rd.	40	2	CM3A/CM4C
101	84	8,635	8,635	Long Beach	LACFCD	-	-	-	CM4C
3	84	9,206	2,531	Long Beach, South Gate	Roadway/SCE	De Forest Ave.	40	2	CM1/CM2
100	84	24,418	1,396	Long beach, Paramount, South Gate	LACFCD/SCE/Roadway	N Atlantic Pl.	70	4 + bike lanes	CM1/CM2
						Hunsaker Ave.	80	4 + center lane	
						Alondra Blvd	82	4 + median	
7	84	3,700	180	South Gate	SCE	-	-	-	CM2
21	84	23,415	7,745	South Gate, Downey, Commerce, Pico Rivera, Montebello	SCE/LACFCD	-	-	-	CM2/CM3A
23	84	19,433	1,497	Montebello, Pico Rivera	LACFCD/Roadway	El Camino Real	55 to 85	4 + median	CM1/CM3A
						Paramount Blvd	85	4 + median	
						Beverly Blvd	80	4 + median	
38	84	17,937	1,921	Pico Rivera, Industry, Unincorporated	SCE/Roadway	SG River Pkwy	100	4 + median	CM1/CM2
						Rose Hills Rd.	60	4	
						Workman Mill Rd	85	4 + median	
						Peck Rd	75	4 + median	
44	84	28,748	4,575	South El Monte, Industry, Baldwin Park, Irwindale, Unincorporated	SCE/LACFCD	-	-	-	CM2/CM3A
52	84	2,292	-	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	22 to 60	2, 4 + center lane	CM1
60	84	4,884	528	Baldwin Park, Irwindale	Roadway	Rivergrade Rd	60 to 80	4 + center lane	CM1
56	84	1,166	-	Irwindale	Roadway	Live Oak Ave.	80	4 + median	CM1
58	84	3,339	517	Irwindale	SCE/Private	-	-	-	CM2
59	84	9,028	1,723	Irwindale	LACFCD	-	-	-	CM3A
TOTALS		**193,110**	**42,687**						

Note 1: See Section 3.4 for details on typical construction methods, including definitions of abbreviations.

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Table 7-4 Areas Requiring Specific Consideration During Subsequent Design Phases

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
General	Where the LA River Alignment would cross a seismic hazard/ fault, a detailed seismic assessment which may include finite element analysis would be required in subsequent design phases to design for seismic resiliency (Segments 2 and 101).
	At this feasibility level of planning, sufficient information is not available to determine the preferred construction method, cut-and-cover or trenchless construction, at intersections crossing the Preferred Alignment. For planning purposes, this FLDR assumed that all intersections would be crossed using cut-and-cover construction unless there are known jurisdictional requirements prohibiting it (i.e., crossing railroad tracks, rivers, bridges, and Caltrans roads or highways). The FLDR applies a premium to account for the higher cost of construction at all intersections that the traffic analysis report considered to be a Major Intersection. Further evaluation will be completed during Preliminary Design when a comprehensive investigation and mapping of buried utilities, additional traffic control analysis, and coordination with local jurisdictions would be completed.
	This FLDR assumed that when the pipeline alignment would cross beneath freeway overpasses with adequate clearance from the bridge structure to the ground for construction equipment, and no on or off-ramp access, the pipeline would be constructed using cut-and-cover methods. Based on prior experience with Caltrans District 7, this would be feasible as long as the edge of pipe is at least 10 ft from the bridge footings and abutment. Additionally, a casing is typically required, even with cut-and-cover construction methods. These crossings would be evaluated on a case by case basis. Additional coordination should be conducted with Caltrans during subsequent design phases to better understand their design requirements. No discussions with Caltrans were held at this stage of the project.
	Further investigation into designated wetlands and sensitive wildlife areas along the Los Angeles and SG Rivers and associated spreading grounds would be required in subsequent design phases.
1	Assumptions made for the crossing of Alameda Corridor and Dominguez Channel from Reach 1, Sta. 139+17 to Reach 1, Sta. 173+59 should be verified. Should any issues be encountered with the proposed crossing during subsequent design phases, two other viable crossings were identified and are presented in Appendix R.[1]
	Numerous underground utilities were identified along Sepulveda Boulevard and Willow Street. Additional utility research and potholing should be completed to confirm the alignment.[2]
2/101	The proposed alignment crosses Interstate 405, the Newport-Inglewood Fault Zone, a historic environmental storage clean up site, and MCTA railroad tracks all in the same vicinity. This FLDR assumed that trenchless construction would be used to cross the fault zone perpendicularly. Due to the estimated width of the fault zone, the alignment would be in Los Cerritos Park before it reached the edge. To minimize the impact on the residential neighborhood and Virginia Country Club, the FLDR proposes to continue tunneling to avoid these features. The alignment would follow the existing public right-of-way of Country Club Drive and then cross beneath private properties before rejoining the LA River. The alignment shown was chosen to establish a conservative budget for the Project with the understanding that further evaluation is required to verify.[1]
3/100	The proposed alignment would impact various above grade features that are currently located on SCE's existing rights-of-way. These features are generally constructed to be temporary and include nurseries, equestrian areas (i.e. stables and pens), storage units, RV and boat storage, and community parks between Alondra Boulevard and Garfield Avenue.

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
100	This FLDR assumed that trenchless construction would be required to cross East Artesia Blvd and the mobile home community directly south. Alternative alignments, such as taking 63rd Street to Atlantic Avenue, were identified but were deemed to have a larger impact on the community. The alignment shown was chosen to establish a conservative budget for the Project with the understanding that further evaluation is required to verify.[1]
7	None.
21	This FLDR assumed that trenchless construction would be required to cross Firestone Blvd, railroad tracks, and the Rio Honda Golf Club. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project stakeholders to determine if the golf course can be constructed with cut-and-cover methods.[1]
	From Reach 1, Sta. 885+00 to Reach 1, Sta. 969+00, the workspace available for construction would be limited due to congestion in the LADWP transmission line corridor and the speed of construction may be impacted.
	This FLDR assumed that trenchless construction would be required to cross Interstate 5 along the Rio Honda Bike Path. However, it may be possible to use cut-and-cover methods, along with a casing pipe, for this crossing.
23	This FLDR assumed the alignment would be constructed around the perimeter of the LACFCD spreading basins. Additional evaluations into the impacts the pipeline construction could have on the spreading basins recharge capacities should be completed in subsequent design phases. If pipeline construction is determined not to impact the recharge capacities, a straighter alignment may be possible through the basins with LACDPW's consent.
38	This FLDR assumed that the crossing of a drainage channel that crosses SG River Parkway, just west of Interstate 605, would be constructed using trenched construction methods. During subsequent phases of design, this assumption should be further evaluated, including obtaining input from Project Stakeholders and construction staff to determine if the crossing would be required to be made with trenchless construction methods.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
44	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
52	A general corridor was selected that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. However, utility information has not been received from the Cities of Baldwin Park and Irwindale. Future utility investigation should be completed during subsequent design phases and the alignment should be adjusted accordingly.
	The FLDR identified a feasible alignment parallel to the Upper SG Valley Municipal Water District's future IRRP pipeline along the SG River. Additional coordination would need to occur to verify the feasibility of this alignment.
	Due to the narrow width of Rivergrade Road (approx. 32 ft) from Reach 2, Sta. 1724+00 to Reach 2, Sta. 1744+50, a full road closure may be required.

SEGMENT[4]	CONSIDERATIONS FOR SUBSEQUENT DESIGN PHASES
60	None.
56	None.
58	Construction is required on private property from approximately Reach 2, Sta. 1807+80 to Reach 2, Sta. 1831+50.
59	The corridor selected involves crossing the Santa Fe Dam from approximately Reach 2, Sta. 1885+90 to Reach 2, Sta. 1898+00. Additional evaluations would need to be completed to determine the preferred crossing method.

Notes:
1. See Section 7.4.7 for additional details.
2. See Section 7.4.8 for typical cross-sections.
3. See Section 3.4.3 for typical section.
4. See Figure 5-8 for identification of segments comprising the LA River Alignment.

7.4 FEASIBILITY-LEVEL PIPELINE DESIGN

The following section establishes the pipeline design basis, including the pipeline flow rate, hydraulic profile, diameter, material, and governing design standards.

7.4.1 Design Flow

Pipeline diameters were sized for the full program build out of 150 mgd.

7.4.2 Optimization of Pipe Sizes and Pumping Costs

Since the LA River Alignment is so similar to the SG River Alignment hydraulically, it is anticipated that the feasibility-level analysis optimizing the pipe size for the SG River Alignment to balance pumping power cost with capital construction cost would be the same for the LA River Alignment. The analysis compared the amortized capital costs and the annual energy consumption to determine the most cost-effective pipe diameter. A more detailed evaluation should be conducted during preliminary design to validate the results. The pipe size optimization calculation is presented in Appendix H. The pipeline diameters selected for each reach are presented in Table 7-5. The stated diameter shall be the clear inside diameter after application of linings.

Table 7-5 Pipe Sizes

REACH	PIPE DIAMETER (IN.)	DESIGN FLOW (MGD)	PIPE VELOCITY (FPS)
1	84	150	6.0
2	84	150	6.0

7.4.3 Hydraulic Profile

Preliminary hydraulic profiles were developed for the LA River Alignment and are presented on Figure 7-3 thru Figure 7-5.

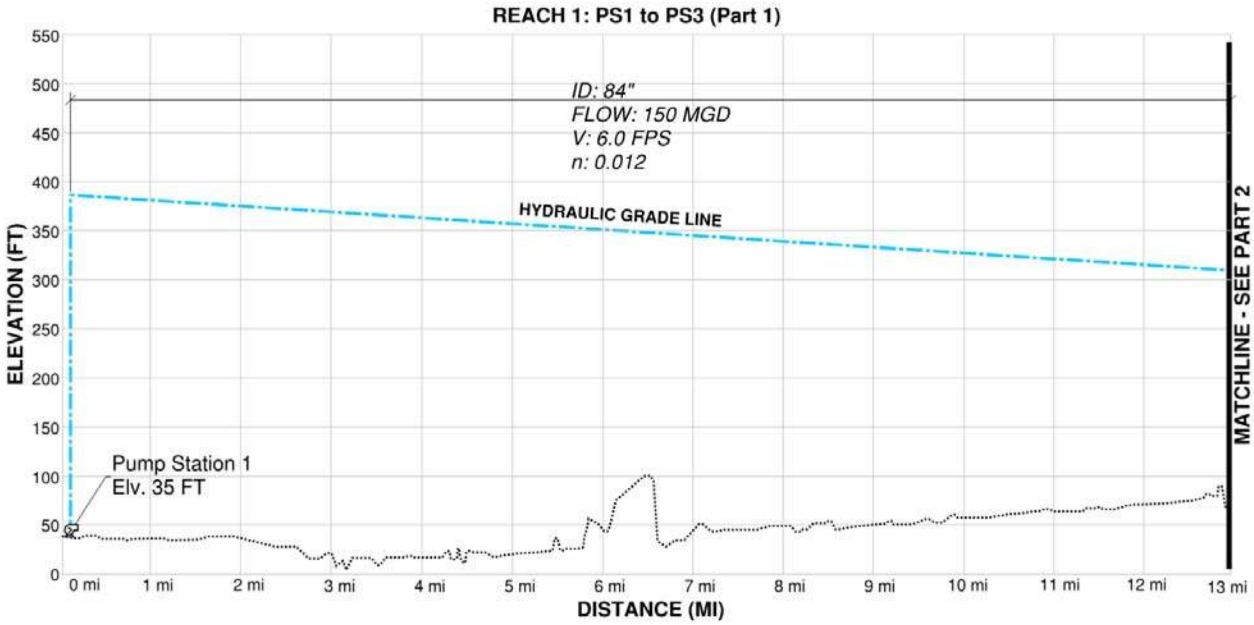


Figure 7-3 Reach 1, Part 1 Hydraulic Profile (LA River Alignment)

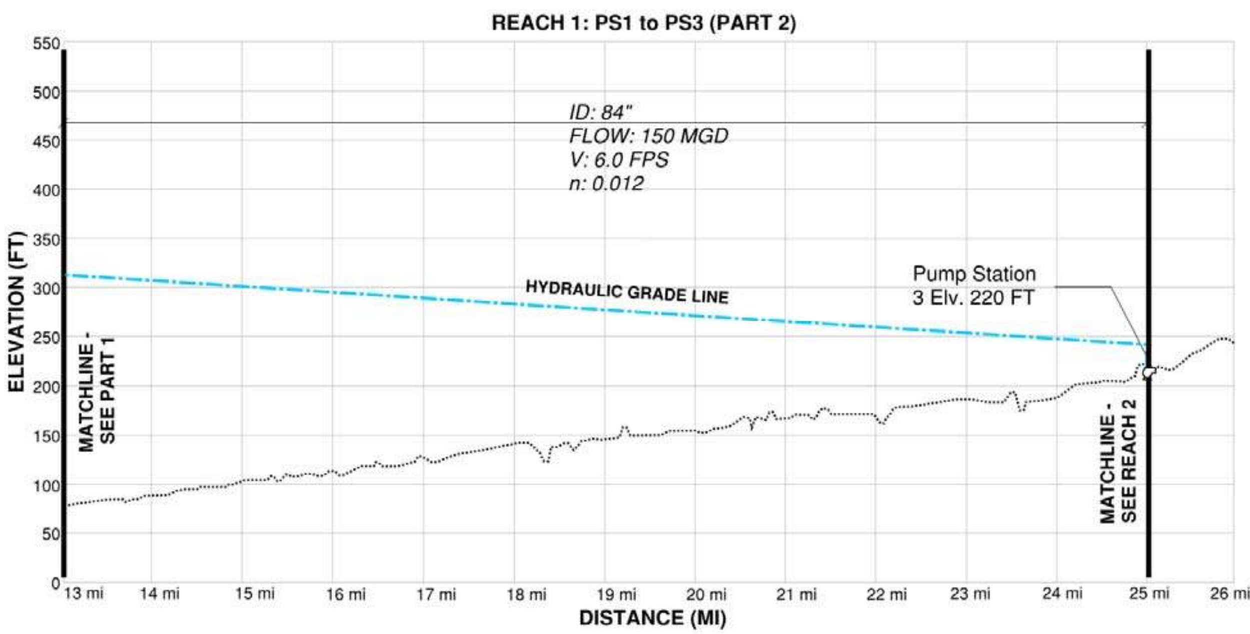


Figure 7-4 Reach 1, Part 2 Hydraulic Profile (LA River Alignment)

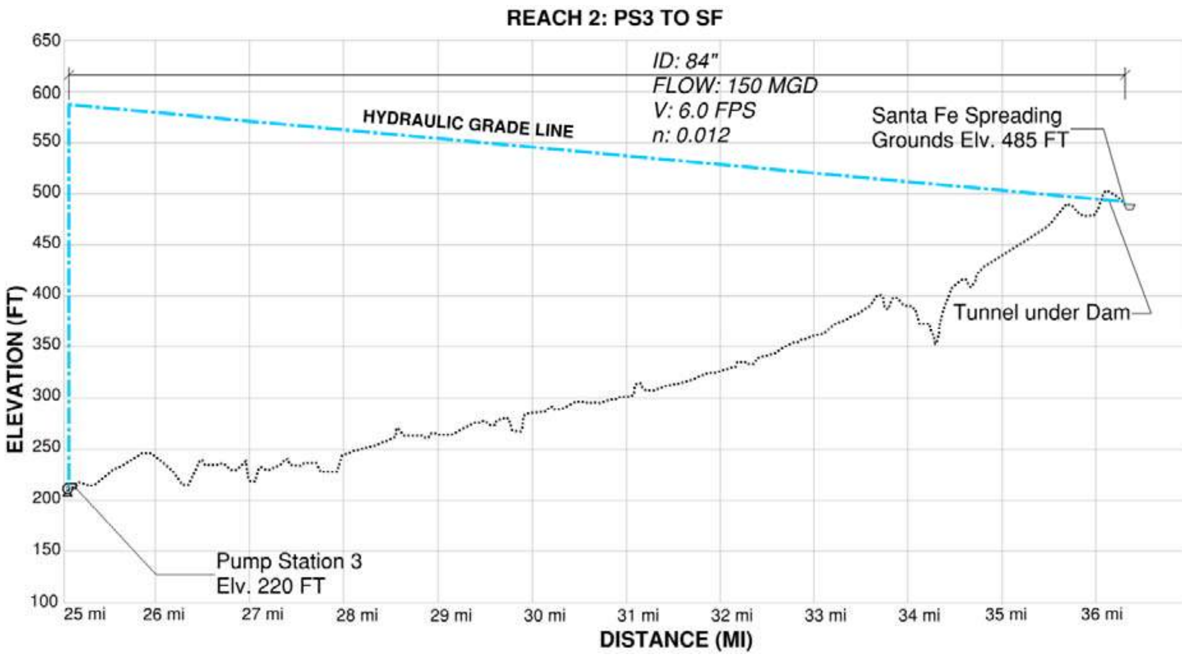


Figure 7-5 Reach 2 Hydraulic Profile (LA River Alignment)

As can be seen on Figure 7-5 above, the proposed alignment crosses the Santa Fe Dam spillway to reach the SFSG. It is currently envisioned that the alignment would cross under the dam using trenchless construction methods, which is technically feasible but could lead to permitting challenges. Additional coordination with the governing jurisdictions would be required during future phases of work to determine the preferred construction method.

7.4.4 Pipe Materials

Pipeline materials would be welded steel pipe in accordance with Metropolitan standards. Lining material selection was not evaluated as part of the study but was assumed to be cement mortar for purposes of establishing a budgetary cost. Metropolitan's design standards will be followed with evaluating and selecting lining material during future phases of work, in conjunction with water quality data from the demonstration plant.

7.4.4.1 Steel Cylinder Design Calculations

Initial pipeline plate thickness calculations were completed for the SG River Alignment. Since the LA River Alignment has the same, or slightly less, lift required at each pump station (since the alignment is slightly shorter), the plate thicknesses calculated for the SG River Alignment were used for the LA River Alignment.

The steel plate thickness was determined based on four loading conditions: permanent loads, semi-permanent loads, transient loads, and exceptional loads. Loads included both internal and external conditions. In addition, a minimum plate thickness due to handling and installation was considered. The evaluation was limited to a basic segment by segment analysis to support cost estimating and provide an initial basis for preliminary design development. Site specific calculations should be completed during preliminary design.

The recommended steel plate thicknesses for each pipe segment are summarized in Table 7-6. Details of the initial pipeline plate thickness calculations are presented in Appendix I.

Table 7-6 Steel Cylinder Thicknesses

REACH	PLATE THICKNESS (IN.)
1	0.500
2	0.500
Note: Steel cylinder thickness calculations assume 42 kips per square inch steel and a minimum plate thickness of 0.375 inches per Metropolitan's standard specification Section 02662.	

7.4.5 Pipeline Appurtenances

Pipeline appurtenances would be required for the proper operation and maintenance of the RRWP conveyance system. Appurtenances would include combination air-release and vacuum valves (ARVV), blow-offs, access manways, isolation valves, discharge connections, pumping wells, and other miscellaneous appurtenances. Metropolitan's standard drawings should be used to develop typical details for these appurtenances. All facilities will be designed in accordance with Metropolitan's standards and guidelines, which includes cross contamination prevention at air valve sites.

As part of the preliminary design, a study should be performed to determine potential blow-off and ARVV locations along the alignment. Locations where blow-offs could be connected to storm drains, existing channels, or drainage courses would also be identified during preliminary design.

In general, blow-offs would be located at low points along the pipeline and ARVVs would be located at high points.

7.4.6 Intersections

A list of Major and Minor Intersections, as designated by the Traffic Impact Analysis, for each Segment of the LA River Alignment is provided in Table 7-7.

Table 7-7 Summary of Intersection Designations

SEGMENT	INTERSECTION	CLASSIFICATION
1	Sepulveda Blvd. @ Dolores St.	Minor
	Sepulveda Blvd. @ Marbella Ave.	Minor
	Sepulveda Blvd. @ Panama Ave.	Minor
	Sepulveda Blvd. @ Avalon Blvd.	Major
	Sepulveda Blvd. @ Banning Blvd.	Minor
	Sepulveda Blvd. @ Wilmington Ave.	Major
	Sepulveda Blvd. @ Tesoro/Phillips 66	Minor

SEGMENT	INTERSECTION	CLASSIFICATION
	Sepulveda Blvd. @ Alameda Connector	Minor
	Sepulveda Blvd. @ Intermodal Wy.	Minor
	Sepulveda Blvd. @ R/R Xing	Major
	Sepulveda Blvd. @ ICTF	Minor
	Sepulveda Blvd. @ Middle Rd.	Minor
	Sepulveda Blvd. @ CA-103 terminus	Minor
	Sepulveda Blvd. @ Regway Ave.	Minor
	Sepulveda Blvd. @ Santa Fe Ave.	Major
	Sepulveda Blvd. @ Easy Ave.	Minor
2	None.	N/A
101	None.	N/A
3	None.	N/A
100	Hunsaker Ave. @ Alondra Blvd.	Major
	Alondra Blvd. @ Orange Ave.	Major
	Alondra Blvd. @ Gundry Ave.	Minor
7	None.	N/A
21	None.	N/A
23	Whittier Blvd. @ Myrtle St.	Minor
	Whittier Blvd. @ Paramount Blvd.	Major
	Paramount Blvd. @ Beverly Rd.	Major
	Paramount Blvd. @ Beverly Blvd.	Major
	Beverly Blvd. @ Acacia Ave.	Minor
	E Beverly Blvd. @ Rosemead Blvd.	Major
	E Beverly Blvd. @ Durfee Ave.	Minor
	E Beverly Blvd @ Sandoval Ave.	Minor
	E Beverly Blvd @ SG River Pkwy.	Minor
38	Shepherd St. @ Rose Hills Rd.	Minor
	Rose Hills Rd. @ Workman Mill Rd.	Minor
	Workman Mill Rd. @ E Mission Mill Rd.	Minor
	Workman Mill Rd. @ Rose Hills Gate 1	Minor
	Workman Mill Rd. @ College Dr.	Minor

SEGMENT	INTERSECTION	CLASSIFICATION
	Workman Mill Rd. @ Peck Rd.	Minor
	Peck Rd. @ Pellissier Rd.	Minor
	Peck Rd. @ Rooks Rd.	Major
44	None	N/A
52	Rivergrade @ Brooks Dr.	Minor
60	Rivergrade @ Live Oak Ave.	Minor
56	Live Oak @ Graham	Minor
58	None	N/A
59	None	N/A

7.4.7 Trenchless Construction Recommendations

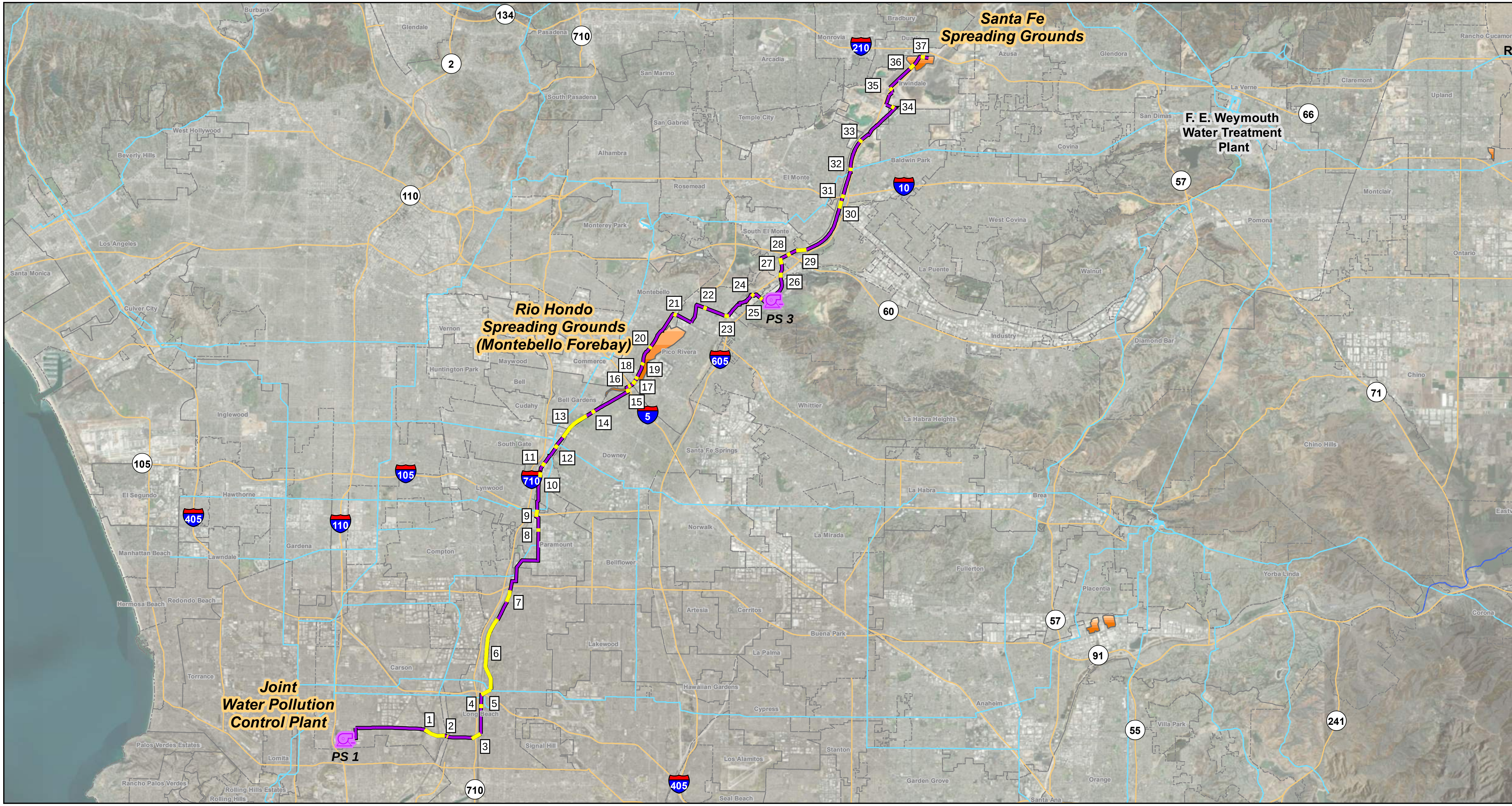
Similar to the SG River Alignment, feasible trenchless installation methods were selected for each location identified as potentially necessitating it for the purposes of establishing a conservative budget.

The next phase of the Project is expected to include site specific subsurface geotechnical explorations, comprehensive investigations, and mapping. These site-specific analyses will allow for a final selection of trenchless installation methods to be used at each location and may warrant that the trenchless methods described herein be revised.

The selected trenchless methods provided the basis for development of the feasibility-level Engineer's OPCC for the Project. Figure 7-6 correlates the trenchless identification number listed in Table 7-8 (shown below) with the location of each trenchless sub-segment along the LA River Alignment.

Table 7-8 summarizes the assumptions used to select the trenchless methods. The geotechnical information presented in Table 7-8 was based on the provided in the Desktop Geotechnical Evaluation.

It should be noted that a conservative depth of cover was assumed generally equal to three times the excavated diameter for the purposes of establishing a conservative budget for each trenchless crossing. Section 7.4.8 evaluates eleven trenchless crossings in greater detail. At these locations, the depth of cover that was assumed to be required were further refined, which, in some cases, led to them being reduced to less than three times the excavated diameter based upon the trenchless construction method assumed, the anticipated ground conditions, and the sensitivity of facilities for which it would cross beneath.



Existing MWD Distribution System

Los Angeles River Alignment

Trenchless / Tunnel Undercrossing with ID #

Pump Station or Flow Control Structure

Spreading Basins

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program

Figure 7-6: Los Angeles River Alignment Trenchless/Tunnel ID

0 0.75 1.5 3 4.5 Miles

N W E S

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Table 7-8 Assumed Trenchless Construction Methods (LA River Alignment)

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
1	3,442	Intersection / railroad / river	7	11	33	Yes	Traditional Tunneling (EPBM)	No	No	Yes	Length and curves would make microtunneling (MT) difficult but not impossible. This FLDR assumed EPBM at this time.
2	88	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk when crossing a railroad.
3	1,544	Freeway / River	7	9	11	Yes	Microtunneling	Yes	No	No	Length is too short to warrant conventional tunneling and it would be difficult to dewater and use jack & bore.
4	315	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
5	1,845	Freeway / Railroad	7	9	11	Yes	Microtunneling	Yes	Yes	No	Length is too long to reliably complete with jack & bore. Tunnel 5 is assumed to share a launching/receiving portal with Tunnel 6.
6	12,841	Steep Terrain / railroad / Road	7	11	22	Yes	Traditional Tunneling (EPBM)	Yes	Yes	No	EPBM is recommended for budgeting purposes due to the length.
7	2,326	Intersection / Community Crossing	7	9	22	Yes	Microtunneling	Yes	No	No	Length and curves would make MT difficult but not impossible. EPBM is recommended for budgeting at this time. Further analysis would be recommended to confirm in later design stages.
8	209	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
9	1,031	Freeway	7	9	11	Yes	Microtunneling	Yes	No	No	MT would be best suited to manage risk under freeway and flood control basin.
10	156	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
11	205	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
12	180	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
13	5,699	Road / railroad	7	11	22	Yes	Traditional Tunneling (EPBM)	Yes	No	No	EPBM is recommended for budgeting at this time due to length. Further analysis would be recommended to confirm in later design stages.
14	282	Road	7	9	27	Yes	Jack & Bore	No	No	No	Short drive length favors jack & bore.
15	422	River	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under river.
16	222	Freeway	7	9	27	Yes	Jack & Bore	No	No	No	Could be installed with cut-and-cover and a carrier pipe due to the freeway crossing above via a bridge. Assumed to be installed by jack and bore for budgeting. Further anlaysis would be recommended to confirm later in design.
17	382	Railroad / road	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
18	148	Road	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.
19	432	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
20	157	Road	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.

TUNNEL NO.[1]	LENGTH (FT)	DESCRIPTION	PIPE INTERNAL DIAMETER (FT)	CASING OR TUNNEL OUTER DIAMETER (FT)	MINIMUM DEPTH (FT)[2]	GROUND WATER IMPACT	METHOD SELECTED	COBBLES, GRAVEL, BOULDERS	FAULT CROSSING	OIL FIELD	COMMENTS
21	526	River	7	9	27	Yes	Microtunneling	No	No	No	Crossing is not suitable for jack & bore as a river crossing.
22	283	Intersection	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.
23	688	River	7	9	27	Yes	Microtunneling	No	No	No	Crossing is not suitable for jack & bore as a river crossing.
24	325	Freeway	7	9	27	Yes	Jack & Bore	No	No	No	MT would be best suited to manage risk under railroad.
25	88	Railroad	7	9	27	Yes	Microtunneling	No	No	No	MT would be best suited to manage risk under railroad.
26	842	Freeway	7	9	27	Yes	Microtunneling	No	No	No	Length lends it to MT.
27	666	River	7	9	27	Yes	Microtunneling	Yes	No	No	Crossing is not suitable for jack & bore as a river crossing.
28	381	Freeway	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
29	1,825	River	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
30	1,631	Railroad / River	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
31	325	Freeway	7	9	27	Yes	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
32	128	Road	7	9	27	Yes	Jack & Bore	Yes	No	No	Short drive length favors jack & bore.
33	285	Road	7	9	27	No	Jack & Bore	Yes	No	No	Short drive length favors jack & bore.
34	528	River	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT
35	517	Freeway	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
36	1,215	Dam	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.
37	508	Freeway	7	9	27	No	Microtunneling	Yes	No	No	Length and lack of clay lend it to MT.

Notes:
1. Tunnel identification number corresponds with Figure 7-6.
2. Depth below ground surface or river channel to top of pipe or crown of tunnel; generally equal to 3 times the excavated diameter.

7.4.8 Feasibility-Level Technical/Construction Details

This section discusses segments of the LA River Alignment where the typical construction methods would not be sufficient to construct the pipeline due to terrain, such as rivers, and/or physical barriers, such as freeways or railroads, or to avoid impacts to the community.

A preliminary review of the LA River Alignment identified eleven locations warranting feasibility-level technical / construction details. The eleven feasibility-level technical / construction detail locations are identified in Table 7-9 and presented on Table 7-9. Where a location is identified for the LA River Alignment that is common to the SG River Alignment, the description was not repeated. Instead, in Table 7-9 it was noted and a reference to the description in Chapter 6 was provided. Descriptions for each location include details on site conditions, existing utilities, easements, and trenchless methodology. Additionally, plan and profiles have been developed for each location. Ground elevations shown were obtained through Google Earth and are approximate. Ground surveys were not completed for this FLDR.

Table 7-9 Feasibility-Level Technical/Construction Detail Locations

NO.	STATION	DESCRIPTION	COMMENT
1	Reach 1, Sta. 139+17 – Reach 1, Sta. 173+59	Trenchless crossing of Alameda Street/railroad corridor and the Dominguez Chanel along Sepulveda Boulevard.	See Section 6.4.8.
2	Reach 1, Sta. 225+38 – Reach 1, Sta. 240+82	Trenchless crossing of 710 Freeway and Los Angeles River along Sepulveda Boulevard.	Described below.
3	Reach 1, Sta. 308+55 – Reach 1, Sta. 327+00	Trenchless crossing of 405 Freeway	Described below.
4	Reach 1, Sta. 327+05 – Reach 1, Sta. 455+46	Trenchless crossing of Los Cerritos / Los Angeles River bank.	Described below.
5	Reach 1, Sta. 488+80 – Reach 1, Sta. 512+06	Trenchless crossing of East Artesia Blvd and mobile home community.	Described below.
6	Reach 1, Sta. 678+62 – Reach 1, Sta. 688+93	Trenchless crossing of the 105 Freeway	Described below.
7	Reach 1, Sta. 828+68 – Reach 1, Sta. 885+67	Trenchless crossing of Firestone Blvd and Rio Hondo Golf Course.	Described below.
8	Reach 1, Sta. 1250+25 – Reach 1, Sta. 1257+13	Trenchless crossing of SG River along Beverly Blvd.	Described below.
9	Reach 2, Sta. 1467+00 – Reach 2, Sta. 1485+25	Trenchless crossing of the Walnut Creek Wash along the SG River.	See Section 6.4.8.
10	Reach 1, Sta. 1790+45 – Reach 1, Sta. 1795+73	Trenchless crossing of the SG River along Live Oak Avenue.	See Section 6.4.8.
11	Reach 1, Sta. 1917+30 – Reach 1, Sta. 1922+38	Trenchless crossing of the 605 Freeway.	See Section 6.4.8.

