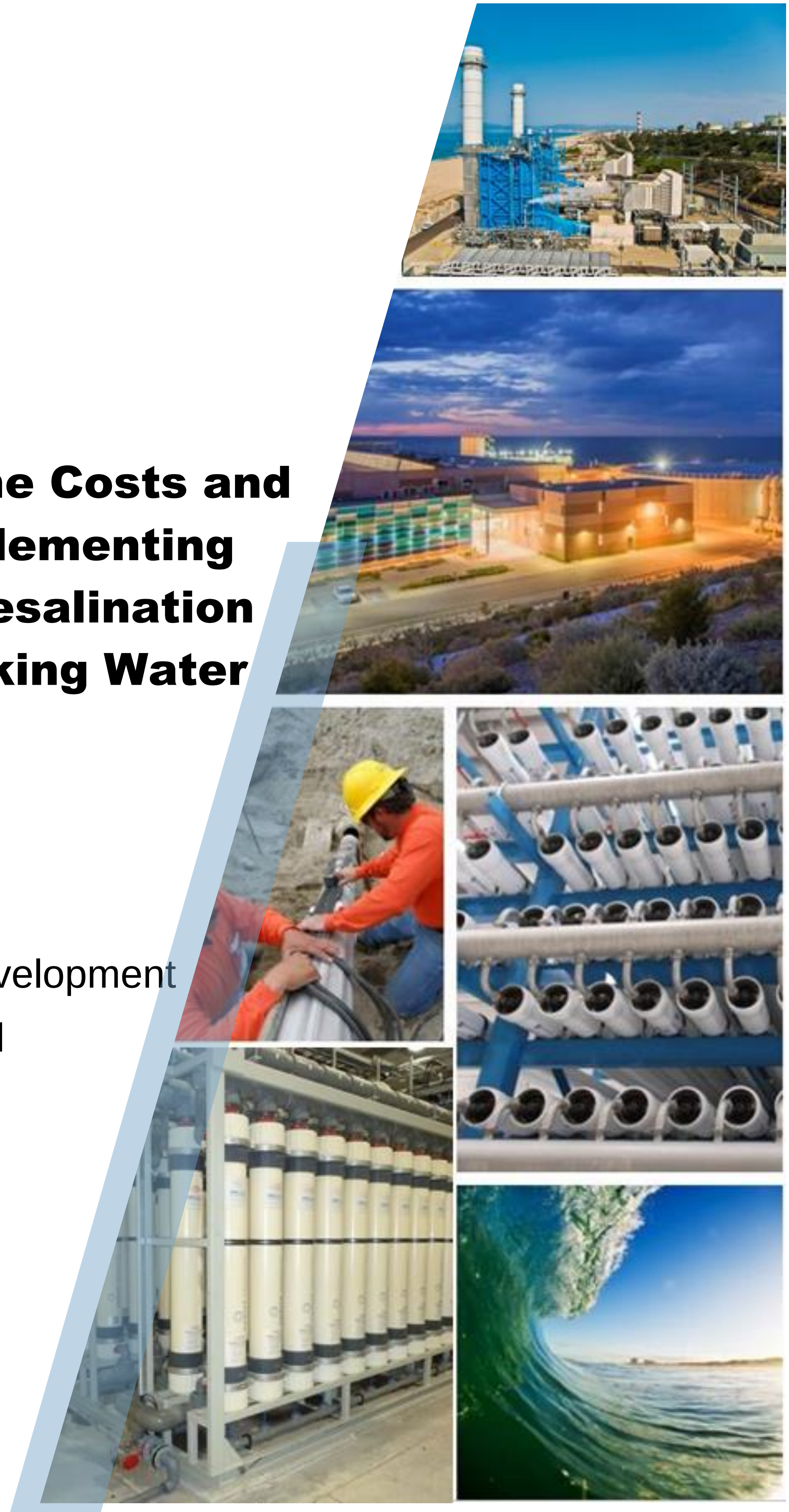
Evaluation of the Costs and Benefits of Implementing Ocean Water Desalination as a Local Drinking Water Supply



Chapter II

Project Designs
and Assumptions Development

West Basin Municipal
Water District

Final Report
July, 30 2021

Submitted by

GHD

in association with

RAFTELIS

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1. Introduction

1.1 Scope and Purpose

Chapter II of the *Evaluation of the Costs and Benefits of Implementing Ocean Water Desalination as a Local Drinking Water* (the Study) includes:

- Discussion of the assumptions and costs of the project designs considered in this Study. This includes: the Current Project Design and the Subsurface Intake Design for a 20 million gallons per day (MGD) Ocean Water Desalination Project (OWDP, 'Project'), as well as a "No Project" alternative.

The Study commenced in March 2019 and was completed in July 2021. It was undertaken in a five-stage process as covered in five Chapters of this Report (plus an Executive Summary):

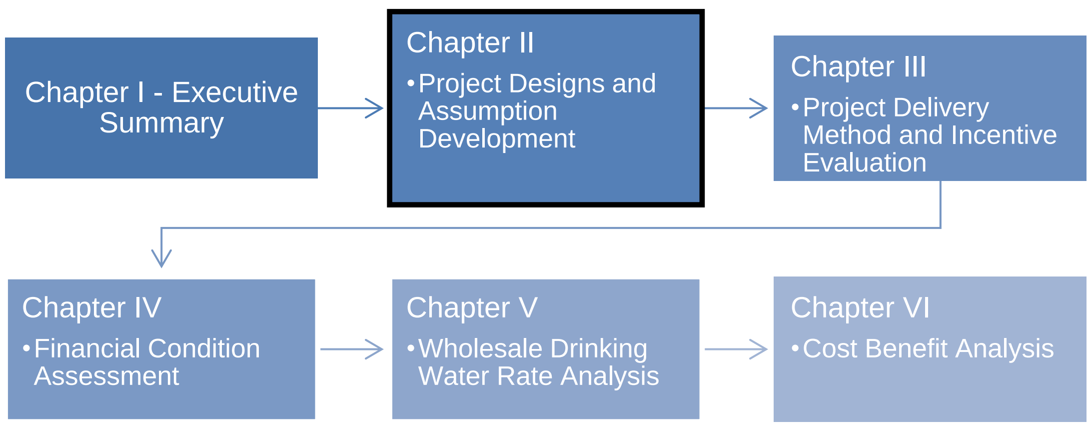


Figure II-1 Structure of this Study: Evaluation of Cost and Benefits of Implementing Ocean Water Desalination as a Local Drinking Water Supply

The Chapter should be considered in the context of the detailed discussion included in the supporting Chapters as well as the assumptions, constraints and limitations of this Study.

1.2 Overview of Project Designs

Project elements for the OWDP generally consist of four main components, outlined below:

1. An onshore desalination treatment facility located within the El Segundo Generating Stations (ESGS) site,
2. An onshore product water distribution system,
3. An offshore ocean water intake, and
4. A brine discharge system.

The Current Project Design considers a facility using similar project design assumptions contained in the Final Environmental Impact Report (EIR), while the Subsurface Intake Design considers a project design using the Desalination Amendment to the California Ocean Plan (OPA) preferred technologies for intake (subsurface) and brine discharge (commingled with existing wastewater ocean outfall).

The onshore components for both project designs are identical, with the exception of pretreatment, which is tailored to the respective offshore intake method. Below, Figure II-2 outlines a high-level summary for each design.

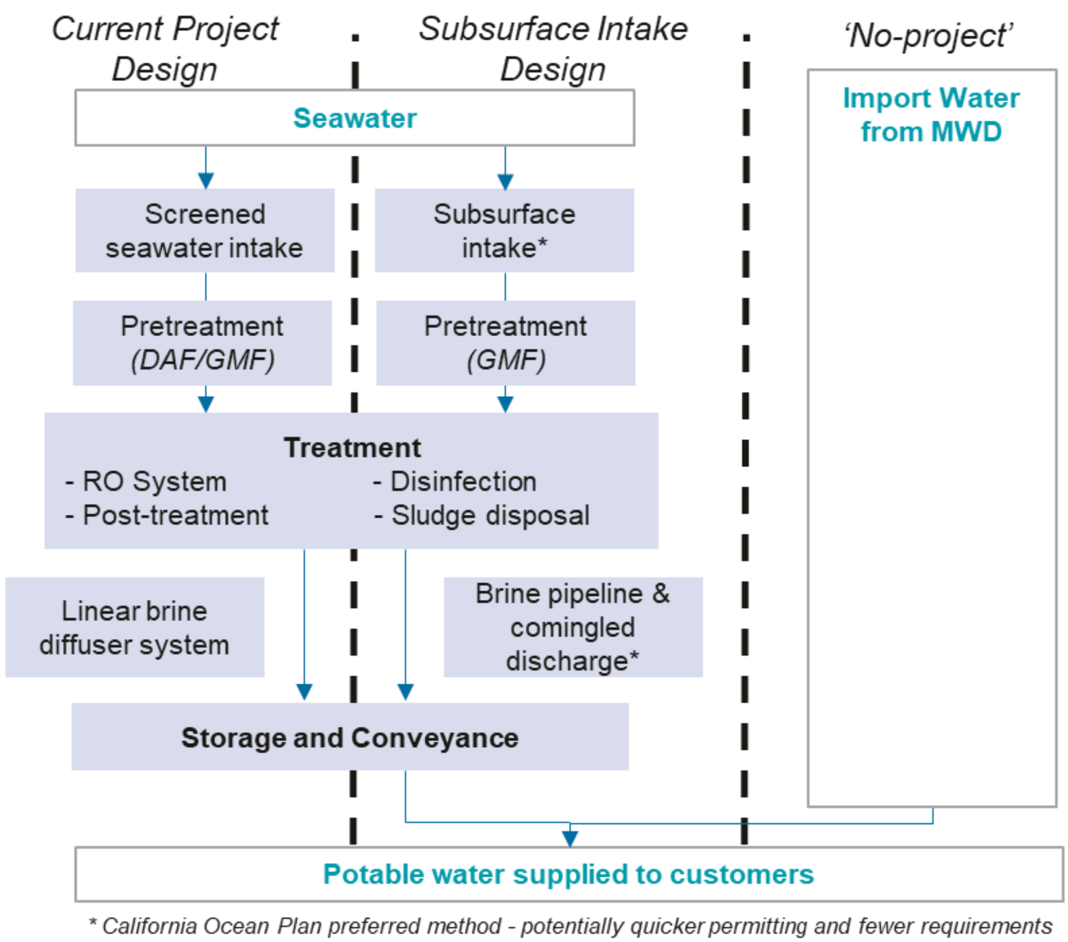


Figure II-2 Project Designs Summary

1.3 Structure of This Chapter

A breakdown and description of each of the shared project components is provided in Section 2, while unique project components for both project designs are described in Sections 3 and 4, respectively. Section 5 provides a description of the assumptions for the 'No-Project' option.

Cost estimates for each option are derived and discussed in Section 6. A brief summary of the analysis is provided in Section 7.

1.4 Reference Documents

In addition to the Reference Documents listed in Chapter I of this Study, the following documents are foundational to the discussion in this Chapter. Other references are noted using footnotes throughout the rest of this document.

- West Basin Municipal Water District Ocean Water Desalination Program Delivery Analysis - Final Report, CH2M, January 8, 2018 and supporting documents.

- Seabed Infiltration Gallery Construction and Life-Cycle costs for a Proposed 20 MGD Ocean Water Desalination Facility El Segundo, California, Geosyntec, December 2017.
- West Basin Municipal Water District Ocean Water Desalination Discharge Feasibility Study, Carollo Engineers, December 2016.
- Feasibility Assessment of Subsurface Seawater Intakes Proposed Desalination Facility El Segundo California, Geosyntec, March 2016.
- West Basin Municipal Water District Ocean Water Desalination Program Master Plan (PMP), Malcolm Pirnie, Arcadis, January 2013.
- Redondo Beach Generating Station Clean Water Act Section 316(b) impingement mortality and entrainment characterization study, MBC, Tenera Environmental, December 2007.
- El Segundo Generating Station Clean Water Act Section 316(b) Impingement Mortality and Entrainment Characterization Study. Final Report. Prepared for El Segundo Power, LLC., January 2, 2008.

1.5 Limitations, Exclusions and Assumptions

Limitations and Exclusions pertaining to the Study overall are included in Chapter I and apply here.

2. Project Designs – Shared Project Components

2.1 Site Civil Works

For this study, it is assumed that demolition of the existing power generating units, and any necessary site remediation, will be completed by the site owner. Site civil works only consider minor grading and paving around new desalination project facilities. An estimated one-time lease payment was developed based on similar projects in Southern California.

2.2 Electrical

Power to the OWDP would be provided by Southern California Edison (SCE). Electrical power supply required for the desalination facility, intake pump station, and desalinated water pump station is estimated at 13 kilowatt-hours (kWh) per 1000 gallons; refer to Table II-1. It is anticipated that the Project would require a total annual demand of 90,200 megawatt-hours (MWh) per year. An electrical substation would be installed on site to lower the voltage from service voltage to site distribution voltage.

Table II-1 Electrical Power Supply Summary (MW)

Component	Estimated Project Power Supply Requirements (MW)
Intake and Pretreatment	0.9
First-Pass Reverse Osmosis[1]	8.3
Second-Pass Reverse Osmosis[1]	0.6
Post-Treatment	0.1
Distribution	1.7
Residuals and Other	0.4
Miscellaneous	0.1
Contingency (3%)	0.4
TOTAL	12.5

Notes:
These are preliminary estimates done for CEQA analysis and may be modified during the Project's regulatory permitting, final design, and/or construction process.
[1] Energy consumption is estimated based on the use of existing energy recovery device technology.

2.3 Onshore Intake Pump Station

Seawater from the Pacific Ocean would be conveyed to an onshore concrete intake vault wet well by one of the intake methods specified in both Project Designs. Intake pumps, drawing water from the wet well, would pump the feedwater directly into adjacent pretreatment facilities. This intake pump station would have a pumping capacity of 42 to 45 MGD (depending on the ultimate process design), and a combined horsepower (HP) of approximately 750 HP.

2.4 Reverse Osmosis (RO) System

Following pretreatment, outlined below for both Project Designs, desalination would be accomplished using RO, a process that uses high pressure to push water through semi-permeable membranes to remove dissolved salts. This process produces a purified permeate stream and a concentrated brine stream. The proposed arrangement for this project would include a first-pass RO membrane system, followed by a second-pass RO membrane system treating a portion of the permeate from the first-pass. The purpose of the second-pass system is to provide additional removal of monovalent ions, such as boron and chloride. Target recovery (the ratio of permeate extracted per unit of feedwater) is 50 percent for the first-pass system and 90 percent for the second-pass system. The system is tailored to produce finished water with a target boron concentration of less than 0.5 mg/L, a bromide concentration level of less than 0.3 mg/L, and a chloride concentration level of less than 100 mg/L.

Cartridge filters would be used ahead of the RO system to remove suspended particulates that may pass through from the pretreatment step.

A large Process Building would house all pretreatment and RO equipment. The RO system would include first-pass process trains, and second-pass process trains, with each process train being composed of a high-pressure pump, membrane elements in 8-inch-diameter pressure vessels mounted on racks (arrays), and connecting piping and valve manifolds for feed, permeate, cleaning, and flush supplies. The first-pass RO process would include an energy recovery system (ERS). RO concentrate from the first-pass would be conveyed through the ERS, then to the Brine Discharge Tank, before being discharged to the ocean via one of the two discharge methods discussed in the following sections. Second-pass RO concentrate would be returned ahead of the cartridge filters.

