THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Committee Item
INFORMATION

Engineering, Operations, and Technology Committee

8/17/2026 Committee Meeting

6c

Subject

Seawater Desalination Research Study Findings

Executive Summary

In November 2023, Metropolitan's Board authorized a professional services agreement for a reconnaissance-level seawater desalination study for Metropolitan's service area. The study was undertaken as part of Metropolitan's broader efforts to identify, evaluate, and advance potential future core water supply projects that could enhance long-term regional water supply reliability and resilience. At the time the studies were authorized by the Board, staff was directed to focus the work on desalination projects that would meet the State's recently promulgated guidelines for streamlined permitting as outlined in the California Seawater Interagency Group's Seawater Desalination Siting and Streamlining Report (Streamlining Report). The consultant inventoried and ranked potential project sites in Metropolitan's service area, identified partnership opportunities, and evaluated new technologies, including offshore desalination. The initial inventory of potential project sites and subsequent ranking prioritized sites presented in the report generally meet the requirements for streamlined permitting. This prioritization resulted in sites with subsurface intakes and discharges comingled with wastewater being ranked highly. The study identified the following three potential sites for further analysis: a 10 mgd expansion of the Doheny Ocean Desalination Project, a 20 mgd facility in Port Hueneme, and a 10 mgd facility in El Segundo.

Fiscal Impact

None

Applicable Policy

Metropolitan Water District Administrative Code Section 8121: General Authority of the General Manager to Enter Contracts

By Minute Item 52946, dated August 16, 2022, the Board adopted a resolution affirming a call to action and committing to regional reliability for all member agencies.

By Minute Item 53381, dated October 10, 2023, the Board adoption of RCP 8.5 as Metropolitan's planning standard for Climate Change impacts.

By Minute Item 53409, dated October 10, 2023, the Board approved an approach to issue a Request for Proposals to fund member agency studies and research under the Future Supply Actions Funding Program.

By Minute Item 53431, dated November 12, 2023, the Board authorized a professional services agreement with CDM Smith Inc. for a seawater desalination study.

By Minute Item 53436, dated April 8, 2025, the Board approved the Climate Adaptation Master Plan for Water Five-Year Implementation Strategy.

By Minute Item 54347, dated December 9, 2025, the Board adopted the Legislative Priorities and Principles for 2026.

Related Board Action(s)/Future Action(s)

None

Details and Background

Background

Metropolitan's long-term water resources planning has identified the potential need for additional conservation and water supply resources to help maintain regional water supply reliability under future conditions. Consistent with planning scenarios that evaluate plausible futures with more severe climate and hydrologic impacts, staff initiated efforts to assess the potential of brackish groundwater and seawater desalination as opportunities to diversify and strengthen Southern California's water supply portfolio. These efforts are intended to better understand the feasibility, benefits, costs, and implementation considerations associated with developing new water supplies that could enhance long-term regional resilience.

Request for Proposals No. 1327 solicited proposals for services to implement desalination studies in Metropolitan's service area. Findings from the proposed studies will contribute to Metropolitan's current overall assessment of potential water supplies for the region. Consistent with Metropolitan's planning framework, potential projects identified through this effort may be considered in future CAMP4W reliability assessments alongside other supply and demand management strategies.

In June 2023, an action item requesting funding for the studies was deferred to allow for the release of the Draft Streamlining Report. Deferring the studies provided an opportunity to incorporate recommendations from the Draft Streamlining Report in the studies' scopes of work. In October 2023, staff received additional Board input on the proposed studies. That input included focusing the studies on desalination projects that would meet the State's recently promulgated guidelines for streamlined permitting as outlined in the California Seawater Interagency Group's Seawater Desalination Siting and Streamlining Report (Streamlining Report). In November 2023, the Board approved the professional services agreement with CDM Smith, Inc. (CDM) to not exceed $475,000 for the Seawater Desalination study.

Metropolitan and CDM developed the Seawater Desalination Research Study with support from several coastal water agencies whose expertise and operational experience informed key elements of the evaluation. These agencies provided early guidance that helped the study team understand practical siting considerations, infrastructure constraints, local environmental conditions, and regional water reliability objectives. Metropolitan staff thanks the following agencies for their input and review throughout the study:

- Calleguas Municipal Water District (Calleguas)
- Municipal Water District of Orange County (MWDOC)
- South Coast Water District (SCWD)
- West Basin Municipal Water District
- Long Beach Utilities
- San Diego County Water Authority

Study Scope

The scope of work included a literature review, hydrogeologic screening, an assessment of emerging technologies, and a siting analysis using a multi-criteria decision analysis (MCDA) framework. For the top three sites, CDM also conducted water quality and system integration evaluations, regulatory and permitting reviews, and planning-level cost and schedule development. The MCDA incorporated seven weighted criteria: water supply benefit (20 percent), permitting ease (20 percent), cost-effectiveness (15 percent), environmental and social justice impacts (15 percent), technology readiness (15 percent), system integration (10 percent), and sea level rise vulnerability (5 percent). These criteria reflect both CAMP4W planning priorities and the Streamlining Report.

Emerging Technologies

CDM evaluated a wide range of emerging technologies using NASA's Technology Readiness Level scale. The evaluation resulted in a list of technologies sufficiently established for near-term adoption and another warranting future consideration. Offshore desalination approaches such as subsea treatment pods (OceanWell, Flocean, and Waterise), floating buoy systems (Seawell), and wave-powered desalination (Oneka) were identified as promising new technologies. The study concluded that the offshore technologies require further piloting and validation before they can be considered for large-scale potable supply.

Site Evaluation and Ranking

A total of 12 site alternatives spanning San Diego to Ventura Counties were evaluated (**Attachment 1** – Potential Seawater Desalination Sites). CDM's screening considered hydrogeologic feasibility, intake type, availability of existing wastewater outfalls, environmental and community impacts, regulatory complexity, system integration needs, and capital and O&M costs. Sites relying on subsurface intakes and existing wastewater outfalls scored highest due to strong alignment with the streamlined permitting track in the Streamlining Report and reduced permitting risk. CDM's MCDA results identified four high-performing sites, with three selected for detailed evaluation based on proven technology readiness:

1. Doheny Ocean Desalination Project (Doheny Expansion) – Slant Wells (additional 10 mgd)
2. Port Hueneme – Slant Wells (20 mgd)
3. Port Hueneme – Offshore (20 mgd) ranked highly, but CDM recommended excluding it from the detailed assessment due to reliance on an emerging technology
4. El Segundo – Slant Wells (10 mgd)

Top 3 Potential Sites

The three sites advanced for detailed evaluations are Doheny Expansion, Port Hueneme, and El Segundo (**Attachment 2** – Site-Specific Fact Sheets). Each site represents a location where the combination of coastal hydrogeology, existing infrastructure, and regional water supply needs creates a promising site for a seawater desalination project meeting the State's streamlined permitting requirements.