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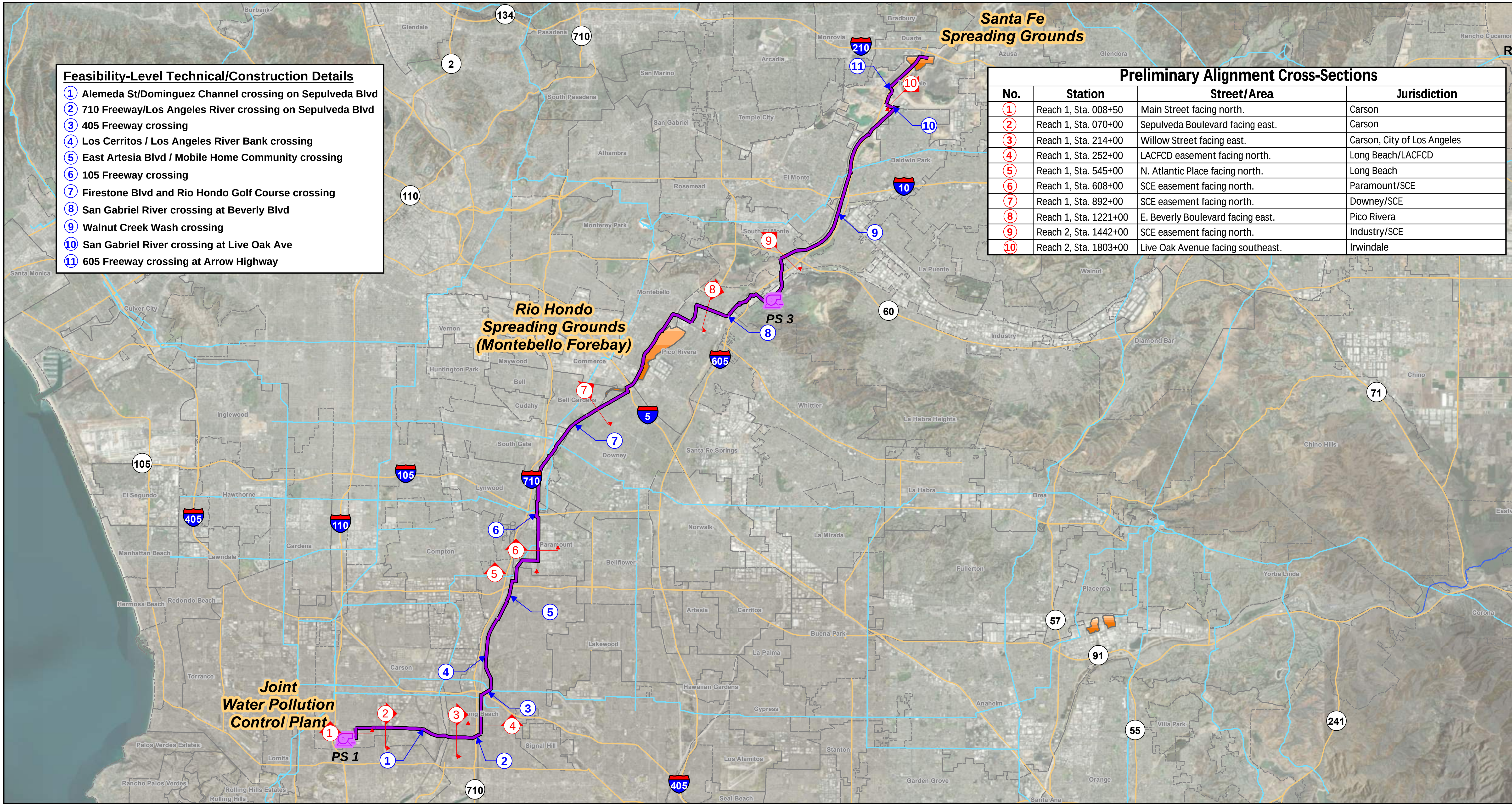

Preliminary Alignment Cross-Sections

No.	Station	Street/Area	Jurisdiction
1	Reach 1, Sta. 008+50	Main Street facing north.	Carson
2	Reach 1, Sta. 070+00	Sepulveda Boulevard facing east.	Carson
3	Reach 1, Sta. 214+00	Willow Street facing east.	Carson, City of Los Angeles
4	Reach 1, Sta. 252+00	LACFCD easement facing north.	Long Beach/LACFCD
5	Reach 1, Sta. 545+00	N. Atlantic Place facing north.	Long Beach
6	Reach 1, Sta. 608+00	SCE easement facing north.	Paramount/SCE
7	Reach 1, Sta. 892+00	SCE easement facing north.	Downey/SCE
8	Reach 1, Sta. 1221+00	E. Beverly Boulevard facing east.	Pico Rivera
9	Reach 2, Sta. 1442+00	SCE easement facing north.	Industry/SCE
10	Reach 2, Sta. 1803+00	Live Oak Avenue facing southeast.	Irwindale

Existing MWD Distribution System
Los Angeles River Alignment
Trenchless / Tunnel Undercrossing with ID #
Pump Station or Flow Control Structure
Spreading Basins
Preliminary Alignment Cross-Section
Location of Concept Construction Details

Feasibility-Level Design of Conveyance for Potential RW Supply Program

Figure 7-7: Los Angeles River Alignment Feasibility-Level Technical/ Construction Detail and Cross Section Locations

0 0.75 1.5 3 4.5 Miles

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7.4.8.1 710 Freeway and Los Angeles River Crossing

The LA River Alignment proposes crossing below the 710 Freeway and the LA River from Reach 1, Sta. 225+38 to Reach 1, Sta. 240+82. The proposed crossing is shown in plan on Figure 7-8 and in profile on Figure 7-9. Key details of the crossing are provided in Table 7-10.

Table 7-10 Trenchless Method Summary of the 710 Freeway and Los Angeles River Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,544	River / Freeway	7	11	Yes	MT	Y	N	Y	N	N

Launching is recommended from the west side of the 710 Freeway based upon potentially available space for portal excavation and contractor staging in the vacant lot on the corner of the on/off ramp to the 710 Freeway. Further investigation of the property would be required to finalize portal location and availability. Other locations could include a portal within Fashion Avenue or in the open space between the 710 Freeway and the on/off ramp. Receiving is recommended from the east side of the Los Angeles River in the LACFCD ROW adjacent to De Forest Avenue. This property is recommended for the receiving portal due to limited available space. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

This drive length may require an intermediate jacking station. Although with good continuously replenished overcut lubrication, it may be possible without one. The MT boring machine is assumed to need disc cutters to fracture any boulders encountered and the shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. While the cover under the LA River is not known at this time, it is assumed that a minimum of 11 ft would be required below the lowest point, with more cover provided along the rest of the route.

Willow Street is congested with existing utilities. These utilities include existing storm drains, water, sanitary sewer, oil and gas piping, and telecommunications. Potholing of these utilities is recommended. Additionally, a corridor of existing oil and gas pipes runs parallel to the Los Angeles River on the east side. Potholing of these utilities is also recommended to confirm the location of the receiving portal.

It is recognized that this is a challenging crossing. Towards that end, other locations to cross the 710 Freeway and the LA River have been identified and include a crossing using the cul-de-sac at the end of Spring Street. Further evaluation is recommended during the next phase of design.

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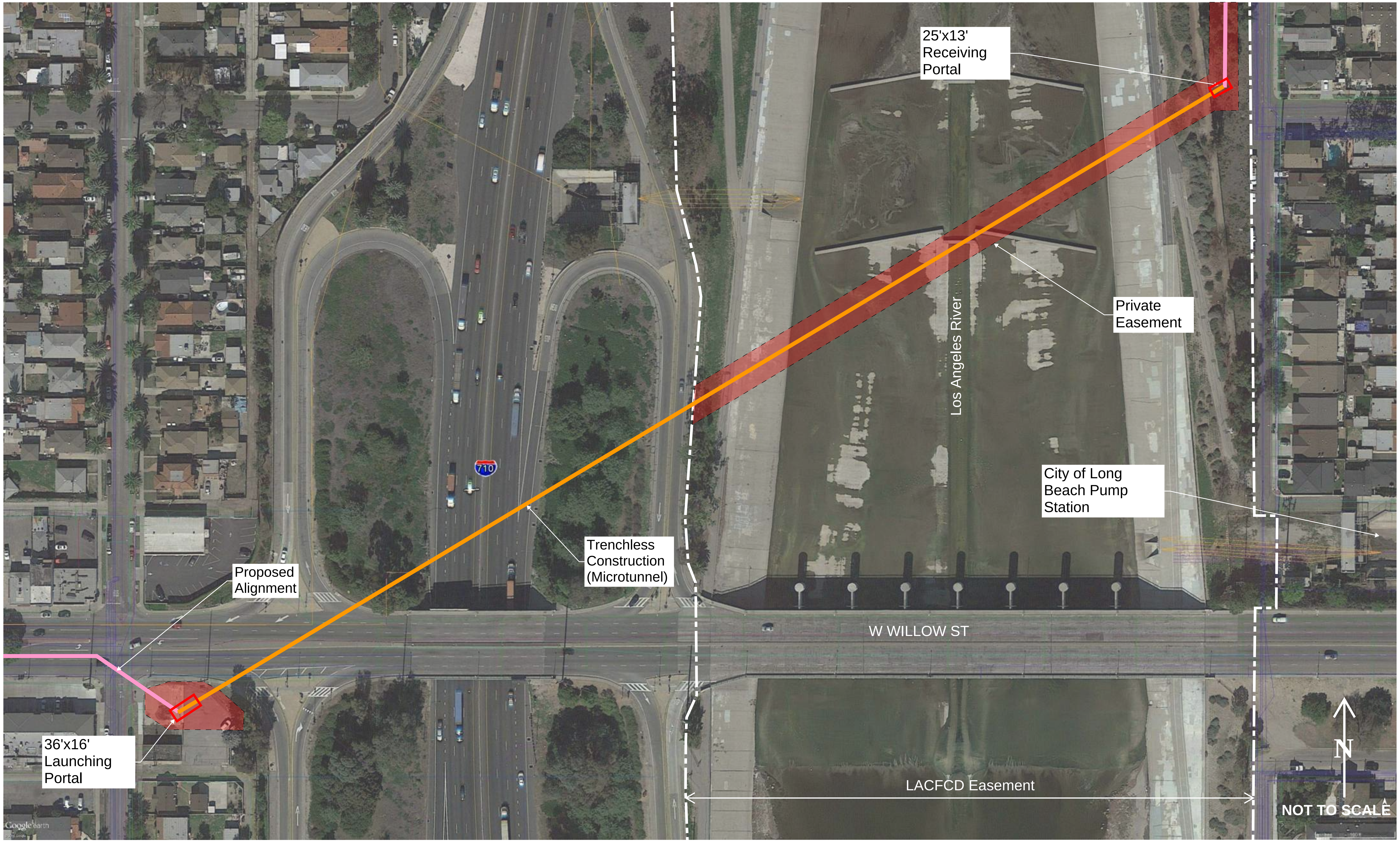

BLACK & VEATCH

Open-Trench Construction Method - Roadways
Trenchless Construction Method - Microtunnel
Private Easement
Launching/Receiving Pit

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
710 Freeway and Los Angeles River Crossing

FIGURE 7-8

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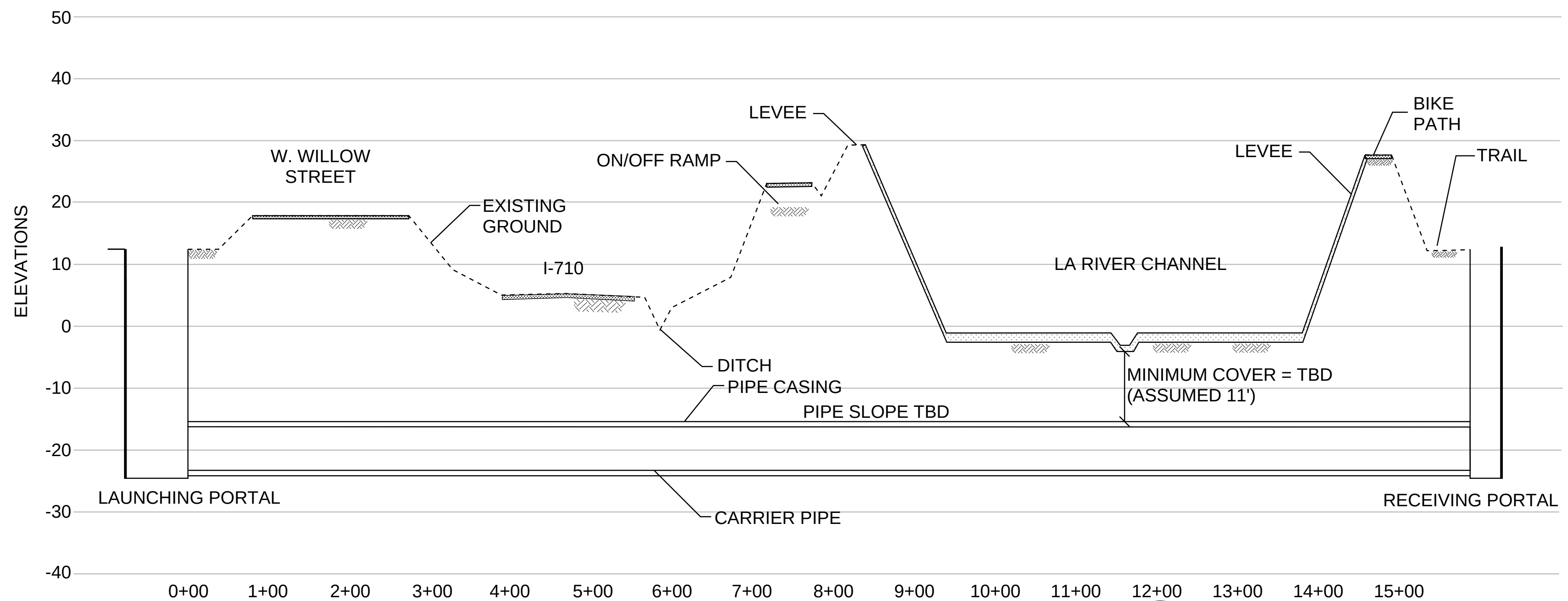

MICROTUNNEL CROSSING OF 710 FREEWAY AND THE LA RIVER (1)
HORZ: 1" = 200'
VERT: 1" = 25'

BLACK & VEATCH

1" = 200' 0 100' 200' 250' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 710 Freeway and Los Angeles River Crossing

FIGURE 7-9

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7.4.8.2 405 Freeway Crossing

The LA River Alignment proposes crossing the 405 Freeway, railroad tracks, and an existing environmental storage cleanup site from Reach 1, Sta. 308+55 to Reach 1, Sta. 327+00 using trenchless construction methods.

The proposed crossing is shown in plan on Figure 7-10 and in profile on Figure 7-11. Key details of the crossing are provided in Table 7-11.

Table 7-11 Trenchless Method Summary of 405 Freeway Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,845	Freeway/ Railroad	7	11	Yes	MT	Y	N	Y	Y	N

Launching is recommended from the southwest side of the freeway based upon potentially available space for portal excavation and contractor staging. This area is primarily in the LACFCD ROW and is undeveloped. The receiving portal is recommended on the northeast side of the freeway and railroad tracks in Los Cerritos Park.

Acquisition of temporary and permanent easements would be required.

Due to the length of the drive, it is assumed that an intermediate jacking station would be required along with continuously replenished overcut lubrication to reduce side friction and minimize the risk of getting stuck. The intermediate jacking station is recommended on the north side of the 405 Freeway.

Due to the depth of the receiving portal, a circular shaft has been assumed.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

The end of the trenchless crossing is proposed to be the beginning of the next trenchless crossing, as described in the following section. Site use coordination between the two drives would be required. It is recommended that the use of a common shaft between the two drives or two separate shafts be evaluated during subsequent design phases as the logistical challenges may outweigh the benefits.

The Newport-Inglewood Fault Zone crosses through this area roughly parallel and adjacent to the existing rail road tracks. This fault zone is estimated to be 865 ft wide in this vicinity and the best estimate of the right-lateral displacement is 6.5 ft average displacement according to the Desktop Geotech Report. The proposed alignment was selected to cross the fault zone perpendicularly. If Metropolitan requires the conveyance system to remain functional after a major earthquake, special design and construction measures would be required.

Special considerations would be required by the tunneling contractor when tunneling through faults and fault zones. These considerations could include slowing the tunnel advance rate, monitoring of groundwater inflow, and/or modifying the initial and final tunnel ground support and/or final lining. This is because the weakened state in the fault zone could lead to increased ground support requirements, which slows the overall tunnel advance rate, in addition to the increased potential for groundwater inflow.

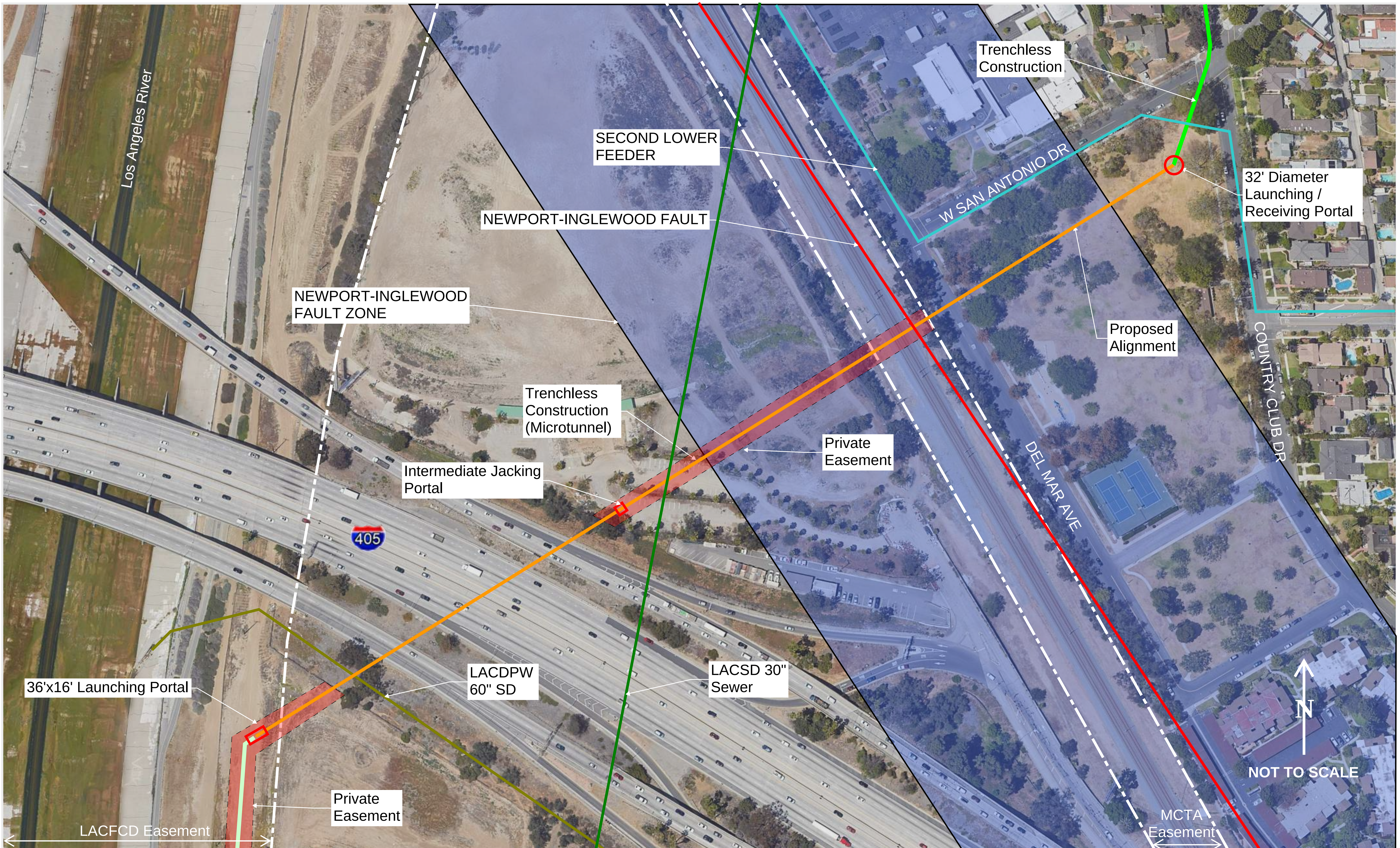
Specialized designs would be required for fault crossings. These designs could include, but are not limited to: 1) over-excavation or enlargement of the tunnel to provide for future movement of the fault where the tunnel crosses; 2) filling of the annular space between the initial tunnel excavation and the exterior of the tunnel final lining with low strength material such as cellular concrete; 3) grouting the faulted ground to increase the strength and ductility of the faulted ground; and/or 4) using flexible joints to increase the longitudinal flexibility of the tunnel final lining.

No seismic design criteria have been established at this stage but will be critical as the RRWP progresses to future phases of work.

The former sedimentation basin, a portion of which is currently being used as a golf center / driving range, that this alignment would cross near is the home of a historic environmental storage cleanup site. The selected alignment made efforts to minimize the length of the crossing in the potentially contaminated zone. By the time the fault zone is crossed, the alignment would be in Los Cerritos Park.

The receiving portal is assumed to be circular due to its depth to account for the change in ground elevation from the launching portal to the receiving.

An existing LACDPW storm drain parallels the 405 Freeway close to the LA River Alignment. Additionally, an existing LACSD sewer also crosses the 405 Freeway in the vicinity and intersects with the proposed alignment just north of the 405 Freeway. Potholing these utilities is recommended to confirm the alignment. No other utilities are anticipated.



Open-Trench Construction Method - LACFCD Easement (River Bank)
Trenchless Construction Method - Microtunnel
Trenchless Construction Method - EPBM Tunnel
Launching/Receiving Pit
Private Easement
Second Lower Feeder
LACDPW Storm Drain
Fault Zone
Active Fault
LACSD Sewer Pipe

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

405 Freeway Crossing

FIGURE 7-10

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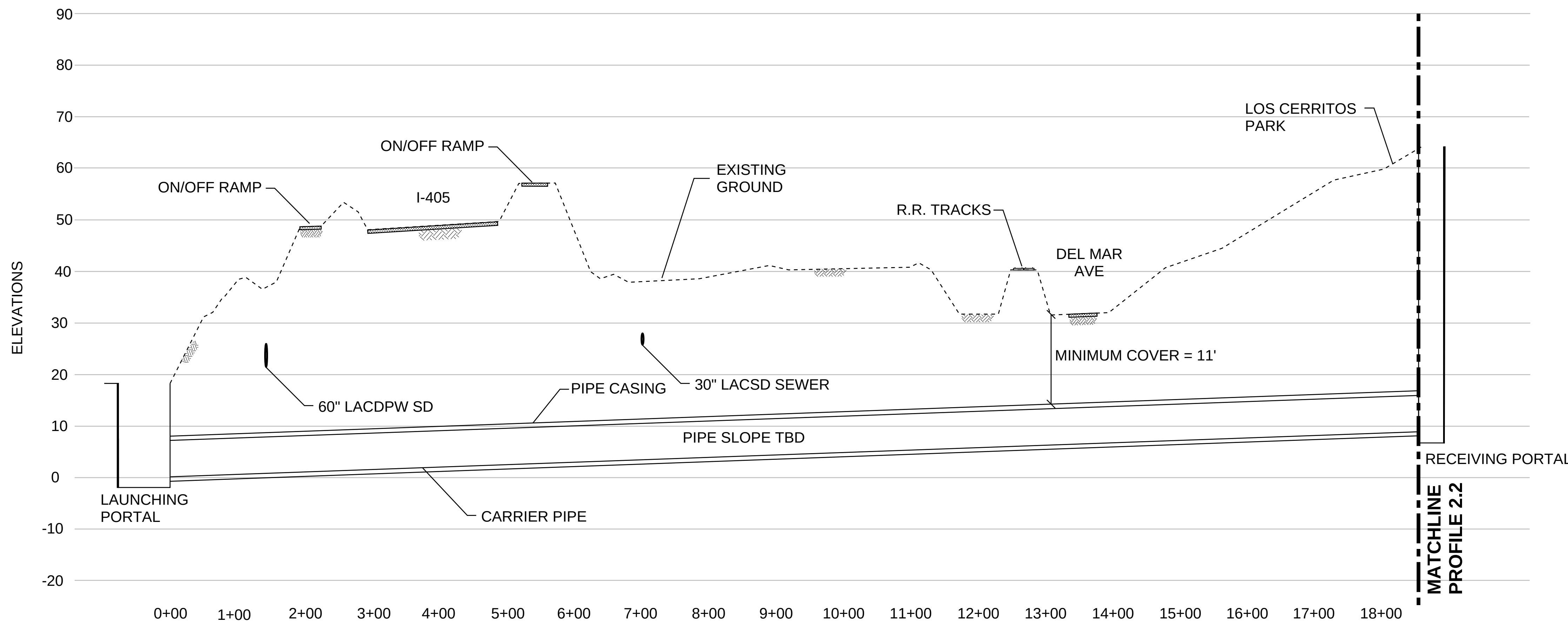

MICROTUNNEL CROSSING OF 405 FREEWAY (2.1)

HORZ: 1" = 200'
VERT: 1" = 25'

BLACK & VEATCH

1" = 200' 0 100' 200' 250' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 405 Freeway Crossing

FIGURE 7-11

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7.4.8.3 Los Cerritos / Los Angeles River Bank Tunnel Crossing

The LA River Alignment proposes crossing the Los Cerritos community and a portion of the LA River bank from Reach 1, Sta. 327+05 to Reach 1, Sta. 455+46 using trenchless construction methods. The proposed crossing is shown in plan on Figure 7-12 and Figure 7-13 and in profile on Figure 7-14 and Figure 7-15. Key details of the crossing are provided in Table 7-12.

Table 7-12 Trenchless Method Summary of Los Cerritos / LA River Bank Tunnel Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
12,841	Steep Terrain, Railroad	7	22	Yes	EPBM	Y	N	Y	Y	N

The trenchless crossing of the 405 Freeway and the Newport-Inglewood Fault Zone ended in the Los Cerritos Park by the time it was out of the fault zone, as described in Section 7.4.8.2. The Los Cerritos Park is surrounded by a residential neighborhood. To minimize the impact on the residents, this FLDR proposed a traditional tunnel that follows the existing public rights-of-way of Country Club Drive then traverses beneath private property, including the Virginia Country Club before returning to adjacent to the LA River within LACFCD right-of-way. From here, the tunnel would continue to avoid impacts to the newly completed improved wetland and spreading basins alongside the LA River.

It is assumed that this would be constructed in one continuous span with a launching portal at Los Cerritos Park. The receiving portal is assumed to be located in the LACFCD easement adjacent to De Forest Avenue, north of Long Beach Boulevard.

It is assumed that a minimum of two excavated diameters, or 22 ft, of cover would be required along the tunnel. The depth of the tunnel would be driven by the elevations within the golf course or along the spreading basins adjacent to the LA River. The launching portal is assumed to be circular due to its depth required from the change in ground elevation between the launching portal and the alignment low points.

The use of a shielded TBM would help prevent explosion risk and toxic gas risk if any gas is present in ground or groundwater.

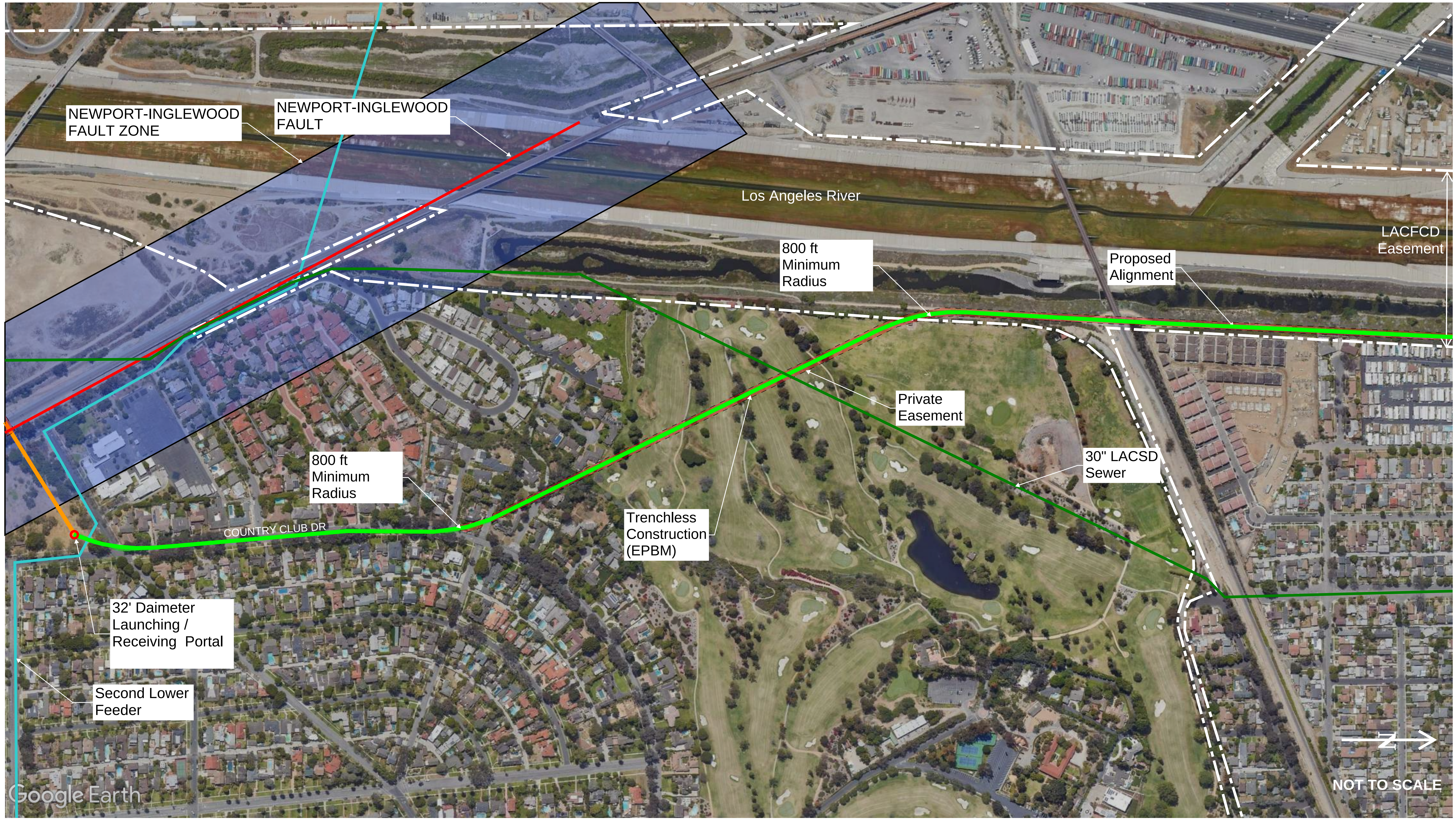
The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Portions of the alignment would pass close to bridges which are anticipated to have deep foundations. Detailed stress change and ground movement analysis is recommended at these locations.

Generally, a minimum tunnel radius of 800 ft is recommended for EPBM tunneling with segments and was the minimum radius assumed herein. This radius provides for efficient installation of the 20 ft long steel carrier pipe segments and allows for a wider pool of TBMs. Smaller radii can be considered but require careful curve evaluation. Tighter curves can result in a larger excavation / casing diameter to account for carrier pipe placement and grouting. For these reasons, among others, tighter curves are more expensive.

This tunnel alignment crosses Metropolitan's Second Lower Feeder when exiting the Los Cerritos Park. Additionally, it crosses LACSD's North Long Beach Trunk in the golf course and is parallel to the Joint Outfall A – Unit 6 Trunk sewer from south of Long Beach Boulevard to the end of the tunnel. It also crosses multiple storm drain lines discharging into the spreading basins adjacent to the LA River. Potholing these utilities is recommended to confirm the alignment. Other utilities, such as potable water and sewer connections for the neighborhood and recycled water for irrigation of the golf course, would be anticipated.

Acquisition of temporary and permanent easements would be required.



Trenchless Construction Method - Microtunnel
Trenchless Construction Method - EPBM Tunnel
Private Easement
LACSD Sewer Pipe
Launching/Receiving Pit
Second Lower Feeder
Fault Zone
Active Fault

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Los Cerritos / Los Angeles River Bank Tunnel - Part 1

FIGURE 7-12

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Open-Trench Construction Method - Roadways
Trenchless Construction Method - EPBM Tunnel
Private Easement
Launching/Receiving Pit
LACDPW Storm Drain
LACSD Sewer Pipe

BLACK & VEATCH

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Los Cerritos / Los Angeles River Bank Tunnel - Part 2

FIGURE 7-13

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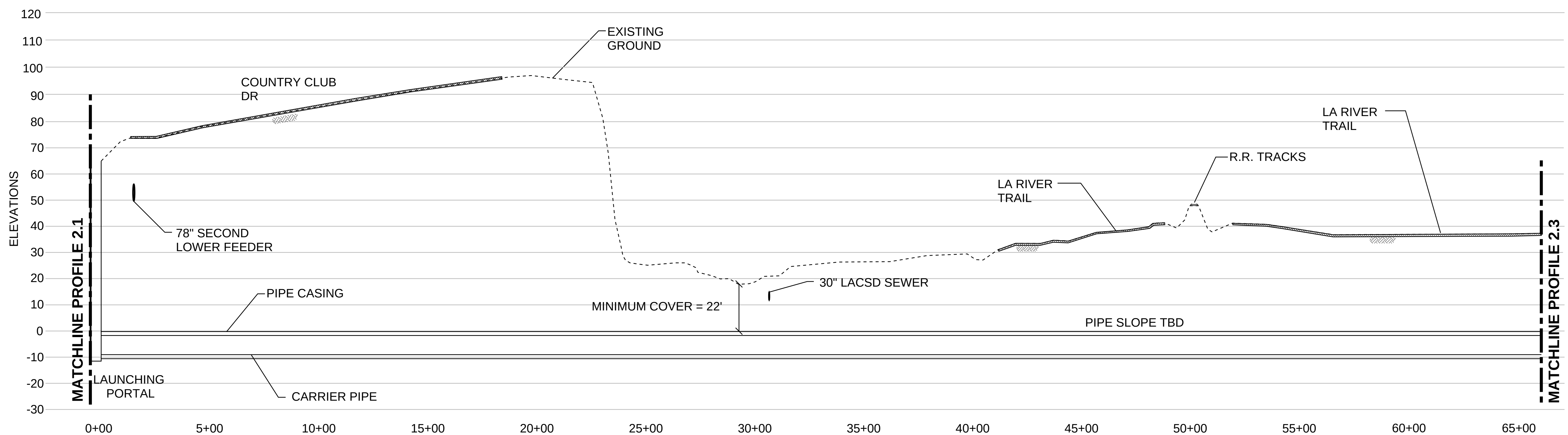

CONVENTIONAL TUNNEL (EPBM) LOS CERRITOS AND LA RIVER BANK

2.2

HORZ: 1" = 500'
VERT: 1" = 40'

BLACK & VEATCH

1" = 1000' 0 250' 500' 750' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Los Cerritos / Los Angeles River Bank Tunnel - Part 1

FIGURE 7-14

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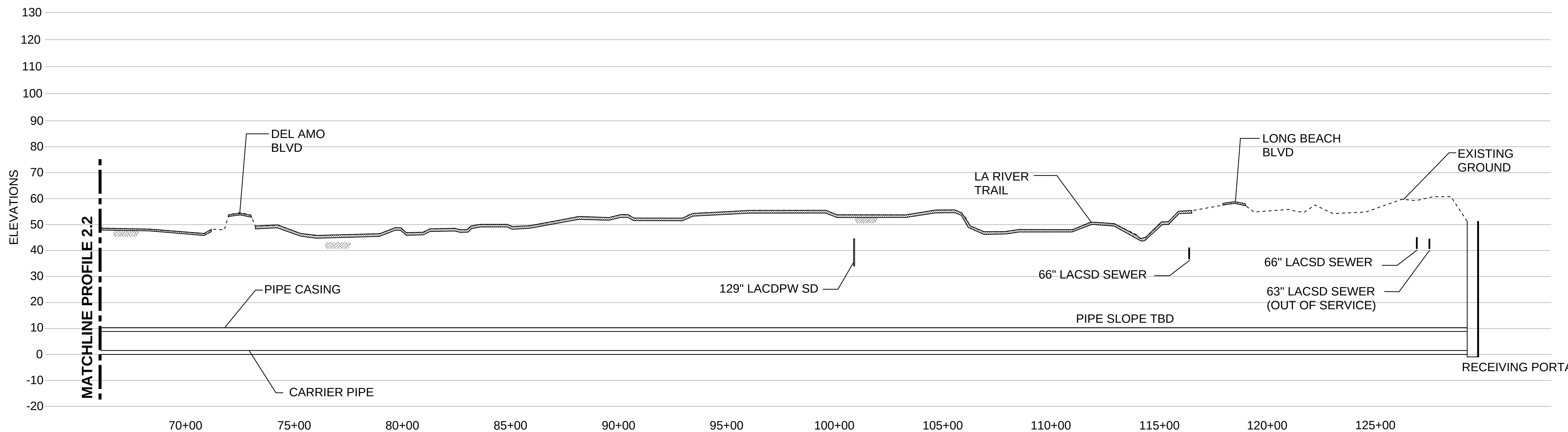

CONVENTIONAL TUNNEL (EPBM) LOS CERRITOS AND LA RIVER BANK

2.3

HORZ: 1" = 500'
VERT: 1" = 40'

BLACK & VEATCH

1" = 1000' 0 250' 500' 750' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Los Cerritos / Los Angeles River Bank Tunnel - Part 2

FIGURE 7-15

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7.4.8.4 East Artesia Boulevard Crossing

The LA River Alignment proposes crossing East Artesia Boulevard and a mobile home community from Reach 1, Sta. 488+80 to Reach 1, Sta. 512+06 using trenchless construction methods. The proposed crossing is shown in plan on Figure 7-16 and in profile on Figure 7-17. Key details of the crossing are provided in Table 7-13.