Periodic cleaning of RO membrane elements using a clean-in-place (CIP) system significantly extends their useful life. A CIP system typically includes a cleaning water tank (or two), circulation pump and cartridge filters to prevent foulants from re-entering the membrane during recirculation. A tank heater is included to optimize the cleaning process. Necessary chemicals may include caustic soda, detergents, acids, or proprietary cleaners.

2.5 Post Treatment

The purpose of post-treatment is to stabilize the product water, first by adding hardness/alkalinity (remineralization) into the RO permeate. This is typically done by first dosing the permeate with carbon dioxide before allowing it to flow through a calcite contactor.

Following the RO system, permeate water would flow to the RO Permeate Flush Tank, then on to the calcite contactors for stabilization.

After stabilization, the pH of the water would be adjusted through the addition of sodium hydroxide. Sodium hypochlorite would be added for chlorine disinfection in the Product Water Storage Tank. The Product Water Storage Tank has been sized to 3.0 MG to provide sufficient chlorine contact time and additional operational flexibility. Ammonia would be added at the outlet of the Product Water Storage Tank with additional sodium hypochlorite trimming to provide a residual chloramine concentration to maintain disinfection in the distribution system.

2.6 Chemical Storage and Handling

Chemicals required for the treatment process would be stored on-site and used for control of biological fouling, pretreatment, membrane cleaning, and post-treatment. These chemicals typically include:

- Sodium hypochlorite - To periodically shock-chlorinate the intake piping system, and for disinfection in the product water tank and to generate chloramines in the distribution system.
- Sodium bisulfite – To neutralize the chlorine residual that remains after shock chlorination, prior to water entering the cartridge filters, to protect the RO membranes.
- Ferric-based coagulant – Used routinely during the flocculation process as part of the Gravity Media Filtration (GMF) pretreatment train.

- Citric acid and other proprietary chemicals (approved for use in potable water treatment facilities) - For membrane cleaning operations.
- Carbon dioxide and calcite - For post-treatment.
- Ammonia (aqueous form) - To make chloramine (with sodium hypochlorite) for disinfection.
- Sodium hydroxide - For pH adjustment of the second-pass RO feed water and desalinated water.
- Proprietary antiscalant chemicals (approved for use in potable water treatment facilities) - For the RO process.
- Polymer (i.e. binding agent) – For pretreatment coagulation/flocculation and for solids handling processes

Bulk chemicals would be stored in gaseous form (carbon dioxide), solid form (calcite), and liquid form (all other chemicals). All chemicals would be safely stored in bulk on-site in a chemical storage area equipped with a separate chemical spill containment area for each chemical.

2.7 Product Water Storage Tank

A Product Water Storage Tank has been sized to 3.0 MG to provide sufficient chlorine contact time to achieve the necessary pathogen inactivation and destruction, and additional operational flexibility. Ammonia would be added at the outlet of the Product Water Storage Tank with additional sodium hypochlorite trimming to provide a residual chloramine concentration to maintain disinfection in the distribution system.

2.8 Backwash Water Treatment and Solids Handling

The spent backwash from pretreatment GMF backwashes (both Project Designs) would flow to a Spent Backwash Tank. From there, flow would be pumped to Lamella clarifiers for solids removal. The clarified effluent would be pumped to the Brine Discharge Tank, where it would mix with RO brine and be discharged to the ocean. Sludge from the Lamella clarifiers would be pumped to a Floated Sludge Tank, which would also collect the sludge from a pretreatment in-filter dissolved air flotation system (in-filter DAF) utilized, as described below, for the Current Project Design. From there the sludge would be sent to dewatering centrifuges, with the option to add polymer available. Dewatered solids leaving the centrifuges would be collected and hauled offsite for landfill, while effluent would be combined with Lamella Clarifier effluent and sent to the Brine Discharge Tank.

2.9 Brine Discharge Tank

The Brine Discharge Tank would collect concentrated brine from the RO process, as well as clarified effluent from the backwash water treatment and solids handling facilities, to provide some flow equalization before being pumped for offshore discharge by the adjacent brine discharge pumps.

2.10 Operations/ Administrative Building

The Administration/Operations Building would accommodate the desalination facility operational and administrative staff. It would include a reception area, administrative offices, conference room, restrooms, lunchroom/kitchen, operations center, lockers, and a maintenance workshop.

2.11 Product Water Pump Station

A Product Water Pump Station would pump the disinfected desalinated (finished) water into a new conveyance pipeline, which would deliver the finished water to the distribution system. The pump station would operate at approximately 2,400 HP (1,700 KW). Surge-control facilities, consisting of one or more hydro-pneumatic tanks, would be required to protect the pump station and pipeline system from hydraulic transients and surges. The surge tanks would be connected to the discharge of the pump station and would be located next to the pump station.

2.12 Product Water Conveyance Pipeline

New conveyance infrastructure would convey product water from the desalination facility to the existing distribution system that delivers potable water to local area and regional supply feeders owned by Metropolitan Water District (MWD). The closest regional potable water feeder system is MWD's West Basin Feeder located within Manhattan Beach Boulevard and the West Coast Feeder located within El Segundo Boulevard. Both of these regional feeders are fed by the MWD Sepulveda Feeder, which is located within the north-south Van Ness Avenue. The locations of existing MWD facilities and the proposed conveyance pipeline alignment are shown in Figure II-3. The recommended pipeline alignment by GHD for the OWDP, used for this cost estimate, is shown in light blue.

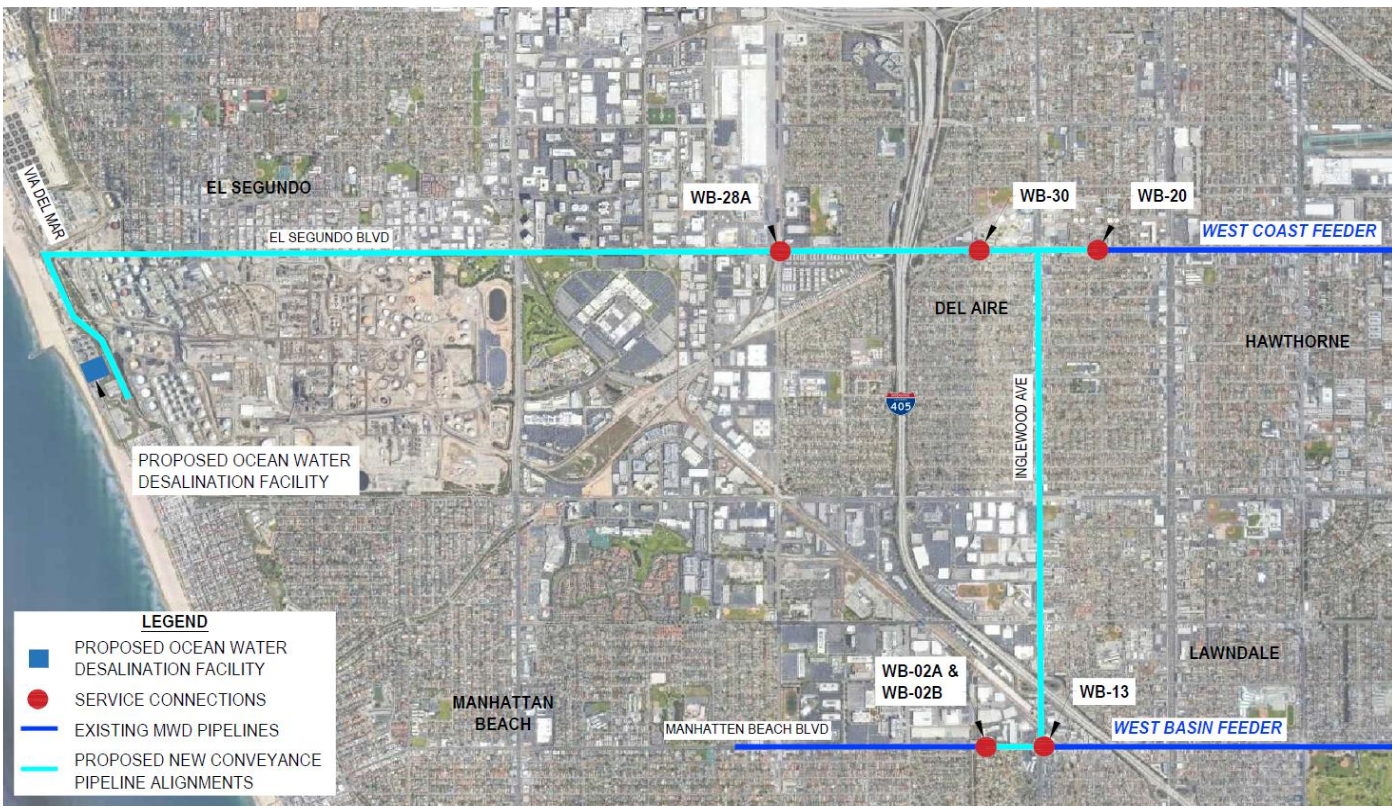


Figure II-3 Desalinated Water Conveyance Recommended Alignment

From the desalination facility, the pipeline route would head north on Vista del Mar Boulevard, then east on Grand Avenue, and continue east along El Segundo Boulevard. From the intersection at El Segundo Ave. and Inglewood Ave. the proposed conveyance pipeline alignment would head south on Inglewood Ave. and end at Manhattan Beach Blvd. The pipeline would be 54-inch diameter HDPE, sufficient to convey product water for the 20 MGD capacity, and potential future expansion.

3. Current Project Design - Unique Project Components

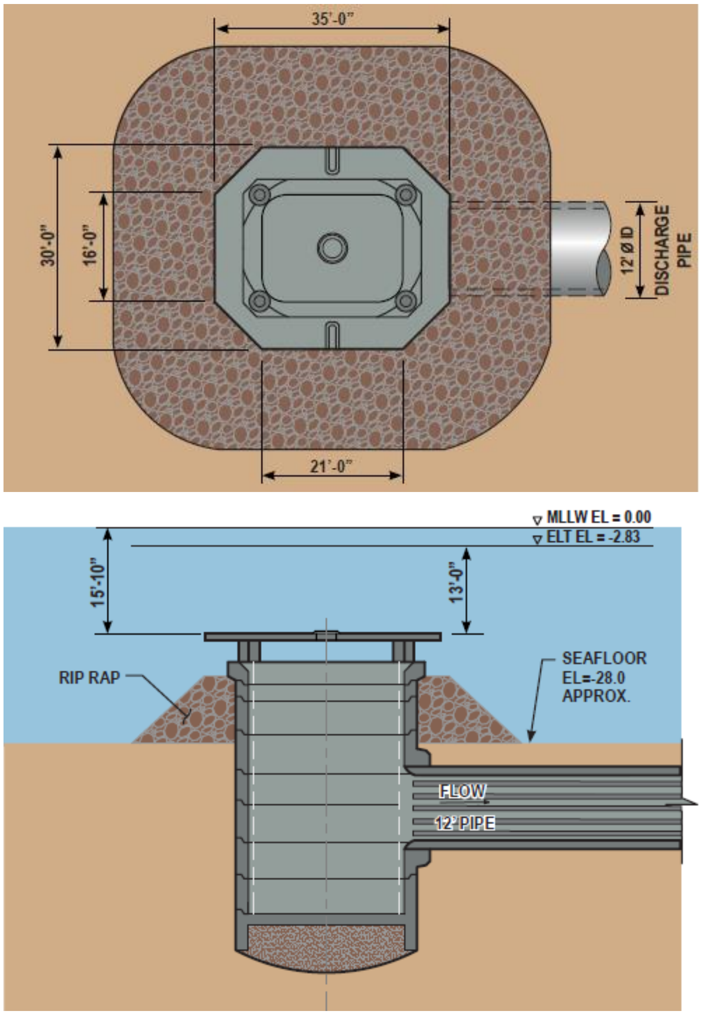
3.1 Offshore Seawater Intake Piping and Open Ocean Screens

The screened intake (and concentrate discharge system) considered for the Current Project Design would utilize the existing intake/discharge tunnels that have supported the cooling system at the El Segundo Generating Station (ESGS). The existing tunnels extend westerly into the Pacific Ocean. NRG has plugged the existing 12-foot diameter intake and discharge tunnels with concrete. Before the District can utilize the tunnels, the concrete plugs must be removed. Consideration for removal of these plugs has been included in this cost estimate work. Following decommissioning and replacement of the conventional power generating stations at the power plant the tunnels are no longer required for cooling.

The Project would involve installation of five[1] new 42-inch pipes inside the existing ESGS intake tunnel to convey ocean water to the desalination facility onshore. Only two of these pipelines would be used for a plant with 20 MGD capacity, and the three additional pipelines would be installed to support a potential future expansion. The existing intake structure is shown below in Figure II-4.

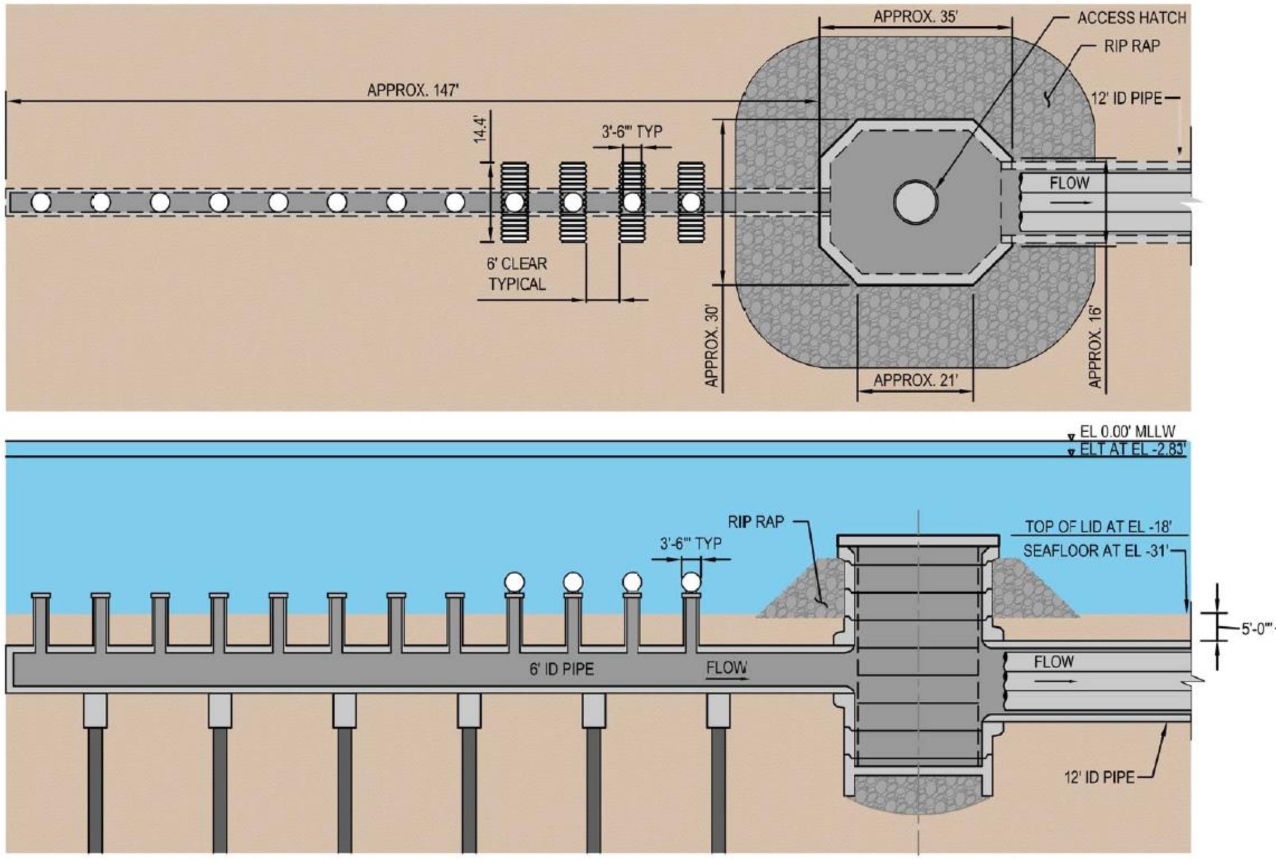
The existing intake structure would be modified with an extended header pipe connected to four new wedge wire screen risers and screens as seen below in Figure II-5. The tops of the wedge wire screens would be approximately 18 feet below the water surface and approximately 13 feet above the ocean floor.