CDM developed the Association for the Advancement of Cost Engineering Class 5 opinions of probable construction costs for the top three sites, encompassing raw water intake, treatment technologies, brine concentrate disposal, and conveyance. O&M costs include variable costs such as energy, chemicals, membrane replacement, and brine disposal, as well as fixed costs such as labor, permit compliance, indirect costs, and maintenance. Potential mitigation costs associated with intake and outfall permitting requirements and environmental mitigation are not included and would require site-specific evaluation during future project development. Table 1 provides a side-by-side cost comparison for the top three ranked sites.

Table 1: Side-by-Side Cost Comparison

Site	Capacity	Capital Cost	Annual O&M Cost	Annualized Cost	Unit Cost ($/AF)
Doheny	10 mgd	$448–569M	$19M	$49–56M	$4,300–$5,000
Port Hueneme	20 mgd	$1.35–1.66B	$39M	$127–147M	$5,700–$6,600
El Segundo	10 mgd	$573–745M	$19M	$57–68M	$5,100–$6,100

Note: Costs shown exclude conveyance and distribution infrastructure beyond that identified to connect the plant to the system integration tie-in points, and environmental/other project mitigation costs. Land acquisition is included only where explicitly stated (e.g., El Segundo).

Doheny Expansion – 10 mgd

The potential 10 mgd Doheny Expansion would use additional slant wells to bring the current 5 mgd facility up to 15 mgd. The current 5 mgd phase of the project is estimated to go online in 2029. Brine would be discharged through the existing San Juan Creek Ocean Outfall, commingling with wastewater effluent, consistent with the Streamlining Report. Treated desalinated water produced at Doheny could be integrated into the Joint Transmission Main, the Water Importation Pipeline, or the South County Pipeline, providing multiple options to serve South Orange County. For the purposes of the cost estimate, it was assumed that this conveyance integration includes one mile of new pipeline and two pump stations. There is also a potential 5 mgd direct potable reuse component that could be co-developed with the Doheny Expansion, bringing the facility's total to 20 mgd. CDM recommends that Metropolitan continue coordinating with SCWD and MWDOC to monitor project development and gather insights applicable to a future expansion.

Port Hueneme – 20 mgd

The potential 20 mgd Port Hueneme facility would feature subsurface slant wells and brine discharge through the Oxnard Wastewater Treatment Facility outfall. Because Port Hueneme lies at the western edge of Metropolitan's service territory, system integration is achieved by conveying treated water 30 miles to Calleguas' primary distribution hub at the Lake Bard Water Filtration Plant. For the purposes of the cost estimate, it was assumed that this conveyance integration includes 30 miles of new pipeline and three pump stations to move the water to Lake Bard. CDM recommends additional research on refining the technical feasibility of subsurface slant wells through a targeted hydrogeologic investigation. Collaborative studies with Calleguas and the United States Navy could identify data gaps and opportunities for shared infrastructure.

El Segundo – 10 mgd

The potential 10 mgd El Segundo facility would rely on subsurface slant wells located near the Chevron Refinery site. Brine would be commingled with treated effluent discharged through the Hyperion Water Reclamation Plant (Hyperion) outfall. Treated water from El Segundo would be integrated directly into Metropolitan's West Coast Feeder. For the purposes of the cost estimate, it was assumed that this conveyance integration includes two miles of new pipeline and one pump station to move the water to the West Coast Feeder. The El Segundo site was originally sized at 20 mgd but was limited to 10 mgd due to concerns about land availability. CDM recommends that Metropolitan continue monitoring progress on the Pure Water LA program, with particular attention to how the use of Hyperion's effluent may evolve.

Conclusion

CDM's reconnaissance study provides Metropolitan with a regional assessment of the potential for seawater desalination under the State's criteria for the streamlined permitting track (**Attachment 3** – Seawater Desal Research Study Final Report). After evaluating 12 possible project configurations and different intake and treatment approaches, the study identified three sites, Doheny Expansion, Port Hueneme, and El Segundo, as the highest-ranked technically feasible options. These sites use subsurface intakes, have nearby wastewater outfalls for brine commingling, and can be integrated into existing distribution networks. Their configurations meet the State's criteria for a streamlined permitting track, but as a result, the potential projects have limited capacities. Overall, they provide Metropolitan's CAMP4W with three conceptual projects that may be used in future portfolio assessments.