Table 7-13 Trenchless Method Summary of East Artesia Boulevard Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
2,326	Road/ Community	7	22	Yes	MT	Y	N	Y	N	N

This proposed crossing would run parallel to, and between, three existing LACSD sewers (two active and one out of service) that also have the same crossing. Like the existing sewer lines, the proposed crossing would pass beneath the mobile home community in LACFCD's existing easement (quitclaim). To minimize the impacts on the community, it is assumed that this crossing would be completed with trenchless construction methods.

Launching for the trenchless construction is recommended from the north side of Artesia Boulevard and the LACDPW storm pump station in the LACFCD easement based upon potentially available space for portal excavation and contractor staging. The receiving portal is recommended on the south side of the mobile home community. The recommended receiving portal is located in the LACFCD easement. Acquisition of temporary and permanent easements would be required.

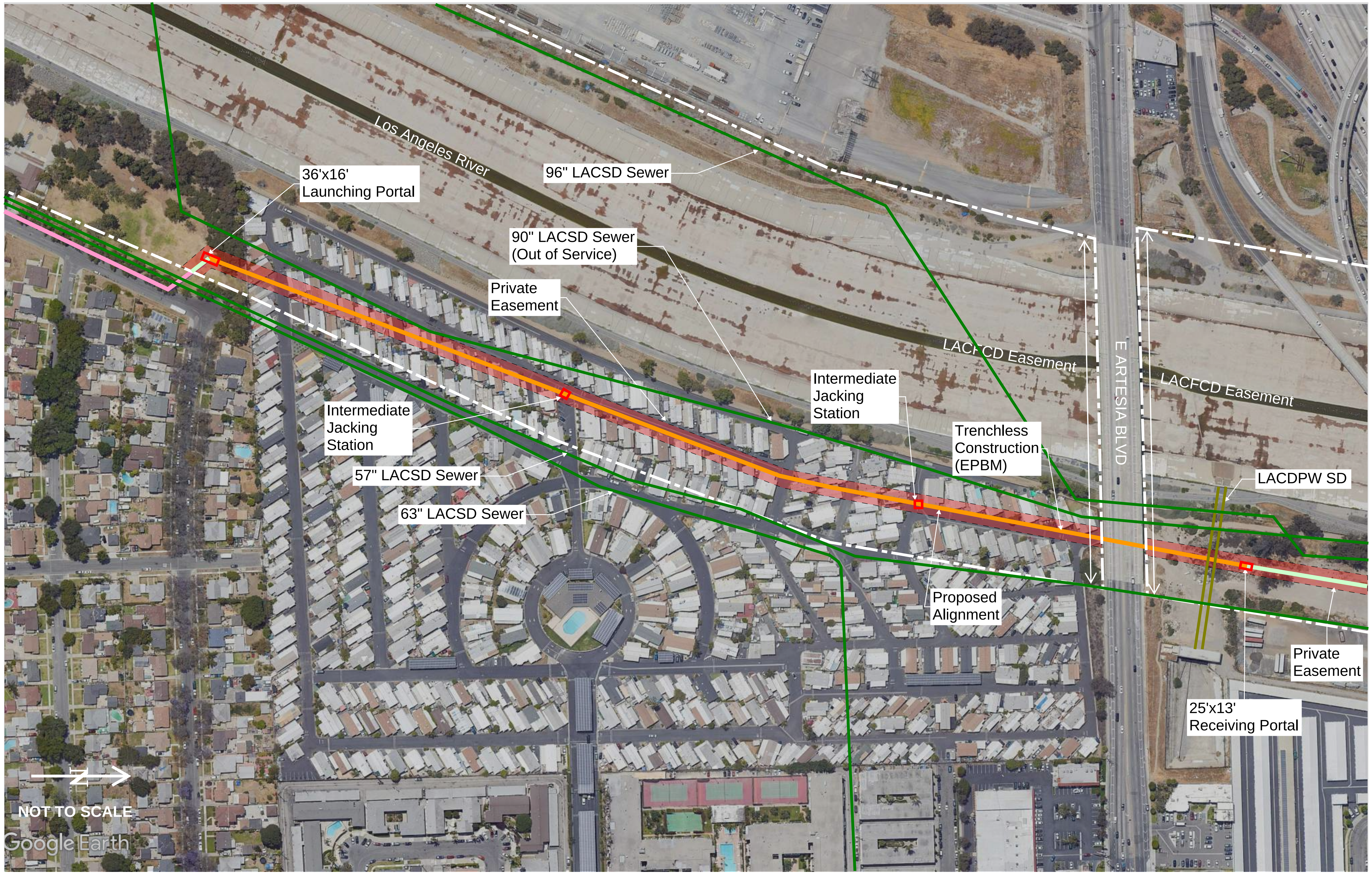
Due to the length and the curve radius, two intermediate jacking stations with continuously replenished overcut lubrication would work to reduce the side friction and minimize the risk of getting stuck. Since the proposed crossing would cross beneath trailer homes, the tunnel should be deep enough to provide at least 22 feet of cover below the ground surface.

The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. Due to their depth, circular shafts should be considered.

The proposed alignment would pass close to the bridge for Artesia Blvd. The bridge abutment and piers are likely supported by piles or drilled shaft foundations. Detailed stress change and ground movement analysis is recommended at these locations. Should the foundations extend below the proposed tunnel invert, then as assessment is recommended to determine if bridge underpinning or ground improvements would be required.

Existing LACFCD storm pipes run perpendicular to the Los Angeles River and the proposed alignment just north of East Artesia Boulevard. The alignment would cross the LACDPW storm pipes near the launching portal. As mentioned previously, the alignment is parallel to, and between, three existing LACSD sewer lines, with a fourth joining near Artesia Boulevard. Potholing would be required to finalize portal and alignment locations and feasibility.

Alternative routes to crossing beneath the mobile home community, such as following 63rd Street to Atlantic Avenue, were considered. However, these alternative routes were anticipated to have a greater impact on the community. Further coordination is required with property owners in subsequent phases of work to confirm this alignment. The alignment shown provides a conservative budget should an alternative be required.



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Open-Trench Construction Method - Roadways	Launching/Receiving Pit		
Trenchless Construction Method - Microtunnel	Private Easement		
Open-Trench Construction Method - LACFCD Easement (River Bank)	LACDPW Storm Drain		
	LACSD Sewer Pipe		

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

East Artesia Boulevard Crossing

FIGURE 7-16

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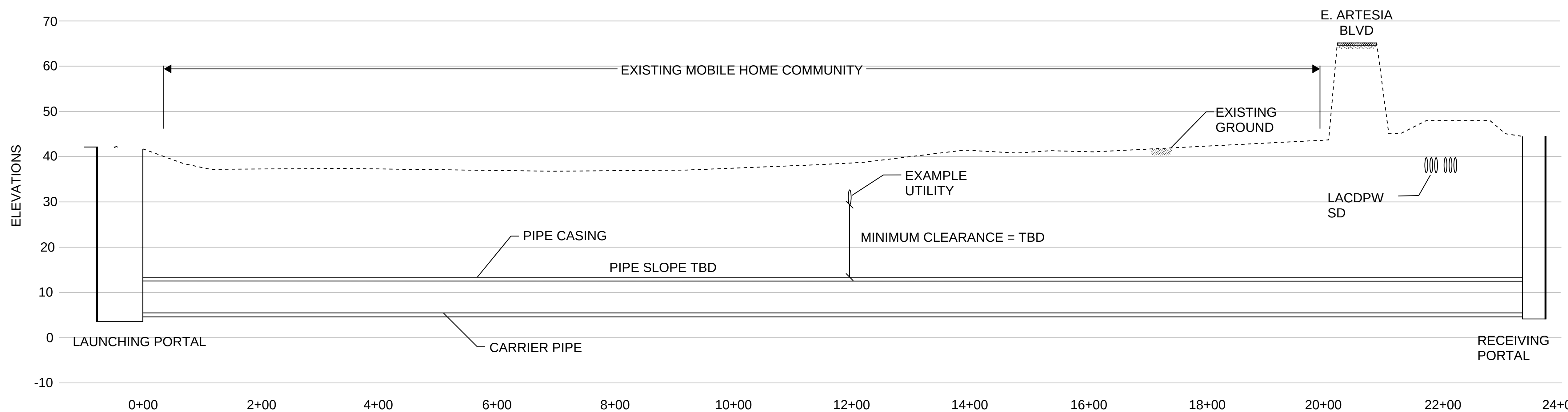

MICROTUNNEL CROSSING OF EAST ARTESIA BOULEVARD

HORZ: 1" = 200'

VERT: 1" = 25'

4

BLACK & VEATCH

1" = 200' 0 100' 200' 250' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of East Artesia Boulevard Crossing

FIGURE 7-17

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7.4.8.6 105 Freeway Crossing

The LA River Alignment proposes crossing the 105 Freeway from Reach 1, Sta. 678+62 to Reach 1, Sta. 688+93 using trenchless construction methods. The proposed crossing is shown in plan on Figure 7-18 and in profile on Figure 7-19. Key details of the crossing are provided in Table 7-14.

Table 7-14 Trenchless Method Summary of 105 Freeway Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
1,031	Freeway	7	11	Yes	MT	Y	N	Y	N	N

The crossing would a feature trenchless construction segment crossing the railroad tracks, the 105 Freeway, a LACDPW stormwater retention basin, and Metropolitan's West Coast Feeder. Launching for the trenchless construction is recommended from near the dead end of railroad tracks in the MTA easement. Additional investigations and coordination with the owner of the railroad corridor would be required in subsequent design phases to confirm this portal location.

The receiving portal is recommended on the north side of the LACDPW retention basin and Metropolitan West Coast Feeder in SCE's easement. The area is currently being leased by a nursery and the plants would require temporary relocation during construction. Construction and easements would have a significant impact on both properties, and early real property acquisition is recommended to confirm the alignment and acquire access. Acquisition of temporary and permanent easements would be required.

No intermediate jacking stations would be anticipated to accomplish this drive length. Continuous replenishing of the overcut with lubrication should reduce the side friction sufficiently to manage the risk of getting stuck.

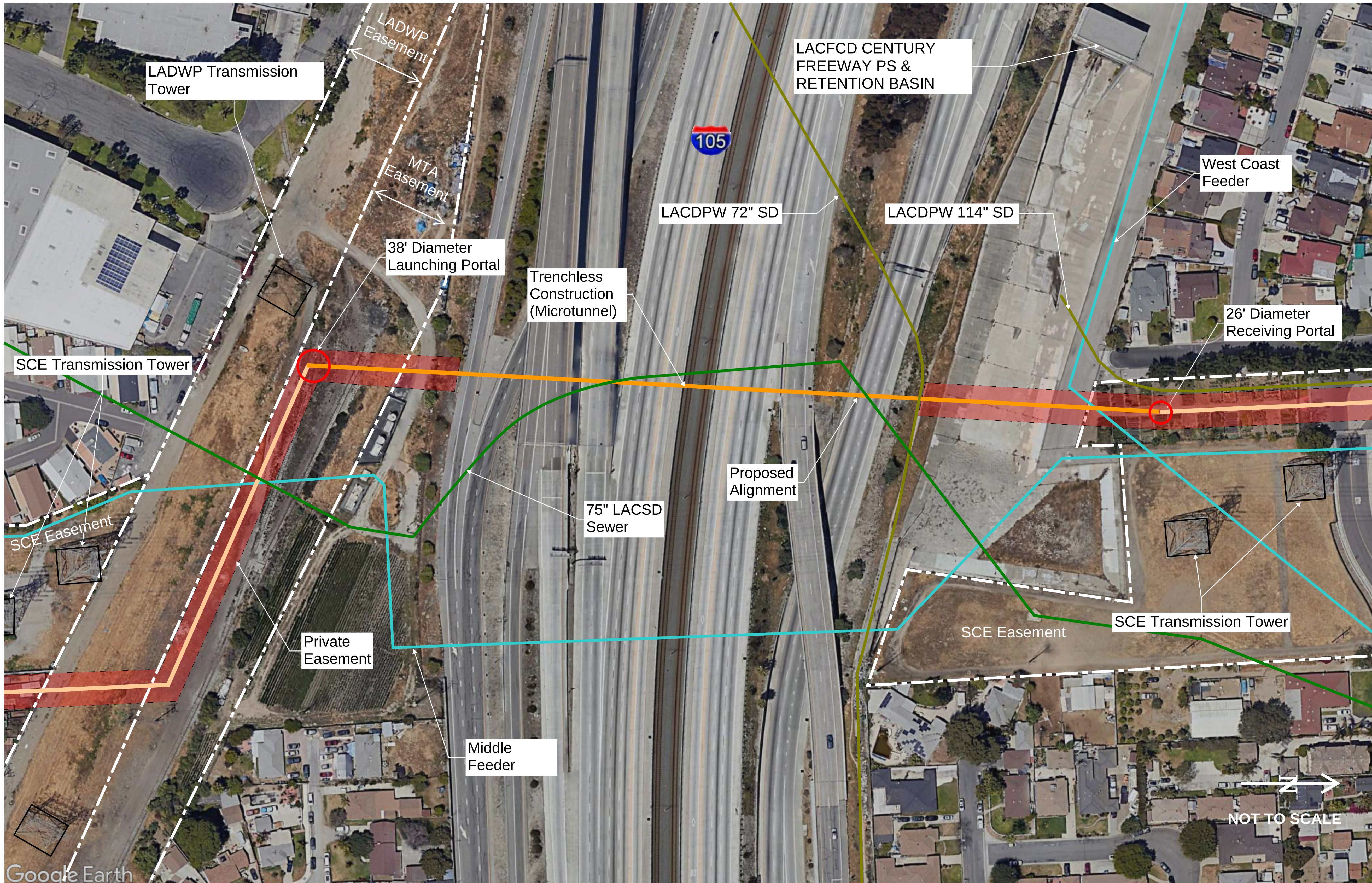
The proposed alignment passes beneath Interstate 105, along with two bridges, so the excavation would need to be deep enough to provide at least 11 ft of cover at the deepest point. Due to the depth required to accomplish this, the launching and receiving portals are recommended to be circular.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required.

Metropolitan's Middle Feeder South and LACSD's Joint Outfall B – Unit 1C Trunk line cross the freeway in a similar location, with the sewer crossing the proposed tunnel alignment. On the north side of the 105 Freeway, LACDPW owns a storm drain detention basin and two storm drain pipes, one crossing the proposed alignment and the other parallel to the alignment. Additionally, Metropolitan West Coast Feeder crosses the proposed tunnel alignment near the receiving portal.

Due to the number of large utility / significant infrastructure crossings for the proposed tunnel, early coordination with stakeholders is recommended to determine feasibility of crossing and launching/receiving portal locations. Potholing would also be required to finalize portal and alignment locations and feasibility.

The on and off ramps associated with the freeway interchange occurring in this area are supported by piers and abutments. The bridge piers and abutments are likely supported by piles or drilled shaft foundations, which are not known at the time of this FLDR. Detailed stress change and ground movement analysis is recommended at these locations. Should the foundations extend below the proposed tunnel invert, then as assessment is recommended to determine if bridge underpinning or ground improvements would be required. It is anticipated that the proposed trenchless alignment would be modified once the bridge supports are known.



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Open-Trench Construction Method - SCE Easement	Launching/Receiving Pit
Trenchless Construction Method - Microtunnel	Private Easement
MET Pipelines	LACDPW Storm Drain
	LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

105 Freeway Crossing

FIGURE 7-18

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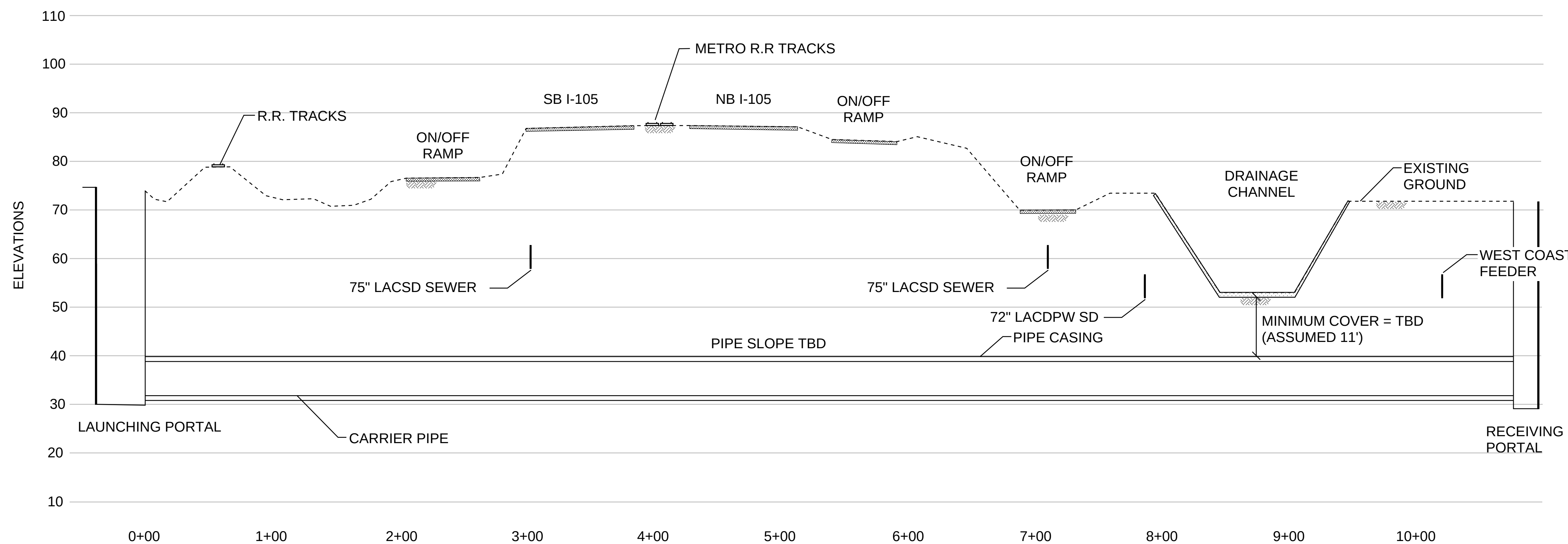

MICROTUNNEL CROSSING OF 105 FREEWAY

HORZ: 1" = 100'
VERT: 1" = 25'

5

BLACK & VEATCH

1" = 100' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of 105 Freeway Crossing

FIGURE 7-19

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7.4.8.7 Firestone Boulevard / Rio Hondo Golf Course Crossing

The LA River Alignment proposes using trenchless construction methods from Reach 1, Sta. 828+68 to Reach 1, Sta. 885+67 during which the pipeline would cross Firestone Boulevard, railroad tracks, a community park, and the Rio Hondo Golf Course. The proposed crossing is shown in plan on Figure 7-20 and in profile on Figure 7-21. Key details of the crossing are provided in Table 7-15.

Table 7-15 Trenchless Method Summary of Firestone Boulevard / Rio Hondo Golf Course Crossing

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
5,699	Road / Railroad	7	22	Yes	EPBM	Y	N	Y	N	N

This FLDR proposed trenchless construction beneath the storage facility located south of the railroad tracks and the park, neighborhood and the Rio Hondo Golf Course on the north side of the tracks to minimize the impact of the Project to the community. It may be warranted to complete an economic analysis comparing cut-and-cover construction through the golf course with the currently proposed trenchless construction during the next phase of work. However, this FLDR conservatively assumed that trenchless construction would be required.

This crossing is assumed to be constructed in one continuous span with launching and receiving portals both located in SCE easements. Both ends of the proposed tunnel appear to have enough available open space for portal excavation and contractor staging. The launching portal is recommended southwest of Firestone Boulevard and the receiving portal is recommended northeast of the Rio Hondo Golf Course.

A minimum cover of 22 ft is assumed at the lowest point, which appears to be along Rio Honda Dr. While the slope of the tunnel has not yet been determined, for this Project the receiving portal was assumed to be 3 ft higher than the launching portal. Due to the depth required, it is recommended that the receiving portal be circular. The launching portal is assumed to be rectangular. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. The proposed tunnel alignment is parallel to LACSD's existing JOA-1A Los Coyotes WRP Interceptor Trunk line for the first 2,000 ft. The alignment would also cross multiple LACDPW storm drain lines. Potholing would be required to finalize portal and alignment locations and feasibility. Additional utilities that would be anticipated are local utilities (water, sewer, recycled water, and dry utilities) in Firestone Boulevard and Rio Hondo Drive, as well as irrigation lines in the Rio Hondo Golf Course.Acquisition of temporary and permanent easements would be required.

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Open-Trench Construction Method - SCE Easement
Trenchless Construction Method - EPBM Tunnel
Private Easement
Launching/Receiving Pit
LACSD Sewer Pipe

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Firestone Blvd / Rio Honda Golf Course Crossing

FIGURE 7-20

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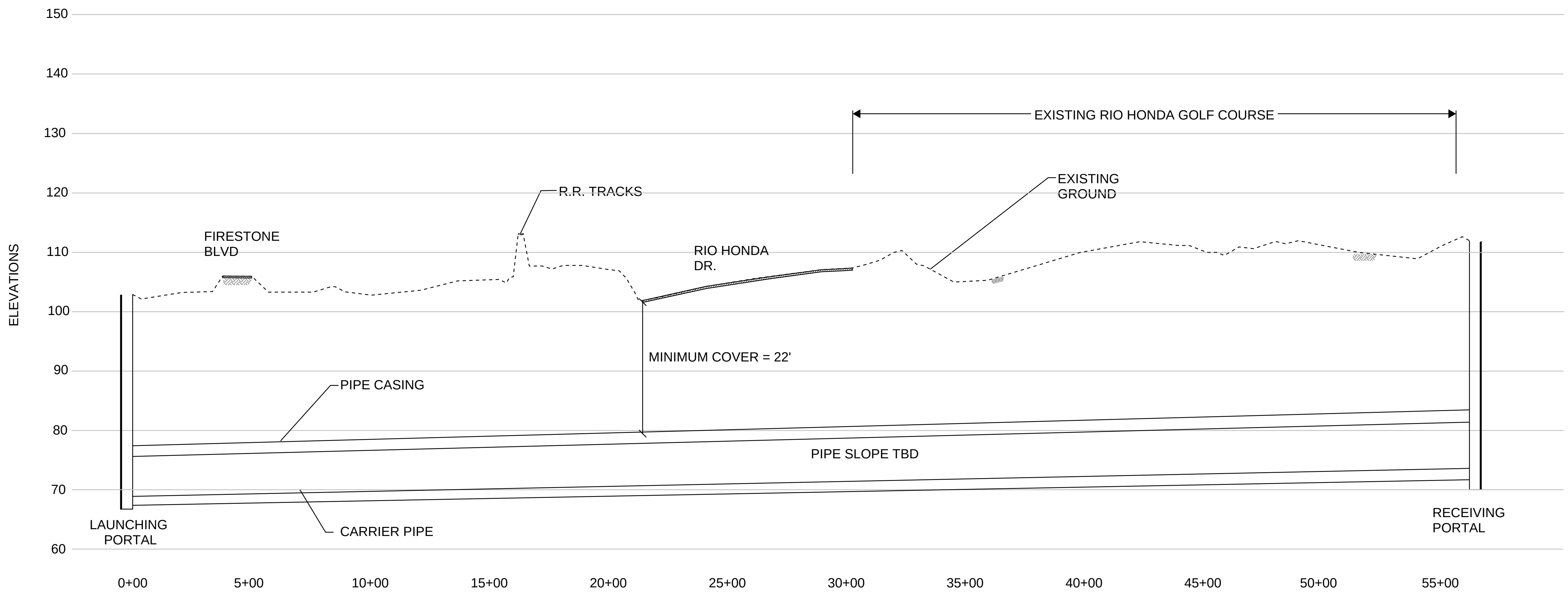

CONVENTIONAL TUNNEL (EPBM) FIRESTONE BLVD AND RIO HONDA GOLF COURSE 6

HORZ: 1" = 500'
VERT: 1" = 20'

BLACK & VEATCH

1" = 500' 0 250' 500' 750' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of Firestone Blvd / Rio Honda Golf Course Crossing

FIGURE 7-21

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7.4.8.8 SG River Crossing – Beverly Boulevard

The LA River Alignment proposes crossing the SG River near Beverly Blvd from Reach 1, Sta. 1250+25 to Reach 1, Sta. 1257+13 using trenchless construction methods.

Key details of the crossing are provided in Table 7-16.

Table 7-16 Trenchless Method Summary of SG River Crossing at Beverly Boulevard

LENGTH (FT)	UNDERCROSSING DESCRIPTION	PIPE DIAMETER (FT)	MINIMUM DEPTH (FT)	GW LEVEL ABOVE TUNNEL (Y/N)	RECOMMENDED TRENCHLESS METHOD	DEWATERING FOR PORTALS (Y/N)	DEWATERING ALONG ALIGNMENT (Y/N)	COBBLES, GRAVEL, BOULDERS (Y/N)	FAULT CROSSING (Y/N)	OIL FIELD (Y/N)
688	River	7	11	Yes	MT	Y	N	Y	N	N

The proposed crossing is shown in plan on Figure 7-22 and in profile on Figure 7-23.

Launching is recommended in the SCE easement on the east side of the river due to available space in the area. The receiving portal is recommended on the eastern side of the river in the public right-of-way. Further investigation of the surrounding area and the traffic control requirements would be required to finalize portal location and availability.

No intermediate jacking stations are anticipated to accomplish this drive length. Continuous replenishing of the overcut with lubrication should reduce the side friction sufficiently to manage the risk of getting stuck.

The MT boring machine is assumed to need disc cutters to fracture any boulders encountered. The shafts are assumed to need to be water tight to prevent excess inflows, bottom instability, and excess settlement. Tunnel portals would likely need local ground improvement such as jet grouting if the ground is granular (silt, sand, gravel). Surface / subsurface settlement monitoring would likely be required. Due to their depth, circular shafts should be considered.

The proposed alignment would pass close to a building that may have shallow spread footings and a bridge abutment. The bridge abutment is likely supported by piles or drilled shaft foundations. A settlement trough evaluation should be completed to determine the potential impacts on the foundations and if any ground improvement is needed to minimize the risk. Should the foundations extend below the proposed tunnel invert, then as assessment is recommended to determine if bridge underpinning or ground improvements would be required.

The proposed trenchless crossing would intersect three LACSD sewer lines and one LACDPW storm drain line. It is also anticipated that other local utilities would be located within Beverly Boulevard. Potholing is recommended to confirm the portal and alignment locations. Additional utility information should be gathered in this area during subsequent phases of design.

Acquisition of temporary and permanent easements would be required.

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Open-Trench Construction Method - Roadways		Launching/Receiving Pit	
Trenchless Construction Method - Microtunnel		Private Easement	
Open-Trench Construction Method - SCE Easement		LACSD Sewer Pipe	

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

San Gabriel River Crossing at Beverly Blvd

FIGURE 7-22

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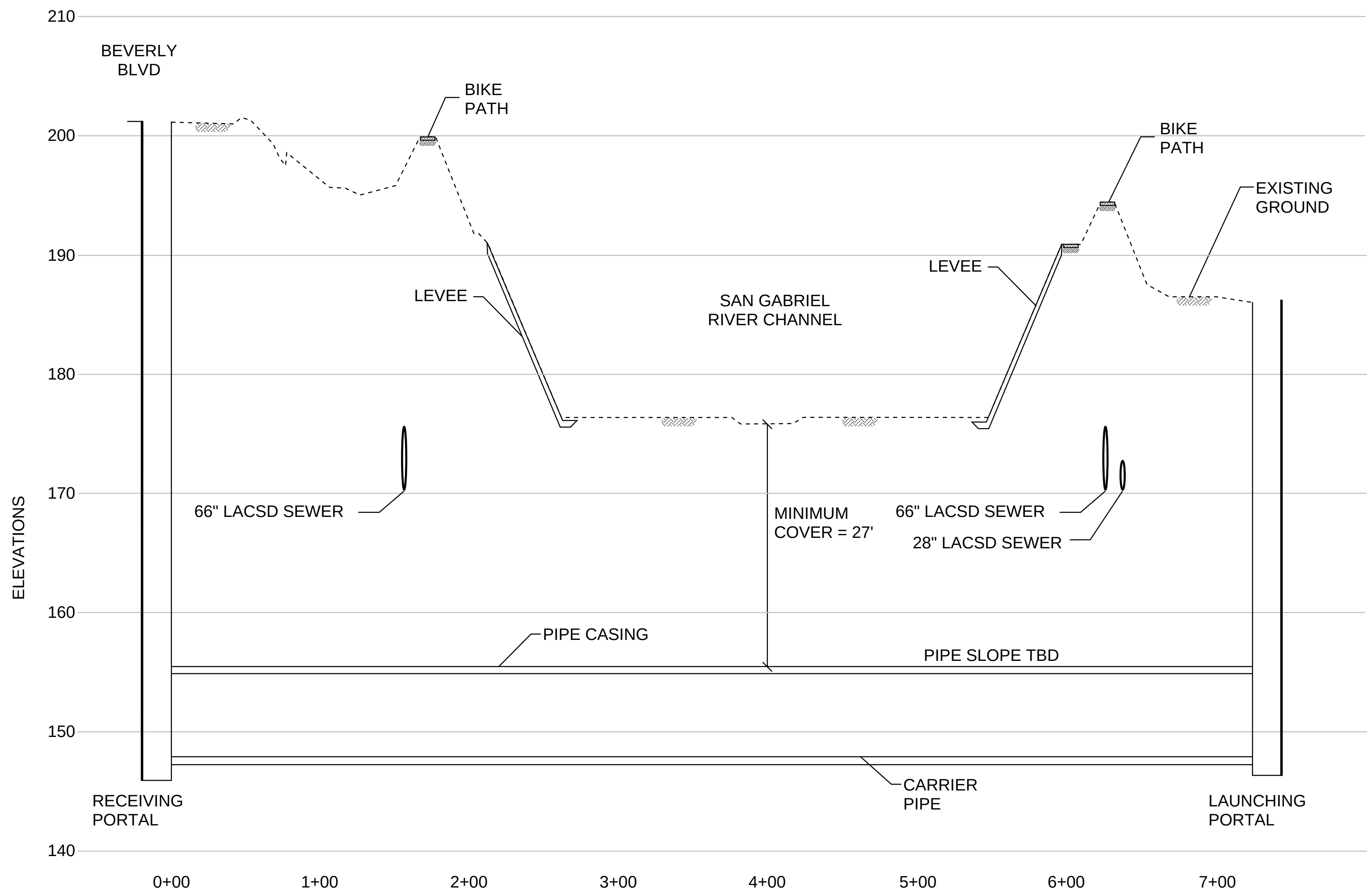

MICROTUNNEL CROSSING OF THE SAN GABRIEL RIVER AT BEVERLY BLVD 7

HORZ: 1" = 100'
VERT: 1" = 12.5'

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1" = 50' 0 50' 100' 150' FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

Profile of San Gabriel River Crossing at Beverly Blvd

FIGURE 7-23

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7.4.9 Preliminary Alignment Cross-Sections

Utilizing GIS mapping and right-of-way information, feasibilitiy-level alignment cross-sections were developed to depict the approximate location of the LA River Alignment relative to known major utilities and key surface features. The proposed location of the LA River Alignment was developed based on extensive research of existing utilities based on above grade features and available utility maps. The cross-sections are graphical in nature and are not intended to represent design-level detail. However, the alignment does reflect a general corridor that the pipeline could be built in that avoids known major utilities, surface obstructions, and minimizes traffic impacts. Additional utility investigations, including subsurface investigations, will be completed during subsequent design phases and the alignment is anticipated to be adjusted accordingly.

Since the LA River Alignment would traverse long stretches of existing streets with utilities varying in location, no "typical" section is provided to represent the location of the pipeline along the entire alignment. Instead, the alignment attempts to account for the presence of existing utilities and constructability concerns at each specific location. The representative cross-sections at key corridors are identified in Table 7-17 and presented on Figure 7-24 thru Figure 7-28. Figure 7-7 presents the location of each representative cross-section.

Where a location is identified for the LA River Alignment that is common to the SG River Alignment, the figure was not repeated. Instead, in Table 7-17 it was noted and a reference to the figure in Chapter 6 was provided.

Table 7-17 Preliminary Alignment Cross-Section Locations

NO.	STATION	DESCRIPTION	LOCATION OF DESCRIPTION
1	Reach 1, Sta. 8+50	Main Street facing north.	See Section 6.4.9.
2	Reach 1, Sta. 70+00	Sepulveda Boulevard facing east.	See Section 6.4.9.
3	Reach 1, Sta. 214+00	Willow Street facing east.	See Section 6.4.9.
4	Reach 1, Sta. 252+00	LACFCD Easement facing north.	
5	Reach 1, Sta. 545+00	N. Atlantic Place facing north.	
6	Reach 1, Sta. 608+00	SCE Easement facing north.	
7	Reach 1, Sta. 892+00	SCE Easement facing north.	
8	Reach 1, Sta. 1221+00	E. Beverly Boulevard facing east.	
9	Reach 2, Sta. 1442+00	SCE easement facing north.	See Section 6.4.9.
10	Reach 2, Sta. 1803+00	Live Oak Avenue facing southeast.	See Section 6.4.9.