[1] Installation of five pipelines within the existing intake tunnel represents the worst-case construction impact scenario given that the conditions of the tunnels are unknown. In the future, if the District determines that the conditions of the tunnels are adequate and chooses to use the existing tunnel without internal pipe installation, construction impacts and schedule would be reduced.



Source: OWDP EIR Section 3

Figure II-4 Existing Intake Structure (Plan and Section views)



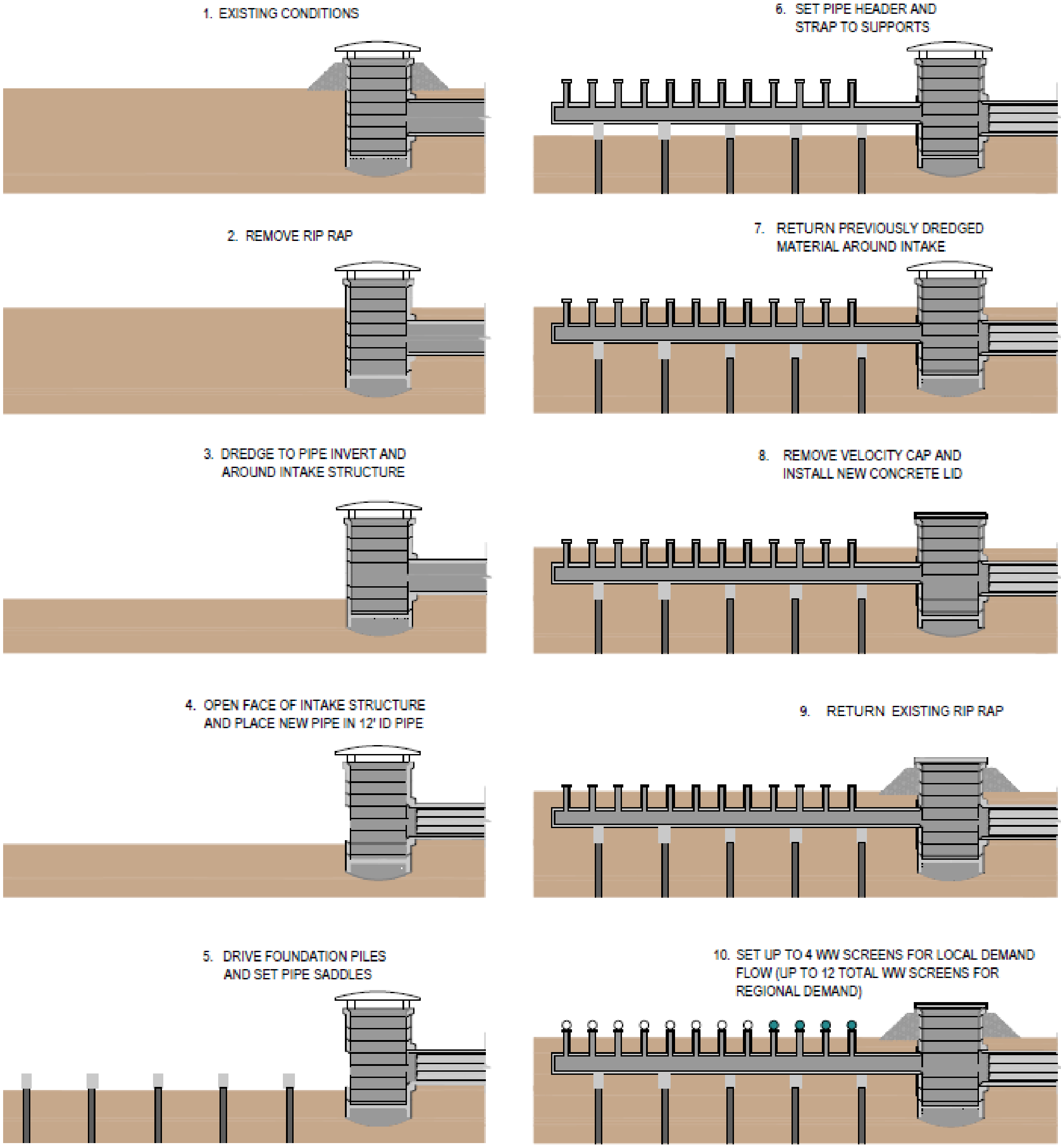
Source: OWDP EIR Section 3

Figure II-5 Proposed Intake Structure (Plan and Section views)

To install the new intake screens at the terminus of the tunnel, the existing riprap around the concrete risers would be removed. The riprap would be temporarily stockpiled on the seafloor or stored in barges in harbor during construction. Dredging of the ocean floor would be required to expose the existing intake structure. A hole would be cut into the structure and the area in front of the structure would be dredged to allow for insertion of the five 42-inch pipes. Once the new pipelines were installed into the 12-foot-diameter tunnel, a new header would be installed at the end of the tunnel and the intake risers and wedge wire screens would be attached. The new header would be secured to the ocean floor with new foundation piles. Once the wedge wire screens were attached to the new header, the header would be covered with the previously dredged material. The installation process is depicted in Figure II-6 below.

The Project would use only four risers and wedge wire screens. The new header would be equipped with additional risers that could accommodate up to twelve wedge wire screens if a potential future expansion is pursued, eliminating additional temporary disturbance of the seafloor during underwater installation. The total intake flow for the Project would be approximately 42 MGD.

The openings of the wedge wire screens would not exceed 1 millimeter (mm; or 0.04 inch) and would have a through-screen velocity of less than 0.5 feet per second (fps), consistent with the OPA requirements for ocean water desalination facilities. This could be accomplished with up to four wedge wire screens in a cylinder (likely) or plate configuration with a total (combined) net open area of at least 140 square feet. The Figure below shows a typical wedge wire screen.



Source: OWDP EIR Section 3

Figure II-6 Intake Structure Installation

Figure II-7 Typical (Cylindrical) Wedge Wire Screen Design

3.2 Pretreatment System – In-Filter DAF

Conventional open-ocean intake requires robust pretreatment to condition the raw seawater prior to RO membrane filtration, and to mitigate against challenging water quality events such as during algae blooms or storm events. As a variation to what was included in the EIR, we have assumed that pretreatment for the Current Project Design would include conventional coagulation and flocculation followed by an in-filter DAF system. In-filter DAF has been identified as the preferred pretreatment method for a similar proposed open ocean intake desalination project in southern California, with suitable process performance guarantees.

The in-filter DAF process consists of dissolved air flotation over deep bed GMF. In the process, solids would be floated to the water surface with dissolved air bubbles and removed by a passive hydraulic method, or with a scraper, and the clarified water would be gravity filtered through the GMF. The collected sludge is transported to the Floated Sludge Tank and on to solids handling. The clarified filtered water is dosed with sodium bisulfite and antiscalant, as necessary, and sent to the cartridge filters.

Backwashing of the GMF to remove accumulated solids would occur approximately once per day. This backwash waste would be sent to the Spent Backwash Tank for backwash water treatment and solids handling.

3.3 Offshore Brine Diffuser System

The proposed Project would discharge continuous flows of concentrate (brine) from the RO process, and a small portion of treated media filter washwater, to the ocean. The Current Project Design would utilize the existing ocean intake/discharge tunnels that have supported the cooling system at the ESGS to convey discharge through a modified discharge structure. The existing discharge structure is shown below in Figure II-8.

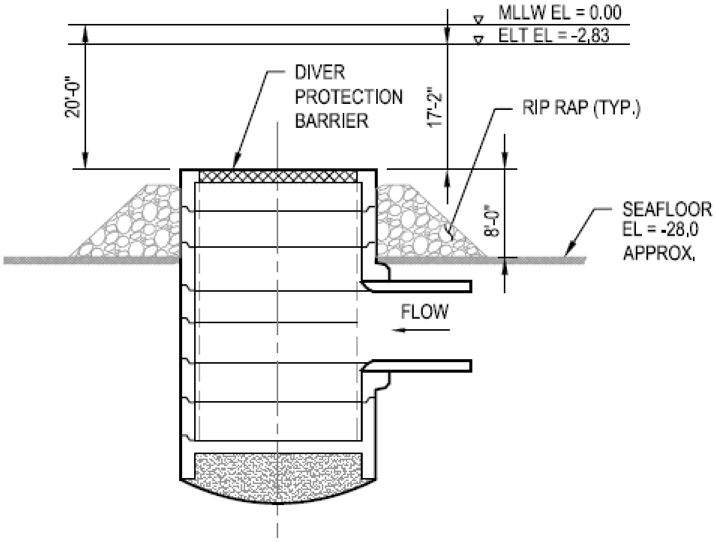
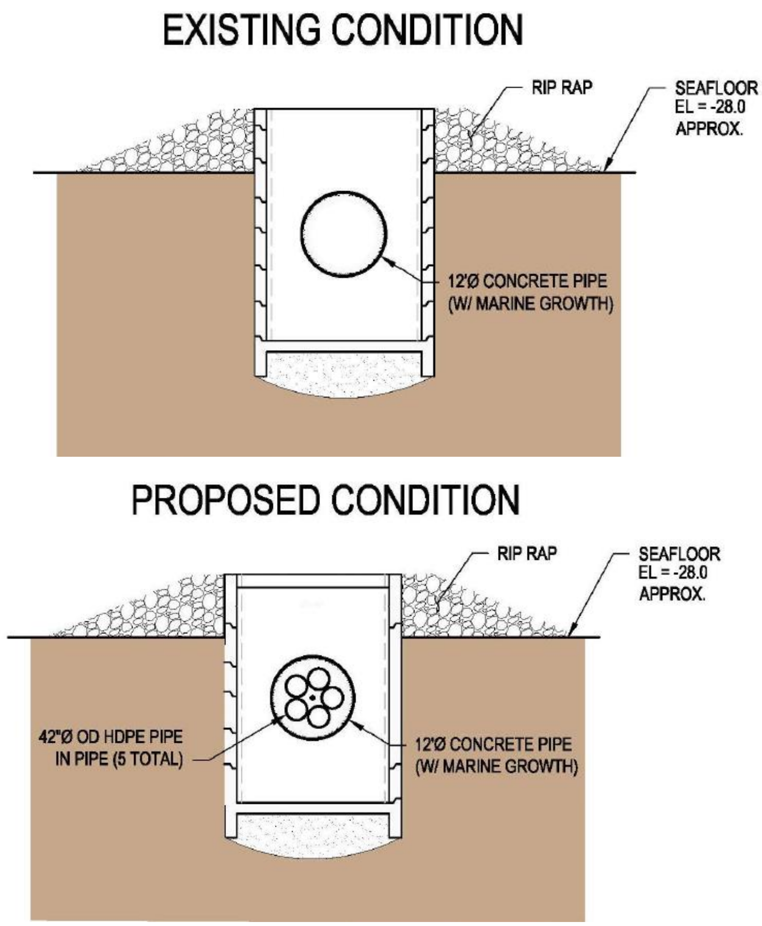


Figure II-8 Existing Discharge Structure

The terminus of the discharge tunnel is approximately 500 feet closer to shore than the terminus of the intake tunnel. Similar to the intake system for the Current Project Design, five new 42-inch pipelines would be installed inside the existing ESGS discharge tunnel (see Figure II-9 below).

Only two pipelines would be used for the Project, while the three additional pipelines would be available to meet the demands of a potential future expansion. To access the offshore terminus of the discharge pipeline, the existing riprap around the discharge tower would be removed and either temporarily stockpiled on the seafloor or stored in barges in harbor during construction. The area around the terminus structure would be dredged to allow for the new pipelines to be inserted into the tunnel and construction of the new discharge manifold.