7/30/2026

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7/30/2026

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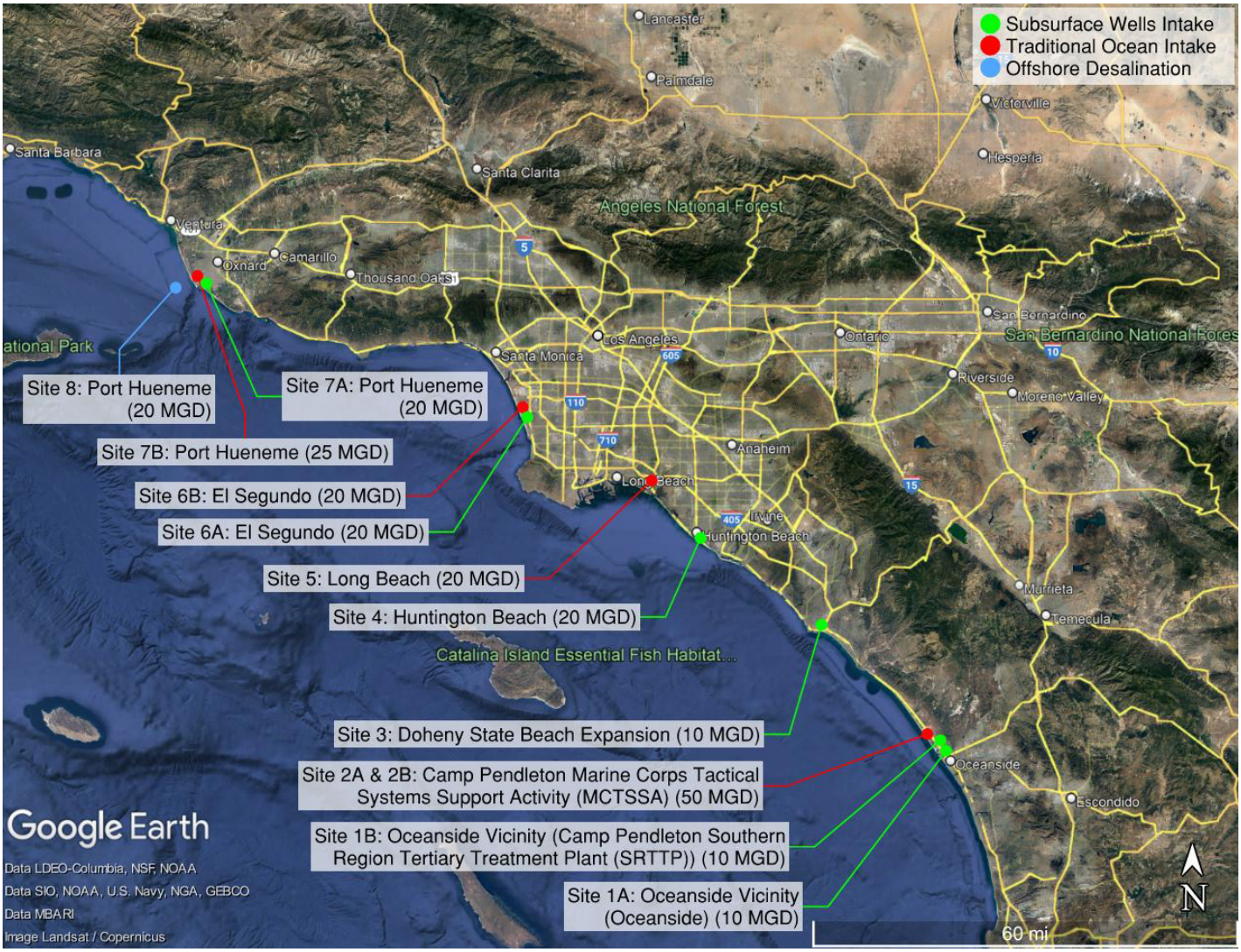
Attachment 1 – Potential Seawater Desalination Sites

Attachment 2 – Site-Specific Fact Sheets

Attachment 3 – Seawater Desal Research Study Final Report

Ref# wrm12711299

Potential Seawater Desalination Sites with Supply Production



The map above shows the 12 original potential sites evaluated and ranked using CDM Smith's multi-criteria decision analysis (MCDA) framework. The El Segundo site was originally sized at 20 mgd but was limited to 10 mgd due to concerns about land availability.

Subsurface Intakes: The state's preferred intake technology. For this study, slant wells were selected as the specific subsurface intake type. Other types of subsurface well intakes include vertical beach wells, horizontal directionally drilled wells, radial collector wells, and infiltration galleries.

Traditional Ocean Intake: Traditional screened open ocean intakes collect seawater directly from the ocean via offshore inlet structures. The majority of large seawater desalination facilities worldwide use this intake method. California regulations for open-ocean intakes require 1 mm slot screens and intake velocities below 0.5 feet per second.

Offshore Desalination: Site 8 included offshore seabed pods as the intake system. This potential site reflected the current technologies being developed by OceanWell, Flocean, and Waterise. Other offshore desalination technologies float on the surface (SeaWell) and utilize wave power (Oneka).

Site-Specific Fact Sheets

Doheny Ocean Desal Project Expansion

Location: Dana Point, CA; co-located with the current Doheny Ocean Desalination Project

Capacity: 10 mgd (Bringing the facility total to 15 mgd)

Intake: 6 new slant wells

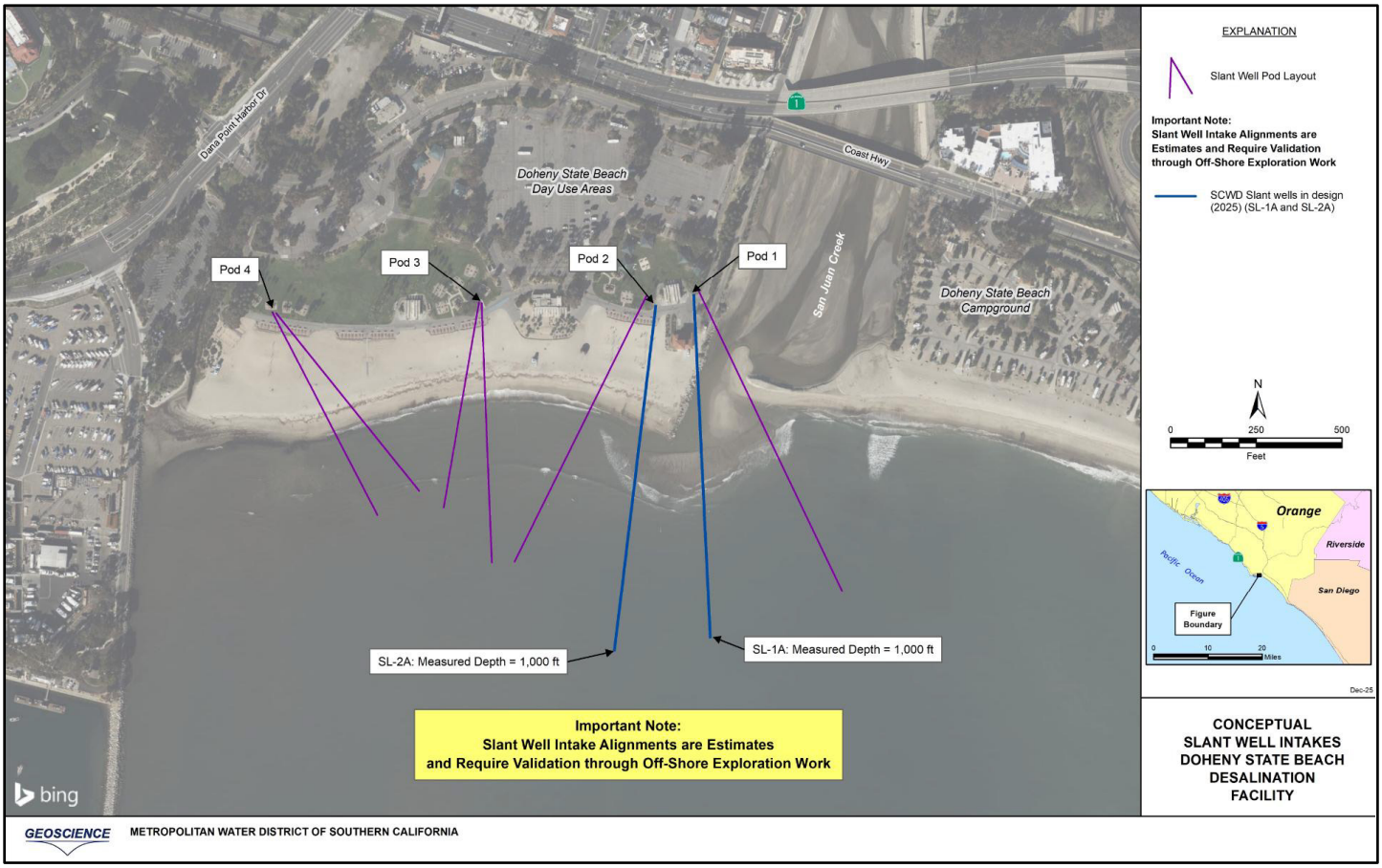
Outfall: San Juan Creek Ocean Outfall (Owned by South Orange County Wastewater Authority)