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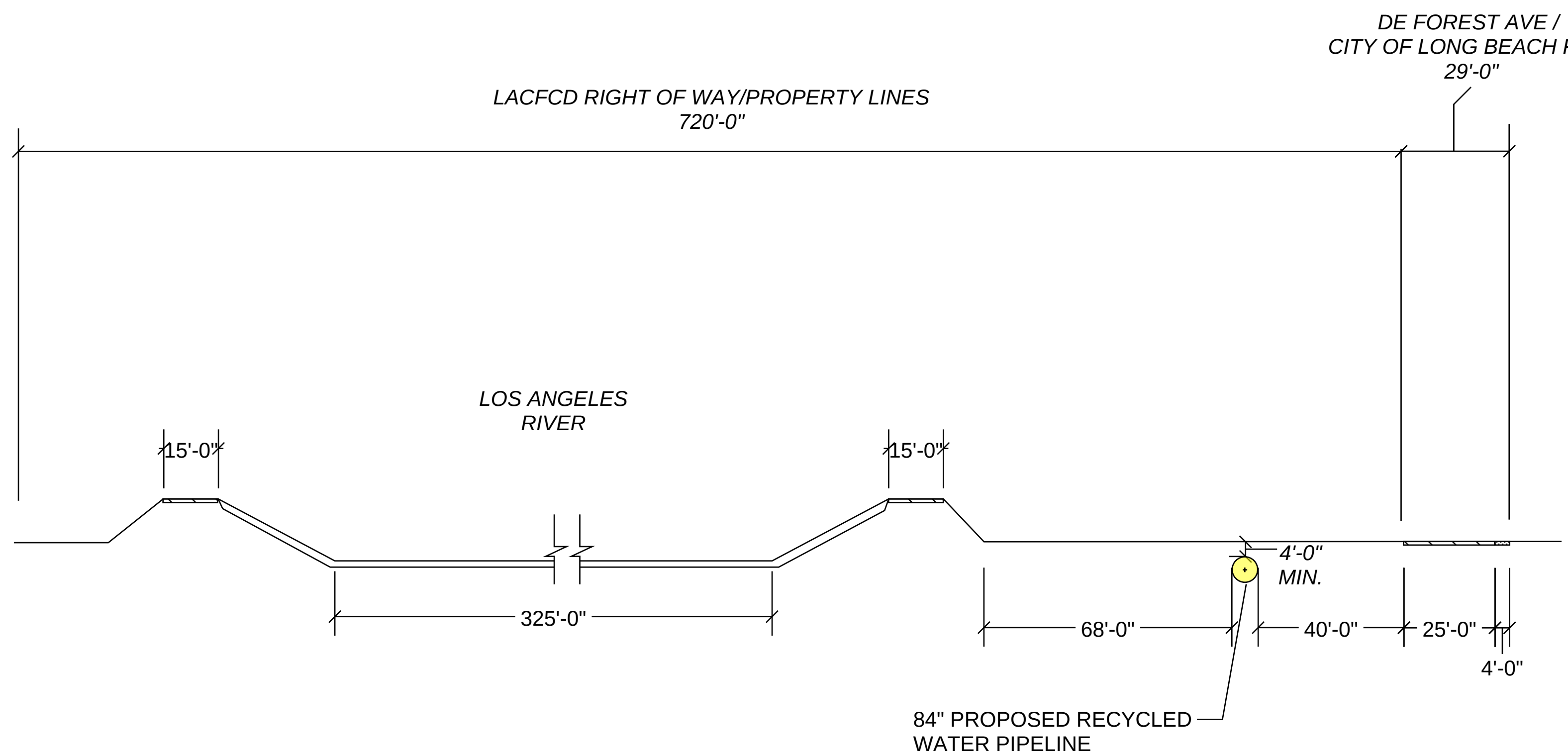

CROSS SECTION 4 -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDERED TO AVOID FUTURE EXPOSURE OR CONFLICT.
2. ALL DEPTHS OF EXISTING UTILITIES ARE ASSUMED.

BLACK & VEATCH		**POTENTIAL REGIONAL RECYCLED WATER PROGRAM** **PRELIMINARY ALIGNMENT CROSS-SECTION 4 – LACFCD EASEMENT FACING NORTH (REACH 1, STA 252+00)**	**FIGURE 7-24**

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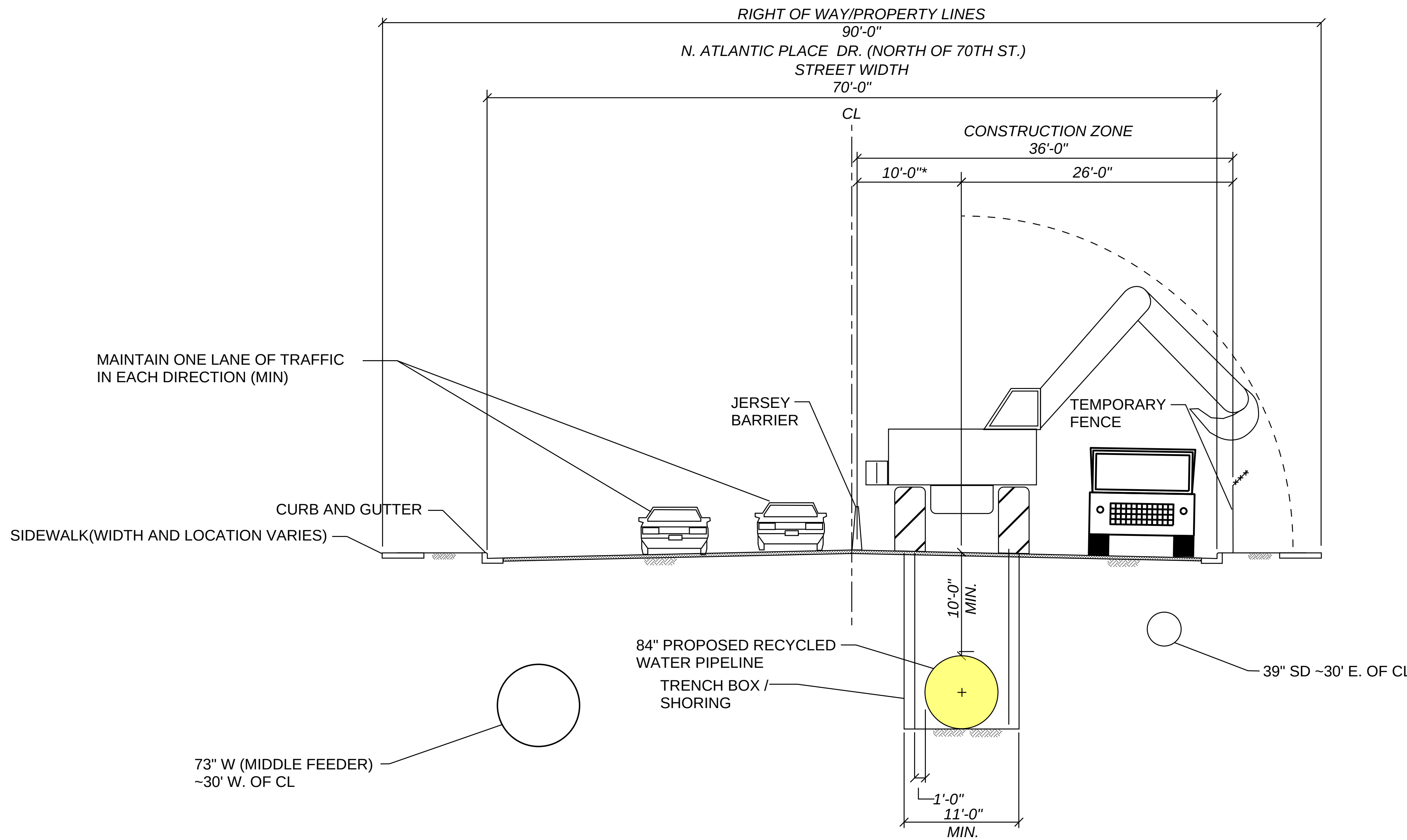

CROSS SECTION 5 -
NO SCALE

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- LA COUNTY DEPT OF PUBLIC WORKS GIS RECORDS
- METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA GIS RECORDS

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 5 – NORTH ATLANTIC PLACE FACING NORTH (REACH 1, STA 545+00)

FIGURE 7-25

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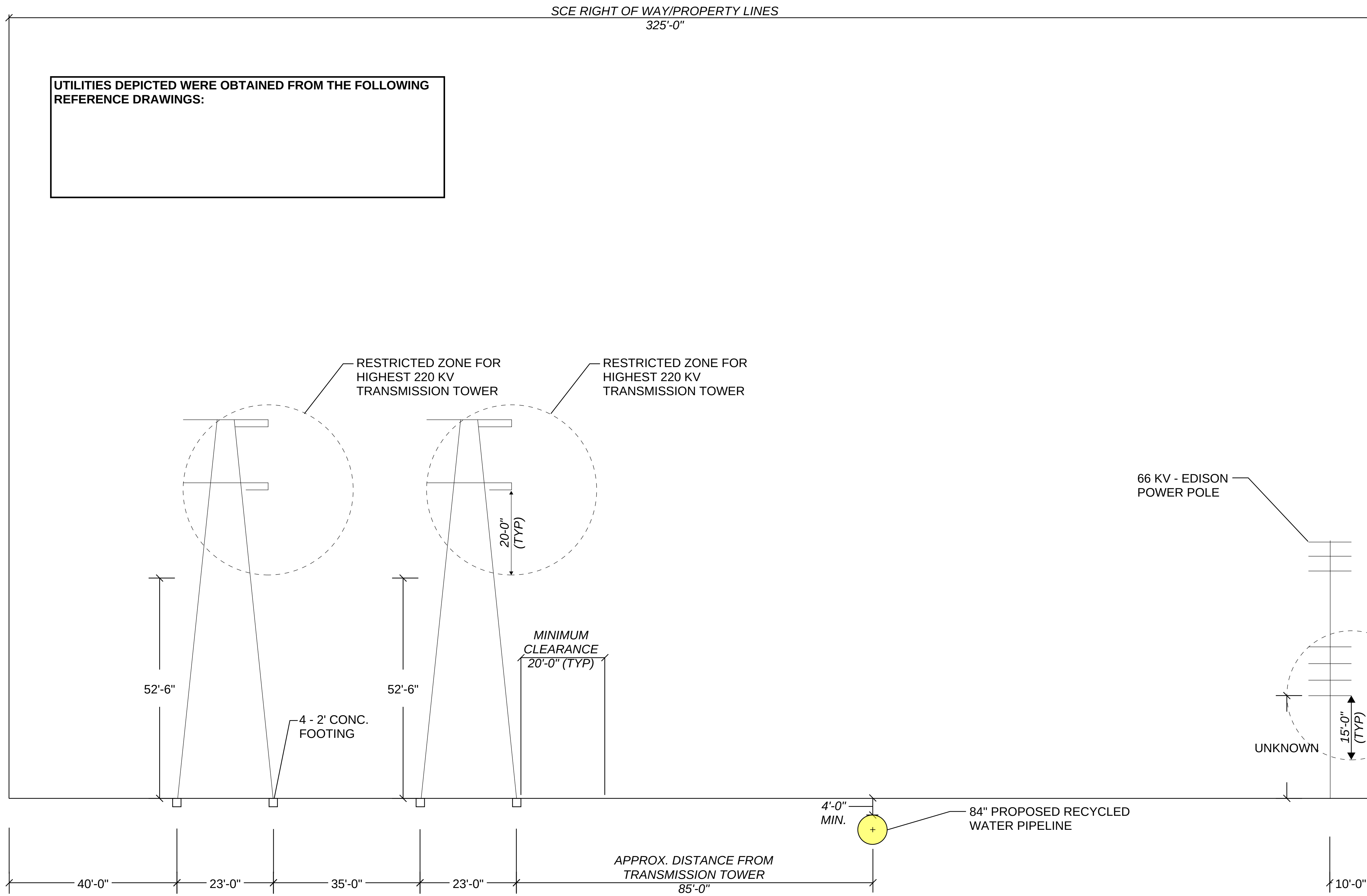

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

CROSS SECTION 6 -

NO SCALE

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

BLACK & VEATCH

0 10 20 30 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 6 – SCE EASEMENT FACING NORTH (REACH 1, STA 608+00)

FIGURE 7-26

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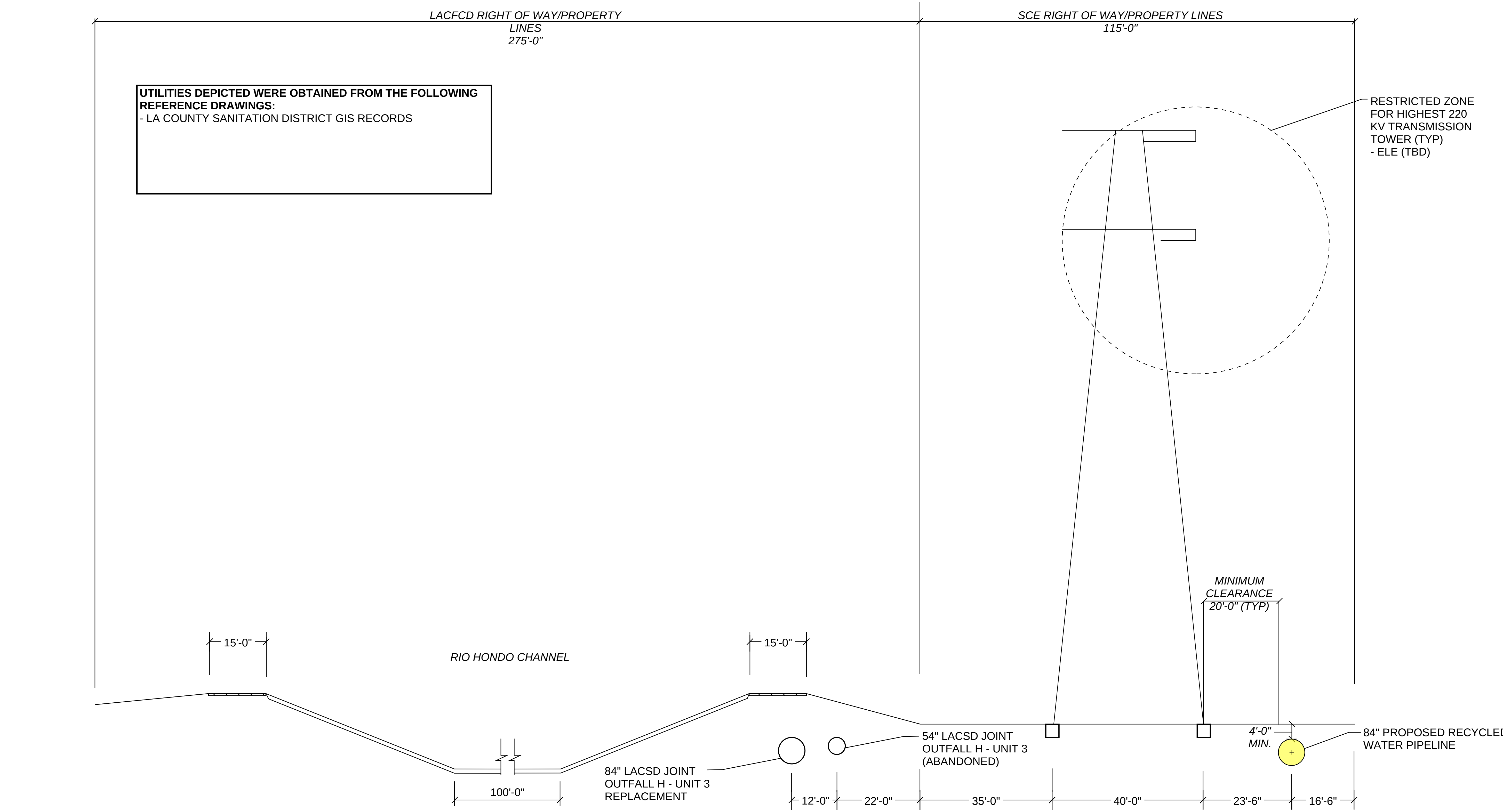

NOTE:

* *WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

CROSS SECTION 7
NO SCALE

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFLICLT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.
3. HEIGHT OF POWER CABLES FOR TRANSMISSION TOWERS AND POWER POLES ARE ASSUMED.

BLACK & VEATCH

0 10 20 30 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM

PRELIMINARY ALIGNMENT CROSS-SECTION 7 – SCE EASEMENT FACING NORTH (REACH 1, STA 892+00)

FIGURE 7-27

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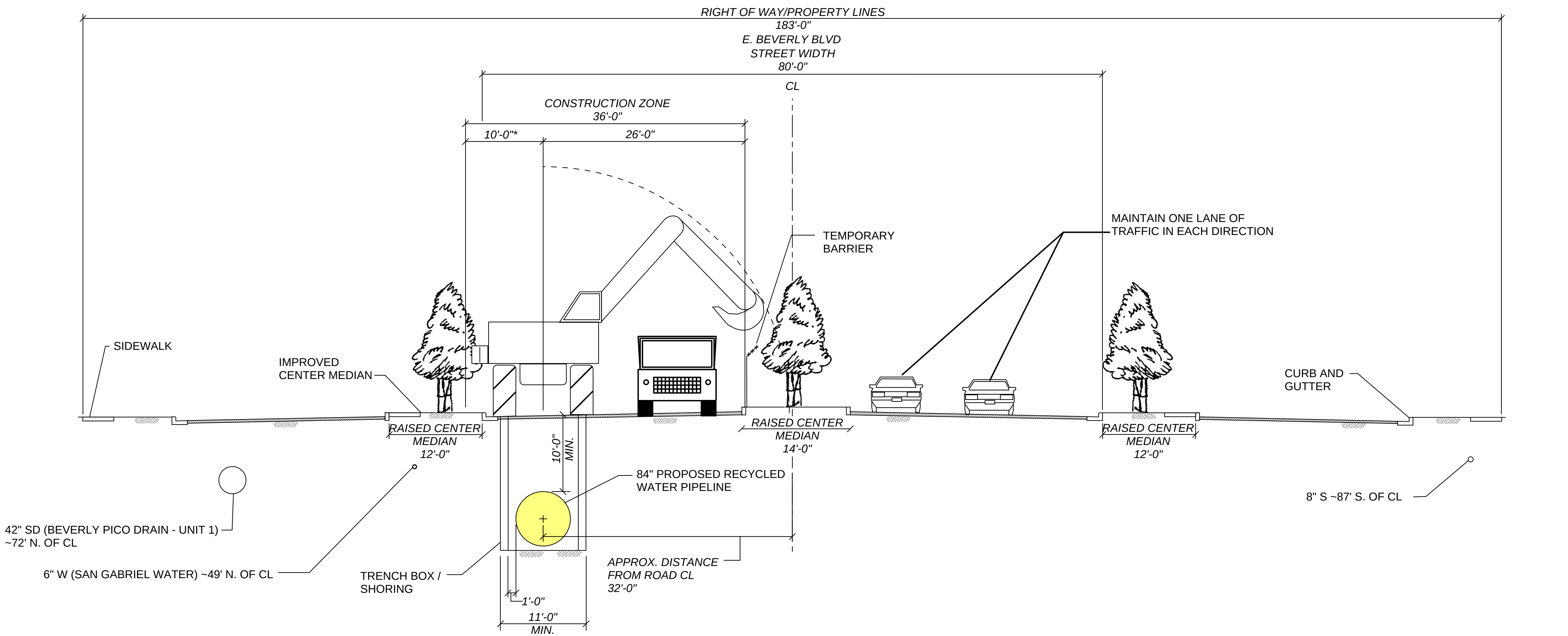

CROSS SECTION 8
NO SCALE -

NOTE:
1. THE LOCATIONS OF EXISTING UTILITIES WERE IDENTIFIED USING CITY PROVIDED GEOGRAPHIC INFORMATION SYSTEM (GIS) DRAWINGS, UTILITY BASE MAPS, AND EXISTING UTILITY RECORD DRAWINGS. THE EXACT LOCATION OF THESE EXISTING UTILITIES AND CRITICAL POTENTIAL CONFLICTS SHOULD BE FIELD INVESTIGATED DURING THE DESIGN PHASE USING POT HOLES. ANY UTILITY CROSSING WITH LESS THAN 24 INCHES OF SEPARATION SHOULD BE CAREFULLY CONSIDRED TO AVOID FUTURE EXPOSURE OR CONFILCT.
2. ALL DEPTHS OF EXISTING UTILITES ARE ASSUMED.

UTILITIES DEPICTED WERE OBTAINED FROM THE FOLLOWING REFERENCE DRAWINGS:
- L. A. COUNTY ROAD DEPT. PERMIT DIV. DWG PR-16
- LA COUNTY DEPT OF PUBLIC WORKS GIS RECORDS

NOTE:
** WIDTH CAN REDUCE TO 6'-0" IF THERE IS 4'-0" OF TEMPORARY CONSTRUCTION EASEMENT AVAILABLE ON ADJACENT PROPERTY.*

BLACK & VEATCH

0 5 10 15 FEET

POTENTIAL REGIONAL RECYCLED WATER PROGRAM
PRELIMINARY ALIGNMENT CROSS-SECTION 8 – EAST
BEVERLY BOULEVARD FACING EAST (REACH 1, STA 1221+00)

FIGURE 7-28

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8.0 Pump Station Analysis

This chapter provides feasibility-level design information for the pump stations that would be necessary to convey water from the AWT plant to the various groundwater recharge locations. The section begins with an overview of the pump station system and continues through more detailed discussions of key feasibility-level design criteria and features that would serve as a basis for subsequent design activities.

A brief overview of the analysis documented in this chapter is as follows:

- **Pump Station Overview.** Two pumps in series would be required for the Backbone System: PS-1 and PS-3. This section includes a description of the system, the components that are anticipated at each station, and the approach utilized to size the stations.
- **Conceptual Operating Strategy.** This section describes the planning level control strategy for the pump system that was developed to guide the subsequent operation of the pump stations. There are alternate control strategies which should be further investigated during subsequent phases of work.
- **Pump Station Hydraulic Analysis and Pump Evaluation.** A planning level hydraulic analysis was performed to determine preliminary sizing of the pumping equipment at each station, including system curve development, pumping equipment characteristics, and preliminary pump selections.
- **Planning Level Pump Station Design and Sizing.** This section documents the feasibility-level design of the pump station components for the purposes of feasibility-level station configuration, cost estimating, and site planning, including 1) pump station building, 2) hydraulic surge control facilities, 3) storage facilities, 4) yard piping, dichlorination, and metering, and 5) power supply and electrical requirements.
- **Pump Station Site Investigations.** This section documents the identification and comparison of potential pump station sites. PS-1 is anticipated to be located at the AWT plant site. While not a part of the Backbone System, potential sites were identified for PS-2 or the flow control facility if needed in the future and are presented in Appendix V. Five potential sites were considered for PS-3.
- **Site and Yard Piping Development.** Preliminary site plans were developed for each pump station site. Specific site plans were developed for PS-1 at the AWT plant, while a typical site plan was developed for PS-3 that is applicable to the five potential sites that were identified. The preliminary site plans are presented in Appendix L.

This chapter was originally prepared for the 2018 Draft Report, focusing on a conveyance system intended only for IPR and included the reach to the OC Spreading Grounds. At the time, this chapter also went on to note what revisions would be anticipated to the pump stations should Metropolitan elect to implement what is now known as the Backbone System. This effort was not developed to the same level of detail. Metropolitan has made the decision as an organization to reserve additional funding for the upcoming phases of work. As such, the analysis completed on the pump stations has not been updated since the 2018 Draft Report, except that the material was reviewed relative to changes to the Project concept since that time.

Based on that review, it was determined that:

- The general location for PS-3 shown herein remains applicable to the Backbone System. Other sites besides those identified herein may also warrant consideration during the next phase of planning and design.
- The general location for PS-3 shown herein is applicable to both the SG and LA River Alignments, as the hydraulics are similar.
- For cost estimating, the planning level cost of PS-1 and PS-3 are similar.

Additional evaluations will be required in the next phase of design to further refine the size and location of the pump stations for the Backbone System, as well as the control strategy. The size and location of the pump stations required for the future connection to the FEWWTP will also need to be determined.

Figure 8-1 summarizes the Project methodology as it applies to this chapter.

Phase	Phase 1 Metropolitan's Initial Evaluation	Phase 2 Alignment Verification / Initial Screening	Phase 3 Detailed Alternative Alignment Evaluation	Phase 4 Final Refinements	**Phase 5 Feasibility-Level Pipeline and Pump Station Design**
Tasks	• Identification of potential pipeline alignments • Identification of Initial Base Case	• Data collection • Review of Metropolitan studies • Desktop analysis • Alternate alignment development • Field investigations • Initial screening • Desktop Geotechnical Report • Traffic Analysis and Impact Report • Constructability evaluations	• Development of decision model • Evaluation criteria • Weighting of evaluation criteria • Coarse screening • Secondary screening • Final screening • Ranking of alternatives	• Incorporation of stakeholder input • Conduct supplemental evaluations	• Steel size and wall thickness • Feasibility-level pipeline plan drawings • Hydraulic analysis and profile • Special construction zones and cross-sections • **Pump station siting and feasibility-level site and building layout** • Cost development • Quantity take-off • Preliminary construction duration
Workshops		• Initial screening workshops	• Detailed evaluation workshops	• Workshops with Stakeholders • Workshops with Metropolitan's Environmental Team	• Pipeline focus meetings/ workshops • **Pump station focus meetings/ workshops** • Unit cost development workshops
Outcomes	• Initial Base Case alignment • Report entitled, "Potential RRWP – Conveyance System Feasibility Assessment"	• Revised Base Case alignment	• Initial Preferred Alignment	• Final Preferred Alignment	• **Feasibility-level pipeline and pump station design** • Engineer's cost opinion and Project schedule
Chapters	• Chapter 1	• Chapter 2 • Chapter 3	• Chapter 4	• Chapter 5	• Chapter 6 • Chapter 7 • **Chapter 8** • Chapter 9

Figure 8-1 Chapter 8 Methodology

8.1 PUMP STATION OVERVIEW

This section describes the pump station system, the associated pump station components, and the analysis approach for developing the feasibility-level design information.

8.1.1 System Description

As described in Chapter 5, multiple pump stations would be required to convey recycled water from the AWT plant to the anticipated discharge locations, which are located several miles away and at higher elevations than the AWT plant. Table 8-1 summarizes the approximate ground elevations of these discharge points. The ground elevation at the AWT plant is approximately 42 ft. Elevations are relative to MSL.

Table 8-1 Groundwater Recharge Location Elevations

RECHARGE LOCATION	APPROXIMATE GROUND ELEVATION (FT)
Potential Future (West Coast Basin) Injection Wells	90
Potential Future (Central Basin/Long Beach) Injection Wells	60
OC Spreading Grounds	230
Rio Hondo Spreading Grounds (Montebello Forebay)	145
Santa Fe Spreading Grounds	485-500

As described previously, the analysis in this chapter has not been revised since the preparation of the 2018 Draft Report, as Metropolitan is reserving additional funding to complete those efforts as part of upcoming phases of work, coincident with additional decision making on Project concepts and potential partnerships. At the time of the 2018 Draft Report, three pumping concepts were being considered. However, two of those concepts were based upon delivering flow to the OC Spreading Grounds, which has since been removed from the initial implementation phases envisioned for the Project. Therefore, those two pumping concepts have been removed from this chapter and are provided in Appendix V for future reference, if needed. The remaining pumping configuration for the Backbone System is described herein. This concept was evaluated based upon the SG River Alignment, which is the more conservative of the two alignments due to longer length.

- **Alternative A-Backbone System – Potential for DPR.** This concept includes two pump stations where PS-1 pumps directly to PS-3. This concept does not include PS-2 nor a junction structure at the original proposed location of PS-2. Thus, pumping to the OC Spreading Grounds is not included.

While PS-2 is no longer a part of this Project, the numbering of the pump stations has remained unchanged in the event that deliveries to the OC Spreading Grounds become desirable in the future. It may be warranted to rename facilities during subsequent phases of work.

Table 8-2 summarizes the proposed pump stations, including their general locations, capacities, and configuration. PS-1 would have two sets of pumps and discharge pipelines to deliver recycled water to two separate discharge locations. PS-3 would have one set of pumps to send recycled water to the Santa Fe Spreading Grounds, with the Rio Hondo Spreading Grounds being served by gravity from the storage tank at PS-3.

Table 8-2 Summary of Pump Station Attributes (Backbone System)

PUMP STATION	GENERAL LOCATION (WITH APPROXIMATE GROUND ELEVATION)	PRELIMINARY FIRM CAPACITY	PUMPS TO
PS-1	AWT plant/JWPCP, Carson (42 ft)	Set A: 15 mgd Set B: 150 mgd	Set A: West Basin Set B: PS-3 Forebay
PS-3	Near Whittier Narrows, Pico Rivera (220 ft)	Set A: 150 mgd	Set A: Santa Fe Spreading Grounds

8.1.2 Station Components

Each pump station would have similar components that would be adjusted to account for the station's specific location and capacity. The components reflected in the feasibility-level design include, but are not limited to, the following:

- Main pump area: This area would include the pumps and motors, surge tank air compressors, and administration area. At PS-1, the pumping equipment itself would be outdoors with a building sized just for administration, storage, and air compressors. Since PS-1 will be located at the AWT plant site, ultimately the design of PS-1 will need to be coordinated with that of the AWT plant. At PS-3, all the equipment associated with this area would be located within a building.
- Surge control area: This area would include above-grade, air-over-water hydropneumatic surge tanks and associated piping. The tanks would be located outdoors and would be shielded by a curtain wall.
- Pump station forebay/suction storage facility: At PS-1 and PS-3, this was assumed to be an above grade circular tank. The pump station forebay at PS-1 will need to be coordinated with the hydraulic grade line coming out of the AWT plant, which may necessitate it to be below grade. Additionally, to reduce the site requirements for PS-3, a buried forebay could also be considered. Pump station forebay configurations should be further studied during the next phase of work and should be coordinated with design of the AWT plant.
- Dechlorination facility on storage tank overflow: This structure, mostly located below-grade, would use granular activated carbon to dechlorinate any overflow before entering offsite drainage channels. This component would be required at PS-1 and PS-3.
- Electrical room/building: This building would house the main electrical equipment for the station, including variable frequency drives (VFDs) and switchgear.
- Electrical transformer area: This area would house the electrical transformers that feed the electrical room/building.
- Miscellaneous facilities, including valve and meter vaults.

8.1.3 Analysis Approach

The feasibility-level design of the pump stations is based on first establishing a conceptual operating strategy describing how the multiple pump stations would be controlled. This was followed by determining the preliminary size of the pumping equipment (flow, head, and power) based on the conveyance system configuration described in the previous sections. With basic control and equipment sizing established, the ancillary facilities were sized. The information provided is at the feasibility level and will be refined and detailed in subsequent design phases. Preliminary calculations and equipment selections supporting the feasibility-level design are included in Appendix J.

8.2 CONCEPTUAL OPERATING STRATEGY

The pump stations must operate and be controlled in a carefully coordinated manner to deliver flow at the required rates to the various discharge points. The method of control will dictate design of the pump stations, including the size of storage facilities and size and speed ranges of pumping equipment. This section describes a conceptual control strategy for the system that was developed to guide the subsequent conceptual operation of the pump stations. There are alternate control strategies which should be further investigated during subsequent phases of work.

8.2.1 Overall Conceptual Control Strategy

In general, the proposed primary control strategy is based on coordinated flow set points calculated for each set of pumps/flow control stations based on AWT plant production and desired delivery points. These set points would be communicated to each set of pumps/flow control stations and associated flow meters so that the flow rate entering a pump station would be equal to the flow rate leaving a pump station. The control strategy for the Project is shown on Figure 8-2. The control strategy is anticipated to be further refined during subsequent phases of work.

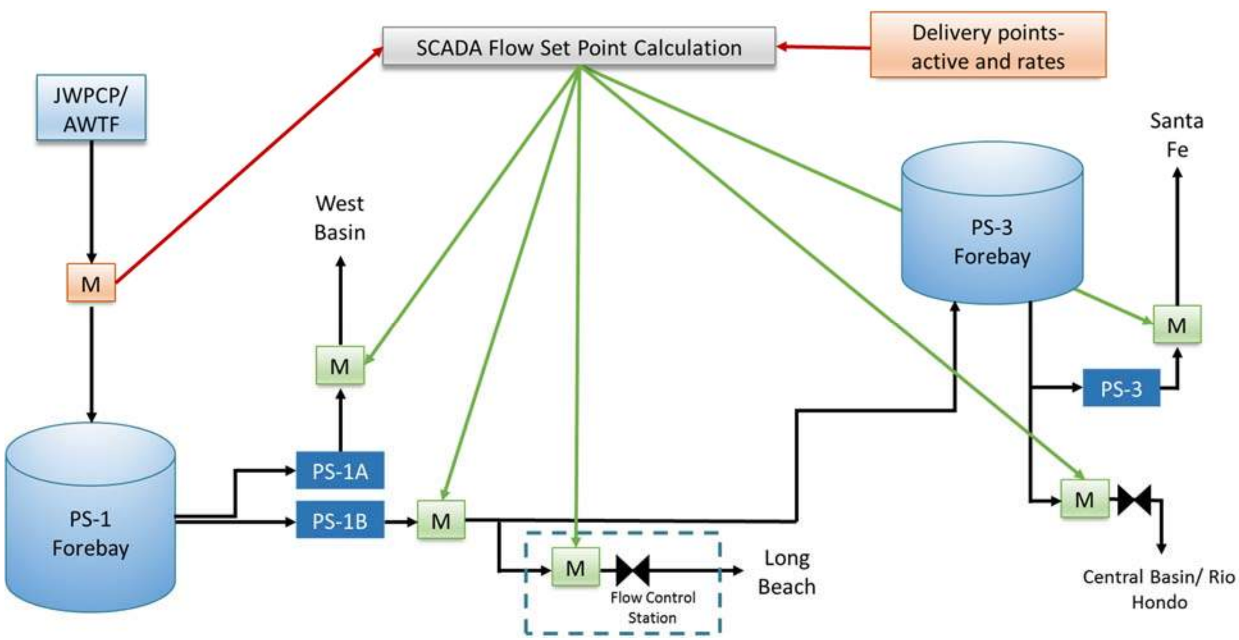

Figure 8-2 Overall Control Strategy Concept

The flow set points would be achieved by modulating the VFD-driven pumps or flow control valves to meet the flow set point. The flow set point would be modified, or trimmed, based on the level in the upstream storage tank. For example, if the level in the tank were rising above a desired level set point, the flow set point of the downstream pumps would be increased until stable tank levels are achieved. The control approach for PS-1 is illustrated on Figure 8-3. This general control framework would be supplemented by a range of control interlocks to keep the stations operating within designated parameters, which will reduce the risk of unanticipated operating scenarios. These interlocks are discussed in greater detail below.