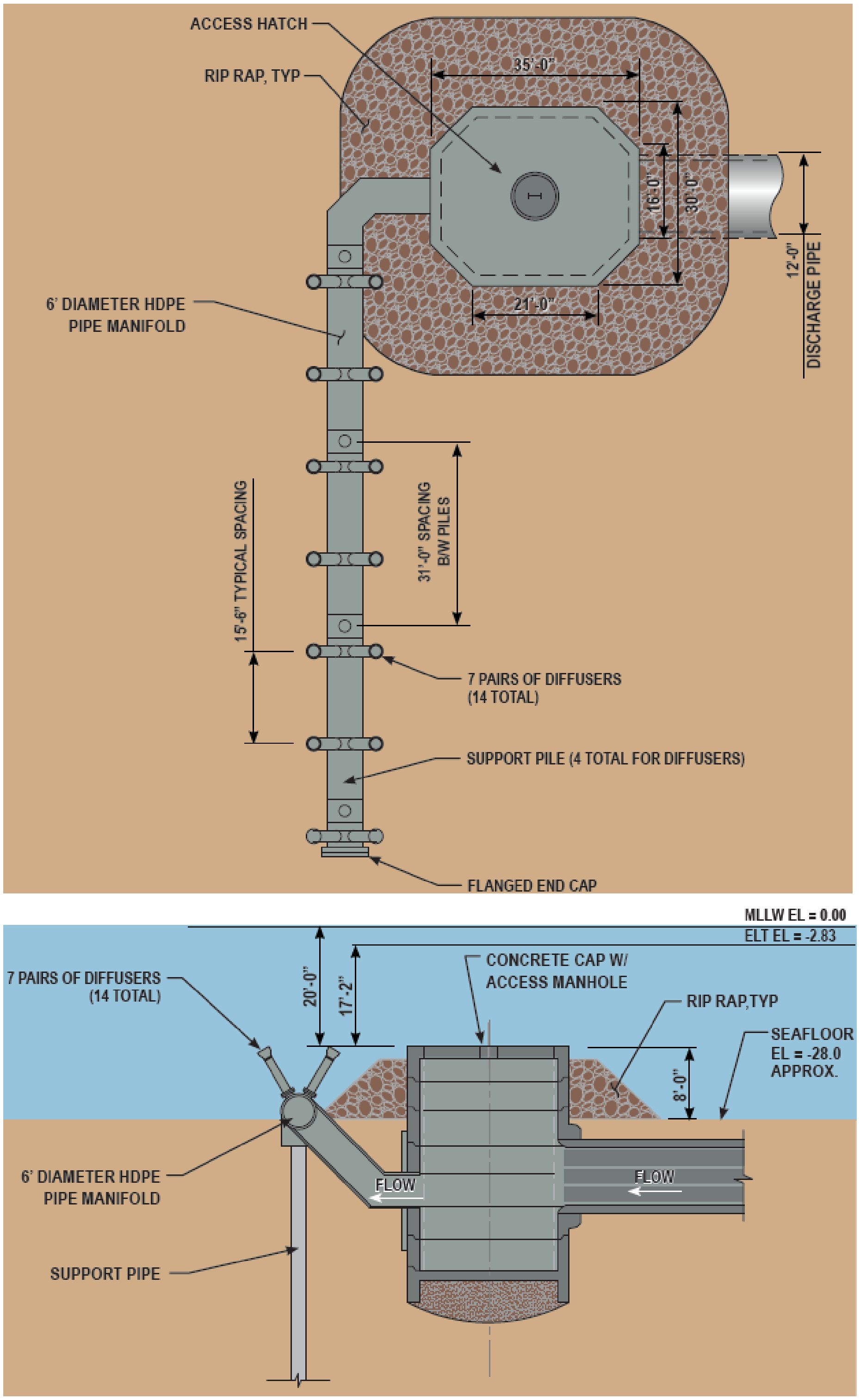


Source: OWDP EIR Section 3

Figure II-9 Discharge Cross Section

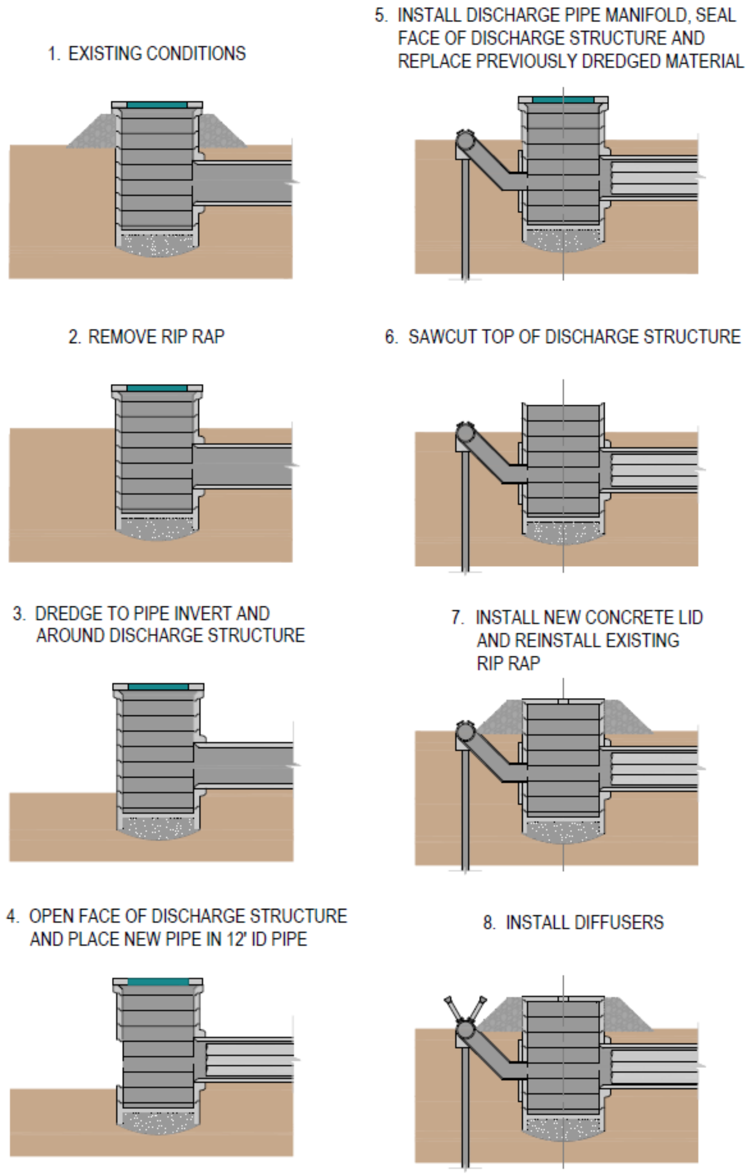
Once the new pipelines are installed, a multi-port diffuser system consisting of a pipe manifold with multiple diffuser ports would be installed directly onto the side of the existing discharge tower, and extend approximately 120 feet south. A total of fourteen 9-inch diameter diffuser ports would be installed during construction of the Project. As shown below in Figure II-10, the diffuser ports would be positioned approximately 15.5 feet apart, with 7 diffuser ports on opposite sides (14 total) of the discharge pipe at approximately 8 feet above the ocean floor and approximately 20 feet below the ocean surface.

They would be designed at upward angles (preliminary design indicates a 60-degree angle from horizontal) to allow for high dilution and rapid reduction of salinity down to the regulated levels allowed for brine discharges in the OPA. Once installed, the exposed end of tunnel would be resealed and covered with the stockpiled dredge material and the stockpiled riprap will be put back around the discharge tower. The installation process is demonstrated below in Figure II-11.



Source: OWDP EIR Section 3

Figure II-10 Proposed Discharge Structure



Source: OWDP EIR Section 3

Figure II-11 Diffuser Installation Process

For the 20 MGD Project, the assumed amount of flow to be discharged from the ocean desalination facility would be approximately 21.4 MGD, which would be composed of approximately 19.4 MGD of RO concentrate (brine) and 2.0 MGD of treated backwash water from the GMF process.

At times, during startup and infrequently during upsets while the plant is in operation, it may be necessary to bypass the entire treatment facility to discharge. While the expected frequency of such events is minimal, the discharge system would be sized for a peak discharge from the plant of approximately 42 MGD.

4. Subsurface Intake Design, OPA Preferred Technologies – Unique Project Components

4.1 Offshore Subsurface Intake System

This project design investigates preferred technologies for intake (subsurface) and brine discharge (commingled with existing wastewater ocean outfall), as outlined in the 2015 OPA. Section M.2.d.(1).(a) of the OPA stipulates that “the regional water board in consultation with State Water Board staff shall require subsurface intakes [for seawater desalination] unless it determines that subsurface intakes are not feasible based upon a comparative analysis of the factors listed [in the Plan] for surface and subsurface intakes.”

Seawater intake for Subsurface Intake Design considers the use of Seabed Infiltration Galleries (SIGs) based on previous investigation by Geosyntec, and provided design input from GHD. A SIG is essentially a buried structure comprised of one or more collection cells made up of screens that allow infiltration of water from the surrounding soil. SIGs have the benefit of some natural sand bed filtration, and provide a buffer against challenging water quality events such as during algal blooms or rain events.

In a 2016 report (Appendix 2A to the EIR) Geosyntec evaluated seven different subsurface seawater intake (SSI) technologies, including:

1. Vertical wells
2. Slant wells
3. Radial (Ranney) collector wells
4. Horizontal directional-drilled wells
5. Seabed infiltration gallery (SIG)
6. Beach (surf zone) infiltration gallery
7. Deep infiltration gallery (water tunnel)

The analysis determined that none of the seven SSI technologies are feasible for the design intake rate of ~40 MGD (required to produce 20 MGD of treated water) due to various limiting factors such as hydrogeologic offshore conditions for SSI well technologies (1 through 4), and oceanographic constraints for the SSI infiltration gallery technologies (5 through 7). In addition, the study indicated a lack of economic feasibility for a SIG due to high construction costs.

Despite these initial findings, Geosyntec expanded on their cost analysis for a SIG intake in a follow-up 2017 report (Appendix 2B to the EIR) that considered a range of combinations of screened open intake and SIG intake rates to meet the desired 40 MGD intake capacity. Geosyntec concluded that lowering SIG intake rates could decrease overall intake costs, but it would diminish the economies of scale.

GHD agrees that this Subsurface Intake Design is not feasible due to technical challenges. It was included in this Study as a cost evaluation and cost comparison **to the current project design.**

The SIG design proposed for Subsurface Intake Design, with input from GHD, provides for the full 40 MGD intake capacity. The design includes a gallery of 24 prefabricated high-density polyethylene (HDPE) cells, each comprised of 12-inch diameter lateral pipe screens connected to a 28-inch diameter collection header. Each header connects two screens with a 40-inch collection main. Three collection mains each convey intake from four headers to the onshore intake pump station. An image of this conceptual SIG arrangement is shown below in Figure II-12.

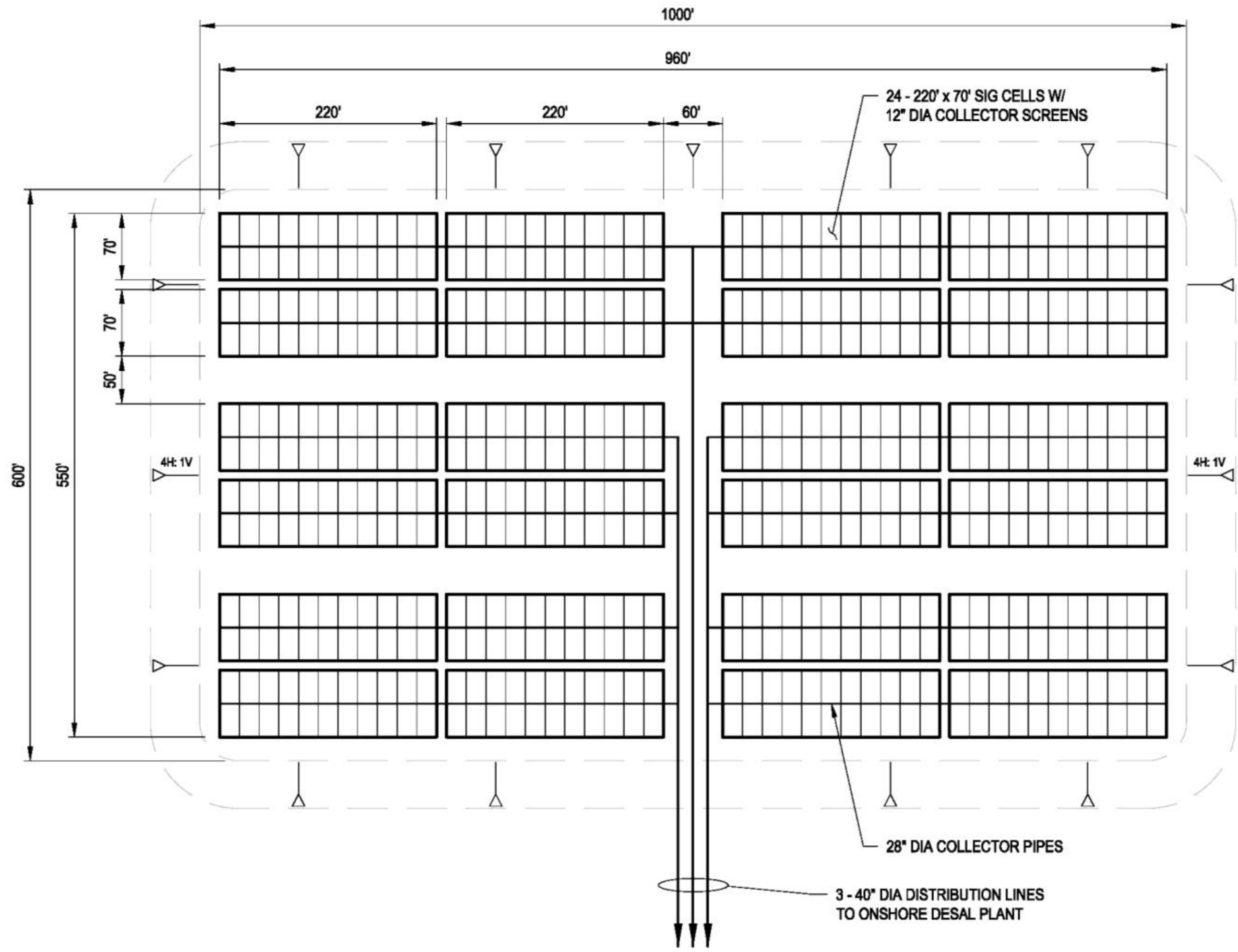


Figure II-12 Seabed Infiltration Gallery (SIG)

GHD assumes a large footprint within the seabed would be dredged to approximately 12.5 feet deep and each prefabricated 220' x 70' HDPE cell would be floated into place and laid on a gravel bed. The cell piping would be connected to the intake piping from shore, and the cells would be filled with layered gravel and sand to seafloor elevation. Figure II-13 provides a cross-section view of the proposed SIG design.

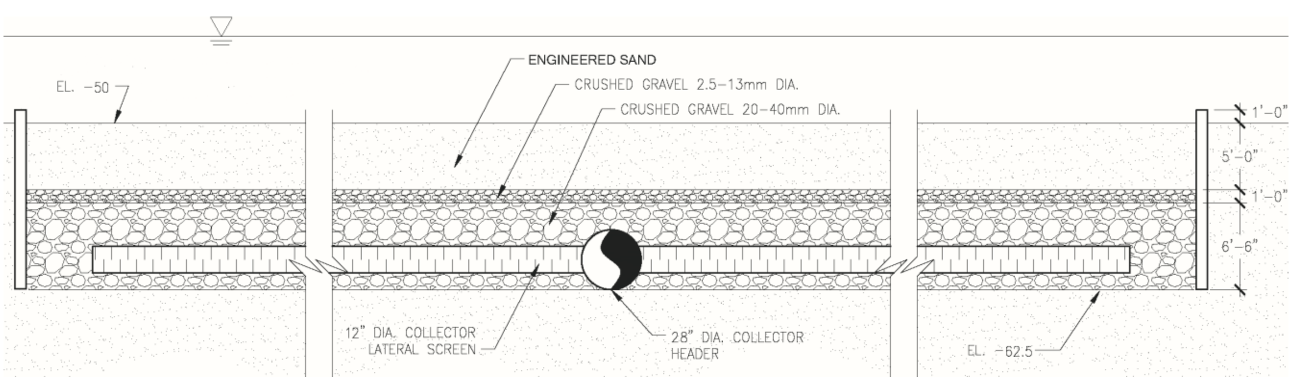


Figure II-13 Seabed Infiltration Gallery (SIG) Cross Section

GHD proposes three 40-inch diameter collection mains would be jack and bored for the first 1,000 feet from the onshore jacking pit at the plant, then run along the seafloor to an offshore location where they would be connected to similar size header piping and then to the 28-inch collector pipes for the pre-manufactured SIG cells. HDPE gate (or slide) valves would be installed at key locations in the collector pipes to allow for cell isolation with diver assistance.

The walls of the HDPE SIG cells would extend up to the seafloor elevation, eliminating the need for sheet piling. HDPE piping and sheeting is durable and does not easily degrade in the marine environment.

4.2 Pretreatment System – GMF

SSI requires less robust pretreatment than conventional open-ocean intake due to the benefit from natural sand bed filtration, and a buffer against challenging water quality events. However, California Division of Drinking Water still considers ocean water a surface water, and is subject to surface water treatment rule requirements. As such, a pretreatment step is still required. Pretreatment for the Subsurface Intake Design would include conventional coagulation and flocculation followed by a GMF system.

The GMF system would consist of deep bed gravity granular media filters arranged around a pipe gallery that would contain feed piping and valves, backwash, and surface wash piping and valves, filter control valves and compressed air piping and valves. In the process, clarified feedwater would be gravity filtered through the GMF after which the filtered water is dosed with sodium bisulfite and antiscalant, as necessary, and sent to the cartridge filters.

Backwashing of the GMF to remove accumulated solids would occur approximately once per day. This backwash waste would be sent to the Spent Backwash Tank for backwash water treatment and solids handling. Backwash water would be discharged to the ocean through the discharge facility in combination with RO concentrate. The GMF approach has been used with success in other large-scale desalination facilities, such as the Claude “Bud” Lewis Carlsbad Desalination Plant in San Diego County, California.