Integration: Two options

1. Two pump stations (1,010 ft of head) co-located at the desalination plant, one of which would tie-in to the existing Joint Transmission Main (JTM) and the other to the existing Water Importation Pipeline (WIP). Approximately 3,400 LF of new pipe.
2. Three pump stations (1,980 ft of head) would be required, two at the desalination plant and one at the Tri-Cities Pressure Regulating Station. This option would allow the new supply to be conveyed to the JTM, the WIP, and the South County Pipeline, which is accessed through the WIP pipeline. Approximately 5,900 LF of new pipe.

Capital Cost: $448-569 Million (Class 5 opinions of probable construction cost encompassing raw water intake, treatment technologies, brine concentrate disposal, and conveyance)

Unit Cost: $4,300-5,000 per acre foot (Excluding mitigation and land costs)



Port Hueneme

Location: Naval Base Ventura County (Port Hueneme, CA)

Capacity: 20 mgd

Intake: 20 new slant wells

Outfall: Oxnard WWTP Outfall (Owned by the City of Oxnard)

New Pipe: 9,600 LF of 24-inch pipe (between well pods), 12,300 LF of mixed 42-inch and 24-inch pipe (well pods to facility), and 153,100 LF of 40-inch pipe (facility to LBWFP).

Pump Stations: 3 pump stations (1,218 ft of head)

Integration: Lake Bard Water Filtration Plant (LBWFP) clear wells

Capital Cost: $1.35-1.66 Billion (Class 5 opinions of probable construction cost encompassing raw water intake, treatment technologies, brine concentrate disposal, and conveyance)

Unit Cost: $5,700-6,600 per acre foot (Excluding mitigation and land costs)

El Segundo

Location: Chevron Refinery (El Segundo, CA). The initial screening assumed that the El Segundo Power Plant site would be available for redevelopment. However, NRG Energy indicated that this will not be feasible at this time. Multiple sites at the adjacent Chevron Refinery and Scattergood Generating Station were identified as potential alternatives.

Capacity: 10 mgd (Reduced from 20 mgd due to land availability concerns)

Intake: 9 new slant wells

Outfall: Hyperion Water Reclamation Plant Ocean Outfall (Owned by the city of Los Angeles)

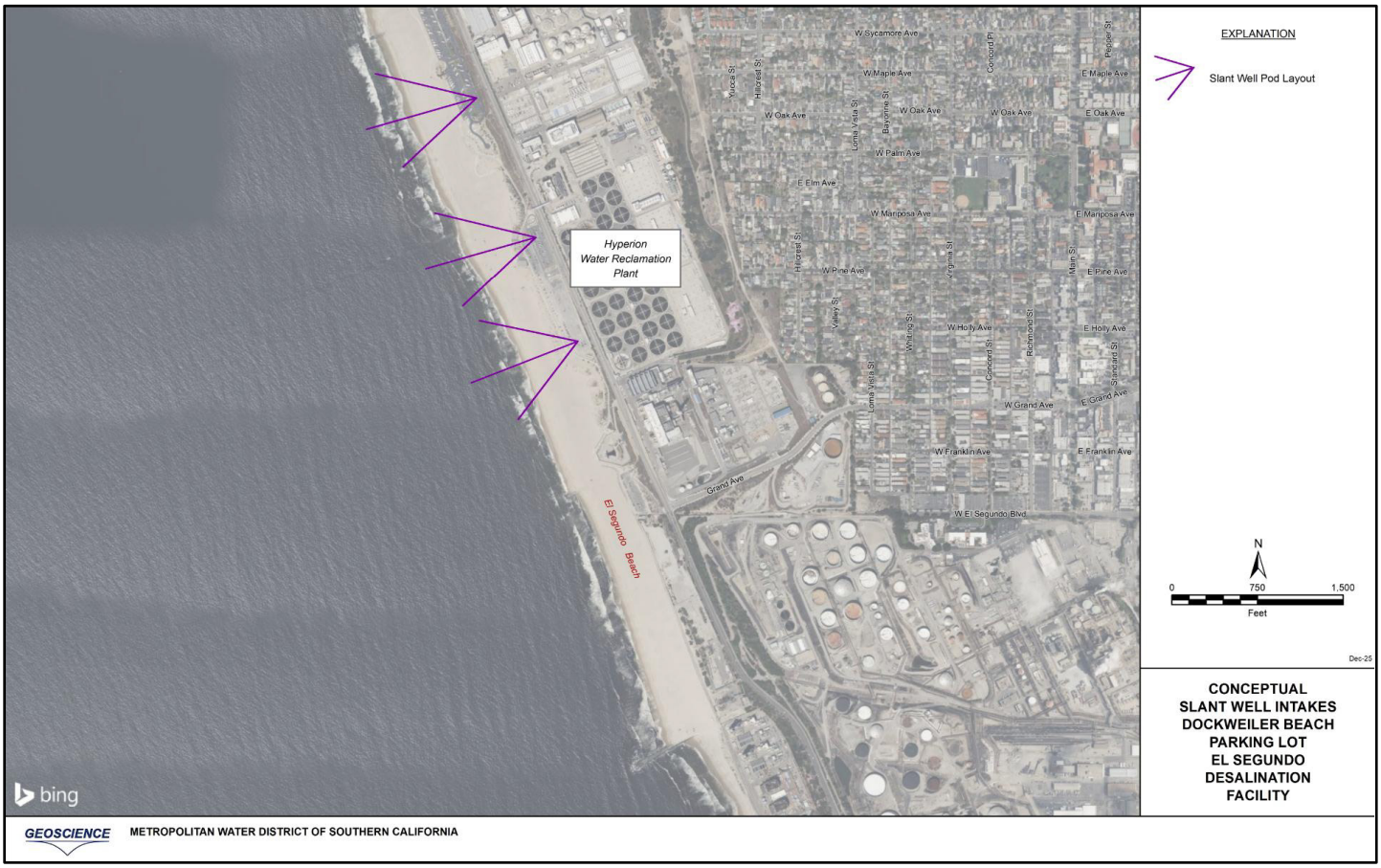
New Pipe: 4,000 LF of 30-inch pipe (slant wells to facility), 8,700 LF of 24-inch pipe (facility to outfall), 10,600 LF of 24-inch pipe (facility to WC Feeder).