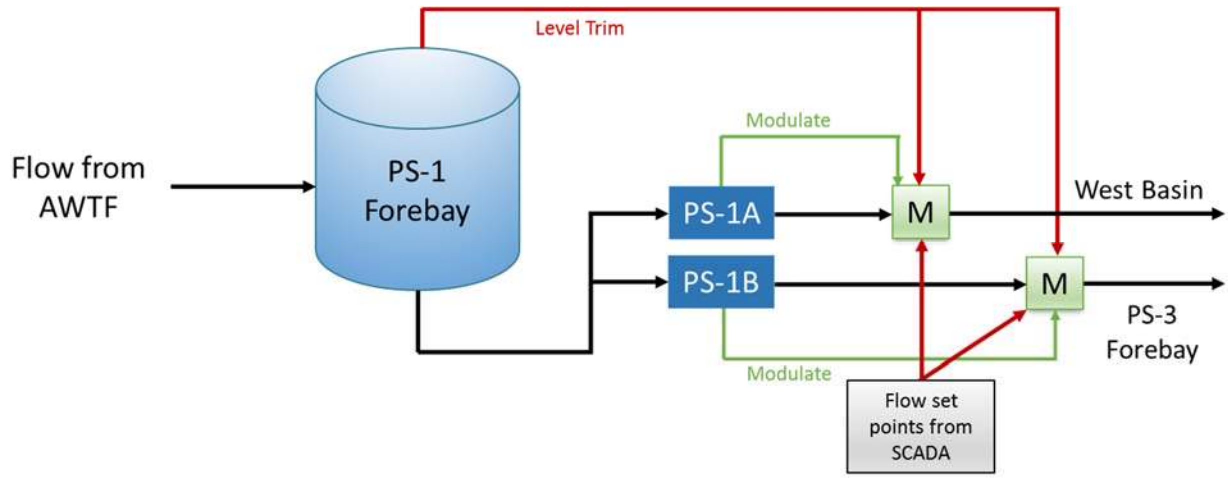

Figure 8-3 Flow Control with Level Trim and PS-1

The goal of the conceptual control strategy described above is to achieve stable tank levels, typically at around 50 percent of the forebay tank depth. When the system is stable, tank level should not change, and the need for storage would be minimal. However, there would be instances, especially during normal starting and stopping of the system, when flow imbalances would be expected to occur and the level in the forebay storage tank would either go up or down.

To estimate the volume associated with a flow imbalance during normal starting and stopping operations, a conceptual starting and stopping sequence was developed as depicted on Figure 8-4 and Figure 8-5. The ramp-up times for the system to start (time for pump to accelerate from OFF to the preset speed) were estimated at 2 minutes, which is expected to exceed the critical period for the longest length of pipe to reduce pressure surges. The “critical period” is the time required for an acoustic wave to travel from the pump station to the end of the pipe and back.

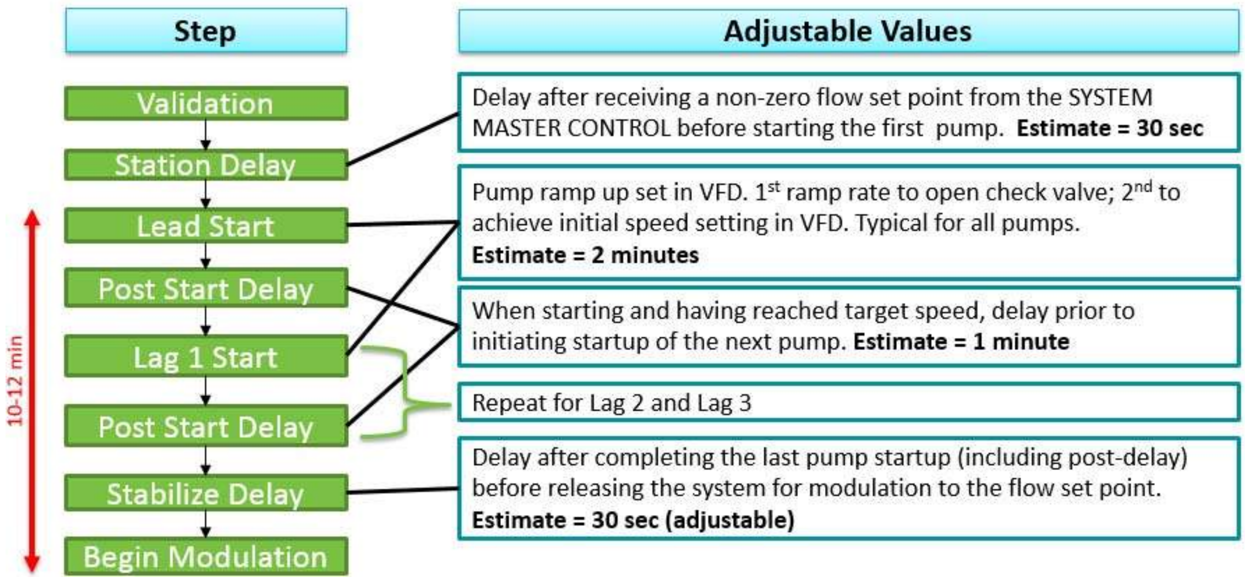

Figure 8-4 Conceptual Starting Sequence

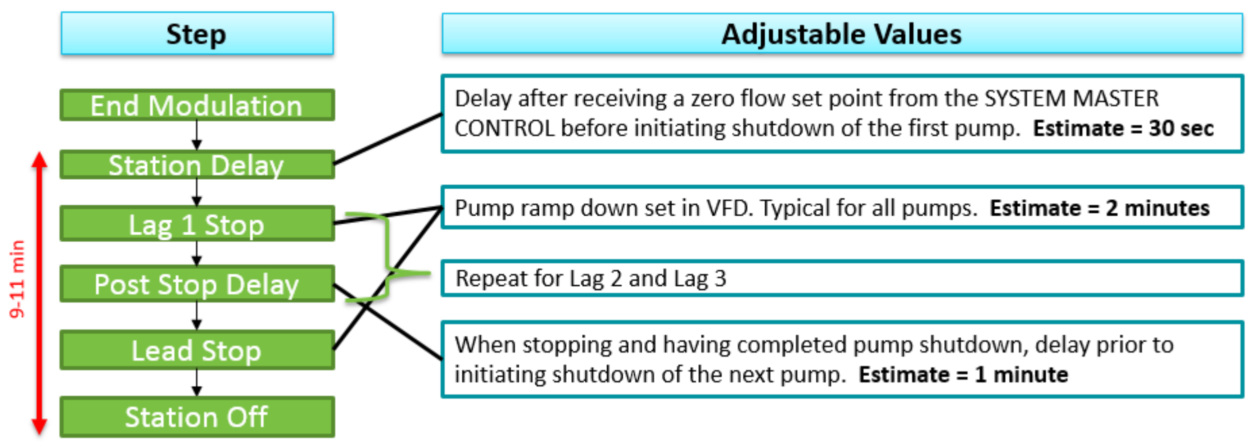

Figure 8-5 Conceptual Stopping Sequence

The estimated time for a controlled startup would range from 10-12 minutes based on the initial estimated ramping rates and control delays. The time for a controlled ramp down would range from 9-11 minutes. An emergency stop would happen essentially instantaneously as power is cut to the pumps and they decelerate (i.e., spin down) according to the system inertial characteristics. In an emergency stop scenario, the stored energy in the hydro-pneumatic surge control tanks would help to gradually reduce the flow and protect the system from damaging hydraulic surge conditions.

The operating and control philosophy presented was developed collaboratively with Metropolitan and presents one feasible approach that takes into account the size of the pumps. Pump operating and control philosophy, as well as forebay sizing will be further refined during the next stage of the project.

8.2.2 Control System Interlocks and Backup Systems

The control system for the conveyance system would be designed with various features to prevent the system from operating outside of design parameters. These features would include software and hardwired interlocks as well as backup control systems. Examples of interlocks that would be implemented include:

- Level transmitters – high or low tank level shuts down upstream/downstream of pump station.
- Redundant high and low float switches in tanks, hardwired to pumps - high or low tank level would shut down upstream/downstream of a pump station.
- Pressure transmitter/switches – out of range would shut down pump stations.
- If one station were to shut down, then all stations would shut down.
- Peer-to-peer heartbeat: if pump stations were to lose communication, all pump stations would shut down after a set delay.
- Loss of communication time-out: if a pump station would be unable to communicate, it would shut down.
- Flow coordination check routines in software to make sure flow rates at each station would match.
- Redundant operator verifications to modify automatic controls and interlocks.

Examples of backup control systems include switching to local level control if communication is lost. In this scenario, the pump station would operate to maintain the level in its associated upstream storage tank. This would prevent overflow of the local storage tank; however, it would not prevent overflow of the downstream storage tank if that facility was shut down. Thus, loss of communication is likely a scenario that would require a shutdown.

8.3 PUMP STATION HYDRAULIC ANALYSIS AND PUMP EVALUATION

This section describes the hydraulic analysis performed to determine preliminary sizing of the pumping equipment at each station. Specifically, this section describes system curve development, pumping equipment characteristics, and preliminary pump selections.

8.3.1 System Curve Development

System curves were developed for each set of pumps to document the required total dynamic head at the pump stations from the static condition to the maximum capacity. These curves were then used to select candidate pumping equipment. Detailed preliminary system curve calculations are provided in Appendix J. The following system curves were developed for each station to provide an envelope of operating points:

- High Manning's: This system curve assumes low suction tank level, high discharge tank level, and calculation of friction losses using the Manning's equation with n=0.012, as prescribed by Metropolitan's Hydraulic Design Manual. This results in the highest head condition and was the basis for the rated point on pump selections. Since this was considered to likely be a conservative condition, this point was selected left of best-efficiency point (BEP) when selecting pumps, which would provide additional runout capacity for lower head conditions when fewer pumps are operating.

- Low Manning's: This system curve assumes high suction tank level, low discharge tank level, and calculation of friction losses using the Manning's equation with n=0.012, as prescribed by Metropolitan's Hydraulic Design Manual.
- High Darcy: This system curve assumes low suction tank level, high discharge tank level, and calculation of friction losses using the Darcy-Weisbach equation with a surface roughness of 0.000225 ft, which is considered at the upper range for cement mortar lined steel pipe. The value of 0.000225 ft is 1.5 times 0.00015 ft, the surface roughness used in the Low Darcy scenario.
- Low Darcy: This system curve assumes high suction tank level, low discharge tank level, and calculation of friction losses using the Darcy-Weisbach equation with a surface roughness of 0.000015 ft, which is considered at the lower range for cement mortar lined steel pipe. This curve was the lowest estimated system curve. If possible, pumps were selected to also intercept this curve to prevent runout of a single pump at 100 percent speed. However, in some cases this would not be possible due to the relatively high friction head for some of the pump sets and would require limiting pump operating speeds for single pump operation, which is readily achievable with VFD operation and control.

8.3.1.1 PS-1 System Curves

Table 8-3 summarizes the key inputs used to develop the system curve for PS-1 and the resulting rated design point used for subsequent pump selection. The key inputs include suction tank water surface elevation (WSE) range, discharge elevation, discharge pipe length and diameter, and the rated point for pump selection.

Table 8-3 PS-1 System Curve Inputs (Backbone System)

PARAMETER	SET A	SET B
Suction Tank (PS-1) WSE Range (ft)	44 - 74[1]	44 - 74
Discharge Elevation (ft)	136	222
Discharge Pipe Length (ft)	26,400	141,478
Discharge Pipe Diameter (in)	30	84
Rated Point for Pump Selection	**7.5 mgd at 165 ft**	**37.5 mgd at 352 ft**

Note:
1. Assuming ground elevation of 42 ft with a tank level range of 2 ft to 32 ft.

Figure 8-6 and Figure 8-7 present the associated system curves developed for PS-1 Set A and Set B, respectively. The curves include an overlay from one of the candidate pump selections (see Section 8.3.3).

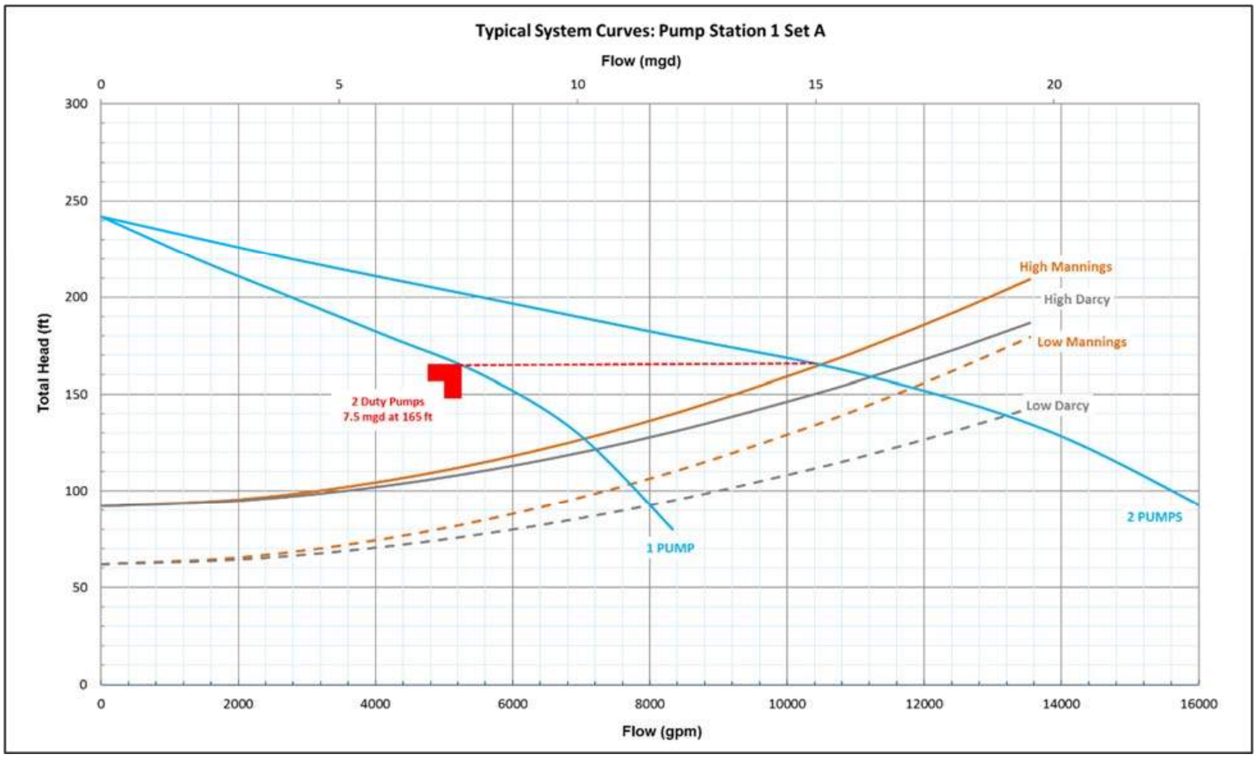

Figure 8-6 PS-1 Set A System Curves

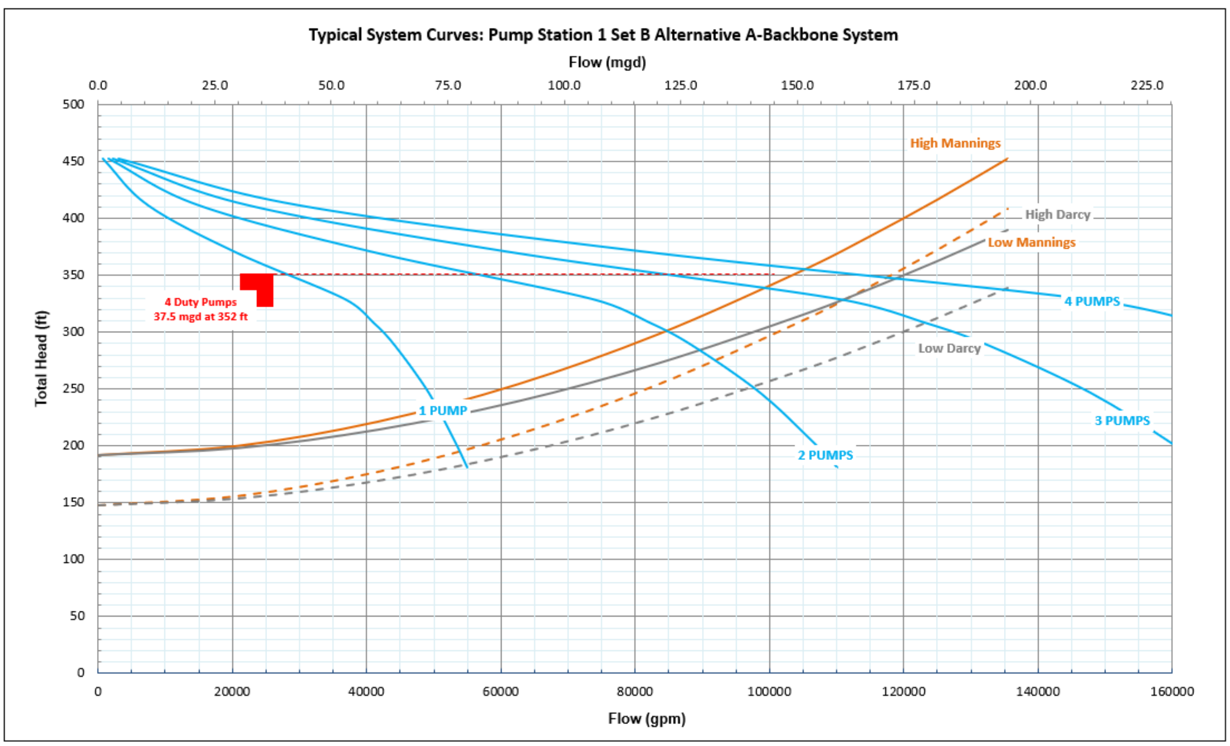

Figure 8-7 PS-1 Set B System Curves – Backbone System

8.3.1.2 PS-3 System Curves

Table 8-4 summarizes the key inputs used for both Alternative A and B to develop the system curve for PS-3 and the resulting rated design point used as the basis for subsequent pump selection.

Table 8-4 PS-3 System Curve Inputs (Backbone System)

PARAMETER	SET A
Suction Tank (PS-3) WSE Range (ft)	222 - 236[1]
Discharge (Santa Fe Spreading Grounds) Water Surface Elevation with 20 ft Distribution Head (ft)	505
Discharge Pipe Length (ft)	58,800
Discharge Pipe Diameter (in)	**84**
Rated Point for Pump Selection	**37.5 mgd at 352 ft**

Note:
1. Assuming ground elevation of 220 ft with a tank level range of 2 ft to 16 ft.

Figure 8-8 presents the associated system curves developed for PS-3. The curves include an overlay from one of the candidate pump selections (see Section 8.3.3).

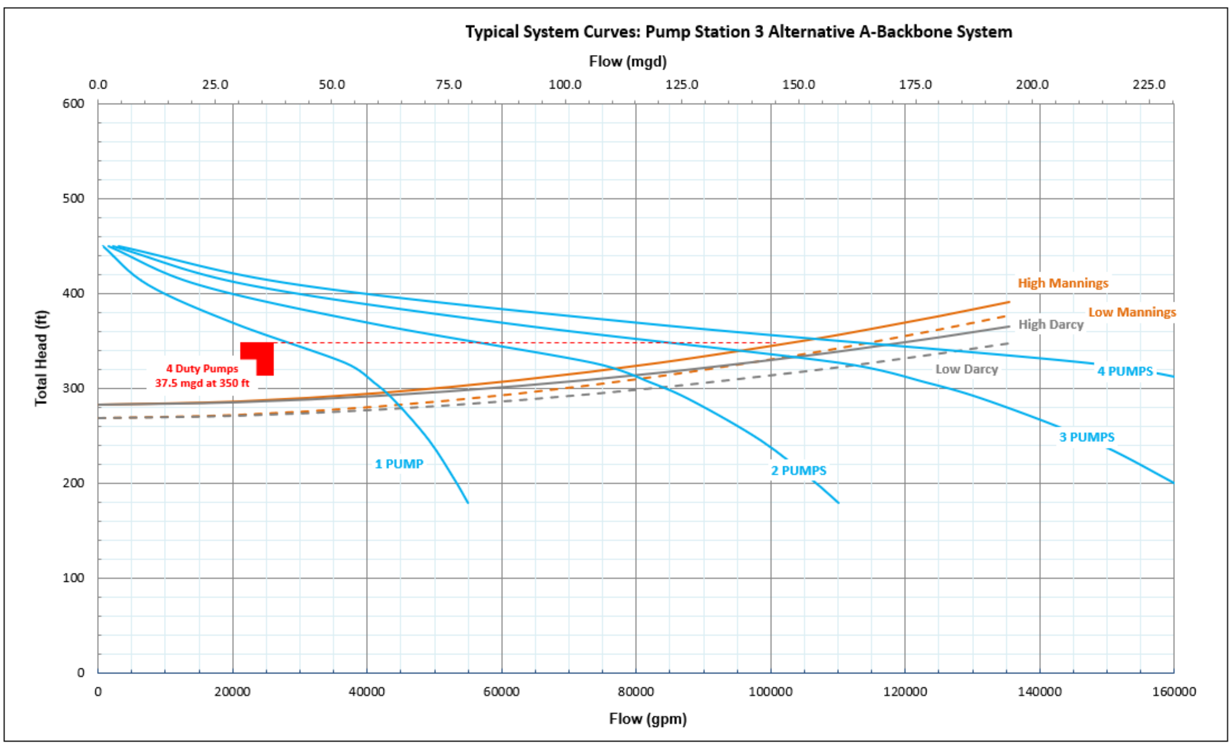

Figure 8-8 PS-3 System Curves (Backbone System)

8.3.2 Pumping Equipment

The recommended pumping 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 would be installed in cans/barrels and separated from the water storage tank.

8.3.3 Feasibility-Level Pump Selection

The hydraulic conditions described in Section 8.3.1 were used to identify candidate pumping equipment that meets the preliminary performance requirements. Initial curves were selected from three typical manufacturers: Fairbanks, Ebara, and Sulzer. These preliminary selections are summarized in Table 8-5, and the associated performance curves are included in Appendix K. The purpose of these selections was to demonstrate the availability of equipment in these sizes from multiple manufacturers and to verify motor sizes to develop the feasibility-level electrical system design (see Section 8.8.1). In subsequent design phases, the following additional analyses are recommended to optimize the pump selections:

- Refine system hydraulic calculations to include station specific losses, final pipeline alignments and hydraulic properties, and final pump station locations.
- Identify the relative frequency of various operating conditions and optimize selections to minimize power consumption.
- Investigate selections from other acceptable manufacturers to identify optimal selections and increase procurement competition.
- Develop detailed technical specifications based on Metropolitan's requirements for pumping equipment with modifications specific to the proposed service of the equipment.

Table 8-5 Summary of Feasibility-Level Pump Selection (Backbone System)

STATION	RATED DESIGN POINT	FAIRBANKS NIJHUIS	EBARA	SULZER
PS-1 Set A	7.5 mgd at 165 ft	27ML-BRZ 890 RPM, 300 horsepower (HP)	600X400VYBM 890 RPM, 350 HP	SJT-28GMC 885 RPM, 350 HP
PS-1 Set B	37.5 mgd at 352 ft	63HRO 7000 592 RPM, 4,500 HP	1500X1000VYB2M 710 RPM, 5,000 HP	SJT-56TMC 595 RPM, 4,000 HP
PS-3	37.5 mgd at 352 ft	63HRO 7000 592 RPM, 4,500 HP	1500X1000VYB2M 710 RPM, 5,000 HP	SJT-56TMC 595 RPM, 4,000 HP

8.3.4 Suction and Discharge Piping Sizing

As mentioned in Section 8.3.2, the vertical turbine pumps are proposed to be installed in cans/barrels. Recycled water would be supplied from the storage tanks via a suction header pipe with suction laterals feeding each pump can.

Per Hydraulic Institute (HI) Standard 9.8 - Intake Design for Rotodynamic Pumps, the maximum flow velocity recommended for a suction lateral entering a closed-bottom can below the elevation of the discharge lateral is 4 fps. Table 8-6 provides a summary of the flow velocities that can be anticipated in the suction laterals for the corresponding pump sets. The pipe sizes have capacity to accommodate a maximum flow rate of 150 percent of the design flow rate. The maximum flow rates were determined based on the can sizing, as discussed in Section 8.3.5, and also to provide flexibility to operate individual pumps across a wider range of flows. It was assumed that the pump VFDs would limit maximum runout conditions to maintain flow velocities below 4 fps. Detailed suction lateral sizing calculations are provided in Appendix J.

Table 8-6 Preliminary Suction Lateral Sizing (Backbone System)

PUMPS	PIPE SIZE (IN.)	DESIGN FLOW RATE (MGD)	FLOW VELOCITIES (FPS)(1)
PS-1 Set A	30	7.5	2.4 – 3.6
PS-1 Set B	66	37.5	2.4 – 3.7
PS-3	66	37.5	2.4 – 3.7

Note:
1. Velocity range: lower limit at design flow rate, upper limit at 150% of design flow rate.

HI Standard 9.6.6 - Rotodynamic Pumps for Pump Piping, recommends that pipe sizes for pump discharge laterals be designed to limit flow velocities to 15 fps. For the purposes of this evaluation, the maximum allowable flow velocity is assumed to be 10 fps in order to reduce both friction losses and life-cycle costs for each station. Table 8-7 provides a summary of the flow velocities that can be anticipated in the discharge laterals for the corresponding pump sets. Detailed discharge lateral sizing calculations are provided in Appendix J.

Table 8-7 Preliminary Discharge Lateral Sizing (Backbone System)

PUMPS	PIPE SIZE (IN.)	DESIGN FLOW RATE (MGD)	FLOW VELOCITY (FPS)
PS-1 Set A	16	7.5	8.2
PS-1 Set B	36	37.5	8.2
PS-3	36	37.5	8.2

8.3.5 Pump Can Sizing

As part of the initial pump sizing described in Section 8.3.3, the manufacturers provided estimated sizing for the pump cans. HI Standard 9.8 provides maximum velocities to guide the sizing of various aspects of the pump cans/barrels. The maximum velocity through the barrel at both the bowl and the bell is 5 fps. Figure 8-9 shows the standard configuration of a pump can and the acceptable dimensions and velocities per HI Standard 9.8.

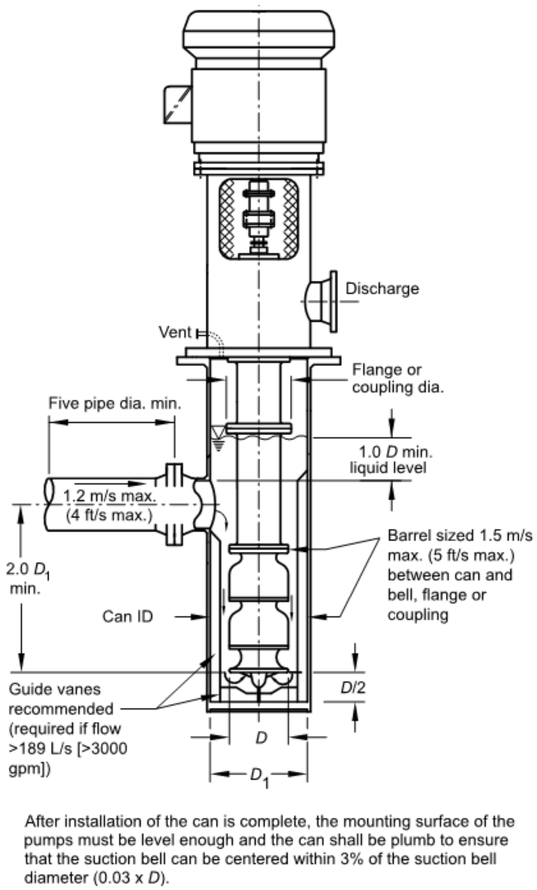

Figure 8-9 Closed Bottom Can Standard Configuration

The can sizing provided by Fairbanks Nijhuis, including the inside diameter (ID) of the barrel, outside diameter (OD) of the bowl, and OD of the bell, were used to estimate the maximum allowable flow rate through the pump can by limiting the velocity through the barrel to 5 fps. The desired maximum flow rate is 125 to 150 percent of the design flow rate. The pump can dimensions and maximum flow rates are presented in Table 8-8 and Table 8-9. Detailed can sizing calculations are provided in Appendix J.

Table 8-8 Preliminary Pump Can/Barrel Sizing – Fairbanks Nijhuis (Backbone System)

PUMPS	ID OF BARREL (IN.)	OD OF BOWL (IN.)	OD OF BELL (IN.)
PS-1 Set A	36.75	26.60	22.50
PS-1 Set B	96	64	64
PS-3	96	64	64

Table 8-9 Preliminary Pump Can/Barrel Maximum Flow Rates (Backbone System)

PUMPS	DESIGN FLOW RATE (GALLONS PER MINUTE [GPM])	MAXIMUM FLOW RATE (GPM)(1)	MAXIMUM VELOCITY IN BARREL AT BOWL (FPS)	MAXIMUM VELOCITY IN BARREL AT BELL (FPS)
PS-1 Set A	5,208	7,813	4.98	3.63
PS-1 Set B	26,042	39,063	3.13	3.13
PS-3	26,042	39,063	3.13	3.13

Note:
1. 150% of design flow rate.

8.4 PUMP STATION BUILDING

The pumping equipment, discharge piping and valves, and surge tank air compressors would be housed in a building at PS-3, along with areas for maintenance and administrative functions (control room, storage, etc.). Since PS-1 would be located at a treatment plant facility, the pumping equipment at that site would be outdoors, and the building would only include the air compressors and administrative facilities.

The pump building at PS-3 would be of sufficient height to allow for installation of a bridge crane for servicing the pumps and valves. Above-grade discharge laterals would include check and isolation valves for each pump before the piping extends below grade. The pumping area would also include sufficient room to assemble and disassemble a pump and perform applicable onsite maintenance. The approximate pump building/space footprint for each station is presented in Table 8-10.

Table 8-10 Preliminary Pump Building/Pad Size Estimates (Backbone System)

PUMP STATION FACILITY	LOCATION	APPROXIMATE ROOM/ PAD SIZE
PS-1	Outdoor pad	145-ft x 50-ft
PS-3	Building[1]	165-ft x 50-ft

Note:
1. Includes administration/control room.

8.5 HYDRAULIC SURGE CONTROL AND FACILITIES

Metropolitan's preferred method of surge control is to use air-over-water hydro-pneumatic tanks (also known as "air chambers"). On downsurges, as when a pump fails, the pressurized air in the tank forces fluid out into the pipeline to make up for the reduction in pipeline flow caused by the pump shutdown. As the pressure in the tank decreases from the expansion, the flow out of the tank decreases. Thus, flow changes are gradual rather than abrupt, and surge pressures are reduced. On reverse flow and upsurge, the surge chamber acts as a cushion and storage device. For a conveyance system of this size, the surge control system usually consists of several tanks, connecting pipelines with isolation valves, air compressors, liquid level sensors, and controls. The tanks themselves would be located outdoors on a pad (with appropriate curtain walls for shielding at PS-3), with the air compressors, add-air and vent-air solenoids, and controls panels located in the adjacent pump and/or control building.

Final sizing of the surge tanks would require detailed hydraulic transient analysis to investigate potential surge conditions and the required system performance under each of these conditions. This level of analysis would be completed during the detailed design phase of the Project. However, for the purposes of the feasibility-level station configuration and site planning included in this report, surge tank sizes were estimated based on pipeline lengths, estimated flows, and typical surge performance requirements. The procedure used is described by Stephenson (2002) and the associated calculations are included in Appendix J. Table 8-11 summarizes the estimated surge tank sizes and associated footprints.

Table 8-11 Preliminary Surge Tank Size Estimates (Backbone System)

PUMP STATION FACILITY	SURGE TANK SIZE	APPROXIMATE PAD SIZE
PS-1	6 tanks at 6,000 cu-ft	202-ft x 100-ft
PS-3	4 tanks at 6,000 cu-ft	141-ft x 100-ft

8.6 STORAGE FACILITIES

8.6.1 Overall Considerations

There are several features to consider when determining the optimal storage volume for a water transmission system such as the RRWP. Table 8-12 summarizes these design considerations and how they apply to this Project based on the current concept for the system.

Table 8-12 Storage Design Considerations

ITEM	STORAGE FUNCTION	APPLIES TO RRWP?	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 AWT 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.

ITEM	STORAGE FUNCTION	APPLIES TO RRWP?	REMARKS
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 spreading basins and potential future injection wells, so the temporary disruption of flow will not have critical impacts. If future customers require continuous delivery they can be required to provide their own on-site storage.
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 RRWP will be equipped with variable frequency drives to match flow rates with adjacent stations.
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 PS-1, with a total volume of less than 0.7 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 RRWP includes multiple pumps stations all with multiple pumping units as well as long transmission mains. Thus, storage facilities are necessary for improved operational control, especially during starting and stopping.
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.
Risk Mitigation	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.	Yes	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.

As noted in Table 8-12, the feasibility-level storage sizing approach for the RRWP Pump Stations was based primarily on considerations of controls, balancing, and risk management. The following sections provide additional detail on the minimum volume recommended for each of these considerations.

8.6.2 Control and Balancing Volume

Storage upstream of the pump stations provide an atmospheric break between the pump stations which simplifies the controls and allows for short-duration flow imbalances between facilities, especially during starting and stopping of pumps. To determine the volume necessary for these control and balancing functions, the Project team developed a conceptual control strategy for the RRWP, which was presented in Section 8.2.

Based on the discussion in Section 8.2, the estimated duration of a flow imbalance during starting or stopping would be on the order of 12 minutes before the flow set point – level trim control algorithm engages and stabilizes tank levels. Since each station would have a slightly different size and/or number of pumps, a small flow imbalance would be likely. It is difficult to quantify the exact flow imbalance at this stage of the feasibility-level design, but it is believed it would be on the order of 5 mgd during the duration of the starting or stopping sequence. At a flow rate of 5 mgd, twelve minutes of flow imbalance would result in a total balancing storage volume of approximately 0.02 million gallons (MG), which is a relatively small volume.

8.6.3 Risk Mitigation Volume

As noted in Section 8.6.2, it is anticipated that a relatively small storage volume would be needed for pump station control. However, this assumes the station controls and interlocks are operating correctly. In the event of a control system/interlock failure, flow imbalances at a storage tank could be much higher than the controlled scenario investigated above. If a large flow imbalance occurs and is not corrected, the storage tank could either fully drain, potentially damaging the downstream pumping equipment, or it could overflow, releasing recycled water from the conveyance system. Thus, providing additional storage at each pump station would provide an increased level of risk mitigation by providing time for the control system to recover and/or for the system to shut down either automatically or via operator intervention.

8.6.4 Reaction Times

The volume of storage that should be provided for risk mitigation ultimately is a decision based on the estimated likelihood of a control failure and the potential consequences of a tank drain or overflow scenario. The probability of control failure is difficult to quantify at the feasibility-level level, but modern control and communication systems can be designed with high levels of reliability. The consequences of an overflow can also be managed in the design of the stations. The feasibility-level design presented in this report includes facilities to discharge to the nearest drainage way, including a system to dechlorinate the recycled water before discharge off-site.

Table 8-13 summarizes the required storage volumes in MG for a range of flow imbalances and reaction times.