4.3 Brine Discharge Conveyance Pipeline to Commingled Discharge

Section M.2.d.(2).a of the OPA indicates “the preferred technology for minimizing intake and mortality of all forms of marine life resulting from brine discharge is to commingle brine with wastewater (e.g., agricultural, municipal, industrial, power plant cooling water, etc.) that would otherwise be discharged to the ocean. The wastewater must provide adequate dilution to ensure salinity of the commingled discharge meets the receiving water limitation for salinity.”

The Subsurface Intake Design assesses two nearby facilities, the Hyperion Water Reclamation Plant and the Chevron El Segundo Refinery, with existing wastewater outfall pipelines to the ocean that the OWDP could feasibly tie into for brine discharge.

4.3.1 Hyperion Outfall

The Hyperion Outfall is a 12-foot diameter outfall pipeline terminating approximately 5 miles offshore at a depth of approximately 187 feet below the ocean surface. The discharge ends in a “Y” shaped diffuser consisting of two 3,840-foot legs. The Outfall conveys 275 MGD of wastewater to the ocean, on an average dry-weather day. The maximum design and permitted capacity for the Outfall is 450 MGD, with a peak wet weather hydraulic capacity of 850 MGD. A 2016 discharge feasibility study done by Carollo Engineers Inc. (Appendix 11 to the EIR) indicated that the Outfall capacity is sufficient to accept brine flows from the proposed OWDF.

In addition to the main "5-mile Outfall" that is the focus of this analysis, the plant has two other outfalls, however this is the only outfall permitted for routine discharge of undisinfected secondary treated effluent. The other outfalls include a 12-foot diameter "1-mile outfall" permitted for limited use, and a 20-inch diameter "7-mile outfall" originally used to discharge sludge, but decommissioned in 1987 and not maintained since.

Connection to the Hyperion Outfall would require a brine conveyance pipeline of approximately 7,000 linear feet, primarily within Vista Del Mar Blvd. The pipeline would need to convey approximately 21 MGD of brine from the Brine Discharge Tank to an onshore connection point in the Hyperion Outfall. Design for this estimate considers an HDPE pipe with an outer diameter of 54-inches, sufficient to convey brine from both the Project and a potential future expansion.

4.3.2 Chevron Outfall

The Chevron Outfall extends approximately 3,500 feet offshore with its terminus at a depth of 42 feet and a permitted max flow of 27 MGD of waste discharges. Chevron proposed discharges are up to 27 MGD during wet-weather and 8.8 MGD during dry-weather. According to the National Pollutant Discharge Elimination System (NPDES) permit the original 300-foot outfall line was voluntarily extended by Chevron in 1994 by fitting a 3,200-foot HDPE pipe with a nominal 60-inch diameter and 2.4-inch wall thickness to the original line. The original 300-foot line is a 60-inch diameter concrete pipe constructed in 1957. The extended outfall provides a minimum dilution ratio of 80 parts of seawater to one part of effluent (80:1).

Connection to the Chevron Outfall would require a brine conveyance pipeline of approximately 2,000 linear feet, primarily within Vista Del Mar Blvd. The pipeline would need to convey roughly 21.4 MGD of brine from the Brine Discharge Tank to an onshore connection point in the Chevron Outfall. Design for this estimate considers an HDPE pipe with an outer diameter of 54-inches, sufficient to convey brine from both the Project and a potential future expansion.

The Chevron Outfall would need to be capable of handling the peak 27 MGD discharge flow from Chevron, in addition to the full intake capacity for the Project of 42 MGD during times when the plant needs to bypass due to challenging water quality or other issues. From a purely hydraulic perspective, 68.6 MGD of flow could be discharged through the 60-inch pipe at a reasonable velocity of 5.4 feet per second (fps). However due to the age of the pipe, particularly the original 300-foot concrete section, further investigation, including a condition assessment and a dilution study would likely be required, if this option is pursued. Additionally, the pipe is undersized to handle brine discharge from a potential future expansion.

Because of these limitations, we have only developed costs for brine discharge via the Hyperion outfall, and not the Chevron outfall.

5. No-Project Alternative

A No-Project alternative was considered, where the 20 MGD of drinking water supply that could have been offset via local ocean water desalination would be provided from imported water purchased from MWD. The future costs of purchasing imported water are estimated for a defined study horizon of 30 years.

Refer to Section 6.3 for the forecast methodology that has been adopted.

6. Analysis

Section 6 presents a breakdown of the detailed cost estimates for each of the proposed Project Designs. A summary comparison of these costs is provided in Table II-19 at the end of Section 6.

6.1 The Current Project Design

6.1.1 Capital Cost

Capital costs for project components have been developed to a Class V level using both "Top Down" and "Bottom Up" cost estimating techniques. A Class V estimate, per AACE International guidelines, is defined by minimal project definition and subsequently a wide range of accuracy (typically L: -20% to -50%, H: +30% to +100%).

"Top Down" costs were developed from costs from similar projects, and factored to make these costs suitable for this project. For example, pricing for Seawater Reverse Osmosis Equipment for a 50 MGD project can be estimated for a 20 MGD project by applying "the 6/10th rule" in Equation 1 where C_A and C_B represent the capital costs and A_A and A_B represent the respective sizes of project components.

$$\frac{C_A}{C_B} = \left(\frac{A_A}{A_B}\right)^{0.6} \qquad \text{Equation 1}$$

"Bottom Up" cost estimating involves developing conceptual material take offs and quantities, and labor factors. For example, costs for linear infrastructure such as potable water pipelines and pump stations are often developed this way. Estimated Capital Costs for the Current Project Design are provided in Table II-2. Project development costs such as EIR, and permitting and public outreach have not been considered in this estimate.

6.1.2 Operations & Maintenance (O&M)

O&M costs for the Current Project Design and Subsurface Intake Design are developed from similar projects in Southern California. The O&M cost is broken down into several items, as outlined below.

O&M costs for the OWDP consist of both variable costs and fixed costs. Variable costs include, power, chemical costs, sludge disposal costs, etc. Fixed costs include labor, maintenance, membrane replacement, performance bond, insurance, etc. A miscellaneous fixed cost is considered for other operational and maintenance items, given the high level of this estimate. Additionally, fixed costs for NPDES required monitoring and State Lands lease are included in this estimate.

Some additional discussion regarding the basis of the power, NPDES monitoring and State Lands lease costs is included below.

The total annual O&M costs estimated for the Current Project Design are summarized in Table II-4 at the end of this section.

Table II-2 Current Project Design - Estimated Capital Costs (Class V)

Item No.	Description	Cost
1	Plant Site Civil Works & Plant Site Land Lease	$13,636,000
2	Electrical Equipment, Transformers, etc.	$5,100,000
3	Offshore Seawater Intake Piping and Screens	$10,538,500
4	Onshore Intake Pump Station	$12,915,000
5	Pretreatment System (In-Filter Dissolved Air Flotation/GMF)	$33,200,000
6	RO System (SWRO and Partial 2nd Pass)	$83,896,750
7	Post Treatment	$6,975,000
8	Chemical Storage and Handling	$1,800,000
9	Product Water Storage Tank	$1,400,000
10	Backwash Water Treatment and Solids Handling	$25,000,000
11	Brine Discharge Tank	$750,000
12	Offshore Brine Diffuser System	$10,938,750
13	Operations/Admin Building	$15,000,000
14	Product Water Pump Station	$6,800,000
15	Product Water Conveyance Pipeline	$38,502,000
16	Concrete Plug Demolition/ Site Improvements	$5,000,000
17	Interconnecting Pipe, Valves, & Auxiliary Systems	$26,550,000
18	Control & Instrumentation	$6,450,000
Subtotal		$304,452,000
19	Mitigation Monitoring (0.75% of subtotal)	$2,283,500
20	Spare Parts	$1,500,000
21	Engineering & Other Consulting (8% of subtotal and item 20)	$24,476,250
22	Overhead & Fee (20% of subtotal and items 20-21)	$66,085,750
23	Contingency (25% of subtotal and items 20-22)	$99,128,500
TOTAL		$497,926,000

Power

Electrical costs make up the largest portion of the O&M costs for a seawater desalination project, with the bulk of the energy used being used by the high-pressure RO feed pumps. An electrical usage value of 13 kWh per 1000 gallons is estimated for the Current Project Design based on the build-up shown in Table II-2 (from the EIR). This table indicates that the maximum power draw of the facility is 12.5 megawatts (MW).

The cost of power is a complex parameter which depends on a multitude of factors, including high exposure to cost drivers outside the District's control. Subsequent efforts in this Study (refer to Chapter III) will involve deeper investigation of the drivers of power costs in Southern California with a view to develop a range of reasonable power cost forecast scenarios between 2019 and the end of the operating life of the facility (at least 35 years away).

In this Chapter, GHD sought to understand the current power price landscape faced by the District, whose electricity provider is Southern California Edison.

GHD reviewed the published SCE rate tariffs for General Service – Large Customers (Schedule TOU-9-RTP). The real-time power costs included in the Schedule were valid from March 2019. It should be noted that SCE introduced a new calculation procedure from March 2019 and GHD used this new, revised format for our calculations.

Under the Schedule, the energy cost (i.e. a variable charge per kWh of electricity consumption) charged to customers is dynamic and fluctuates hourly, and is also dependent on the prevailing weather conditions, season, and demand conditions faced by SCE.

In addition to variable costs, there are a number of fixed costs outlined in the Schedule rates.

GHD's analysis used average weather conditions in Los Angeles as a base and determined that the annual average electricity cost for a 20 MGD facility operating year-round is **$0.097/kWh** which applies for year 2019 and includes all fixed and variable costs.

Using the identified SCE energy cost of $0.097/kWh and an average electricity consumption of 13kWh/1000 gal, the cost of power is approximately $1.26 per 1000 gal.

NPDES-Required Monitoring

The OWDP will operate and discharge brine to the coastal waters under the auspices of a NPDES permit issued by the Los Angeles Regional Water Quality Control Board (LARWQCB). NPDES permits have been issued to a surface water intake-supported seawater desalination plant in California under the OPA (Tentative Order No. R9-2019-0003 for the Carlsbad Desalination Plant) and recently the Huntington Beach project. Using the monitoring and reporting program requirements of Tentative Order No. R9-2019-0003 the annual receiving water monitoring budget during the five-year permit term is estimated at $507,000 (Table II-3).

Table II-3 Estimated NPDES-Required Monitoring Costs for Each Year of the NPDES Permit

Permit Year	Elements	Estimated Cost
Year 1	Benthic Monitoring Plan	$15,000
	Water Quality Surveys	$25,000
	In-plant Monitoring	$75,000
	Annual Report	$30,000
Year 1 Total		$145,000
Years 2, 4	Water Quality Surveys	$25,000
	Benthic Survey	$72,000
	Annual Report	$60,000
	In-plant Monitoring	$75,000
Years 2, 4 Total		$232,000
Years 3, 5 Total	Water Quality Surveys	$25,000
	Annual Report	$30,000
	In-plant Monitoring	$75,000
Years 3, 5 Total		$130,000

Permit Year	Elements	Estimated Cost
5-Year Permit Cycle Total Estimate		$507,000
Yearly Average		$101,000

State Lands Lease

The California State Lands Commission manages 4 million acres of tide and submerged lands, often referred to as sovereign or Public Trust Lands, which would include the intake and discharge facilities for the project. Based on similar project lease rates, it is assumed that the costs for leasing Public Trust Lands needed for project operation would be approximately $25,000 per acre. The EIR indicates that the disturbance area for the intake and discharge facilities for the Current Project Design would be up to eight acres. Assuming that the State Lands lease would be limited to that area, the lease costs are estimated at **$200,000** per year.

Summary of O&M Costs

The overall annual O&M cost is summarized in Table II-4.

Note that the estimate is a hypothetical one which assumes the plant is operating in 2019, and is expressed in 2019 dollars. Further work will be completed in subsequent tasks (see Chapter III) to apply inflation factors and other escalation factors to determine the operating costs in the actual years of the plant operation.

Table II-4 Current Project Design - O&M Costs (hypothetical operation in 2019)

Item	Value ($/1000 gallons)	Annual Cost ($)*
Variable Costs		
Annual Cost of Power	1.26	$8,750,000
Sludge Disposal	0.06	$420,000
Chemicals	0.12	$830,000
Fixed Costs		
Maintenance	0.16	$1,110,000
Membrane & Cartridge Replacement	0.12	$800,000
Labor	0.24	$1,670,000
Other/Misc.	0.06	$420,000
NPDES Required Monitoring	-	$100,000
State Lands Lease	-	$200,000
NRG Property Lease		TBD
Total		$14,300,000

* Assumes 95% annual availability for 20 MGD plant (i.e. produces 21,280 acre-feet per year).

6.1.3 Rehabilitation & Replacement (R&R)

Rehabilitation and replacement (R&R) refers to expenditure associated with replacement and other works on assets at their end of life, or to extend their operational life. This is different from O&M expenditure which is focused on maintaining existing assets during their operational life.

R&R expenditure often takes the form of capital projects delivered over a few years, rather than regular yearly costs. R&R related costs are likely to ramp up significantly near the end of the operating term of the desalination facility, as operators of the facility improve the plant components to meet handback conditions in the operating contract. However, R&R expenditure is difficult to forecast precisely as the actual expenditure profile will depend on asset performance and deterioration over medium to long-term timeframes, as well as the specifics of the handback obligations in operating contracts.

At the feasibility stage, the most common approach to accounting for R&R expenditure is to include an averaged, ongoing allowance in the cost model.

Based on GHD's experience, a yearly allowance of 1% of the relevant capital items has been adopted as the R&R allowance. The relevant capital items in this case are all major process and transfer items in the desalination facility including pretreatment, RO, sludge handling, pump stations and control/instrumentation. The offshore intakes, pipelines and civil works are excluded. The R&R allowance includes direct and indirect costs (i.e. engineering, overheads and contingency are included).

For the Current Project Design, the relevant capital items account for approximately 75% of the total CAPEX and the yearly R&R allowance is approximately $4.3 million per year (2019 dollars).

It is assumed that with this level of R&R expenditure, the desalination facility will have a salvage value of 25% of its initial CAPEX at the end of its 30-year operating life.

6.1.4 Biological Mitigation

Biological mitigation, referred to simply as mitigation in the OPA, is defined as "the replacement of all forms of marine life or habitat that is lost due to the construction and operation of a desalination facility after minimizing intake and mortality of all forms of marine life through best available site, design, and technology." More specifically, biological mitigation would be required due to the construction and operation of the seawater intake and brine discharge systems.

Mitigation Monitoring

The EIR calls for a Construction Management Plan, a Construction Safety Lighting Plan, and General Monitoring and compliance. Because these plans, and their implementation are related to the duration of construction, costs are typically estimated as a percentage of total construction costs. For these specific activities, costs are estimated at 0.75% of construction costs, captured as a line item in the Capital Cost Estimate Table II-2.

Mitigation Assumptions – Current Project Design

Biological mitigation for the Current Project Design is required to alleviate Area of Production Foregone (APF) due to intake entrainment, Brine Mixing Zone (BMZ), discharge shear attributable to the brine, and permanent habitat loss due to construction. The estimated APF for each of these project components is shown below in Table II-5.

Mitigation cost component considerations include intake location, allowable mitigation ratio, and appropriate mitigation project or fee. The OPA indicates that "the mitigation ratio shall not be less than one acre of mitigation habitat for every ten acres of impacted open water or soft-bottom habitat," and goes on further to clarify that "the regional water boards may increase the required mitigation ratio for any species and impacted natural habitat calculated in the Marine Life Mortality Report when appropriate to account for imprecisions associated with mitigation including, but not limited to, the likelihood of success, temporal delays in productivity, and the difficulty of restoring or establishing the desired productivity functions." The final mitigation ratio (area of mitigation for acres of

APF) will likely be between 1:5.8 and 1:7.5 based on the published precedent of the proposed Huntington Beach Desalination Project. Since the project will be using an existing intake structure, it is anticipated that any new 13142.5(b) Water Code determination application will require a new plankton entrainment study. The extent of scaling will depend largely on estimated plankton APF.