Pump Station: 1 pump station (720 ft of head)

Integration: MWD West Coast Feeder

Capital Cost: $573-745 Million (Class 5 opinions of probable construction cost encompassing raw water intake, treatment technologies, brine concentrate disposal, and conveyance)

Unit Cost: $5,100-6,100 per acre foot (Excluding mitigation costs)



SEAWATER DESALINATION RESEARCH STUDY

REPORT

JUNE 2026

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Acknowledgements

Metropolitan and CDM would like to thank the following agencies for their extensive coordination and review:

Calleguas Municipal Water District
Municipal Water District of Orange County
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Long Beach Utilities
Los Angeles Department of Water and Power
San Diego County Water Authority

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Appendix C Cost Summary from Siting Study

Appendix D Environmental Impact Maps

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Appendix G Opinion of Probable Construction Cost of the Three Top-Ranked Sites

Appendix H Total Cost Summary of the Three Top-Ranked Sites

Acronyms and Abbreviations

°C	degrees Celsius
%	percent
$/AF	dollars per acre-foot
AACE	Association for the Advancement of Cost Engineering
ADC	Affordable Desalination Collaboration
AES	Applied Energy Services
AI	Artificial Intelligence
APF	Area of Production Forgone
APN	Assessor Parcel Number
AWPF	Advanced Water Purification Facility
BAT	Best Available Technology
BMZ	Brine Mixing Zone
BOO	Build Own Operate
BOOT	Build Own Operate Transfer
Br^-	Bromide Ion
$Ca(OH)_2$	Lime
$CaCl_2$	Calcium Chloride
$CaCO_3$	Calcium Carbonate
Cal-Am	Cal American Water
CAMP4W	Climate Adaption Master Plan for Water
CAP	Climate Action Plan
CAP	Central Arizona Project
CARB	California Air Resources Board
CCC	California Coastal Commission
CCPP	Calcium Carbonate Precipitation Potential
CCRO	Closed-Circuit Reverse Osmosis
CDI	Capacitive Deionization
CDPs	Costal Development Permits

CEQA	California Environmental Quality Act
CFE	Existing Power Generation Facility
CM	Construction Manager
CMAR	Construction Manager at Risk
CO_2	Carbon Dioxide
Commission	California Coastal Commission
CSDIG	California Seawater Desalination Interagency Group
CSMR	Chloride-to-Sulfate Mass Ration
Cu+	Cuprous Ions
$Cu_2(OH_2)CO_{3(s)}$	Blue-green malachite
Cu^{2+}	Cupric Ions
$Cu_2O_{(s)}$	Reddish-brown cuprite
CuO (s)	Blank tenorite
CWA	County Water Authority
DAC	Disadvantaged Communities
DB	Design-Build
DBB	Design-Bid-Build
DBO	Design-Build-Operate
DBOM	Design-Build-Operate and Maintenance
DBPs	Disinfection by-products
DDW	Division of Drinking Water
DEMWAX	Depth Exposed Membrane for Water Extraction
DH-DS1	Doheny Pump Station 1
DH-DS2	Doheny Pump Station 2
DH-DS3	Doheny Pump Station 3
DH-DS4	Doheny Pump Station 4
DODP	Doheny Ocean Desalination Project
DOE	Department of Energy
DPR	Direct Potable Reuse
DWR	Department of Water Resources

EBB	Extraction Barrier and Brackish Water
ED	Electrodialysis
EIR	Environmental Impact Report
EIS	Environmentally Sensitive Index
EPA	Environmental Protection Agency
EPCM	Engineering, Procurement, Construction and Management
ERD	Energy Recovery Devices
ERI	Energy Recovery Inc
ES-PS1	El Segundo Pump Station 1
ETM	Empirical Transport Model
EWM	Enviro Water Mineral Company
FO	Forward Osmosis
FRRO	Flow Reversal Reverse Osmosis
ft^2	Square Foot
GFD	Gallons per Square Foot per Day
GHG	Greenhouse Gases
GIS	Geographic Information System
GMF	Granular Media Filtration
GMP	Guaranteed Maximum Price
GPD	Gallons per Day
GPM	Gallons per Minute
H2SO4	Sulfuric Acid
HAAs	Haloacetic Acids
HDPE	High-Density Polyethylene
HGL	Hydraulic Grade Line
HID	Hydraulic Injection Desalination
HOBr	Hypobromous Acid
HOCl	Hypochlorous Acid
HRS	High Recovery Systems
Hyperion	Hyperion Water Reclamation Plant

I&C	Instrumentation and Control
IBank	Infrastructure and Economic Development Bank
ICS	Intentionally Created Surplus
IRP	Integrated Resources Plan
IWRP	Integrated Water Resources Plan
IX	Ion Exchange
JRWSS	Joint Regional Water Supply System
JTM	Joint Transmission Main
kW	Kilowatt
kW/m^3	Kilowatts per Cubic Meter
kWh	Kilowatt-Hour
kWh/m^3	Kilowatt-Hour per Cubic Meter
LASAN	Los Angeles Bureau of Sanitation
LBCWD	Laguna Beach County Water District
LBWFP	Lake Bard Water Filtration
LCP	Local Coastal Program
LF	Linear Feet
LSI	Langelier Saturation Index
LPF4	Las Posas Feeder Unit 4
LVMWD	Las Virgenes Municipal Water District
MAF	Million Acre-Feet
MCDA	Multi-Criteria Decision Analysis
MCTSSA	Camp Pendleton Marine Corps Tactical Systems Support Activity Center
MD	Membrane Distillation
MED	Multiple Effect Distillation
MEDRC	Middle East Desalination Research Center
Metropolitan	Metropolitan Water District of Southern California
MF	Microfiltration
MG	Million Gallon
MGD	Million Gallons per Day

mg/L	Milligrams per Liter
MHHW	Mean Higher High Water
MIT	Massachusetts Institute of Technology
MOU	Memorandum of Understanding
MPA	Marine Protected Area
MRP	Monitoring and Reporting Plan
MSF	Multi-Stage Flash Distillation
MTBM	Micro Tunnel Boring Machine
MW	Megawatt
MWDOC	Municipal Water District of Orange County
NaOH	Caustic Soda
NAWI	National Alliance for Water Innovation
NEPA	National Environmental Policy Act
NF	Nanofiltration
NH_2Br	Monobromamine
NOFO	Notice of Funding Opportunity
NOV	National Oilwell Varco
NQAA	National Oceanic Acid and Atmospheric Administration
NRG	Energy
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
OA	Owners Agent
OAE	Ocean Alkalinity Enhancement
OCED	Organization for Economic Co-Operation and Development
Ocean Plan	Water Quality Control Plan for Ocean Waters of California
OH&P	Overhead and Profit
OPCC	Opinion of Probable Construction Cost
P3	Public Private Partnership
$PbCO_3$	Lead Carbonate Cerussite
$Pb_3(CO_3)_2(OH)_2$	Hydrocerussite