Table 8-13 Required Storage Volumes in MG as a Function of Reaction Time and Flow Rate

CONDITION DESCRIPTION	FLOW RATE		REACTION TIME (MINUTES)									
	MGD	GPM	5	10	15	20	25	30	35	40	50	60
PS-1 to PS-3	150	104,167	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	10.4	12.5
PS-1 Single Pump Capacity	37.5	26,042	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.6	3.1
PS-3 Peak Capacity	150	104,167	1.0	2.1	3.1	4.2	5.2	6.3	7.3	8.3	10.4	12.5
PS-3 Single Pump Capacity	37.5	26,042	0.3	0.5	0.8	1.0	1.3	1.6	1.8	2.1	2.6	3.1
Estimated Ramp Up/Down Imbalance	5.0	3,472	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.4

The volumes reported in Table 8-13 are total operational volumes based on the assumption that the tank would start at 50 percent full, as shown on Figure 8-10. The storage tank would also need a freeboard from the maximum level to the overflow and a minimum level to maintain pump submergence. These are estimated at 3 ft and 2 ft respectively, as shown on Figure 8-10.

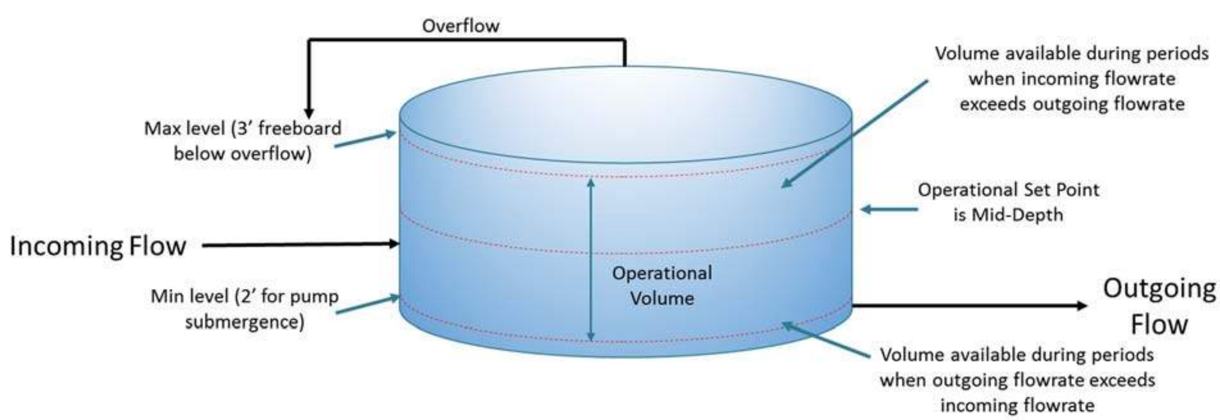

Figure 8-10 Typical Tank Level Configuration

Based on discussions with Metropolitan staff, it was determined that the AWT plant would require between 35 and 40 minutes to react to an unexpected shutdown of the conveyance system since PS-3 is anticipated to be unmanned. At PS-3, it was determined that ten minutes of reaction time would be required to trigger a shutdown of the system if communication and control were lost. Using these criteria, the following storage volumes were recommended for this feasibility-level design.

- PS-1: 7.5 MG
- PS-3: 2.5 MG (Backbone System)

Table 8-14 presents the recommended sizes and the associated storage times in minutes at the range of possible flow rates from low to high.

Table 8-14 Storage Times in Minutes at Various Flow Rates Based on Recommended Storage Volumes

CONDITION DESCRIPTION	FLOW RATE (MGD)	FLOW RATE (GPM)	STORAGE TIME (MINUTES)	
			PS-1 7.5 MG	PS-3 (BACKBONE) 2.5 MG
Estimated Ramp Imbalance	5	3,472	1,080	360
PS-1 to PS-3 and PS-3 Single Pump Capacity	26.7	18,542	202	40
PS-1 Single Pump Capacity	37.5	26,042	144	29
PS-3 Single Pump Capacity (Backbone)	37.5	26,042	N/A	48
PS-3 Peak Capacity (Backbone)	150	104,167	36	12

Several layers of control system failure would be required for a pump station's local storage volume to reach an empty tank or overflow scenario, including:

- Failure of one or more pumps at pump station and inability of station to recover to specified flow set point.
- Failure of interlocks to trigger shut-down due to out-of-range operation.
- Failure of communication between stations to trigger shut-down if one station fails.

8.6.5 Storage Configuration

The proposed storage volume would be provided in above-ground circular tanks at PS-1 and PS-3. Selection of the construction material for the storage tanks (i.e. steel vs. concrete) will be determined in subsequent design phases.

8.7 YARD PIPING, DECHLORINATION, AND MISCELLANEOUS FACILITIES

8.7.1 Discharge Piping and Meter Vault

Individual discharge laterals from each pump would feed a discharge header downstream of the pumps. A meter vault would be provided following the connection to the surge tanks to house and provide operator access to a flow meter and isolation vault installed in each discharge header. The approximate dimensions of the meter vaults are shown below in Table 8-15. It should be noted that the meters do not need to be located in a vault. Meter location and design should be further evaluated during future phases of work.

Table 8-15 Preliminary Meter Vault Size Estimates (Backbone System)

PUMP STATION FACILITY	NO. OF FLOWMETERS	APPROXIMATE VAULT SIZE
PS-1	2	42-ft x 28-ft
PS-3	1	17-ft x 28-ft

8.7.2 Dechlorination

In case of pump station failure, there may be emergency or unplanned discharges of recycled water that would ultimately reach the SG River. In order to discharge recycled water to a waterbody, it is currently anticipated that Metropolitan will need to apply for an Individual National Pollutant Discharge Elimination System Permit from the Los Angeles Recycled Water Quality Control Board, which may require additional water treatment to meet the water quality objectives for the SG River. Due to its nature as advanced treated water, it is likely that the recycled water quality would already meet basin plan requirements, with the possible exception of chlorine.

If required, dechlorination could be provided at the pump station sites to treat emergency overflows before discharging to flood control channels. This is traditionally addressed in one of two ways:

- Option 1: Using a liquid chemical injection system (e.g., sodium bisulfate) mixed into the overflowing volume to neutralize the chlorine during an overflow event. The benefit of this option is that its initial capital costs and overall footprint are typically less than that of a passive flow-through system. However, because the success of this approach relies on the performance of locally stored chemicals which can degrade over time, the cost of maintaining such a system and replacing these chemicals (on at least an annual basis) is viewed as excessive to most utilities- especially if an overflow event does not occur for several years.
- Option 2: Using a passive flow-through system containing media which can neutralize the chlorine during an overflow event. This approach is more likely to require a higher footprint and initial capital costs, as compared to a liquid chemical treatment system. However, because the chlorine-neutralizing capabilities of some media, such as granular activated carbon (GAC), are not exhausted with time or contact with chlorine, the need and frequency of replacement is greatly reduced. Another benefit of the passive system is that it is already ‘ready’ for its intended purpose; it requires no startup time, dosage metering or monitoring, and very little to no annual maintenance.

At the current feasibility-level stage of the Project, it was assumed that Metropolitan would select the flow-through system for overflow dechlorination, if required. Assuming that GAC would be utilized as the flow-through media, it is estimated that approximately 56,000 cubic ft (cf) of GAC media would be required to dechlorinate an overflow event of 150 mgd containing up to 5 milligrams per liter (mg/L) chlorine. This volume of media would correspond roughly to a facility

150-ft (long) by 40-ft (wide) by 10-ft (deep). For smaller overflow rates, the size of the facility would be reduced proportionally.

A flow-through dechlorination system is assumed for PS-1 and PS-3, both of which have on-site storage tanks. The design of the dechlorination system should be further evaluated during future phases of work in conjunction with coordination with applicable regulatory agencies.

8.8 POWER SUPPLY AND ELECTRICAL REQUIREMENTS

8.8.1 Major Load Estimation

The major use of electricity at the pump stations would be associated with operating pump motors. The pump selections discussed in Section 8.3.3 and shown in Table 8-5 were used to develop the feasibility-level electrical system design. As shown in Table 8-16, a representative manufacturer's selection for each pump station was used to estimate the amount of power that would need to be supplied to the site and to determine the required sizes of the electrical facilities.

Table 8-16 Summary of Design Motor Size (Backbone System)

STATION	RATED DESIGN POINT	MOTOR SIZE FOR DESIGN
PS-1 Set A	7.5 mgd at 165 ft	3 pumps (2 duty + 1 standby) at 350 HP each
PS-1 Set B	37.5 mgd at 352 ft	5 pumps (4 duty + 1 standby) at 5,000 HP each
PS-3	37.5 mgd at 352 ft	5 pumps (4 duty + 1 standby) at 5,000 HP each

8.8.2 Electrical Facilities and Space Requirements

Each pump station would include an electrical building/room, which is anticipated to be located immediately adjacent to the pump building/pad. This building/room would house electrical equipment that cannot be located outdoors, including motor control centers (MCCs), VFD controllers, and uninterruptable power supply system. In addition to the electrical building/room, an outdoor transformer farm would be included at each pump station for medium and high voltage electrical equipment.

There are two possible electrical service options that are likely to serve the pump stations: Option 1 assumed that the medium voltage (4,160 volts) is supplied by the power utility; Option 2 assumed that higher voltage (above 4,160 volts) is supplied. The power utility would dictate which option needs to be implemented at each site. For this Project, the feasibility-level layouts shown in Appendix L are based on Option 2. The power utility may require additional space either at or near the pump station sites for a switchyard, which is not currently shown on the feasibility-level layouts.

Table 8-17 summarizes the estimated footprint of the electrical facility at each pump station. Coordination with the power utility will be required in future phases of the Project.

Table 8-17 Preliminary Electrical Facility Dimensions (Backbone System)

PUMP STATION	ELECTRICAL BUILDING/ROOM	OPTION 1 TRANSFORMER FARM	OPTION 2 TRANSFORMER FARM
PS-1	68' x 44'	36'-0" x 50'-2"	99' x 68'
PS-3	68' x 44'	36'-0" x 50'-2"	99' x 66'-3"

8.9 PUMP STATION SITE INVESTIGATIONS

8.9.1 Methodology

The site for PS-1 was identified by Metropolitan to be located at the northeast corner of the AWT plant site. It was determined that there would be enough space at the existing site for the pump station and its associated facilities.

While not part of the Backbone System, potential sites for PS-2 or the flow control facility were identified if needed in the future and are presented in Appendix V.

Potential sites for PS-3 were identified during the preparation of the 2018 Draft Report. As discussed in Chapter 5, the revised route around the Whittier Narrows Dam resulted in a high point in the alignment located just upstream of four of the five sites that were identified. Further evaluation will be required to determine the optimal pump station location, as well as the pump station layout and site requirements. The sites identified for PS-3 during the preparation of the 2018 Draft Report were evaluated based on the following criteria: 1) Current Site Uses, 2) Existing Major Utilities, 3) Site Access, 4) Overall Constructability, 5) Environmental Risks, 6) Hazardous Materials Risks, 7) Proximity to Overflow Discharge Locations, and 8) Proximity to Recycled Water Pipeline Alignment. These criteria are explained in further detail below:

- Current Site Uses: Potential sites were evaluated based on existing land use in an effort to minimize impacts to communities. Potentially sensitive sites such as religious facilities, public institutions, and community facilities were eliminated from consideration. It was assumed that Metropolitan would obtain any existing, non-Metropolitan owned properties using eminent domain.
- Existing Major Utilities: The presence of existing major utilities was investigated by performing a desktop review of the available GIS data obtained from Metropolitan and Los Angeles County, the United States Department of Transportation (DOT) National Pipeline Mapping System and a review of aerial maps available online. Utilities analyzed included sanitary sewers, storm drains, overhead electrical lines, oil and gas transmission lines, and railroads.
- Site Access: The potential sites were evaluated for ease of construction and operational access.
- Overall Constructability: Potential sites were evaluated for ease of construction, e.g. topographic constraints of the site, demolition requirements of any existing structures, and trenchless construction requirements for the suction, discharge, and overflow pipelines.

- Environmental Risks: The presence of endangered species habitats was studied using the California Natural Resources Diversity Database.
- Hazardous Materials Risks: The presence of environmental hazard sites was analyzed using the California State Water Resources Control Board (Water Boards) Geotracker database. Sites with active environmental remediation activities were not considered viable (e,g,. environmental hazards include leaking underground storage tanks, or the presence of trichloroethylene (TCE) plumes at former dry cleaner locations).
- Proximity to Overflow Discharge Locations: Potential sites were evaluated based on their ability to gravity flow to existing storm water facilities.
- Proximity to Recycled Water Pipeline Alignment: Potential sites were evaluated based on their proximity to the Recycled Water Pipeline Preferred Alignment to minimize capital costs and pipeline construction impacts.

8.9.2 Feasibility-Level Site Identification

Potential sites have been identified for PS-3, based on a desktop review of locations along the Recycled Water Pipeline Preferred Alignment. Further analysis will have to be conducted including onsite surveys and geotechnical studies to select the preferred pump station location.

8.9.2.1 PS-3: Potential Siting

Five potential sites for PS-3 have been identified in a commercial area near the 605 Freeway between Beverly Boulevard and Whittier Boulevard as shown in Figure 8-11. This general vicinity for PS-3 was originally selected based on balancing flows between PS-3 and the OC Spreading Grounds. However, since flows are no longer anticipated to be delivered to the OC Spreading Grounds, at least initially, the location of PS-3 should be re-evaluated during subsequent phases of work. The PS-3 site, regardless of its final location, was originally anticipated to have a footprint measuring approximately 300’ x 400’, although the Backbone System would likely require a slightly larger footprint (approximately 350’ x 450’).

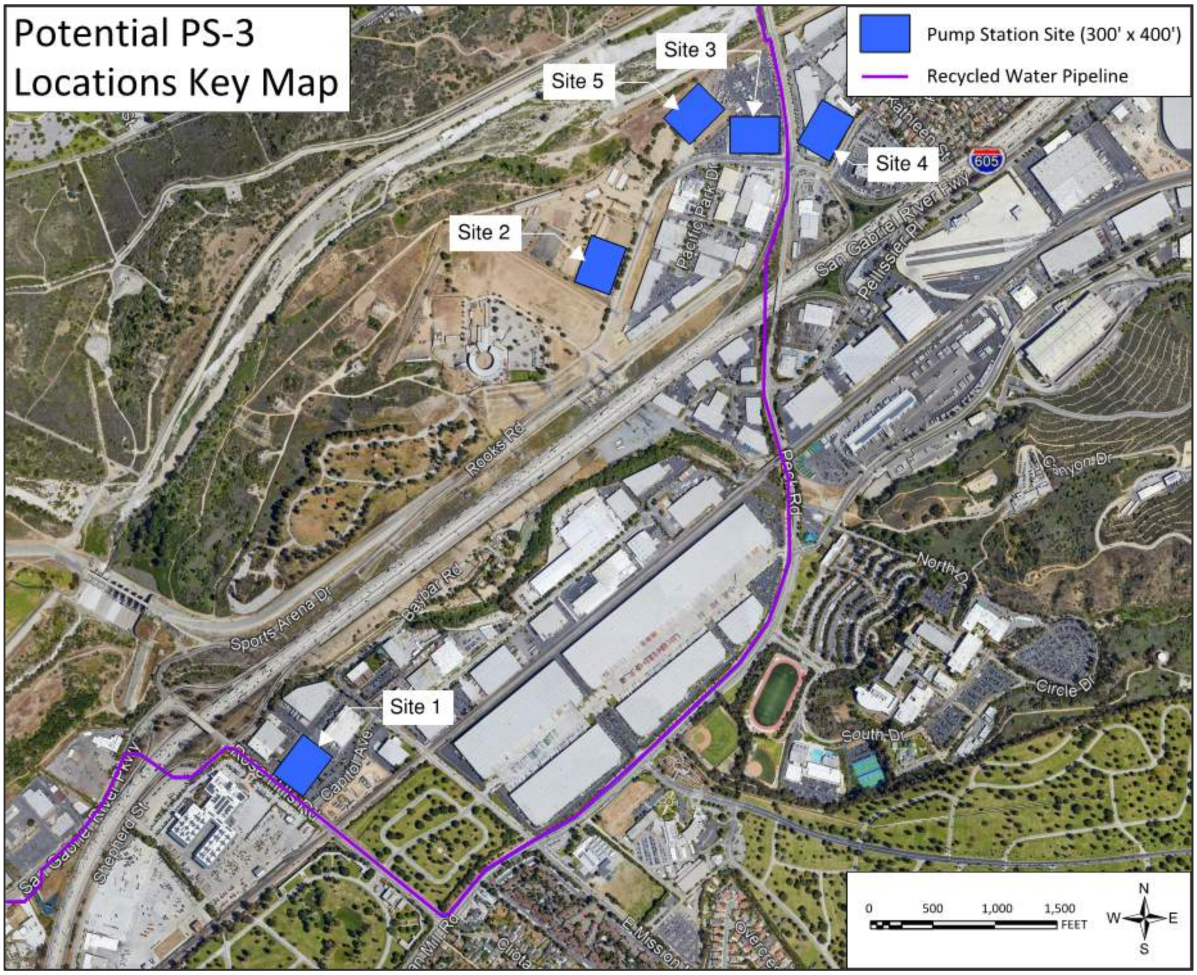

Figure 8-11 Potential PS-3 Locations Key Map

PS-3 Site No. 1 is located near the intersection of Rose Hills Drive and Capitol Avenue. Site No. 2 is located at the intersection of Rooks Road and Sports Arena Drive. Site No. 3 is located at the intersection of Rooks Road and Peck Road. Site No. 4 is located at the intersection of Rooks Road and Kella Avenue. Lastly, Site No. 5 is located west of the intersection of Rooks Road and Peck Road.

8.9.3 Site Attribute Investigation

This section describes the attributes for each potential site according to the criteria described in Section 8.9.1.

8.9.3.1 Potential PS-3 Site Attributes

This section describes the site attributes for the potential PS-3 sites identified during the preparation of this FLDR. A summary of the site attributes is presented in Table 8-18.

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Table 8-18 Attributes of Potential PS-3 Sites

SITE	APPROXIMATE SITE ADDRESS	CURRENT SITE USES	EXISTING MAJOR UTILITIES	SITE ACCESS	CONSTRUCTABILITY	ENVIRONMENTAL RISKS	HAZARDOUS MATERIALS RISKS	PROXIMITY TO OVERFLOW DISCHARGE LOCATION (FT)	PROXIMITY TO PIPELINE ALIGNMENT (FT)	NOTES
1	10015 Rose Hills Road, City of Industry, Ca	Carpenter's Union Training Facility	An existing 54-inch sanitary sewer is located between the site and drainage channel that feeds the SG River. Suction and discharge pipelines would have to cross the existing 54-inch sanitary sewer and 605 Freeway to reach the Preferred Alignment.	The site is fronted by the four-lane Rose Hills Drive and two-lane Capitol Avenue.	The site is level and would require demolition of a commercial facility. Suction and discharge pipelines would require trenchless construction to cross the 605 Freeway.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	700	1,200	This site is close to an overflow location. However, the site is further away from the Preferred Alignment and would require trenchless pipeline crossing of the 605 Freeway. Alternative A-Backbone for this pump station would require acquisition of an additional parcel to the northeast (Industrial Bakery) to accommodate the larger site footprint.
2	11003 Sports Arena Dr, Whittier, CA	Los Angeles County Mounted Assistance Unit Training Site	An existing sanitary sewer crosses the parcel. Overflow pipeline would cross the sanitary sewer and two separate vacant parcels to reach the SG River.	The site is accessible from the four-lane Rooks Road.	The site is level and is currently open space for vehicular parking. The pump station footprint may overlap with an existing training facility.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	1,300	140	The site does not require the demolition of a major building and also appears viable for the larger footprint of the Alternative A-Backbone option.
3	2429 Peck Road, Whittier, CA	Velocity Truck Centers	An existing sanitary sewer and 42-inch storm drain are both in the vicinity of the parcel. The overflow pipeline would cross the sanitary sewer in order to reach the SG River. Overhead powerlines are observed to the north of the parcel.	The site is accessible from the four-lane Rooks Road.	The site is accessible by the two-lane Rooks Road. The overflow pipeline would cross an adjacent parcel that is currently occupied by a parking lot before discharging to the SG River.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	600	150	There is little additional space near this site for the larger footprint of the Alternative A-Backbone option.
4	2450 Kella Ave, Whittier, CA	Rush Truck Center	No major utilities are present on the site. The overflow pipeline would cross an existing sanitary sewer to reach the SG River.	The site can be accessed from the four-lane Rooks Road, and the 605 Freeway.	The site is level and would require demolition of a commercial facility.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	1,400	450	There is little additional space near this site for the larger footprint of the Alternative A-Backbone option.
5	10149 Rooks Road Whittier, CA 9066	Blackwill Equestrian Center (Los Angeles County Parks & Recreation)	There is an existing sanitary sewer and an overhead power line at the south part of the site.	Site is accessible from the four-lane Rooks Road.	The site is level and would not require the demolition of buildings. Pump station footprint would have to avoid an existing power transmission tower on the parcel.	The site does not contain any observed California Protected Areas.	No active remediation sites are observed on the property.	150	250	The site would occupy an open space currently used for equestrian activities There is potentially enough space in the area for the larger footprint of the Alternative A-Backbone option.

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8.9.3.1.1 Potential PS-3 Site 1 Attributes

Potential PS-3 Site 1 is located approximately 1,200 ft away from the Preferred Alignment and is approximately 700 ft away from a nearby drainage channel (see Figure 8-12). The existing drainage channel appears to have enough capacity to receive the overflow from the pump station. The site is currently occupied by Carpenter's Union Training Facility. The site is level but would require demolition of the commercial facility for the construction of the pump station. Suction, discharge, and overflow piping may be constructed via cut-and-cover construction except for the 605 Freeway crossing. Suction and discharge piping may cross the 605 Freeway via trenchless technologies, which would require a Caltrans permit. There appears to be an approximate 20-ft drop in elevation between the pump station site and the drainage channel and may allow the overflow to drain by gravity. Hazardous materials requiring remediation do not appear to be present at this site. The implementation of Backbone System would require the acquisition of an additional parcel to the northeast (Industrial Bakery) to accommodate the larger site footprint.

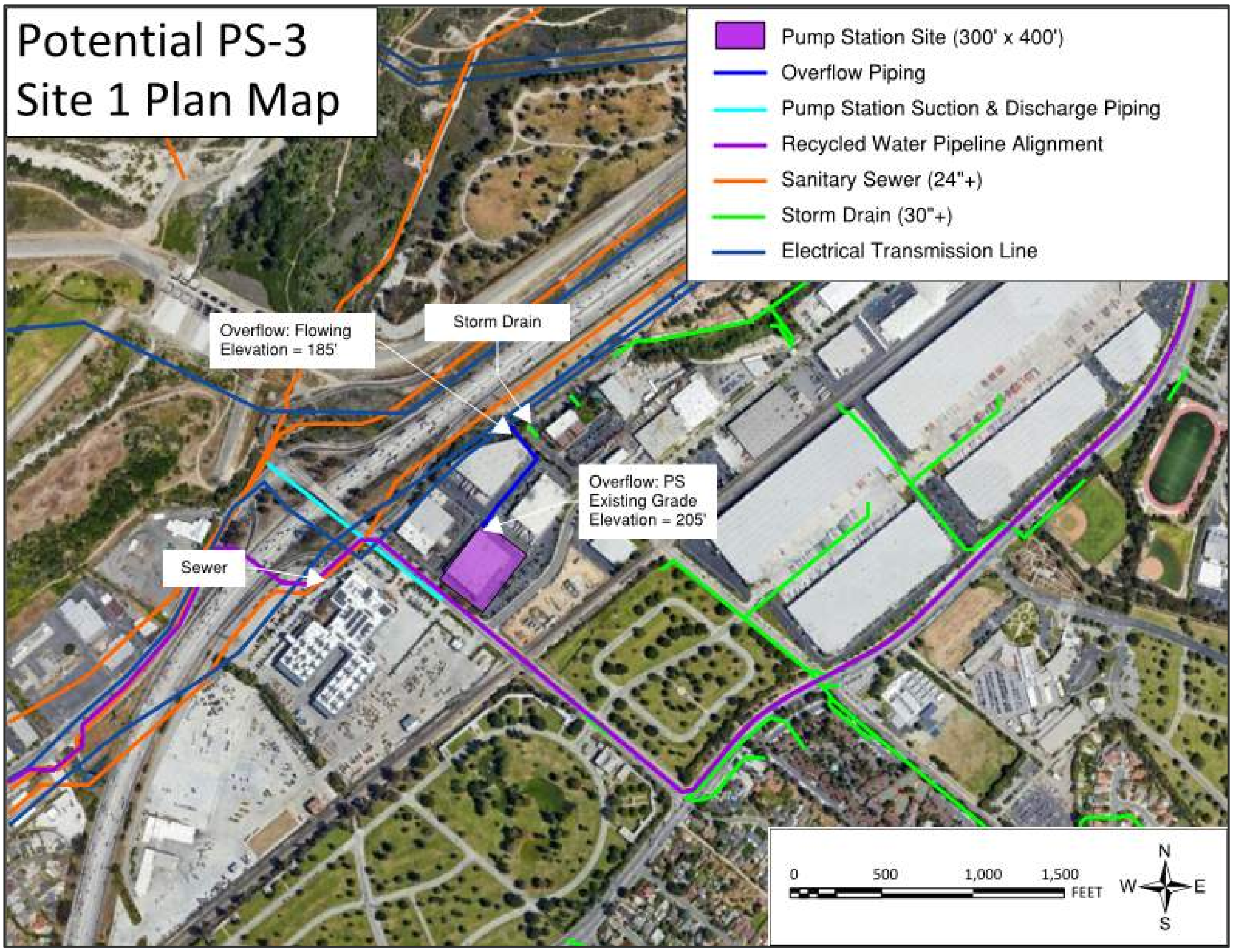


Figure 8-12 Potential PS-3 Site 1 Plan Map

8.9.3.1.2 Potential PS-3 Site 2 Attributes

Potential PS-3 Site 2 is located adjacent to the Preferred Alignment and approximately 1,300 ft away from the SG River (see Figure 8-13). The site is currently occupied by the Los Angeles County

Mounted Assistance Unit. Overflow, suction, and discharge pipelines may be constructed via cut-and-cover construction. The overflow pipeline would have to cross an existing sanitary sewer pipeline and two vacant parcels to the discharge point at the SG River. There appears to be an approximate 26-ft drop in elevation between the pump station site and the river and may allow the overflow to drain by gravity. The site is level and would require minimal demolition of the existing facilities. Hazardous materials requiring remediation do not appear to be present at this site. The site appears to be viable for the larger footprint required for the Backbone System.

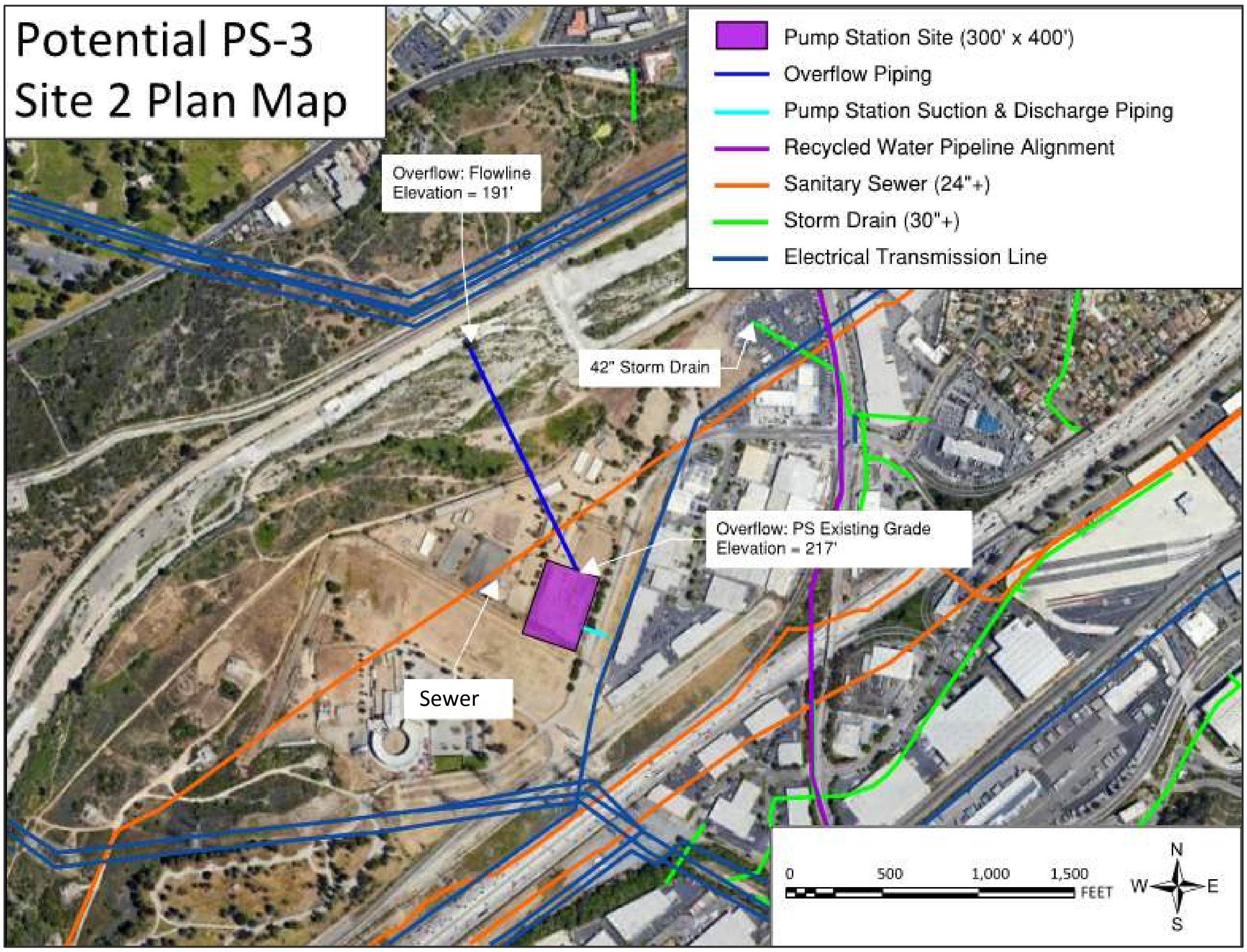


Figure 8-13 Potential PS-3 Site 2 Plan Map

8.9.3.1.3 Potential PS-3 Site 3 Attributes

Potential PS-3 Site 3 is located adjacent to the Preferred Alignment on a parcel by the intersection of Peck Road and Rooks Road (see Figure 8-14). The site is currently occupied by Velocity Truck Center. The site is level and would require the demolition of the existing building. Suction, discharge, and overflow piping may be constructed via cut-and-cover construction. The overflow pipeline would cross an existing sanitary sewer and the adjacent parcel to the north that currently contains a parking lot. There appears to be an approximate 28-ft drop in elevation between the pump station site and the SG River and may allow the overflow to drain by gravity. Hazardous materials requiring remediation do not appear to be present at this site. This site might not have sufficient space for the Backbone System.

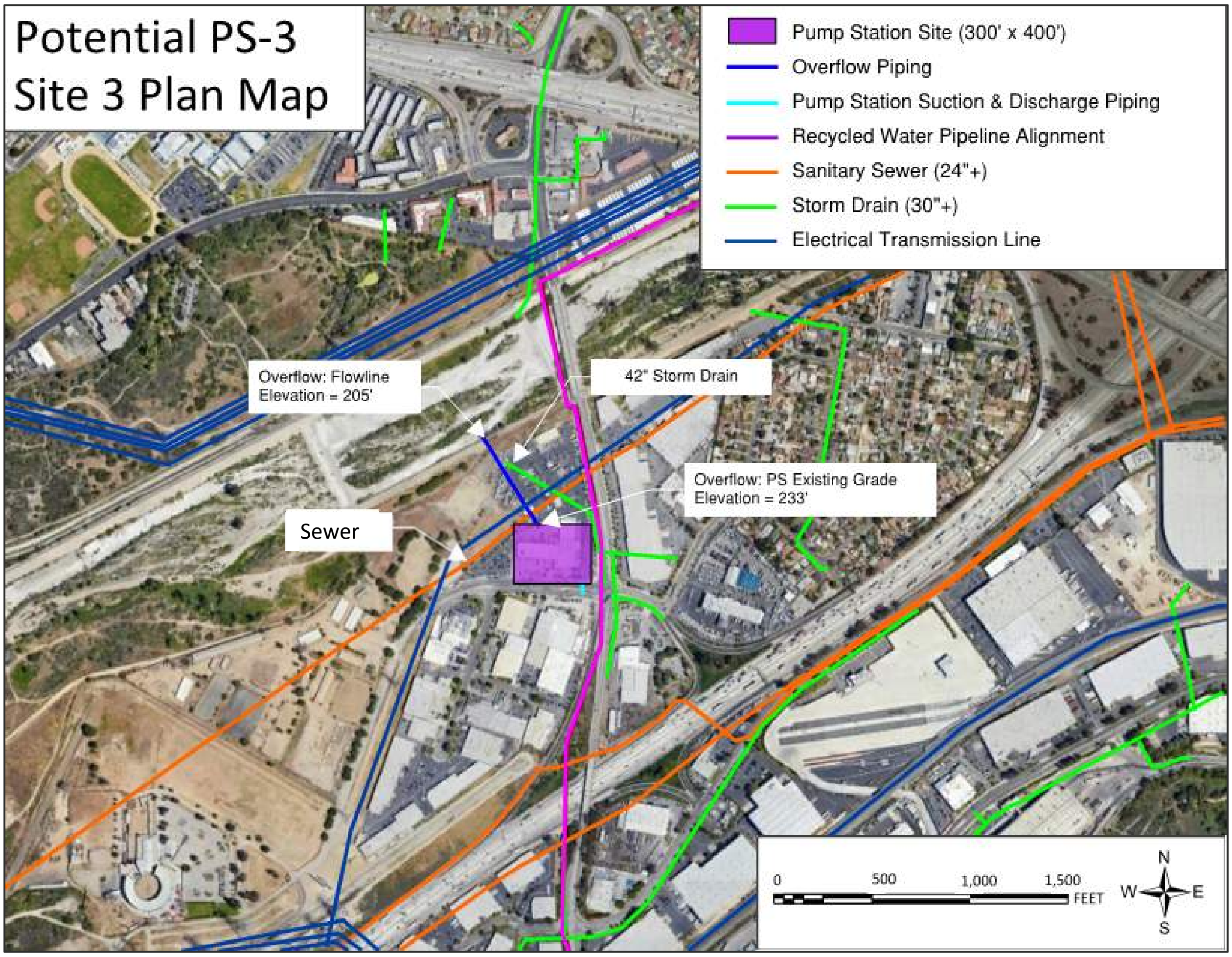


Figure 8-14 Potential PS-3 Site 3 Plan Map

8.9.3.1.4 Potential PS-3 Site 4 Attributes

Potential PS-3 Site 4 is located at a commercial facility at the intersection of Kella Avenue and Rooks Road on the west side of the 605 Freeway (see Figure 8-15). The commercial facility is occupied by Rush Truck Center. The suction and discharge piping would extend approximately 450 ft to the Preferred Alignment at the intersection of Rooks Road and Peck Road. Overflow piping may be routed north along Peck Road towards the SG River and would cross an existing sanitary sewer. There appears to be an approximate 10-ft drop in elevation between the pump station site and the river which may not allow the overflow to completely drain by gravity during periods of discharge. The site is built on level ground and construction would require the demolition of the existing facilities. Hazardous materials requiring remediation do not appear to be present at this site. This site may not have sufficient space for the Backbone System.