The OPA does allow for fee-based mitigation, however, the Agencies have not allowed this for consideration thus far. The OPA prefers mitigation projects that increase biological productivity in the area to offset losses due to the construction and operation of the desalination plant. Estuaries, wetlands, rocky reefs, and giant kelp are among the most common habitats used in mitigation. The OPA requires mitigation to occur within 56.4 km alongshore of the source water of the project.

Construction Impacts

The construction of intake and discharge structures would result in the permanent loss of some benthic habitat. For mitigation purposes, we assume that only the permanent impacts would require mitigation; temporary impacts would not. For the Current Project Design, the total area of benthic habitat lost due to construction would be the sum of the intake and discharge structure footprints.

Table II-5 provides a summary of the operational and construction-related impacts (in APF acres) for the Current Project Design. The maximum area of production forgone estimates derived for a screened intake with a 1% credit are used for intake and discharge impacts but after scaling to 10:1 for impact: mitigation acres. Note that to be conservative, we have not used the values that claim reductions in entrainment greater than the 1% credit allowed in the OPA as these adjustments have not been approved by the Agencies.

Table II-5 Estimated Operational and Construction Related Impacts

Biological Impact	Area of production foregone (APF, acres)
Intake Entrainment	16.2
Discharge Brine Mixing Zone (BMZ)	0.5
Discharge Shear	38.2
Permanent habitat lost due to construction	8
Total	62.9

Available Restoration Projects

There are limited restoration options of the required size currently available in the source water area impacted by the OWDP. Restoration/creation of the Ballona Wetlands is the lone wetlands project presently available in the source water area. No clear restoration/creation plan has been outlined for Ballona at this point due to lack of consensus between stakeholders and local NGOs. The Santa Monica Bay Restoration Commission (SMBRC) has been developing a white paper evaluating the best path to maximize the environmental benefit of the future restored wetlands. However, after 10 years of effort the paper has yet to be released. Due to this uncertainty, the range in potential mitigation cost is high. An average based on various estimates is assumed.

As an alternative, the National Marine Fisheries Service (NMFS) oversees the Montrose Settlements Restoration Program in the project area and have begun development of an artificial reef to offset impacts to fisheries resulting from the Montrose Chemical Corporation’s DDT discharges. Estimates for the mitigation costs per acre for these two projects are indicated in Table II-6.

Table II-6 Available Habitat Mitigation Projects in the Source Water Area

Project	Habitat	Total Acres	Cost/Acre
Ballona Wetlands	Wetland	618.1	$171,000
NMFS Artificial Reef	Reef	TBD	$162,500

Estimated Mitigation Costs

Mitigation cost estimates reflect the estimated capital cost to execute the mitigation project, but do not include permitting and monitoring costs. Performance standards should be expected, but none have yet been approved under the OPA and cannot be reliably quantified at this time. Monitoring will be required for the operational life of the OWDP, which is not yet determined. In an attempt to capture these costs, a scaling of 300% on each estimate is assumed to capture the permitting and monitoring costs. The capital costs for biological mitigation for the Current Project Design are provided in Table II-7. The additional operational costs for permitting and monitoring are captured in Table II-8 averaged over a 30-year Project life.

Table II-7 Estimated Capital Costs for Mitigation Projects for the Current Project Design

Project	Capital Cost	Total Capital Cost*
Ballona Wetlands	$10,756,000	$10,956,000
NMFS Artificial Reef	$10,221,250	$10,421,250

Table II-8 Estimated Operational Costs for Mitigation Projects for the Current Project Design

Project	Total Operational Cost	Average Annual Operational Cost
Ballona Wetlands	$21,512,000	$717,100
NMFS Artificial Reef	$20,442,500	$681,400

*averaged over 30-year Project life

6.1.5 GHG

GHG Emissions

The District is committed to reducing emissions to be net carbon neutral. As described in Mitigation Measures GHG-1 and GHG-2 in the EIR, the District would be required to use the applicable energy intensity and emission factors at the time to quantify the GHG emissions associated with electricity used by imported water compared to a new desalination facility. Mitigation measure GHG-1 requires that the gap in calculated GHG emissions between imported water and ocean water desalination be closed through mitigation measures.

As outlined in the EIR, a simplified approach was used for estimating the emission factors of the Colorado River Aqueduct (CRA) and State Water Project (SWP) systems by assuming their emission factors to be the same, and equal to the 2016 eGrid factor for California of 528 lbs. CO2e/MWh. Using this approach, the total emissions of imported water is approximately 15,000 metric tons of CO2 equivalent per year (MTCO2e/year) (refer to Section 6.3.3 for further details). Table II-9 presents the total estimated GHG emissions for the 20 MGD desalination facility in annual MTCO2e, including construction emissions for all Project components as well as operational emissions associated with energy use, adapted from the EIR.

Evidently, the 20 MGD OWDP produces approximately 11,000 MTCO2e/year more GHG emissions than the equivalent amount of imported water, and **therefore 11,000 MTCO2e/year in carbon offset credits are required to certify the OWDP as carbon neutral.**

Table II-9 Current Project Design – Total Greenhouse Gas Emissions

Source	Total $MTCO_{2e}$[1,2]/yr
Amortized Construction Emissions per Operational Year[3]	
Desalination Facility	625
Marine Construction Activities	101
Desalinated Water Conveyance	171
Total Direct and Indirect (Construction) Emissions	900
Annual Operational Energy Emissions[4]	
Project Operational Energy Emissions	25,100
Total Project Emissions	26,000
Current Imported Water Emissions	15,000
Total Emissions to be Mitigated (based on current emission factors)	11,000

Notes:
1. CO2 Equivalent values (CO2e) include emissions of CO2, N2O and CH4 reported in CO2 equivalencies using the EPA Greenhouse Gas Equivalencies Calculator (USEPA 2017).
2. Numbers may not add to exact total due to rounding.
3. Construction emissions are amortized over a Project lifetime of 30 years based on conservative estimate of grading at ESGS South site. The Project lifetime is based on the standard 30-year SCAQMD assumption (http://www.aqmd.gov/docs/default-source/ceqa/handbook/greenhouse-gases-(ghg)-ceqa-significance-thresholds/year-2008-2009/ghg-meeting-13/ghg-meeting-13-minutes.pdf?sfvrsn=2, accessed June 2016).
4. Operational energy emissions are indirect emissions from electricity consumption by OWDP equipment operations and conveyance system pumps as stated in EIR Section 3, Project Description (Table 3.7), estimated using the most recent emission factor at the time (2016) publicly reported by SCE using the Power/Utility Protocol (PUP). Direct emissions from generators and vehicle trips are negligible and are not included in operational emissions.
5. Emissions estimate for current imported water, based on a 50:50 blend of CRA:SWP water, the average energy intensity of those imported water supplies (8,616 kWh/MG), and the statewide average GHG emission factor for utility-supplied electricity in California (2016 (eGrid factor = 528 lbs. CO2e/MWh, equivalent to 0.24 MTCO2e/MWh).
Construction emissions were calculated using CalEEMod. Refer to Appendix 3 of the EIR for detailed model input/output data.

GHG Offset Pricing

California's Global Warming Solutions Act of 2006 (AB32) requires California to reduce its GHG emissions to 1990 levels by 2020. One approach to this is California's cap-and-trade program, which officially launched in January 2013, where GHG emitters can purchase Carbon-offset Credits issued by the California Air Resources Board (CARB) from a variety of organizations and projects on an open market. In September 2016, AB32's successor SB32 (which eventually became AB398) was signed into law, and requires emissions reductions of 40% below 1990 levels by 2030, thereby extending the program. As part of the ongoing effort in California to eliminate GHG emissions, Executive Order S-3-05 was signed to further reduce emissions to 80% below 1990 levels by 2050.

These considerations are important if the District decides to carbon offset because stricter regulations will influence the availability and cost of Carbon-offset Credits on the open marketplace.

The market cost of Carbon-offset Credits used in this analysis is predicted from current and historical market prices found on calcarbondash.org, presented in Figure II-14 below, and from projected future credit costs presented in a December 2017 paper by The Brattle Group (Brattle Paper)[2].

Figure II-14 Historical Daily Carbon-offset Credit Price (calcarbondash.org)

Prior to the official program launch in January of 2013, Carbon-offset credit pricing was quite volatile, but eventually settled out toward the end of 2013. To level out the data and help predict future trends, this investigation focused on the data beginning January 2014 (light blue), and the data was smoothed out with a 30-day running average. In addition to projections from The Brattle Group paper, three other projected scenarios from the calcarbondash.org data are presented in this report: a linear fit growth scenario, an exponential fit growth scenario, and a middle ground 4% growth scenario.

Figure II-15 provides a comparison of the four projected scenarios. Prices are indicated in dollars per metric ton of equivalent carbon ($/MTCO2e), abbreviated to dollars per metric ton ($/MT)

It is clear from Figure II-15 that the Brattle Paper projection outpaces the projections from the limited historical data set, peaking at $138/MT leading into 2051. The other scenarios peak in 2050 at $40/MT for the linear fit projection, $64/MT for the 4% growth projection, and $101/MT for the exponential fit projection. This is in contrast to a current baseline composite price of approximately $16/MT in 2019, as indicated on calcarbondash.org. It should be noted that the marketplace consists of a variety of sellers, and that market rates as low as $10/MT may currently be available.

For this project, a baseline carbon cost of $16/MT in 2019 has been adopted, equivalent to an annual cost of **$175,000**. Future prices are forecasted at a 4% p.a. annual increase (refer Figure II-15). This will be sensitivity-tested in subsequent tasks of this Study (refer Chapter III).

[2] http://files.brattle.com/files/11768_the_future_of_cap-and-trade_program_in_california_final_12.4.17.pdf

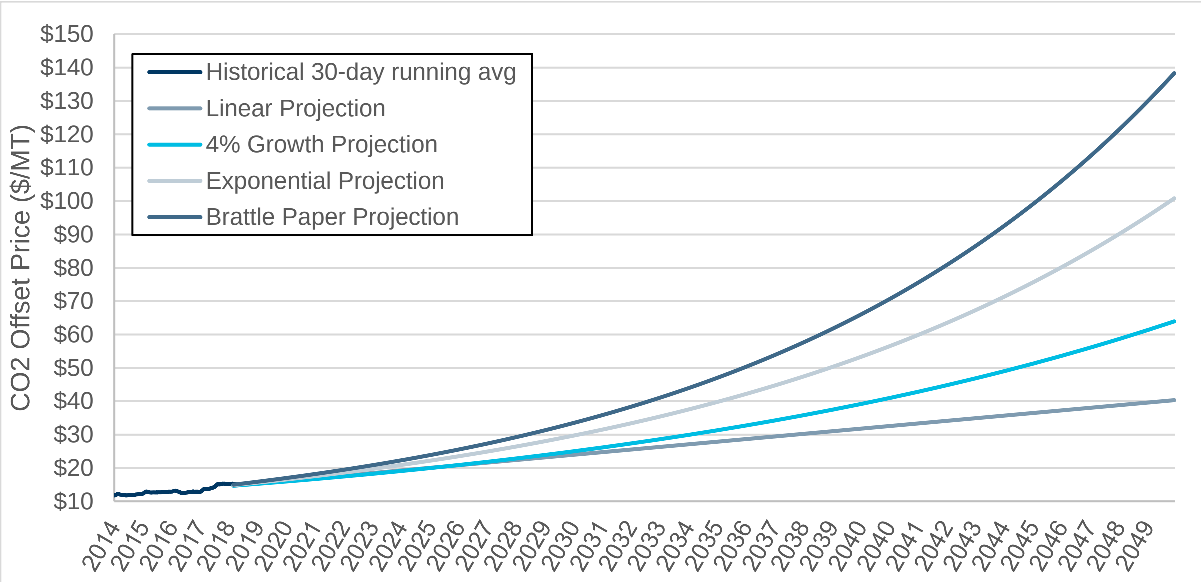


Figure II-15 Historical and Projected Carbon-offset Credit Pricing

6.1.6 Permitting

Permitting will also have impacts on the project cost. A summary of regulatory permits and associated costs, is presented in Table II-10. Costs have been escalated to 2019 dollars. However, permitting costs can vary widely based the on the project design details, and the permitting landscape is changing continually. Note that Table II-10 is not a detailed schedule, or path forward, but it is a good indication of what is anticipated to be required.

For the Current Project Design, which proposes to use a 1-mm screened surface intake at the site of an existing once-through cooling intake, permitting would be comparatively more difficult than for the Subsurface Intake Design, which proposes to use an OPA-preferred intake technology.

For the Entrainment Study required by the State Water Resources Control Board (SWQCB) and the Regional Water Quality Control Boards (RWQCB), we have assumed a total timeframe of 4 years is needed to complete this study and have it reviewed and approved by the Water Boards.

The overall allowance for the permitting process for the Current Project Design is 5 years, though it could likely vary from 3 to 7 years based on publicly presented information from SWRCB staff (Santa Ana Regional Water Quality Control Board 2019) and interactions with SWRCB and RWQCB staff members. It is important to note that no single project has thus far (as of early 2021) completed the Permitting from beginning to end under the amended OPA since its 2016 implementation. Thus, there is no precedent to draw from yet regarding the new regulatory OPA framework in place.

The permitting costs are a relatively small portion of the total project cost. The permitting process is most critical from the perspective of timing and any construction and operational conditions that may be imposed on the project as part of approvals (which may lead to significant extra cost).

Table II-10 Summary of Regulatory Permits, Timeline & Estimated Cost – Current Project Design

Regulatory Agency	Regulatory Permit, Authorization, or Approval	Timeline	Estimated Cost
Federal Agencies			
U.S. Fish and Wildlife Service (USFWS), Ecological Services Branch	Incidental Take Statement and coordination under Section 7 Endangered Species Act of 1973, as amended (ESA)	12-18 months	$100,000 - $600,000 or up
	Incidental Take Permit (ITP) under the Migratory Bird Treaty Act (MBTA)		
	Consultation under the Fish and Wildlife Coordination Act		
NOAA National Marine Fisheries Service (NMFS)	Consultation and biological opinion in accordance with Section 7 ESA	12-18 months	$100,000 - $600,000 or up
	ITP per Section 104, Marine Mammal Protection Act of 1972 (MMPA)		
	Consultation under Section 305(b), Magnuson-Stevens Fishery Conservation and Management Act		
U.S. Army Corps of Engineers (USACE)	Individual Permit in accordance with Section 404 Clean Water Act	6-18 months	$100,000
	Individual Permit under Section 10 Rivers and Harbors Appropriation Act		$50,000
State Agencies			
SWRCB and RWQCB	New Entrainment Study	48 months	$750,000
	Processing costs for SWRCB and RWQCB		$530,000
	Additional site analysis		$100,000
RWQCB	NPDES General Permit for Storm Water Discharges Associated with Construction Activity	12-24 months	$100,000
	NPDES Permit in accordance with Clean Water Act Section 402		$100,000
	Waste Discharge Requirements (WDR) per Porter-Cologne Water Quality Control Act		$50,000
	Water Quality Certification in accordance with Section 401 Clean Water Act		$75,000
California State Lands Commission (CSLC)	Land Use Lease (Right-of-Way Permit)	12-24 months	$50,000
California Department of Fish and Wildlife (CDFW)	ITP in accordance with the California Endangered Species Act (CESA)	6-12 months	$100,000 - $400,000 or up
	Lake/Streambed Alteration Agreement		$50,000

Regulatory Agency	Regulatory Permit, Authorization, or Approval	Timeline	Estimated Cost
California Coastal Commission (CCC)	Coastal Development Permit in accordance with the California Coastal Act	24-36 months	$500,000
California Department of Public Health (CDPH)	Permit to Operate a Public Water System	24-36 months	$1,250,000
California Department of Parks & Recreation Office of Historic Preservation	Coordination under Section 106 of the National Historic Preservation Act	6-12 months	$20,000
California Department of Transportation	Encroachment Permit	12-24 months	$50,000
Regional			
South Coast Air Quality Management District (SCAQMD)	Permit to construct Permit to operate	6-12 months	$100,000 - $300,000
Metropolitan Water District of Southern California (MWD)	Encroachment permit for work within MWD Right of Way	12-24 months	$50,000
Local			
City of Redondo Beach, City of El Segundo, City of Manhattan Beach, City of Hermosa Beach, City of Lawndale, City of Hawthorne, City of Gardena, City of Torrance	Encroachment Permit	3-6 months	$20,000
Total (estimated)		60 months	$5.5 million

6.2 Subsurface Intake Design– OPA Preferred Technologies

6.2.1 Capital

Capital costs for the Subsurface Intake Design were developed using the same approach as for the Current Project Design, to a Class V level. The cost estimate is summarized in Table II-11 below.