PD	Positive Displacement
PDB	Progressive Design Build
PH-PS1	Pump Station 1
PH-PS2	Pump Station 2
PRO	Pressure Retarded Reverse Osmosis
PRS	Pressure Regulating Stations
PS	Pump Station
PSI	Pounds per Square Inch
PPP	Public Private Partnership
PPT	Parts per Thousand
PWLA	Pure Water Los Angeles
PWSC	Pure Water Southern California
Regional Water Board	Regional Water Quality Control Board
ROC	Reverse Osmosis Concentrate
RO	Reverse Osmosis
RRWP	Regional Recycled Water Program
Scattergood	Scattergood Generating Station
SC	Office of Science
SCE	Southern California Edison
SCWD	South Coast Water District
SDCWA	San Diego County Water Authority
SDI	Silt Density Index
SDWA	Safe Drinking Water Act
SJCOO	San Juan Creek Ocean Outfall
SLR	Sea Level Rise
SMP	Salinity Management Pipeline
SMWD	Santa Margarita Water District
SNWA	Southern Nevada Water Authority
SOCWA	South Orange County Wastewater Authority
SRTTP	Camp Pendleton Southern Region Tertiary Treatment Plant

SSI	Subsurface Seawater Intake
SSI	Subsurface Slant Well Intakes
State Water Board	State Water Resources Control Board
STD	Solar Thermal Desalination
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWRO	Seawater Reverse Osmosis
TDS	Total Dissolved Solids
TH	Total Head
THMs	Trihalomethanes
TMs	Technical Memoranda
TOC	Total Organic Carbon
Tolt	Tolt Water Treatment Plant
TRL	Technology Readiness Level
VFD	Variable Frequency Drive
W/m^2	Watts per Square Meter
WBMWD	West Basin Municipal Water District
WDR	Water Discharge Requirement
WEC	Wave Energy Converter
WET	West to East Transmission
WF1	Water Farm 1
WGA	Water Global Access
WIFIA	Water Infrastructure and Innovation Act
WIP	Water Importation Pipeline
WPA	Water Purchase Agreement
WQ	Water Quality
WQTS	Water Quality & Treatment Solutions
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant
WW	Wastewater

WWS	Wedgewire Screens

Executive Summary

The Metropolitan Water District of Southern California (Metropolitan) initiated the Seawater Desalination Research Study to evaluate the role that seawater desalination could play in enhancing long-term water supply reliability and regional resilience. This effort is part of Metropolitan's broader strategy to adapt to the impacts of climate change including increasing drought frequency and severity, evolving regulatory conditions, and growing uncertainty in traditional imported water supplies under its Climate Adaptation Master Plan for Water (CAMP4W). As an input to CAMP4W, Metropolitan also launched two research efforts to study brackish groundwater and seawater desalination opportunities, with CDM Smith selected to conduct the seawater desalination study.

The study is also informed by statewide policy drivers, including California's Water Resilience Portfolio, which emphasizes diversification of climate-resilient water supplies, and the State's greenhouse gas reduction framework established under Assembly Bill 32 that emphasizes consideration of energy use and emissions in future water supply investments. The study was designed to examine the technical, environmental, regulatory, and economic feasibility of developing one or more seawater desalination facilities that could supplement existing and planned regional water supply portfolios while minimizing environmental impacts and maximizing partnership opportunities. This effort is a planning-level research study intended to inform long-term strategic decision-making.

In addition, consistent with the California Seawater Desalination Interagency Group's "Seawater Desalination Siting and Streamlining Report to Expedite Permitting" (California Environmental Protection Agency 2023), Metropolitan would prioritize potential projects that align with the State's recommended siting criteria and streamlining pathways. Projects that leverage existing intake and outfall infrastructure, minimize marine and coastal impacts, demonstrate technology readiness, and integrate with regional water management strategies are more likely to advance efficiently through California's regulatory framework. Aligning future desalination investments with the State's streamlining recommendations can help reduce permitting uncertainty, improve interagency coordination, and support timely implementation of climate-resilient water supplies.

Southern California's water supply reliability has historically been supplemented by imported water sources from the Colorado River via Metropolitan's Colorado River Aqueduct (CRA) and the Sacramento–San Joaquin River Delta (Delta) via California's State Water Project (SWP) system. Both imported water sources face increasing vulnerability due to declining snowpack, more frequent and severe droughts, and environmental regulatory constraints. At the same time, the state's regulatory framework for seawater desalination has evolved significantly since the adoption of the 2015 Ocean Plan Amendment.

The research study began with a literature review of seawater desalination projects, both studied and executed in Southern California, and an extensive assessment of emerging desalination technologies. The literature review focused on prior seawater desalination studies and projects within Southern California and comparable coastal regions, with emphasis on intake and discharge technologies, permitting and environmental challenges, energy use, and operational performance. Lessons learned from pilot studies, full-scale facilities, and regulatory reviews were synthesized to identify recurring

technical and policy considerations that have influenced project feasibility, cost, and implementation timelines. These findings were used to inform subsequent siting, cost, and regulatory evaluations.

The emerging technologies evaluation examined innovative and developing approaches related to desalination treatment processes, subsurface and offshore intake concepts, brine management strategies, energy recovery, and alternative power integration. Each technology was assessed using a Technology Readiness Level (TRL) framework to distinguish between commercially proven solutions and those requiring additional piloting or demonstration. This evaluation provides context on how future advancements could reduce environmental impacts, improve efficiency, or expand feasible siting options for seawater desalination.