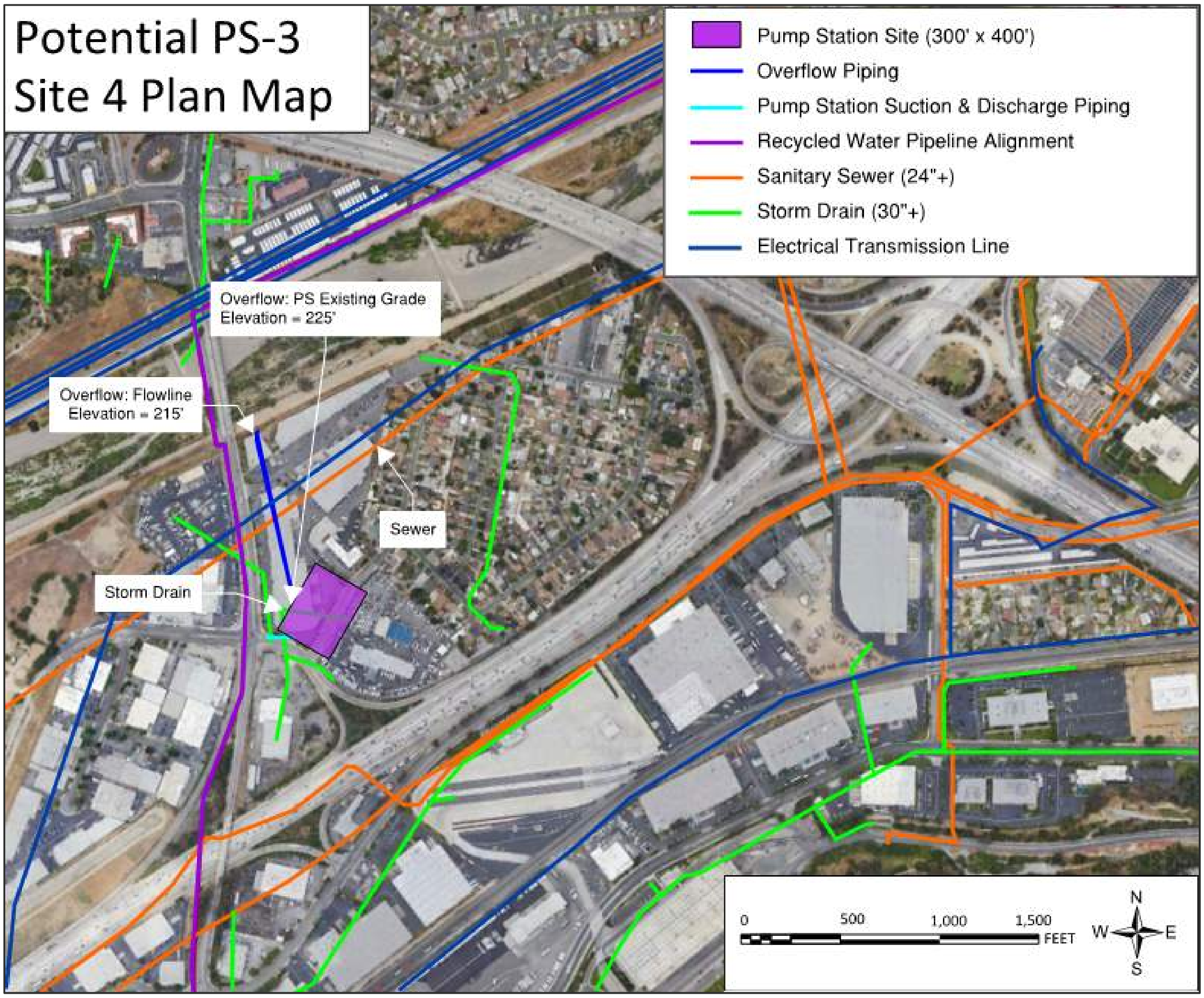


Figure 8-15 Potential PS-3 Site 4 Plan Map

8.9.3.1.5 Potential PS-3 Site 5 Attributes

Potential PS-3 Site 5 is located on an open space parcel currently occupied by the Backwill Equestrian Center (see Figure 8-16). Of the five potential sites, this site would have the shortest suction, discharge, and overflow piping. There is an existing sanitary sewer and an overhead power transmission line of the site. The overflow pipeline would run north and discharge into the SG River. There appears to be an approximate 10-ft drop in elevation between the pump station site and the river which may not allow the overflow to completely drain by gravity during periods of discharge. The site is level and would not require demolition of existing buildings. Hazardous materials requiring remediation do not appear to be present at this site. The area appears to be viable for the larger footprint required for the Backbone System.

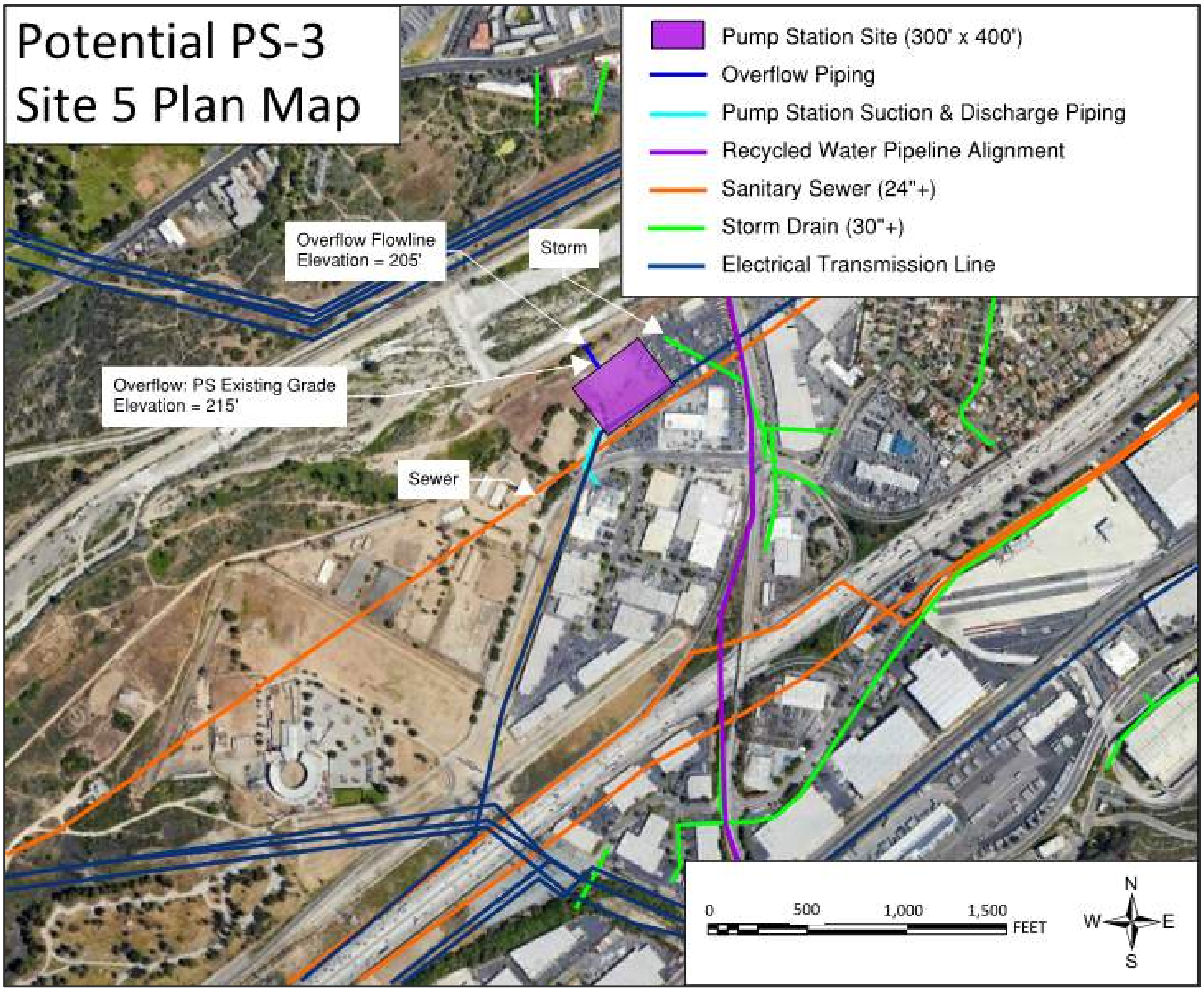


Figure 8-16 Potential PS-3 Site 5 Plan Map

8.10 SITE AND YARD PIPING DEVELOPMENT

Preliminary site plans were developed for each pump station site, as presented in Appendix L. The following sections provide details on each site. For details on PS-2, see Appendix V.

8.10.1 PS-1 Site and Yard Piping Development

PS-1 would be located on the northeast corner of the AWT plant site, as shown on Sheet C-1 in Appendix L. The circular 7.5-MG storage tank and optional dechlorination facility would be on the southern end of the pump station site. The pump pad, electrical room, transformer farm, surge tanks, and meter vault would be located on the northern portion of the site, with a parking lot between the pump facilities and the storage tank. Access to the electrical room would be provided from the east via South Main Street.

Treated recycled water would enter the storage tank from the east through a 102-inch inlet. An overflow pipeline would be provided on the southeast part of the tank and travel through the dechlorination facility, if required. From there, the overflow pipe would travel north to the drainage system. A 102-inch suction header would extend from the northwestern part of the storage tank to the pump pad. The pumps would connect to two discharge headers, which would travel north through the meter vault before exiting the site. The pumps for PS-1 Set A would use a 30-inch discharge pipeline to send water to the potential future injection wells. The pumps for PS-1 Set B would use an 84-inch discharge pipeline to send water to PS-3.

Sheets M-1 and M-2 in Appendix L contain more detailed plan views for PS-1, and Sheet M-3 contains sections of a PS-1 surge tank and valve vault.

8.10.2 PS-3 Site and Yard Piping Development

The site for PS-3 has not yet been selected, but preliminary section and plan drawings are presented on Sheets M-6 and M-7 in Appendix L. The plan drawings were developed assuming that PS-3 would convey 80 mgd. Since the Backbone System would convey 150 mgd, the layout would be the same as shown but the site is anticipated to include a 2.5-MG storage tank, 84-inch inflow pipeline, and 102-inch suction header. The circular 2.5-MG storage tank would be located on the southeast portion of the site. The 84-inch inflow pipeline would enter the storage tank from the south. The pump room would be located to the northwest of the storage tank, fed by a 102-inch suction header. An 84-inch discharge header would exit the site through a meter vault to the east and continue to the Santa Fe Spreading Grounds.

9.0 Project Duration and Cost Opinion

This chapter documents the development of the Engineer's OPCC and estimated construction duration for the conveyance facilities associated with the SG and LA River Alignments. The OPCC was prepared for the Backbone System and is Class 4 as defined by the Association for the Advancement of Cost Engineering (AACE) with an accuracy range of -30% to +50%.

Development of the Engineer's OPCC is broken down into a discussion of the following tasks:

- **Unit Cost Development** – This section describes the development of the unit costs for each facility. The unit cost includes two components: 1) a typical cost that covers the work generally anticipated for each construction method being used and 2) cost "adders" that address non-typical features or features that are not uniformly encountered, such as major utility crossings.
- **Quality Take-Off** – This section documents the quantity of each component being proposed for which a cost is being considered, known as a quantity take-off. This quantity take-off corresponds to the data and information available at the feasibility study level.
- **Engineer's OPCC** – This section applies the unit costs to the quantity of facilities being proposed for the SG and LA River Alignment alternatives to develop the OPCC. The OPCC for the RRWP conveyance system without contingency is as follows:
    - SG River Alignment - $898,700,000 (total project without contingency)
    - LA River Alignment - $830,000,000 (total project without contingency)
- **Preliminary Construction Duration Estimate** – This section presents an estimate of the construction duration for the individual pipeline segments for both the SG and LA River Alignments. This estimate was prepared to provide Metropolitan with information necessary to determine the implementation strategy for the program and is not intended to represent the actual implementation approach. The Metropolitan program management team will determine an implementation schedule which will consider other factors beyond the scope of this Project.

Figure 5-8 and Figure 5-10 depicts the LA River and the SG River Alignments, respectively, and shows the segment numbers comprising each alignment. These segment numbers are referred to in various tables in this chapter.

While not studied in the same level of detail as the Backbone System, a cost opinion was also prepared for the pipelines associated with the preferred connection from the SFSG to the FEWWTP. The OPCC for the pipelines only would be $214,600,000 without contingency. Details are provided following the OPCC for the Backbone System.

Figure 9-1 summarizes the Project methodology as it applies to this chapter.

Phase	Phase 1 Metropolitan's Initial Evaluation	Phase 2 Alignment Verification / Initial Screening	Phase 3 Detailed Alternative Alignment Evaluation	Phase 4 Final Refinements	**Phase 5 Feasibility-Level Pipeline and Pump Station Design**
Tasks	• Identification of potential pipeline alignments • Identification of Initial Base Case	• Data collection • Review of Metropolitan studies • Desktop analysis • Alternate alignment development • Field investigations • Initial screening • Desktop Geotechnical Report • Traffic Analysis and Impact Report • Constructability evaluations	• Development of decision model • Evaluation criteria • Weighting of evaluation criteria • Coarse screening • Secondary screening • Final screening • Ranking of alternatives	• Incorporation of stakeholder input • Conduct supplemental evaluations	• Steel size and wall thickness • Feasibility-level pipeline plan drawings • Hydraulic analysis and profile • Special construction zones and cross-sections • Pump station siting and feasibility-level site and building layout • **Cost development** • **Quantity take-off** • **Preliminary construction duration**
Workshops		• Initial screening workshops	• Detailed evaluation workshops	• Workshops with Stakeholders • Workshops with Metropolitan's Environmental Team	• Pipeline focus meetings/ workshops • Pump station focus meetings/ workshops • **Unit cost development workshops**
Outcomes	• Initial Base Case alignment • Report entitled, "Potential RRWP – Conveyance System Feasibility Assessment"	• Revised Base Case alignment	• Initial Preferred Alignment	• Final Preferred Alignment	• Feasibility-level pipeline and pump station design • **Engineer's cost opinion and Project schedule**
Chapters	• Chapter 1	• Chapter 2 • Chapter 3	• Chapter 4	• Chapter 5	• Chapter 6 • Chapter 7 • Chapter 8 • **Chapter 9**

Figure 9-1 Chapter 9 Methodology

9.1 UNIT COST DEVELOPMENT

Unit costs were developed for the pipeline and pump stations. This section presents those unit costs.

9.1.1 Pipeline

9.1.1.1 Pipeline Cost Development Methodology

The methodology used to develop the Engineer's OPCC for the pipelines was based on the data available at the feasibility-level study phase. The approach included development of typical construction methodologies that were consistently applied along each of the four major alignment types, as well as identification and development of the non-standard features required along the various segments. The key steps are further defined as follows.

- **<u>Typical Construction Methods</u>**: As discussed in Chapter 4, four typical construction methods were developed to cover the materials and work that would be consistently utilized for pipe installation along that alignment type. These methods, and the locations where they would be applied, include:
  - Construction Method 1 – Roadways
  - Construction Method 2 – SCE Easements
  - Construction Method 3 – LACFCD Easements
  - Construction Method 4 – Trenchless (Tunnels)

- **Cost Adders**: Variations from the standard construction methods which would be encountered along each alignment were designated as "Adders". Adders cover features and work methods which were not included in the typical construction method as described above because they were not consistently required or uniformly found along each segment. Consistent with a feasibility- level study, adders are items which are readily discernable and measurable from the desktop analysis, visual observations made in the field, review of utility information, analysis of traffic control requirements, desktop study of geotechnical and groundwater conditions, and so on.
- **Unit Prices:** Standard unit prices were developed for each construction method. Details about this effort are described later in this chapter.
- **Quantity Take-Off:** A quantity take-off was performed along the alignment alternatives as described above, and a count was made of the lengths and quantity of each alignment type and the related "Adders".
- **Engineer's OPCC:** The Engineer's OPCC was produced from the unit costs and the quantity take-off.

The development of costs for the standard construction methods and associated adders for each of the four construction types described in Section 4.3.3 are described herein.

9.1.1.2 Construction Method 1 - Roadways

As discussed in Section 3.4, CM1 was the standard method applied in all roadway/street locations. Figure 3-15 shows the typical manner in which CM1 would be applied to construction along roadways. CM1 is intended to cover all materials and work needed for construction of a finished and functional pipeline along a typical roadway section. The following were 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, such as excavation, shoring, hauling, and compaction of all bedding and backfill
- Pipe material, installation, welding, testing, cleaning, and disinfection
- Appurtenances and ancillary items, such as air valves, blow-offs and cathodic protection
- Utility protection, repair, and relocation

Adders for roadway work included the special features and additional work items not listed above, but which would be counted separately and added to the overall cost of the relevant segment. Adders associated with roadway work included the following:

- Intersection Traffic Control: Applied to signalized intersections and included the cost of all barriers, cones, signage, lighting, re-striping, and re-signalizing required. Intersections requiring traffic control were identified in the Traffic Control Study (provided in Appendix B) along with the type of traffic control to be applied.

- Construction through Major Intersections: Applied to signalized intersections identified in the Traffic Control Study (provided in Appendix B) as a Major Intersection, and not identified as being constructed with trenchless methods. Addresses the additional cost associated with the slower construction production rates that would occur due to construction staging, traffic control, and presence of numerous crossing utilities, or need to utilize trenchless construction methods, as discussed in Section 3.1.1. The cost included for these intersections is the same as to using trenchless installation methods.
- Median Removal and 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 ft. All street alignments were measured and locations with less than 36-ft curb to median were recorded in the quantity take-off.
- Major Utility Crossings: The added cost for crossing a major utility using trenchless installation methods (see Section 4.3.1 for major utility definition).
- Trench Dewatering: A standard dewatering cost adder was applied at all locations where the trench bottom would be below the groundwater level as described in the Desktop Geotechnical Evaluation (provided in Appendix C). A cost premium was added if permeable soils such as sand were also present.

Additional details regarding CM1 - Roadways and related adders can be found in Appendix M.

9.1.1.3 Construction Method 2 – SCE Easements

As discussed in Section 3.4, CM2 was the standard method applied along all SCE easements. Figure 3-16 shows the typical manner in which CM2 would be applied to SCE easements. CM2 was intended to cover all work and materials needed for construction of a finished and functional pipeline along a typical SCE easement. The following were included in the standard unit cost.

- Sitework, including surveying, clearing and grubbing, dust / erosion control, etc.
- Earthwork, such as excavation, shoring, hauling, and compaction of bedding and backfill
- Pipe material, installation, welding, testing, cleaning, and disinfection
- Appurtenances and ancillary items, such as air valves, blow-offs, cathodic protection, etc.
- Site restoration

Adders for pipeline installation in an SCE easement included the special features and additional work items not listed above. SCE Adders included the following:

- Major Utility Crossings: (see Major Utility Crossings in Section 4.3.1.1)
- Trench Dewatering: (see Trench Dewatering in Appendix C and Appendix F)

Additional details regarding CM2 – SCE easements and related adders can be found in Appendix M.

9.1.1.4 Construction Method 3 – LACFCD Easements

As discussed in Section 3.4, CM3 was the standard method applied along all LACFCD easements. Figure 3-17 shows the typical manner in which CM3 would be applied to LACFCD easements. CM3A, 3B, and 3C, described in Section 3.4.3, was intended to cover all work and materials needed for construction of a finished and functional pipeline along a typical LACFCD easement. The following were included in the standard unit cost.

- Sitework, including surveying, clearing and grubbing, dust / erosion control, etc.
- Earthwork, such as excavation, shoring hauling and compaction of bedding and backfill
- Pipe material, installation, welding, testing, cleaning, and disinfection
- Appurtenances and ancillary items, such as air valves, blow-offs, and cathodic protection, etc.
- Site restoration

Adders for pipeline installation in an LACFCD easement cover the special features and additional work items are not included in the list of standard items above. LACFCD Adders include the following:

- Major Utility Crossings: (see Major Utility Crossings in Section 4.3.1.1)
- Trench Dewatering: (see Trench Dewatering in Appendix C and Appendix F)

It should be noted that the entire section shown being installed with cut-and-cover methods within the SG River bed was budgeted using the cost for a tunnel prepared by MJA in their report titled, "Conceptual Review of Three New Tunnel Alignments." This report has been included in its entirety as Appendix W. Additional details regarding CM3 – LACFCD easements and related adders can be found in Appendix M.

9.1.1.5 Construction Method 4 – Trenchless

As discussed in Section 3.4, CM4 covered all of the trenchless construction applications on this Project. Figure 3-20 shows the typical setup for each of the three trenchless construction methods considered. The standard unit cost for CM4A, 4B, and 4C, described in Section 3.4.3, was intended to cover all materials and work 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 portals
- Tunneling equipment, such as 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)

Adders for trenchless work included the special features and additional work items which were not listed above. CM4 – Trenchless adders include the following:

- MT and Traditional Tunneling Dewatering: A cost adder was applied at all locations where the bottom of the tunnel launching and receiving portals would be below the groundwater level. A cost premium was added if permeable soils were also present.
- Jack & Bore Dewatering: Dewatering of the tunnel alignment, from the launching portal to receiving portal, would be provided when the jack & bore method (CM4A) is utilized for an intersection crossing and the tunnel invert is below the water level. A premium was 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 Appendix M.

9.1.1.6 Pipeline Unit Cost Summary

The standard unit costs associated with each construction method and related adders are presented in Table 9-1 and Table 9-2 below. Cost data was obtained from the following primary sources. Additional sources and the details of unit cost development are provided in Appendix M.

- R.S. Means 2nd Quarter of 2016 for Los Angeles, California
- Preliminary Design Report, Prepared by IEM for AECOM, October 2015
- Northwest Pipe Company Budgetary Quote dated July 19, 2018
- Preliminary Traffic Control Assessment, Prepared by Minagar, August 2018
- Black & Veatch, Heavy Civil Cost Data Base
- Desktop Geotechnical Evaluation for RRWP, Prepared by GeoPentech, August 2018

The direct unit costs are direct costs presented in April 2020 dollars and do not include indirect costs or contingency. The total construction unit costs are presented in April 2020 dollars as well, but include 15 percent for general requirements, 15 percent for general contractor overhead and profit, 3.6 percent for bonds and insurance, and 0 percent contingency. All costs were escalated to April 2020 dollars using the Construction Cost Indexes from Engineering News Report for Los Angeles, California.

All construction unit costs were developed using the budgetary quote received from Northwest Pipe Company on July 19, 2018. This quote is in line with historical prices for steel and does not include contingency for future fluctuations in steel prices due to potential tariffs or commodity price fluctuation.

Table 9-1 Construction Method Unit Costs

CONSTRUCTION METHOD	UNIT	DIRECT UNIT COST[1]	TOTAL CONSTRUCTION UNIT COST[2]
CM1 – Roadways			
84”	LF	$1,880	$2,530
60”	LF	$1,340	$1,780
54”	LF	$1,270	$1,700
CM2 – SCE Easements			
84”	LF	$1,400	$1,890
60”	LF	$870	$1,170
54”	LF	$780	$1,050
CM3A – River Bank			

CONSTRUCTION METHOD	UNIT	DIRECT UNIT COST[1]	TOTAL CONSTRUCTION UNIT COST[2]
84”	LF	$1,410	$1,900
60”	LF	$860	$1,160
54”	LF	$770	$1,040
CM3B – Cut-and-cover Earthen Channel			
84”	LF	$3,480	$4,680
60”	LF	$2,610	$3,510
54”	LF	$2,440	$3,280
CM3C – Cut-and-cover Concrete Lined Channel			
84”	LF	$2,350	$3,160
60”	LF	$1,630	$2,200
54”	LF	$1,500	$2,010
CM4A – Jack & Bore			
84”			
<200 ft length	LF	$10,510	$14,150
200-2000 ft length	LF	$5,000	$6,740
60”			
<200 ft length	LF	$9,400	$12,660
200-2000 ft length	LF	$4,100	$5,520
54”			
<200 ft length	LF	$9,200	$12,400
200-2000 ft length	LF	$3,900	$5,260
CM4B – Microtunnel			
84”			
<200 ft length, No Boulders	LF	$11,860	$15,970
<200 ft length, With Boulders	LF	$12,560	$16,910
200-2000 ft length, No Boulders	LF	$5,300	$7,140
200-2000 ft length, With Boulders	LF	$5,450	$7,340
60”			

CONSTRUCTION METHOD	UNIT	DIRECT UNIT COST[1]	TOTAL CONSTRUCTION UNIT COST[2]
<200 ft length, No Boulders	LF	$10,760	$14,490
<200 ft length, With Boulders	LF	$11,500	$15,500
200-2000 ft length, No Boulders	LF	$4,400	$5,930
200-2000 ft length, With Boulders	LF	$4,550	$6,130
54”			
<200 ft length, No Boulders	LF	$10,500	$14,150
<200 ft length, With Boulders	LF	$11,250	$15,150
200-2000 ft length, No Boulders	LF	$4,200	$5,660
200-2000 ft length, With Boulders	LF	$4,350	$5,860
CM4C – Traditional Tunnel			
84”			
EPBM (>2000 ft)	LF	$4,980	$6,700
60”			
EPBM (>2000 ft)	LF	$4,760	$6,410
54”			
EPBM (>2000 ft)	LF	$4,750	$6,395

Notes:
1. The unit costs are direct costs presented in April 2020 dollars and do not include general requirements, general contractor overhead and profit, contingencies, bonds, and insurance.
2. The total construction costs are presented in April 2020 dollars and include 15% for general requirements, 15% for general contractor overhead and profit, 3.6% for bonds and insurance, and 0% contingency.
3. Unit costs for CM4A and CM4B include a larger casing pipe or segmental tunnel liners, grouting, and annular spacers/fill.

Table 9-2 Construction Unit Costs for Adders

ADDED CONSTRUCTION COSTS DESCRIPTION	UNIT	DIRECT UNIT COST	TOTAL CONSTRUCTION UNIT COST[2]
Intersection Traffic Control (Cut-and-cover)	EA	$78,500	$105,700
Intersection Traffic Control (Trenchless)	EA	$12,500	$16,830
Landscaped Median (demo & replace)	LF	$192	$258
Raised Median (demo & replace)	LF	$181	$244
Major Utility Crossings			
84”	EA	$315,232	$424,475
60”	EA	$282,170	$379,950
54”	EA	$276,150	$371,850
Major Intersection Construction Crossing			
84”	EA	$1,000,210	$1,346,830
60”	EA	$820,050	$1,104,240
54”	EA	$780,160	$1,050,520
Seismic Hazards/Fault Zones			
84”	EA	$1,012,100	$1,362,830
60”	EA	$442,170	$595,410
54”	EA	$339,750	$457,500
Dewatering			
CM1 – Roadway	LF	$31	$41
CM2 – SCE Easement	LF	$6	$8
CM3A – River Bank	LF	$6	$8
CM3B & C – River Channel	LF	$9	$11
CM4A – Jack & Bore	LF	$50	$67
CM4B – Microtunnel	LF	$35	$48
CM4C – Traditional Tunneling	LF	$44	$59
Permeable Soils			
CM1 – Roadway	LF	$15	$21
CM2 – SCE Easement	LF	$3	$4
CM3A – River Bank	LF	$3	$4
CM3B & C – River Channel	LF	$4	$6
CM4A – Jack & Bore	LF	$25	$33
CM4B – Microtunnel	LF	$18	$24

ADDED CONSTRUCTION COSTS DESCRIPTION	UNIT	DIRECT UNIT COST	TOTAL CONSTRUCTION UNIT COST[2]
CM4C – Traditional Tunneling	LF	$22	$30

Notes:
1. The unit costs are direct costs presented in April 2020 dollars and do not include general requirements, general contractor overhead and profit, contingencies, bonds, and insurance.
2. The total construction costs are presented in April 2020 dollars and include 15% for general requirements, 15% for general contractor overhead and profit, 3.6% for bonds and insurance, and 0% contingency.

The following observations apply:

- CM2 and CM3A, construction along SCE and LACFCD easements would have the lowest cost per linear ft of the construction methods considered. This is primarily due to the shallower pipe installation, fewer potential utility impacts, and the lack of need for traffic control and pavement removal/replacement.
- Costs would increase significantly if the pipeline were located within the river channel (CM3B and CM3C) due to increased depth required to protect the pipeline from scour and provide concrete encasement of the pipeline in unlined portions of the river, concrete lining removal/replacement in lined portions of the channel, cost of installing and maintaining well point dewatering systems, the need to protect the work area from rainfall events, and reduced available working period during rainy seasons.
- CM1, construction along roadways, would have a high cost per linear ft. Elements contributing to the higher pipeline installation cost along roadways would include depth of the pipe, higher density of crossing and parallel utilities, removal and replacement of paving, and other surface improvements and the need to provide traffic control.
- CM4, trenchless construction methods, would have the highest cost per linear ft. Longer trenchless installations have a lower unit cost than short installations using the same method due to economies of scale coming into play with fixed costs (launching and receiving portals) and variable costs associated with the length of tunnel.
- Due to equipment limitations and man access requirements, CM4C, EPBM tunnels would have a minimum finished diameter of 7.5 ft, although at this diameter, machines are not readily available and would have to be special ordered. This FLDR assumed that all EPBM tunnels would have a minimum finished outer diameter of 118 to 132 inches so that a wider pool of contractors and tunnel boring machines would be available. The excess annular space was assumed to be filled with grout. Therefore, the cost difference for EPBM between pipe sizes would be minimal.

9.1.2 Pump Stations

The cost estimate for the pump stations has been prepared based on the contents of this report in combination with the feasibility-level drawings contained in Appendix L. In general, the following three methods for estimating costs were applied:

- Where sufficient detail is included on the drawings, a deterministic method for quantification of scope and assembly of costs has been utilized. Quantity takeoff was performed and transcribed into individual line item entries based on historical cost data for pricing and productivity. The historical cost archive is maintained primarily in the Sage Timberline Office Estimating application. This estimating system consists of a custom database (over 130,000 items) with assemblies that group items into definable cost systems and a spreadsheet to display results grouped according to user defined Work Breakdown Structures (WBS).
- The equipment pricing for vertical turbine pumps was obtained directly from pump vendors. The cost estimate reflects the most conservative costs obtained from two different vendors for pumps with equivalent design/service conditions.
- Scope items where the level of Project definition is conceptual in nature have been parametrically estimated utilizing cost data from similar projects in scope and size and adjusted to suit the specific requirements of this Project. For example, this approach was used to estimate the cost of the electrical room and transformer farm at each pump station.

Labor costs are adjusted in the OPCC to the Project location based on published prevailing wage rates, R.S. Means Location Adjustments and payroll tax information. The rates used are computed into averages based on a mixture of resources required for a given crew. Multiple crews are utilized in the cost as required for the different disciplines and activities involved in the work. Detailed line items throughout the OPCC are calculated using a production rate that has been established through a combination of estimating guides, historical data and specific experience with the disciplines and trades required to perform the work. Estimating guides that are utilized in the estimate include Richardson's Cost Data, R.S. Means, Mechanical Contractors Association of America (MCAA) and National Electrical Contractors Association (NECA).

Material pricing is maintained in the Sage Timberline Office Estimating database utilizing quoted pricing, vendor updates and multipliers on published list pricing. Pricing used in the OPCC has been reviewed by the estimators and adjusted based on the most current information available that is retained from recent bids on competitive priced projects.

Construction equipment costs are regularly updated based on the National Equipment Rental Blue Book publication. Cost for construction equipment is stored as an hourly rate that is then computed into averages based on a mixture of types of equipment required for a given crew. Multiple crews are utilized in the cost in the same manner as labor crews, with most crews containing both labor and equipment resources and having total amounts displayed in different cost categories. Individual line items are calculated using a production rate that has been established through a combination of estimating guides, historical data and specific experience with the disciplines and trades required to perform the work.

9.2 QUANTITY TAKE-OFF

A quantity take-off was completed for the SG and LA River Alignments. The quantity take-off has been separated into pipelines and pump stations, as presented in the following sections.

9.2.1 Pipeline

A quantity take-off was performed for the pipelines associated with the SG and LA River Alignments. The quantity take-off includes the quantity of each CM utilized and the number of adders found along the alignments.

Table 9-3 compares the total length of each construction method proposed for the SG and LA River Alignments. The complete and detailed quantity take-off is provided in Appendix N.

Table 9-3 Summary of Construction Methods for the SG and LA River Alignments

CONSTRUCTION METHOD	SG RIVER ALIGNMENT (FT)	LA RIVER ALIGNMENT (FT)
CM1 - Roadways	93,220	61,880
CM2 – SCE Easements	42,350	57,540
CM3 – LACFCD Easements	43,100	31,010
CM3A – River Bank	19,110	31,010
CM3B – River Bed (unlined)[1]	19,670	0
CM3C – River Bed (lined) [1]	4,320	0
CM4 – Trenchless	22,490	42,690
CM4A – Jack & Bore	2,540	2,370
CM4B – Microtunneling	12,770	16,010
CM4C – Traditional	7,180	24,310
Total	**201,150**	**193,120**
Note 1: This FLDR has assumed the portion of the SG River Alignment constructed within the SG River bottom would be constructed with cut-and-cover methods. However, for the purposes of establishing a conservative budget, this FLDR used a cost equivalent to tunneling this section.		

The following observations were noted when comparing the construction methods between the SG and LA River Alignments:

- The SG River alignment is roughly 4 percent longer than the LA River Alignment. However, the LA River Alignment requires nearly doubles the length of trenchless construction.
- The LA River Alignment does not include any cut-and-cover construction within a LACFCD riverbed while the SG River Alignment has roughly 25,000 feet.
- The LA River alignment has several long traditional tunnels. This construction method typically results in longer construction durations.

9.2.2 Pump Station

As currently envisioned, the Backbone System for the SG and LA River Alignments would each have two pump stations, PS-1 and PS-3. At this level of study, the hydraulics between the two alignments are similar enough that the pump station feasibility-level design described in Chapter 8 is applicable to either alignment with respect to arrangement, preliminary sizing, and planning level cost. A quantity take-off was performed on the proposed pumping plants.

In general, the following two methods for determining pump station quantities was applied:

- Where sufficient detail is included on the drawings, a deterministic method for quantification of scope and assembly of costs has been utilized.
- Scope items where the level of Project definition is conceptual in nature have been parametrically estimated utilizing data from similar projects in scope and size and adjusted to suit the specific requirements of this Project. For example, this approach was used to estimate the cost of the electrical room and transformer farm at each pump station.

In addition to containing the material quantities shown on the drawings in Appendix L, the pump station estimates also include additional lengths of discharge and suction/inlet piping where necessary to connect to the Backbone System, and an assumed length of overflow piping when this feature is present. These additional pipeline lengths are summarized below in Table 9-4.

Table 9-4 Summary of Additional Pipe Lengths Included with Pump Station Cost Estimates

PUMP STATIONS AND PIPING	PIPE LENGTH (FT)		
	PAVED	UNPAVED	TRENCHLESS
PS-1: 102" Suction Pipe	0	0	0
PS-1: 84" Discharge Pipe	100	120	200 (railroad crossing)
PS-1: 30" Discharge Pipe	100	120	200 (railroad crossing)
PS-1: 102" Overflow Pipe	500	500	0
PS-2[1]: 84" Suction Pipe	Length in estimate matches that shown on Drawing C-2		0
PS-2[1]: 54" Discharge Pipe	Length in estimate matches that shown on Drawing C-2		0
PS-2[1]: 60" Discharge Pipe	Length in estimate matches that shown on Drawing C-2		0
PS-3[2]: 84" Suction Pipe	1,900	0	0
PS-3[2]: 84" Discharge Pipe	1,900	0	0
PS-3[2]: 102" Overflow Pipe	2,000	0	0

Notes:
1. PS-2 was not included as part of the Backbone System.
2. The PS-3 Site 2 location was used for estimating purposes because it has the most conservative lengths of additional piping as compared to the other potential sites for PS-3.