The capital cost estimate for Subsurface Intake Design is significantly higher than the Current Project Design, driven by the costs for the Offshore SIG and Brine Discharge Conveyance Pipeline to Hyperion. Project development costs already incurred such as EIR, and permitting and public outreach have not been considered in this estimate.

Table II-11 Subsurface Intake Design– Estimated Capital Costs

Item No.	Description	Cost
1	Plant Site Civil Works & Plant Site Land Lease	$13,636,000
2	Electrical Substation, Transformers, etc.	$5,100,000
3	Offshore SIG	$155,716,000
4	Onshore Intake Pump Station	$12,915,000
5	Pretreatment System (GMF)	$26,560,000
6	RO System (SWRO and Partial 2nd Pass)	$83,896,750
7	Post Treatment	$6,975,000
8	Chemical Storage and Handling	$1,800,000
9	Product Water Storage Tank	$1,400,000
10	Backwash Water Treatment and Solids Handling	$25,000,000
11	Brine Discharge Tank	$750,000
12	Brine Discharge Conveyance Pipeline to Hyperion	$11,760,000
13	Operations/Admin Building	$15,000,000
14	Product Water Pump Station	$6,800,000
15	Product Water Conveyance Pipeline	$38,502,000
16	Concrete Plug Demolition/ Site Improvements	$5,000,000
17	Interconnecting Pipe, Valves, & Auxiliary Systems	$26,550,000
18	Control & Instrumentation	$6,450,000
Subtotal		$443,810,750
19	Mitigation Monitoring (0.75% of subtotal)	$3,328,500
20	Spare Parts	$1,500,000
21	Engineering & Other Consulting (8% of subtotal and item 20)	$35,504,750
22	Overhead & Fee (20% of subtotal and items 20-21)	$96,163,000
23	Contingency (25% of subtotal and items 20-22)	$144,244,750
TOTAL		$724,551,750

Note, a 10% contingency is included in the capital cost for the offshore SIG in Table II-11. This is due to the increased risk with construction of a SIG versus a screened intake.

6.2.2 Operations & Maintenance (O&M)

The O&M Costs for Subsurface Intake Design are substantially the same as the Current Project Design (refer Section 6.1.2 for further detail) and follow the same structure. Sludge disposal and chemical costs are reduced from the Current Project Design due to expected improved water quality with utilizing a subsurface intake system. The O&M cost estimate for the Subsurface Intake Design is summarized in Table II-12 at the end of this section.

6.2.3 Power

The energy costs between the Current Project Design and the Subsurface Intake Design would not vary significantly. The main difference would be due to the commingled discharge in the Subsurface Intake Design. The added power to pump 21.4 MGD of brine to one of the outfalls would add about 0.2 kWh/1000 gal to the O&M energy requirements, to give a total of 13.2 kWh/1000 gal. Based on this and the power cost estimate for 2019 described for the Current Project Design above, the cost of power is approximately $1.28/1000 gal.

6.2.4 NPDES-Required Monitoring

Similar to the Current Project Design, using the monitoring and reporting program requirements of Tentative Order No. R9-2019-0003 the annual receiving water monitoring budget during the five-year permit term is estimated at $507,000.

6.2.5 State Lands Lease

Based on similar project lease rates, it is assumed that the costs for leasing Public Trust Lands needed for project operation would be approximately $25,000 per acre. Lease costs for the Subsurface Intake Design would depend on the total area occupied by the SIG. Assuming that a SIG and associated infrastructure could be located within an approximate 20-acre area, the lease costs would be approximately $500,000 per year.

6.2.6 Summary of O&M Costs

The overall annual O&M cost, as summarized above, is outlined in Table II-12. Note that the estimate is a hypothetical one which assumes the plant is operating in 2019, and is expressed in 2019 dollars. Further work will be completed in subsequent tasks (see Chapter III) to apply inflation factors and other escalation factors to determine the operating costs in the actual years of the plant operation.

6.2.7 Rehabilitation & Replacement (R&R)

The same R&R approach was adopted for the Subsurface Intake Design as for the Current Project Design.

For the Subsurface Intake Design, the relevant capital items account for approximately 50% of the total CAPEX. This is lower than the Current Project Design because a large amount of the capital cost for the Subsurface Intake Design is tied up in items outside the main treatment plant facility, particularly the offshore SIG.

For the Subsurface Intake Design, the yearly R&R allowance is approximately $4.3 million per year.

It is assumed that with this level of R&R expenditure, the desalination facility will have a salvage value of 25% of its initial CAPEX at the end of its 30-year operating life.

6.2.8 Biological Mitigation

General mitigation requirements, as outlined in Section 6.1.4 for the Current Project Design, would be the same for both Project Designs.

Table II-12 Subsurface Intake Design - O&M Costs (hypothetical operation in 2019)

Item	Value ($/1000 gallons)	Annual Cost ($)*
Variable Costs		
Annual Cost of Power	1.28	$8,880,000
Sludge Disposal	0.03	$210,000
Chemicals	0.11	$750,000
Fixed Costs		
Maintenance	0.16	$1,110,000
Membrane & Cartridge Replacement	0.12	$800,000
Labor	0.24	$1,670,000
Other/ Misc.	0.06	$420,000
NPDES Required Monitoring	-	$100,000
State Lands Lease	-	$500,000
NRG Property Lease		TBD
Total		$14,440,000

* Assumes 95% annual availability for 20 MGD plant (i.e. produces 21,280 acre-feet per year).

6.2.9 Mitigation Assumptions – Subsurface Intake Project Design

Biological mitigation for the Subsurface Intake Design is required to alleviate APF due to discharge shear caused by the additional brine and habitat loss due to construction. The APF for each of these project components is estimated below in Table II-13. The discharge shear APF in Table II-13

- Is assumed to have an incremental increase from the APF for the Current Project Design. This is a conservative overestimate since the actual shearing mortality caused by the addition of brine to the Hyperion outfall has not been estimated and will be variable.

Mitigation for the Subsurface Intake Project Design would not be required for SSI. The following assumptions were made in estimating mitigation costs specific to the Subsurface Intake Design:

- Assume an incremental increase over the Current Project Design brine discharge APF
  - This is the most conservative approach, albeit an overestimate
  - Actual shearing mortality caused by addition of brine to the wastewater effluent has not been estimated and will be highly variable
  - Stations O6 and E3 from the 316(b) Impingement Mortality and Entrainment Characterization Study reports, for Redondo Beach Generating Station (RBGS), and ESGS respectively, were used to represent the area around the Hyperion outfall
    - RBGS Station O6 was sampled at the same time as the ESGS stations in 2006
    - It is the deepest station sampled and therefore the most representative of the environment surrounding the Hyperion 5-mile outfall
    - Assume the incremental increase in larval concentration at Station O6 in comparison to the ESGS Station E3 is translated through the Empirical Transport Model (ETM)/APF

6.2.10 Construction Impacts

It is assumed that the benthic footprint of a SIG or subsurface seabed well is considered a permanent impact, because (per Appendix 2B to the EIR), it would require scraping of the shallow layer, every 5 years. Periodic removal of the surface sediments will prevent successful colonization by benthic infaunal organisms.

To determine estimated construction related impacts for the Subsurface Intake Design, the discharge shear value for the Current Project Design is scaled by 118% based on the estimated difference in larval concentrations between the Current Project Design site and the Hyperion Outfall site. Intake entrainment and discharge brine mixing are not anticipated to have an APF impact due to the application of the OPA preferred intake and discharge technologies. The construction related impacts for the Subsurface Intake Design are outlined below in Table II-13.

Table II-13 Estimated Operational and Construction Related Impacts

Biological Impact	APF (acres)
Intake Entrainment	0
Discharge Brine Mixing Zone (BMZ)	0
Discharge Shear	45.1
Permanent habitat lost to construction	20
Total	65.1

6.2.11 Estimated Mitigation Costs

The two available mitigation projects, Ballona Wetlands and NMFS Artificial Reef, are discussed above in Section 6.1.4 and estimates for the mitigation costs per acre for these two projects are indicated in Table II-7.

Mitigation cost estimates reflect the estimated cost to execute the mitigation project, but do not include permitting and monitoring costs. Performance standards should be expected, but none have yet been approved under the OPA and cannot be reliably quantified at this time. Monitoring will be required for the operational life of the OWDP, which is not yet determined. In an attempt to capture these costs, a scaling of 300% on each estimate is assumed to capture the permitting and monitoring costs. The capital costs for biological mitigation for the Subsurface Intake Design are provided in Table II-14, and include $200,000 for a Coastal Resiliency Study. The additional operational costs for permitting and monitoring are captured in Table II-15, averaged over a 30-year Project life.

Table II-14 Estimated Capital Costs for Mitigation Projects for the Subsurface Intake Project Design

Project	Capital Cost	Total Capital Cost
Ballona Wetlands	$11,132,100	$11,332,100
NMFS Artificial Reef	$10,578,800	$10,778,800

Table II-15 Estimated Operational Costs for Mitigation Projects for the Subsurface Intake Project Design

Project	Total Operational Cost	Average Annual Operational Cost*
Ballona Wetlands	$22,264,200	$742,100
NMFS Artificial Reef	$21,157,600	$705,300

**averaged over 30-year Project life*

6.2.12 GHG

The same GHG offset assumptions as those described for the Current Project Design in Section 2.1.5 have been used to arrive at an annual cost of approximately $175,000.

- 11,000 MTCO2e/year to be offset
- Baseline carbon cost of $16/MT in 2019
- 4% p.a. annual increase

6.2.13 Permitting

Permitting requirements for the Subsurface Intake Design are similar to the Current Project Design with the exception of the Entrainment Study which may not apply, as the project uses OPA-preferred intake and outfall technology.

By avoiding the need for an additional Entrainment Study, the permitting timeframe could be shortened by 3 to 5 years and permitting costs could be reduced by $1.1 million.

Noting that the permitting requirements are still uncertain and highly dependent on the need for an Entrainment Study, we have nevertheless assumed that the Subsurface Intake Design could be fully permitted within 1 to 2 years, and therefore the Subsurface Intake Design permitting cost allowance is **$4.3 million**.

6.3 No-Project Alternative

6.3.1 Description

In this 'No-Project' alternative, the District does not deliver the OWDP and continues to import water from MWD. To compare the cost of this option to the Current Project Design and the Subsurface Intake Design, the costs incurred by the District to continue to purchase water from MWD must be calculated. This represents the 'avoided cost' of imported water by building a localized desalination facility. Note, the 20 MGD Project would offset approximately 20% of MWD imported water.

Note that the cost of imported water in the No-Project Alternative is modelled in more advanced detail in subsequent Chapters of this Study, meaning some of the discussion below has been superseded.

6.3.2 MWD Imported Water Costs

The District incurs a cost to import water, levied to it by MWD. This cost is currently structured as the sum of a volumetric charge ($/AF consumed), readiness-to-serve (RTS) charge ($/AF) and capacity charge ($/cfs peak).

For the purpose of this initial analysis, only the volumetric and RTS charges have been considered. In 2019 the sum of these charges is $1,148/AF. Further work is needed to determine the impact on the capacity charge levied on the District if the OWDP project does or does not proceed.

Also, it has been assumed that the 'reliability service charge' levied by the District to its customer Retail Agencies is not dependent on whether the OWDP project proceeds or does not proceed. Therefore, it has been excluded from this analysis.

MWD has published[3] its forecasted imported water rates from 2018 to 2028, as shown in Table II-16 and Table II-17 below:

Table II-16 MWD Imported Water Cost Forecast – Volumetric Charges

	Rates & Charges	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
A	Tier 1 Supply ($/AF)	$209	$209	$208	$221	$229	$236	$242	$248	$256	$264	$271
B	Tier 2 Supply ($/AF)	$295	$295	$295	$295	$295	$295	$295	$295	$295	$295	$295
C	System Access ($/AF)	$299	$326	$346	$349	$365	$382	$399	$418	$434	$453	$472
D	Water Stewardship ($/AF)	$55	$69	$65	$65	$65	$65	$65	$65	$65	$65	$65
E	System Power ($/AF)	$132	$127	$136	$146	$148	$153	$154	$158	$161	$163	$166
Full Service Untreated Volumetric Cost ($/AF)												
F	Tier 1	$695	$731	$755	$781	$807	$836	$860	$889	$916	$945	$974
G	Tier 2	$781	$817	$842	$855	$873	$895	$913	$936	$955	$976	$998
Full Service Treated Volumetric Cost ($/AF)												
H	Tier 1*	$1,015	$1,050	$1,078	$1,104	$1,130	$1,159	$1,183	$1,212	$1,239	$1,268	$1,297
I	Tier 2	$1,101	$1,136	$1,165	$1,178	$1,196	$1,218	$1,236	$1,259	$1,278	$1,299	$1,321

** From review of West Basin 2018/19 rate sheet, West Basin appears to be charged MWD Tier 1 rate for all water imports; H = A + C + D + E + 'treatment cost', where 'treatment cost' = H – F*

Table II-17 MWD Imported Water Cost Forecast – Other Charges

Rates & Charges	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Readiness -to-Serve Charge ($M)**	$140	$133	$136	$144	$152	$155	$168	$177	$190	$202	$216
Capacity Charge ($/cfs)	$8,700	$8,600	$8,800	$9,400	$9,900	$10,700	$11,400	$11,500	$11,900	$12,000	$12,000

*** From review of West Basin 2018/19 rate sheet, the District's portion of MWD's RTS $140 mil charge in 2018 was converted to a volumetric charge of $98/AF*

Based on the published rates above, a long-term forecast for MWD imported water has been developed:

- MWD Volumetric cost = Tier 1 supply rate from Table II-16 (row H), then escalated at constant 2.8% p.a. beyond 2028.

[3] http://www.mwdh2o.com/PDF_Who_We_Are/Ten-Year%20Financial%20Forecast%20(Board%20Feb.%2013%202018).pdf

- MWD RTS charge = Base value of $98/AF in 2018, then adjusted by the year-on-year percentage change from Table II-17 to 2028, then escalated at constant 2.8% p.a. beyond 2028.