Twelve potential seawater desalination alternatives were initially evaluated, extending from San Diego to Ventura Counties within Metropolitan's service area. Metropolitan reached out to the following agencies for guidance in identifying potential areas that could be suitable for seawater desalination: Calleguas Municipal Water District, Long Beach Utilities, Los Angeles Department of Water and Power, Municipal Water District of Orange County, San Diego County Water Authority, South Coast Water District, and West Basin Municipal Water District.

For each site, planning-level engineering and parametric analysis was used to represent various intake, treatment, and brine discharge facilities with water supply yields ranging from 10 to 50 million gallons per day (MGD). Using MCDA, the ranking of potential sites is presented in **Figure ES.1.1**.

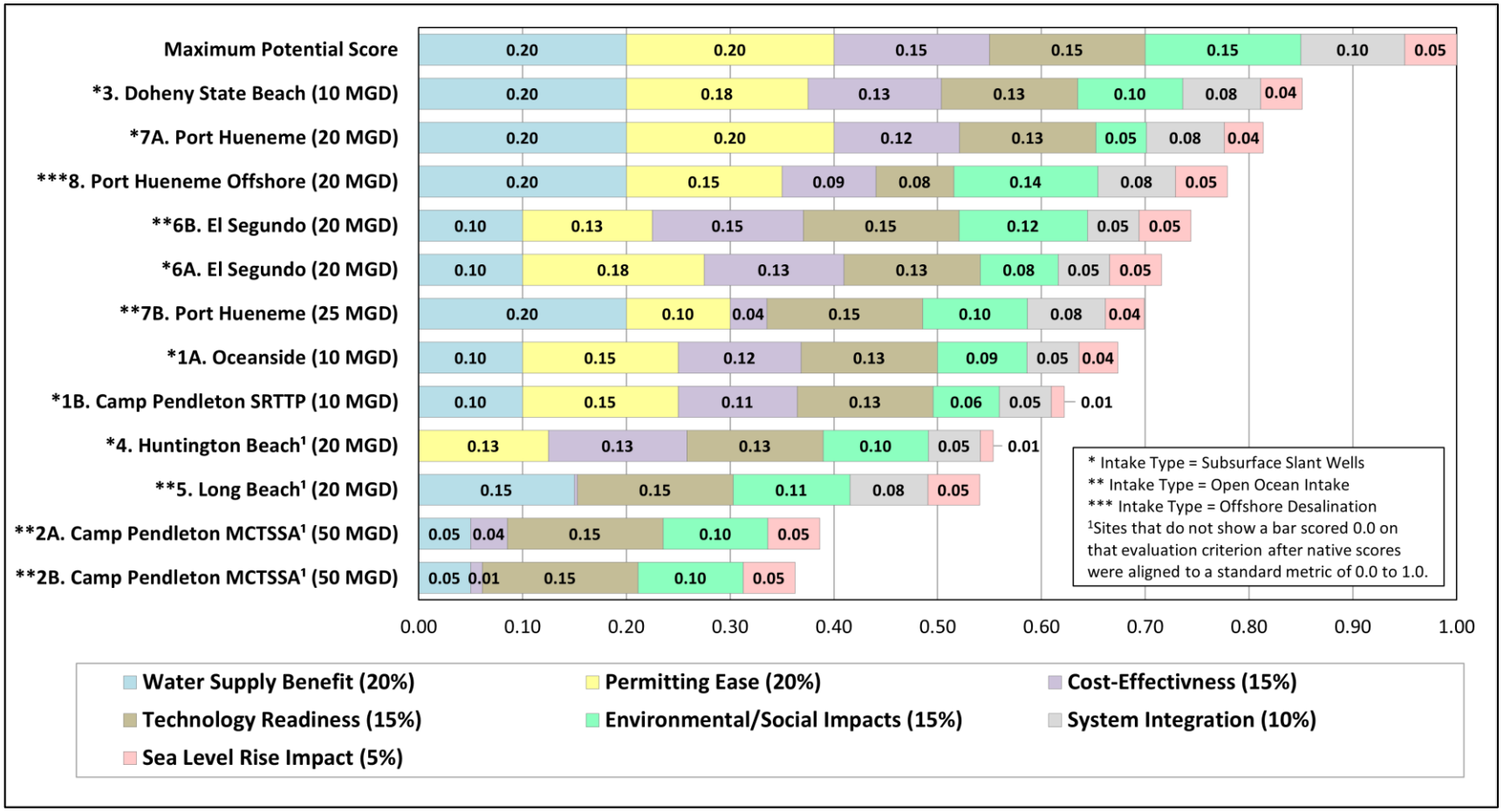


Figure ES.1.1 Ranking of Seawater Desalination Alternatives

Note: The larger the color bar, the better it scores for the criteria shown. If a bar segment is not shown, then the performance criteria was zero.

In **Figure ES.1**, the color bars and their length represent the relative performance of the potential sites for seven criteria—with the criteria weights shown as percentages in the figure legend. This MCDA evaluation easily shows trade-offs between the different sites. For example, while Site 8 (Port Hueneme Offshore, with deep seabed pods) offers the best scores for water supply benefit and environmental/social impact, it does not score as well as Site 3 (Doheny State Beach, with subsurface slant wells) for cost-effectiveness and technology readiness. It should be noted that the relative rankings are dependent on the assumed weighting of evaluation criteria, and changes to those weights could result in different overall site rankings.

The results of the evaluation of potential sites indicate:

- Site 3: Doheny State Beach Expansion of the Planned 5-mgd Plant with Additional Subsurface Slant Wells and Use of Existing Wastewater Outfall (10 mgd) is ranked highest due to its water supply benefit, cost-effectiveness, permitting and system integration ease.
- Site 7A: Port Hueneme with Subsurface Slant Wells and Use of Existing Wastewater Outfall (20 mgd) is ranked second, for many of the same reasons as the Doheny State Beach site.
- Site 8: Port Hueneme with Offshore Seabed Pods (20 mgd) is ranked third, mainly due to its technical readiness and permitting uncertainty.
- Site 6B: El Segundo with Existing Power Intake and Use of Existing Wastewater Outfall (20 mgd) is ranked fourth, mainly due to its water supply benefit and permitting uncertainty.

While the offshore technology using seabed pods off the coast of Port Hueneme Ranked #3 and looks promising, this is still an emerging technology. As such, it received a TRL score of 5, which signifies it is mid-stage in development and would require further piloting and performance validation prior to consideration for large-scale deployment. As there are planned efforts for full demonstration of this technology in the coming years, it is recommended that Metropolitan revisit this siting analysis if the technology meets regulatory and permitting requirements.