9.3 ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

An Engineer's OPCC was prepared from the unit costs and quantity take-off for the SG and LA River Alignments. The following parameters apply to the Engineer's OPCC:

- All prices were escalated to and are presented in April 2020 dollars.
- The Engineer's OPCC is Class 4 from the AACE with an accuracy range of -30% to +50%.

- The Engineer's OPCC includes indirect costs of 22 percent for overhead, profit, bonding, and insurance.
- The Engineer's OPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team.
- The following costs are not included in the Engineer's OPCC:
  - Injection wells
  - Laterals to Project customers, including injection wells
  - Improvements to spreading basins
  - Permits
  - Right of way or easement acquisition
  - Property acquisition
  - Professional services, including engineering
  - Metropolitan staff time, including construction management
  - Design fieldwork, including potholing, geotechnical investigations, environmental fieldwork
  - Contingency for potential tariffs
  - Removal, remediation, and/or disposal of potentially contaminated soils identified as a result of future environmental fieldwork

9.3.1 Pipeline

A summary of the Engineer's OPCC for the SG and LA River Alignments is presented in Table 9-5 and Table 9-6, respectively. Figure 5-8 and Figure 5-10 identify the locations of the segments listed. A detailed breakdown of the costs associated with all the segments included in the SG and LA River Alignments can be found in Appendix O.

Table 9-5 Summary of Construction Costs for the SG River Alignment

SEGMENTS	LENGTH (FT)	DIAMETER (IN)	SEGMENT CONSTRUCTION COST ($)
1	23,957	84	$112,900,000
5	11,004	84	$37,900,000
5A	26,649	84	$91,600,000
10A	6,871	84	$29,400,000
20	32,140	84	$127,600,000
22	20,094	84	$140,100,000
36	4,651	84	$9,300,000
38	21,745	84	$68,900,000
38A	4,592	84	$27,800,000
44	28,748	84	$85,100,000

SEGMENTS	LENGTH (FT)	DIAMETER (IN)	SEGMENT CONSTRUCTION COST ($)
52	2,292	84	$6,800,000
56	1,166	84	$4,600,000
58	3,339	84	$11,300,000
59	9,028	84	$27,400,000
60	4,884	84	$15,600,000
		SG River Alignment Total	**$796,300,000**

Table 9-6 Summary of Construction Costs for the Los Angeles River Alignment

SEGMENTS	LENGTH (FT)	DIAMETER (IN)	SEGMENT CONSTRUCTION COST ($)
1	24,083	84	$113,800,000
2	12,826	84	$61,500,000
101	8,635	84	$62,600,000
3	9,206	84	$35,300,000
100	24,418	84	$72,100,000
7	3,700	84	$9,600,000
21	23,415	84	$90,800,000
23	19,433	84	$67,700,000
38	17,937	84	$63,400,000
44	28,748	84	$85,100,000
52	2,292	84	$6,800,000
56	1,166	84	$4,600,000
58	3,339	84	$11,300,000
59	9,028	84	$27,400,000
60	4,884	84	$15,600,000
		Los Angeles River Alignment Total	**$727,600,000**

9.3.2 Pump Station

A summary of the Engineer's OPCC for the pump stations included in the Backbone System is presented in Table 9-7. At this level of study, the hydraulics between the SG and LA River Alignments are similar enough that the pump station feasibility-level design described in Chapter 8 is applicable to either alignment with respect to arrangement, preliminary sizing, and planning level cost. A detailed breakdown of the line items and costs associated with the elements included in the Pump Stations can be found in Appendix P.

Table 9-7 Summary of Construction Costs for the Pump Stations

PUMP STATIONS	CONSTRUCTION COST ($)
PS-1[1]	$51,200,000
PS-3[2]	$51,000,000
Pump Stations Total	**$102,400,000**

Notes:
1. The PS-1 layout and sizing associated with Alternative A was used for cost estimating purposes.
2. As described in Chapter 8, the hydraulics for PS-1 and PS-3 are similar enough at this planning level as to warrant the use of a common arrangement, preliminary layout, and planning level cost.

9.3.3 Summary of Construction Costs for the RRWP Conveyance Facilities

A summary of the Engineer's OPCC for the entire RRWP Backbone System, including pipelines and pump stations, for the SG and LA River Alignments is presented in Table 9-8. As before, a detailed breakdown of the line items and costs can be found in Appendix O and Appendix P.

Table 9-8 Comparison of Construction Costs for the Backbone System

ITEM	SG RIVER ALIGNMENT TOTAL CONSTRUCTION COST	LA RIVER ALIGNMENT TOTAL CONSTRUCTION COST
Pipeline	$796,300,000	$727,600,000
Pump Stations		
PS-1	$51,200,000	$51,200,000
PS-3	$51,200,000	$51,200,000
RRWP Conveyance System Total	**$898,700,000**	**$830,000,000**

As discussed in Chapter 5, at one time this Project envisioned delivering flow to the OC Spreading Grounds with PS-2 included (Alternative B). For planning purposes, the total cost of the RRWP conveyance system for Alternative B would be $840,400,000.

As stated previously, the Engineer's OPCC is AACE Class 4, which carries an accuracy range of -30% to +50%. The values presented up until this point do not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team. For reference, Table 9-9 presents what the Engineer's OPCC for the Backbone System is using a -30% to +50% contingency.

Table 9-9 Example of Construction Costs with AACE Class 4 Contingency Applied (Backbone)

CONTINGENCY RANGE	SG RIVER ALIGNMENT	LA RIVER ALIGNMENT
Accuracy Range -30%	**$629,000,000**	**$581,000,000**
Accuracy Range +50%	**$1,348,000,000**	**$1,245,000,000**

9.3.4 Conclusion

Per Table 9-8, the cost opinions for the SG and LA River Alignments are within ten percent of each other. At this feasibility level of study and estimating, this is within the level of accuracy of the estimates. Other factors outside of the construction cost opinion impact the overall feasibility and cost of each alignment, such as the property acquisition costs, design costs, and environmental mitigation costs. These are not included in the numbers presented in Table 9-8.

9.4 PUMP STATION OPERATION AND MAINTENANCE COSTS

An estimate of the power, material, and labor operation and maintenance (O&M) costs was developed for the Project's pump stations under the Backbone System. This section describes the O&M costs developed for the pump stations. O&M costs for the pipeline are not included in this FLDR.

9.4.1 Power O&M Costs

The following assumptions were made in the development of the power costs for operation of the pump stations. A comparison of the power costs for operation of the pump stations is presented in Table 9-10.

- The pump efficiency was assumed to be 75 percent. This is a conservative assumption.
- For frictional hydraulic losses, the Manning's equation was used per Metropolitan's Hydraulic Design Manual. A Manning's Coefficient "n" of 0.012 was used for steel pipe.
- At Metropolitan's direction, an assumed cost per kWhr of $0.15/kWhr was used.
- Power usage assumed 150 mgd of flow.

Table 9-10 Preliminary Pump Station Power Operating Costs (Backbone System)

	SG RIVER ALIGNMENT		LA RIVER ALIGNMENT	
PUMP STATION	ANNUAL POWER CONSUMPTION (KWHR)	ANNUAL COST ($)	ANNUAL POWER CONSUMPTION (KWHR)	ANNUAL COST ($)
PS-1	80,282,000	$12,040,000	78,127,000	$11,720,000
PS-3	76,951,000	$11,540,000	76,951,000	$11,540,000

9.4.2 Material O&M Costs

An analysis was conducted to provide a general order-of-magnitude for the material costs, including pumps, motors, and other mechanical equipment, for the operation of the pump stations. During the analysis, the following assumptions were made:

- Material costs were generated in August 2016 and escalated to April 2020 dollars using the Construction Cost Indexes from Engineering News Report for Los Angeles, California.
- Costs are estimated for materials only for pumps, motors, and other mechanical equipment.
- Costs are not included for ancillary system (e.g. structures, software, etc.).
- Costs do not include tax, supplier markup, labor, tools, engineering, or material disposal.

- Costs do not include additional contingency.
- Frequency of component replacement depends heavily on operating conditions, operating frequency, and specific equipment supplied. It is assumed all equipment will have 24 hours per day, 365 days per year operation (8,760 hours per year).
- Values below are estimated capital costs for the pumping equipment based on input received from a typical manufacturer in 2017. These are provided to show a comparison to the estimated material costs for routine O&M. These are equipment costs only with no additional markup.

Table 9-11 presents the annual material costs for maintenance for PS-1 and PS-3 each.

Table 9-11 Annual Material Costs for Maintenance of PS-1 and PS-3 (Backbone System)

MAINTENANCE DESCRIPTION	FREQUENCY / REMARKS	COST PER UNIT ($)	ANNUAL PERCENT	QUANTITY	UNIT	TOTAL ANNUAL COST
Replace motor bearing oil	Every 8,760 hours of operating time	1,105	100%	8	per pump	$8,800
Mechanical seal	Inspect annually; assume replacement every 5 years	5,424	20%	8	per pump	$8,700
Submerged bearings and shaft sleeves	Assume replacement of 6 bearings per pump every 20 years. $5k/bearing	32,343	5%	8	per pump	$12,900
Impeller ring and casing ring	Assume replacement every 20 years; $2.5k per stage; 4 stage	10,748	5%	8	per pump	$4,300
Shaft	Assume replacement every 25 years	107,877	4%	8	per pump	$34,500
Impeller	Assume replacement every 25 years; 4 stages/ $10k/stage	43,191	4%	8	per pump	$13,800
Compressor motor air filters	Inspect annually; assume replacement every 2 years	2,712	50%	1	per pump station	$1,400
Valve seals at PS1	Replace valve seals (at 5% of initial valve material cost of $720k) every 10 years	42,186	10%	1	per pump station	$4,200
HVAC	Inspect and replace air filters, lubricate, minor maintenance twice per year	2,712	100%	1	per pump station	$2,700

MAINTENANCE DESCRIPTION	FREQUENCY / REMARKS	COST PER UNIT ($)	ANNUAL PERCENT	QUANTITY	UNIT	TOTAL ANNUAL COST
Generator	Fuel for annual testing; minor annual repairs	552	100%	1	per generator	$600
Instruments	Inspect annually; assume replacement every 10 years	213,745	10%	1	per pump station	$21,400
Miscellaneous	10% of sum of individual costs above	N/A	10%	1	per pump station	$11,300
Total estimated annual material cost for each pump station's maintenance						**$124,600**

Based on Table 9-11, the estimated annual material cost for both PS-1 and PS-3 is $249,200. For CIP budgeting purposes, this FLDR recommends that Metropolitan consider the potential for more costly, unanticipated, replacements (e.g., upgrade SCADA to new technology, replace electrical gear or components thereto, other structural or piping rehabs) above and beyond the costs provided. For example, if Metropolitan assumed 10 percent of all non-structural materials are replaced every 20 years, the annual amortized cost would be $85,000/year for PS-1 (0.5% of $17M for materials) and $70,000/year for PS-3 (0.5% of $14M for materials). Additional analysis would need to be completed to determine more accurately what that cost would be.

9.4.3 Labor O&M Costs

At this time, it is not known whether new distribution staff specific to the operation of the RRWP will be needed or if Metropolitan's existing potable water distribution staff will be able to maintain operations themselves. For planning purposes, Metropolitan has budgeted for the labor costs of 12 full time equivalents (2,080 hours per year) at $75 per hour. Table 9-12 shows the assumed annual labor O&M costs.

Table 9-12 Assumed Annual Labor O&M Costs

ITEM	COST
Labor O&M	$1,872,000

9.4.4 Summary of O&M Costs

A comparison of the estimated annual power, material, and labor O&M costs developed for the Project's pump stations (Backbone System) is provided in Table 9-13. O&M costs for the pipeline are not included in this FLDR.

Table 9-13 Summary of Annual O&M Costs

ITEM	SG RIVER ALIGNMENT ANNUAL COST	LA RIVER ALIGNMENT ANNUAL COST
Power	$23,580,000	$23,260,000
Material	$249,200	$249,200
Labor	$1,872,000	$1,872,000
Total O&M	**$25,701,200**	**$25,381,200**

9.5 CONNECTION FROM SFSG TO FEWWTP: ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST

An Engineer's OPCC for the pipeline that would be required to connect the SFSG to the Glendora Tunnel, which would be used to convey water on to FEWWTP in the future, was developed upon Metropolitan's request. The pump stations and any modifications, improvements, or repairs to Metropolitan's existing facilities, such as the Glendora Tunnel, La Verne Pipeline, or Upper Feeder Junction Structure, that would be required to form a complete and functioning system, are not included in this cost opinion and should be further evaluated during the next phase of work.

The following parameters apply to the Engineer's OPCC:

- All prices were escalated to and are presented in April 2020 dollars using the Construction Cost Indexes from Engineering News Report 2020 for Los Angeles, California.
- The Engineer's OPCC is AACE Class 4 with an accuracy range of -30% to +50%.
- The Engineer's OPCC includes indirect costs of 22 percent for overhead, profit, bonding, and insurance.
- The Engineer's OPCC does not include a contingency, as this value will be added to the bottom line for the entire RRWP by the program team.

Table 9-14 the Engineer's OPCC for the connection from the SFSG to the FEWWTP. A detailed breakdown of the costs can be found in Appendix O and a feasibility-level quantity takeoff can be found in Appendix N.

Table 9-14 Engineer's OPCC for the Connection from the SFSG to the FEWWTP (Pipeline Only)

ITEM	CONSTRUCTION COST
Pipeline	$214,600,000

As noted above, a cost opinion has not been prepared for the pump stations necessary to convey water from the SFSG to the Glendora Tunnel, and ultimately on to the FEWWTP. However, for budgeting purposes until these facilities can be further evaluated, Metropolitan has indicated that two pump stations of similar size and cost as PS-3 should be used as a place holder. The combined cost for two PS-3's would be:

- $102,400,000

The OPCC for the connection from the SFSG to the FEWWTP for DPR was based upon the quantities presented in Table 9-17.

Table 9-15 Quantity Take Off – Connection from SFSG to FEWWTP for DPR

ITEM	QUANTITY
84-inch Pipeline in Roadways, feet	40,200
Tunnel, feet	10,500
Pump Stations, each	2

9.6 PRELIMINARY CONSTRUCTION DURATION AND CONTRACT PACKAGING

To establish a feasibility-level construction schedule, preliminary construction durations were determined for the conveyance facilities of the RRWP. Installation rates were developed and contract packages were identified to determine a feasibility-level construction schedule to assist Metropolitan with their capital improvement planning and budgeting. While a specific breakdown of construction packages is shown, it should be noted that there are numerous factors that play into the final breakdown of construction packages which are not known at the time of this FLDR, such as annual limits on capital expenditures and implementation strategies. Further evaluation of contract packaging is expected during subsequent planning and design phases of the Project and would be expected to refine the size, number, and duration of each potential contract package.

9.6.1 Purpose of Contract Packaging

The overall size of the conveyance portion of the RRWP, as well as the number of different jurisdictions that it encompasses, makes it prudent to consider splitting the construction of the program into individual contract packages. The strategy used to develop the potential contract packages in this FLDR aimed to satisfy four objectives: 1) reduce overall schedule, 2) obtain competitive pricing, 3) optimize construction management costs, and 4) minimize risk associated with multiple construction contract interfaces.

9.6.2 Installation Rates

An estimate of the installation rate for each construction method was developed as follows:

- A total of six months would be required for pipe procurement and mobilization of each contract package.
- A total of three months would be required for the testing, commissioning, and demobilization of each contract package.
- The rate of construction progress would be expected to vary between a high production rate when experiencing ideal conditions and a low production rate when faced with less than ideal conditions.
  - CM1 would range between 40 ft/day and 80 ft/day
  - CM2 and CM3A would range between 180 ft/day and 200 ft/day
  - CM3B and CM3C would range between 100 ft/day and 140 ft/day

- CM4 work would be performed by a separate tunneling contractor in parallel with cut-and-cover construction being completed by the general contractor. In most cases, the CM4 work is not anticipated to add to the overall duration of work for contract packages, as the longer cut-and-cover sections would dictate the critical path. However, in contract packages with long tunnels proposed, CM4C would set the contract duration. Traditional tunneling assumed the following production rates:
  - Mining / excavation – 20 to 40 ft/shift
  - Carrier pipe install – 80 ft/shift
  - Grouting – 200 ft/shift
  - Launching shaft assumed 5 days mobilization, 2 ft of excavation depth / shift at 45 ft depth, and 5 days to pour the slab, install utilities, and support breakout
  - Assembly of EPBM machine – 1 to 2 months
  - EPBM procurement and delivery would require 6 to 12 months
  - Working days are assumed to be one 10-12 hour shift
  - The overall production range, including all factors of work, would be between 11 and 18 ft/day for CM4C
- The installation rates described above account for “typical” conditions that would be anticipated and do not account non-typical constraints, such as:
  - Environmental constraints, such as nesting birds or mating seasons
  - Jurisdictional constraints, such as restrictions on working hours or working days per week
  - Labor disputes
  - Material delays
  - Forces of nature, such as floods, pandemics, or above average rainfall

9.6.3 Contract Packaging

This section describes the potential contract packages developed for the conveyance facilities of the RRWP.

9.6.3.1 Pump Stations

Pump stations can be grouped into their own contract package, which could be a single contract package encompassing both pump station sites or could be split into individual contracts for each facility. Construction of the pump stations could happen in parallel with the construction of the pipeline.

9.6.3.2 Pipeline

To meet the stated objectives for contract packaging, the SG and LA River Alignments were evaluated to identify potential contract packages of similar size or duration. Other factors considered included municipal/jurisdictional boundaries, the type of construction activity, and location.

The resulting potential contract packages for the SG and LA River Alignments are shown on Figure 9-2 and Figure 9-3 and summarized in Table 9-16 and Table 9-17.

Table 9-16 Potential Contract Packages for the SG River Alignment Pipeline

PIPELINE CONTRACT	DESCRIPTION	STATION START	STATION END	CM-1 STREETS	CM2, CM3A EASEMENTS	CM4 TUNNELING	CONTRACT DURATION - AVG[1] (MONTHS)
1	First Contract to Alameda Corridor	0	13,100	13,100			21
2	Alameda to East Bank of LAR	13,100	24,100	7,570			21
3	LAR to Bellflower Blvd	24,100	48,000	23,900			30
4	Bellflower Blvd to JS	48,000	67,700	19,390		310	26.5
5	JS to Transition to River Bed	67,700	95,400	4,685		23,015	19.5
6	River Transition to Whittier Blvd	95,400	128,300		24,100	8,800	21
7	Whitter Blvd to SJ Creek	128,300	154,100	12,970		6,340	27
8	SJ Creek to Santa Fe	154,100	201,400	8,700		32,300	25

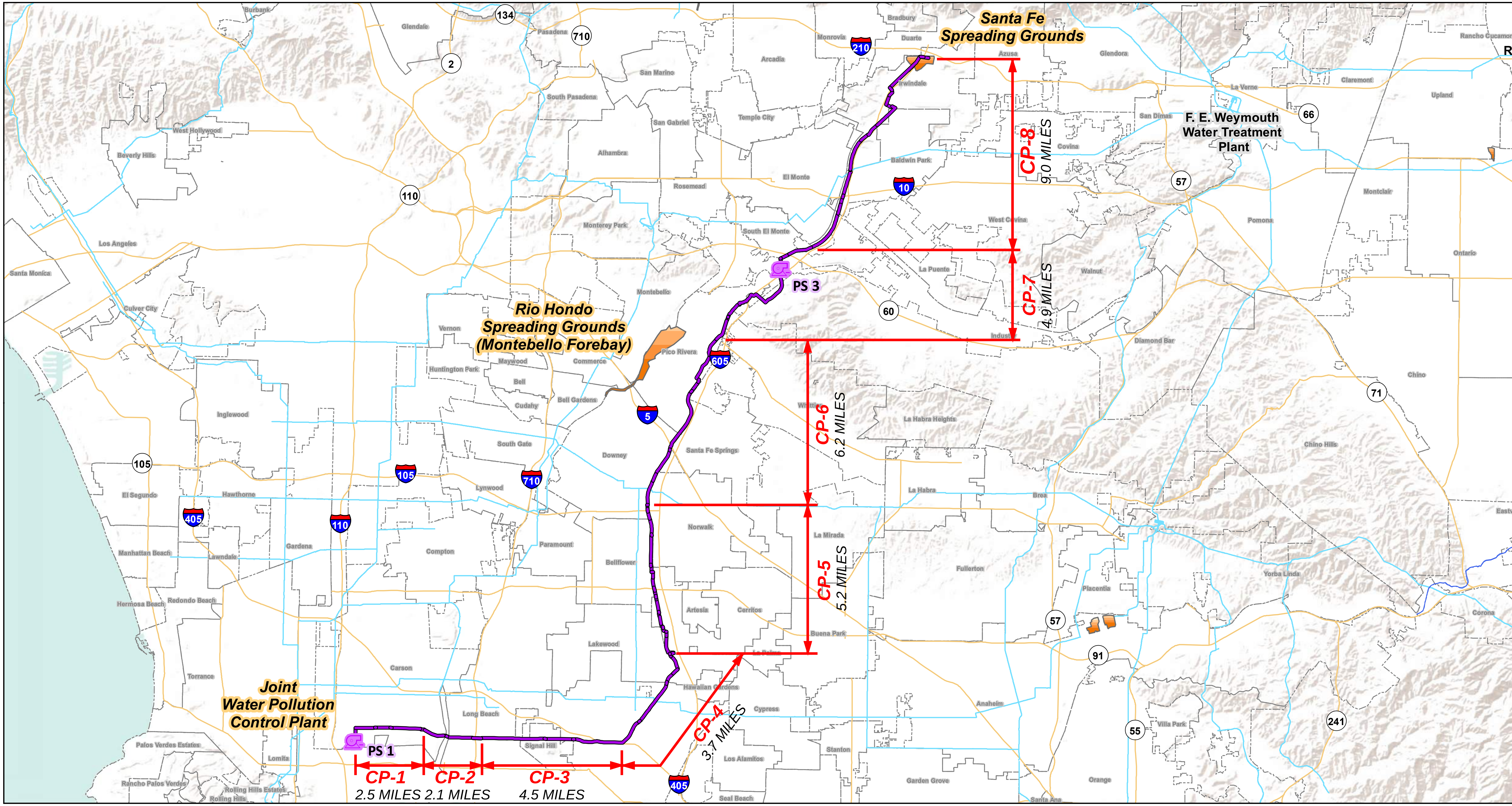
Notes:

1. Average contract duration using the high and low production rates. This duration is recommended for use in high level planning.
2. Minor trenchless crossings for Contracts 1, 3, 4, 5, and 6 would not impact the overall schedule estimate and were therefore not itemized in this schedule estimate.
3. Contract 2 and Contract 7 each include traditional tunnels of 3,430 ft and 3,700 ft, respectively.
4. Contract 8 includes multiple trenchless installations of significant length, which were itemized in this schedule estimate. These trenchless installations would not all occur consecutively and therefore would not add to the duration of the work.
5. Due to construction restrictions, Contract 5 may be required to be constructed using tunneling construction methods within the riverbed. If tunneling is required, the mid-range contract duration for contract 5 is roughly 88 months.

Table 9-17 Potential Contract Packages for the Los Angeles River Alignment Pipeline

PIPELINE CONTRACT	DESCRIPTION	STATION START	STATION END	CM-1 STREETS	CM2, CM3A EASEMENTS	CM4 TUNNELING	CONTRACT DURATION -AVG[1] (MONTHS)
1	First Contract to Alameda Corridor	0	13,100	13,100			21
2	Alameda to East Bank of LAR	13,100	24,100	7,570		3,430	21
3	LAR to Chestnut Ave	24,100	45,300		6,570	14,630	59
4	Chestnut Ave to Somerset Blvd	45,300	62,310	10,500	4,190	2,320	20
5	Somerset Blvd to Century Blvd	62,310	69,800		6,490	1,000	13
6	Century Blvd to Whittier Blvd	69,800	112,600		37,100	5,700	28.5
7	Whittier Blvd to SJ Creek	112,600	145,840	24,210	6,320	2,710	32
8	SJ Creek to Santa Fe	145,840	193,140	8,700	32,300	6,300	27

Notes:
1. Average contract duration using the high and low production rates. This duration is recommended for use in high level planning.
2. Minor trenchless crossings for Contracts 1, 5, and 6 would not impact the overall schedule estimate and were therefore not itemized in this schedule estimate.
3. Contract 2, 3, 4, and 6 each include traditional tunnels.
4. Contract 8 includes multiple trenchless installations of significant length, which were itemized in this schedule estimate. These trenchless installations would not all occur consecutively and therefore would not add to the duration of the work.



Legend

- Alignment
- Spreading Basins
- MWD Pipelines
- Interstate / State Highway

Date: 5/1/2020

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program
Figure 9-2: SG River Alignment Contract Packaging

0 0.75 1.5 3 4.5 Miles

N W E S

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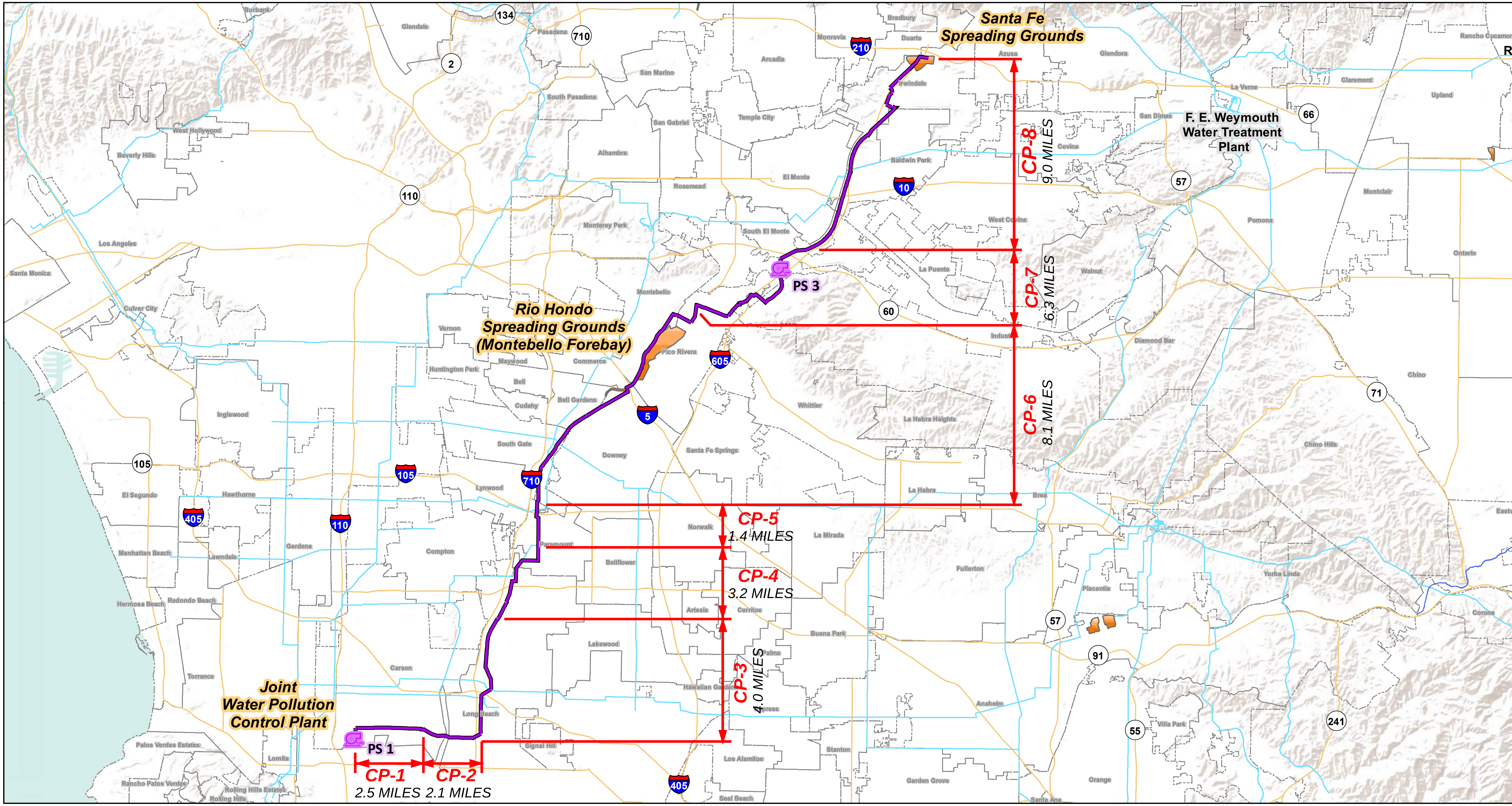

Legend

- Alignment
- Spreading Basins
- MWD Pipelines
- Interstate / State Highway

Date: 5/1/2020

Feasibility-Level Design of the Conveyance for the Potential Regional RW Program
Figure 9-3: LA River Alignment Contract Packaging

0 0.75 1.5 3 4.5 Miles

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9.6.3.3 Contract Packaging Observations

Contract packaging observations include:

- The longest potential pipeline contracts shown for the SG River Alignment would be Contracts 3 and 7. Contract 3 contains a long reach of roadway construction and Contract 7 contains a large traditional tunnel section that would be critical path.
- The longest potential pipeline contract shown for the LA River Alignment would be contract 3, with an anticipated duration of 59 months. Contract 3 contains a traditional tunnel that is roughly 13,000 feet in length.
- Metropolitan is considering various implementation strategies for the RRWP, which were not considered by this contract packaging evaluation. Contract packaging should be further evaluated during subsequent design phases to support the implementation strategies.

  A more detailed evaluation of construction rates and contract packaging is recommended during subsequent design phases and could result in revisions to contract packages to better align with jurisdictional boundaries.

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10.0 Conclusions and Recommendations

It appears that both the LA River and the SG River Alignments are feasible and carry similar levels of impacts based on the information available for this FLDR. Therefore, it is recommended that both alignments be carried forward for more detailed environmental studies and analysis. Chapters 6 and 7 provide detailed descriptions of the proposed facilities for both alignments to support the initiation of environmental studies to comply with CEQA.

While these two alternatives appear most favorable based on the analysis completed to date, the third "street right-of-way" alternative described in Chapter 4 is also feasible. Although not carried forward to the same level of detail as the others, the information presented in this FLDR for the street right-of-way alternative can be used to support CEQA analyses as well, if so desired by Metropolitan.

It is recommended that the future connection from the Backbone System to the FEWWTP utilize the Glendora Tunnel. Additional evaluations, including coordination with the local jurisdictions, should be completed during the next phase of work to determine the preferred alignment to reach the terminus of the Glendora Tunnel, as well as the number and location of the pump stations required. This evaluation should also consider if any improvements are required to Metropolitan's existing facilities to utilize the Glendora Tunnel in this manner, such as repairs to the Glendora Tunnel's lining, service connections (such as PM-26 and USG-3), or the functionality of the Upper Feeder Junction Structure.

This FLDR documents technical analysis completed to date supporting the development of the RRWP conveyance system and provides a basis as the RRWP transitions to the next phase of design. The next phase of design will continue to refine the RRWP conveyance system and will consist of more detailed engineering studies including, but not limited to, those listed below as described in various places throughout the report:

- Continued alignment evaluations to further optimize the alternatives and determine the preferred method of construction throughout
- While it is anticipated that the alignments proposed would continue to be refined throughout as jurisdictional coordination progresses and subsurface investigations are completed, the following locations in particular are highlighted as requiring addition analysis:
  - Crossing of the Newport-Inglewood Fault Zone
  - Alameda Corridor / Dominguez Channel crossing
  - Tunneling verses cut-and-cover methods within existing public rights-of-way associated with streets
  - Tunneling verse cut-and-cover methods within the SG River bed
  - Discharge location at the SFSG and crossing of the Santa Fe Dam
  - Alignment crossing beneath or going around the Whittier Narrows Dam
  - Alignment adjacent to the Upper SG Valley Municipal Water District's Indirect Reuse Replenishment Project (IRRP) pipeline

  - Alignment connecting the Backbone Alignment to the Glendora Tunnel, include the portion in Azusa Avenue, north of Fifth Street (for the potential connection to FEWWTP)
  - Tunnel portal size and locations
- Further refinement of cost opinions, contract packaging, and implementation strategy
- Location and design of appurtenances (blow offs, including discharge locations and dewatering plan, air release and vacuum valves, and sectionalizing valves, if needed)
- Continued coordination with local jurisdictions
- Further refinement of initial traffic control concepts and evaluation of impacts
- Refinement of feasibility-level pump station design, including:
  - Coordination of PS-1 and wet well layout into the overall AWT plant site
  - Further refinement of system curves and pump selection
  - Further refinement of pump station siting, including more detailed siting studies for PS-3
  - Evaluation of infrastructure requirements (incoming power supply and communications)
  - Further investigation and risk assessment for the dechlorination system for off-site facilities, including coordination with applicable regulatory jurisdictions
- Refinement of system hydraulics, including:
  - More detailed surge and transient analysis
  - Further evaluation of the Signal Hill storage tank concept to determine if its required
  - More detailed hydraulic analysis for the connection to FEWWTP, including confirmation of flow capacity
  - More detailed system optimization analysis to validate the planning level balancing of capital costs with annual operating costs
- More detailed evaluations of the connection to FEWWTP, including:
  - Selection of a preferred alignment connecting the Backbone System to the Glendora Tunnel
  - More detailed hydraulic analysis and confirmation of flow capacity
  - Evaluation of pump station requirements, including a more detailed siting study
  - Evaluation to determine if any improvements to Metropolitan’s existing system would be required
- Further refinement of pipe structural design to account for 1) the results of a surge analysis, 2) refinements to the alignment, and 3) the results of a seismic hazard assessment
- Design field-work program:

- Geotechnical evaluations, including dewatering testing/studies, a seismic hazard analysis, and an analysis of trenchless and cut-and-cover construction throughout
- Desktop environmental program to determine the need for a field program to identify possible hazardous soils and groundwater
- Utility research and potholing
- Survey

- Scour analysis of the SG River
- Additional data collection and review of existing records for the following:
  - Existing river and levee design
  - Foundations of LACFCD's in-river rubber dams
  - Foundations of existing facilities, including bridges, abutments, tanks, and buildings
  - Existing utilities
  - More detailed understanding of designated wetlands and sensitive wildlife areas
  - Existing spreading facility design to determine requirements for tie-in
- Further refinement of right of way and ownership evaluations and identification of construction laydown and staging areas
- Development of distribution laterals connecting the Backbone System to proposed injection well sites and identification of improvements at spreading basins to accommodate the program
- Continued coordination with other regional entities regarding partnership opportunities, including the City of LA, the Upper SG Valley Municipal Water District, and the Southern Nevada Water Authority
- Further refinement of Project risks and development of a quantitative risk register
- Additional evaluation of permitting and jurisdictional requirements