This forecast is summarized in Figure II-16 below:

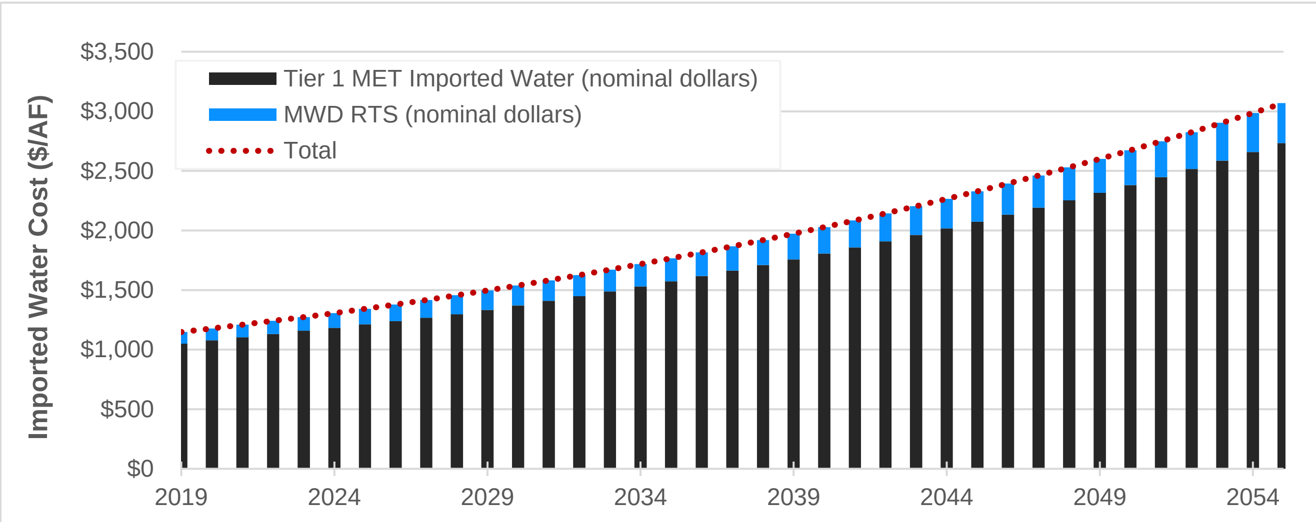


Figure II-16 Forecast of West Basin Municipal Water District's imported water cost

It should be noted that this forecast is likely to be the 'bottom-end' forecast for future MWD imported water rates. It is probable that the actual cost of water will increase at a faster rate due to the need for large scale investment in the imported water system to improve reliability, adapt to climate change and adhere to stricter environmental standards.

Using an imported water rate of $1,148/AF in 2019, the 'avoided cost' of MWD imported water from a 20 MGD desalinated facility is approximately $24.4 million per year.

Note that the cost of imported water in the No-Project Alternative is modelled in more advanced detail in subsequent Chapters of this Study, meaning some of the discussion above has been superseded.

6.3.3 GHG

MWD currently imports most of its water from two sources: the CRA, which collects water from the Colorado River at Lake Havasu and conveys water through a 242-milelong aqueduct; and the SWP, which collects water from rivers in Northern California, primarily through the Sacramento-San Joaquin River Delta, and conveys water over 400 miles, lifting water over 2,000 feet in elevation, to Southern California. Both imported sources of water require extensive pumping that consumes energy. These energy intensities are estimated and shown in Table II-18.

The availability of these imported water supplies to Southern California varies and depends on many factors. During the recent long droughts, there were periods where water allocation from the SWP was zero. The opposite situation (i.e., using only SWP) has also been experienced in the past. Thus, the energy intensity for the imported water ranges between 7,523 kWh/MG and upward toward 9,708 kWh/MG.

Assuming a 50:50 mix CRA:SWP (resulting in an estimated 8,616 kWh/MG), 20 MGD of imported water has emissions of 15,064 MTCO2e/year.

Table II-18 Energy and Greenhouse Gas Intensity of Imported Water (MWD) Sources

Source of Import	kWh/MG[1]
State Water Project to LA Basin	9,708
Colorado River Aqueduct to LA Basin	7,523
Average SWP and CRA (50/50 mix)	8,616

Source: [1]California Air Pollution Control Officers Association 2010.

6.4 Summary Comparison of Total Estimated Cost

Table II-19 below summarizes the findings discussed in Section 6.

Table II-19 Comparison of Total Estimated Costs (all 2019 dollars)

Description		Current Project Design	Subsurface Intake Design
Construction and Upfront Costs			
	Capital Cost	$497,926,000	$724,551,750
	Biological Mitigation	$10,956,000	$11,332,100
	Permitting costs	$5,500,000	$4,300,000
	Permitting time	5 yrs (3 to 7 yrs)	1 yr (1 to 2 yrs)
Ongoing Costs			
	Operations & Maintenance	$14,300,000/yr	$14,440,000/yr
	Rehabilitation & Replacement	$4,340,000/yr	$4,340,000/yr
	Biological Mitigation	$717,000/yr	$742,000/yr
	GHG Mitigation	$175,000/yr	$175,000/yr

7. Total Cost Comparison

7.1 Upfront Cost Comparison

Figure II-17 below summarizes the estimated upfront capital costs for the project options – those costs for permitting and design/construction, as outlined in Table II-19 above.

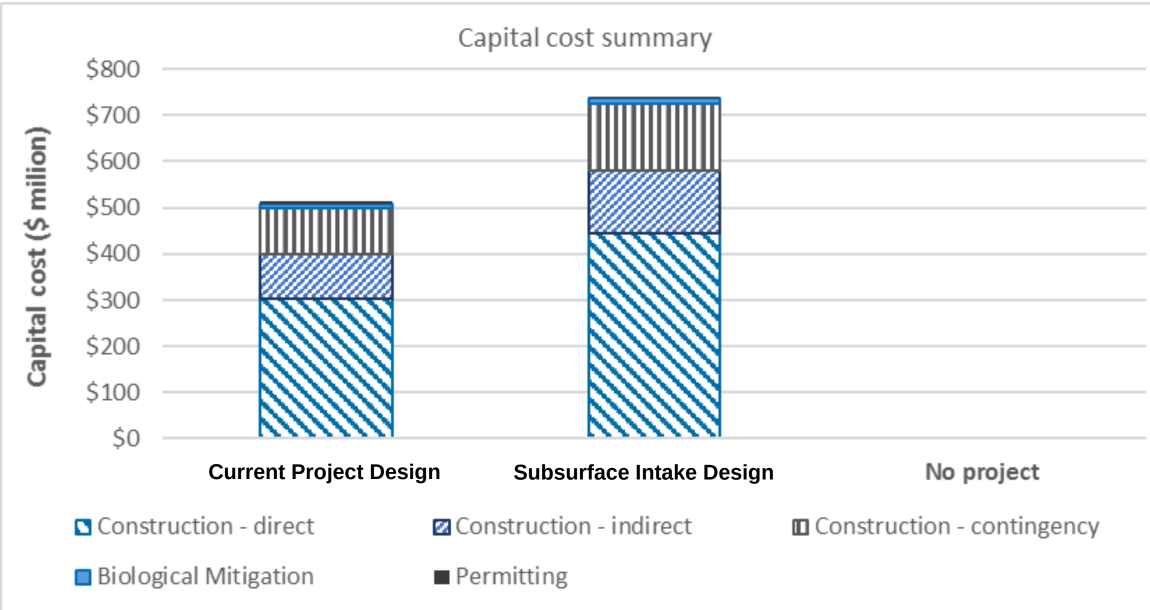


Figure II-17 Upfront cost comparison

The Subsurface Intake Design is approximately $220 million more expensive than the Current Project Design, driven by the higher direct and indirect costs of constructing the offshore sub-surface intake (compared to the offshore sea water intake piping and screens in the Current Project Design).

Additional work to be completed in later phases:

- The 'No-Project' alternative does not have any upfront costs associated with it, since it presumes continued water imports from MWD. However, this may be deceptive as it should consider the cost of any infrastructure that could be avoided in the next 30 years if the desalination plant is built. This may include works by the District to expand connecting infrastructure or capital costs incurred by MWD to improve supply which are passed on to the District.
- Figure II-17 presents the upfront cost as an expenditure at a single point in time, when in reality it will be spread across time during the pre-construction and construction period. The timing of expenditure will impact on the financing and repayment costs, and this is considered in subsequent tasks in this Study (refer Chapter III).
- This analysis does not consider financing options, grants, rebates, or delivery method options which will determine the actual cash-flows incurred by the District to pay for the costs. These is modelled in detail in subsequent tasks in this Study (refer to Chapter III).

7.2 Ongoing Costs Comparison

Figure II-18 presents the estimated yearly costs for the different options. The analysis is based on the following key assumptions (with other assumptions discussed in the rest of this report):

- Costs presented for the year 2019 in nominal dollars
- Power price of $0.097/kWh
- GHG offset price of $16/MT
- MWD imported water cost of $1,148/AF

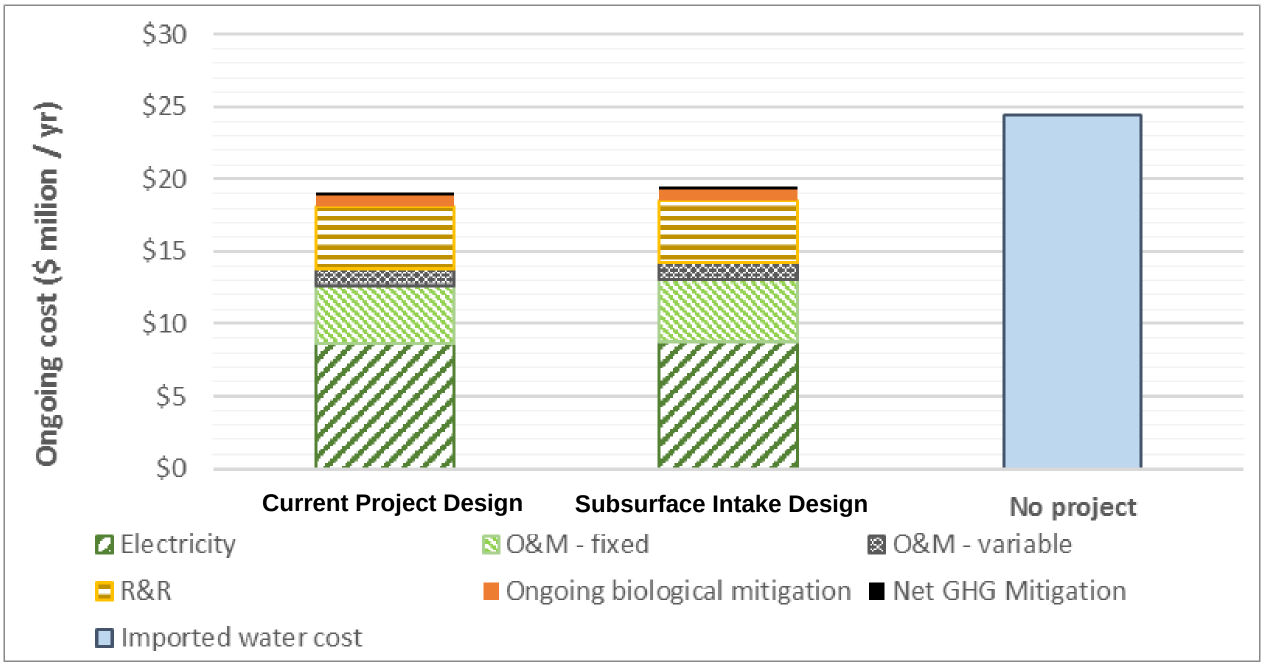


Figure II-18 Ongoing cost comparison

Evidently, the cost of operating the Current Project Design is just below the cost of importing water from MWD, while the cost of operating the Subsurface Intake Design is slightly higher. Electricity costs are by far the biggest cost component in operation of the desalination facility, contributing approximately 50% of the total.

Further detail and refinement of this simplistic analysis is undertaken in Chapter III, including:

- Calculating ongoing costs on a year-by-year basis over the entire project life, accounting for escalation factors.
- More detailed projection profiles for the MWD imported water cost (compared to the simple analysis shown in Section 6.3.2).

8. Glossary

Abbreviation	Meaning	Abbreviation	Meaning
@Risk	@Risk modelling software developed by Palisade Corporation	O&M	Operations and Maintenance
AF	Acre foot	OWDP	Ocean Water Desalination Project
AFY	Acre Feet per Year	OPEX	Operations Expenditure
CAP	Continuous Application Program	PAB	Private Activity Bonds
CAPEX	Capital Expenditure	PCC	Public Contract Code
CARB	California Air Resources Board	PFAS	Poly-fluoroalkyl Substances
CBA	Cost Benefit Analysis	PFHxA	Perfluorhexanoic Acid
CDP	Carlsbad Desalination Plant	PFOA	Perfluorooctanoic Acid
CEQA	California Environmental Quality Act	PFOS	Perfluorooctane Sulfonate
CRA	Colorado River Aqueduct	POU	Point-of-use
CRCWSC	Cooperative Research Center for Water Sensitive Cities	PPCPs	Pharmaceuticals and personal care products
CWSRF	Clean Water State Revolving Fund	PPP	Public-Private Partnership (also P3)
DBB	Design-Bid-Build	PPT	Parts per Trillion
DBFOM	Design-Build-Finance-Operate-Maintain	R&R	Rehab and Replacement
DBOM	Design-Build-Operate-Maintain	RDA	Redevelopment Agencies
DDW	Division of Drinking Water	RO	Reverse Osmosis
(the) District	West Basin Municipal Water District	ROW	Right-of-way
DWSRF	Drinking Water State Revolving Fund	RPS	Renewables Portfolio Standard
EIFD	Enhanced Infrastructure Financing Districts	SCAQMD	South Coast Air Quality Management District
EIR	Environmental Impact Report	SCE	Southern California Edison
EPA	Environmental Protection Agency	SDCWA	San Diego County Water Authority
ESGS	El Segundo Generating Site	SPV	Special Purpose Vehicle
FTE	Full-time Equivalents	SRF	(Drinking Water) State Revolving Fund
GHG	Greenhouse Gas	SWP	State Water Project
GO	General Obligation (Bonds)	TDS	Total Dissolved Solids
HAB	Harmful Algal Blooms	TMs	Task Memorandums
INFFEWS	Investment Framework for Economics of Water Sensitive Cities	UWMP	Urban Water Management Plan
IO	Input-Output	VfM	Value-for-Money
IRR	Internal Rate of Return	WBMWD	West Basin Municipal Water District
kWh	Kilowatt Hour	WIFIA	Water Infrastructure Finance Innovation Act
LRP	Local Resources Program (a rebate program by MWD)	WIIN Act	Water Infrastructure Improvements for the Nation Act
MCL	Maximum Contaminant Level	WPA	Water Purchase Agreement
MGD (or mgd)	Million Gallons per Day	WSAP	Water Supply Allocation Plan
MG/L	Milligrams per liter	WTP	Willingness-to-pay
MMRP	Mitigation Monitoring and Reporting Program		
MT/yr	Metric Tonnes per Year		
MWD	Metropolitan Water District of Southern California		
NAD Bank	North American Development Bank		
NDMA	Nitrosodimenthylamine		
NPC	Net Present Cost		
NPV	Net Present Value		
NOA	Notice of Availability		
NOP	Notice of Preparation		

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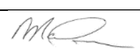
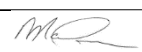
Final	Tyler Abercrombie	Mark Donovan		Mark Donovan		Jul 30 2021

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