During refinement of the El Segundo alternative, Site 6A was advanced over Site 6B after updated information confirmed that the originally assumed location and intake configuration for Site 6B were not feasible for long-term desalination development. Once that location was eliminated, the project team revisited sites previously evaluated in the Ocean Water Desalination Project Draft Environmental Impact Report (West Basin Municipal Water District 2018) to identify nearby viable alternatives. This reassessment determined that a location on the adjacent Chevron Refinery property was the most suitable remaining option. However, the available footprint at this site could only accommodate a facility up to approximately 10 mgd, which required reducing the assumed plant capacity from 20 mgd. In addition, because use of the El Segundo Power Plant cooling water intake was no longer feasible, the intake approach was revised from an open ocean intake to subsurface slant wells. Based on these combined siting, footprint, and intake constraints, Site 6A replaced Site 6B as the representative El Segundo alternative carried forward for further evaluation.

Among the sites with proven technology, these three potential projects were identified for detailed analysis:

- Site 3: Doheny State Beach Expansion of the Planned 5-mgd Plant with Additional Subsurface Slant Wells and Use of Existing Wastewater Outfall (10 mgd).
- Site 7A: Port Hueneme with Subsurface Slant Wells and Use of Existing Wastewater Outfall (20 mgd).
- Site 6A: El Segundo with Subsurface Slant Wells and Use of Existing Wastewater Outfall (10 mgd).

A potential future 10-mgd Doheny State Beach expansion would employ subsurface slant wells. Treated water from the potential Doheny seawater desalination plant could be delivered to South Coast Water District (SCWD) and potentially other south Orange County retail agencies, helping offset imported water demand and enhancing local supply reliability. The project would also utilize an existing wastewater outfall for brine discharge, reducing both cost and permitting complexity.

A potential 20-mgd Port Hueneme seawater desalination plant would utilize subsurface slant wells. The potential project would discharge to the existing Oxnard wastewater outfall and deliver product water to the Calleguas Municipal Water District (Calleguas) system through the Lake Bard Water Filtration Plant. This central distribution strategy would enable delivery to both the Upper and Lower Zones of Calleguas's service area, enhancing flexibility and operational resilience. The potential site's proximity to the Port Hueneme Naval Base offers a unique opportunity for coordination related to infrastructure siting, construction access, system redundancy, and potential capital participation to enhance supply reliability for critical federal facilities. Any cost-sharing or partnership structure would require further evaluation in coordination with Calleguas and the U.S. Navy to align with existing service arrangements and institutional roles.

A potential 10-mgd El Segundo facility would be located near the local Chevron Refinery. Subsurface slant wells were assumed for the intake system. Product water from the potential El Segundo seawater desalination plant could be integrated into existing Metropolitan infrastructure. Coordination with the City of Los Angeles' Pure Water Los Angeles (PWLA) program would be essential, as future wastewater reuse could reduce available blending opportunities at the Hyperion outfall.

To support evaluation of the top three sites, a focused regulatory evaluation was conducted to assess permitting pathways, regulatory constraints, and environmental compliance considerations specific to each project. The regulatory evaluation reviewed consistency with the State Water Resources Control Board (SWRCB) Ocean Plan, Coastal Act requirements, California Environmental Quality Act (CEQA) processes, and anticipated agency coordination needs, including engagement with the California Coastal Commission (CCC), Regional Water Quality Control Boards, and local jurisdictions. Findings from the regulatory evaluation were used to inform comparative site feasibility, schedule assumptions, and overall project risk considerations presented in this study.

Water quality and system integration analyses found that desalinated water from all three potential sites could be treated to meet Metropolitan's potable water quality standards and effectively blended into existing regional distribution networks. The study identified potential tie-in locations, hydraulic capacities, and operational strategies to evaluate potential compatibility with existing infrastructure.

The cost information presented reflects planning-level, Association for the Advancement of Cost Engineering (AACE) Class 5 screening estimates developed for comparative evaluation purposes only. As conceptual estimates prepared at an early stage of project definition, these opinions of probable construction cost are subject to significant uncertainty and carry an expected accuracy range of -50% to +100%. It is important to note that these capital cost estimates exclude conveyance and distribution infrastructure beyond the defined system integration tie-in points, as well as site-specific land acquisition. As a result, total program costs to deliver water to specific demand areas may be materially higher than the values presented; however, these estimates allow comparison of the alternative for planning-level purposes. Cost estimates for capital and O&M costs are summarized in **Table ES.1** and further detailed in **Appendix H**. Capital costs are class 5 opinions of probable construction cost encompassing raw water intake, treatment technologies, brine concentrate disposal, and conveyance were developed for the top three sites. O&M costs include variable costs such as energy, chemicals, membrane replacement, waste disposal as well as fixed costs such as labor, permit compliance, indirect costs, and maintenance.

Table ES.1 Estimates Total and Unit Capital Cost Summary for Top Three Sites[1]

Site	Capacity (mgd)	Estimated Capital Cost (Low-High)	Unit Capital Cost ($M/mgd)	Unit Capital Cost ($K/AFY)	Annualized Capital Cost ($M/yr)	Estimated O&M Cost ($M/yr)	Total Annualized Cost ($/AF)
Doheny[2]	10	$448-569M	$45-57	$40-51	$29-37	$19	$4,300-5,000
Port Hueneme	20	$1.35-1.66B	$68-83	$60-74	$88-108	$39	$5,700-6,600
El Segundo	10	$573-745M	$57-75	$51-67	$37-48	$19	$5,100-6,100

[1]Note: Costs shown exclude conveyance and distribution infrastructure beyond identified system integration tie-in points. Land acquisition is included only where explicitly stated (e.g., El Segundo).

[2]Doheny capacity is for expansion over the existing planned 5 mgd capacity.

Implementation schedules were developed to reflect anticipated durations for environmental review, permitting, design, and construction, accounting for each potential site's unique regulatory complexity and coordination needs. Estimated project timelines are summarized in **Table ES.2**.

Table ES.2 Comparative Estimated Timelines for Top Three Sites

Site	Feasibility/ Environmental	Permitting/ Design	Bidding and Construction	Total Estimated Duration
Doheny	4 years	2 years	3.5 years	9.5 years
Port Hueneme	4 years	4 years	4.5 years	12.5 years
El Segundo	4 years	3 years	3.5 years	10.5 years

In parallel with technical evaluations, the study identified funding and partnership opportunities to support potential future seawater desalination facilities. Available funding mechanisms include federal and state programs, along with potential low-interest financing through the State Revolving Fund. Partnership opportunities include collaboration with regional agencies such as Calleguas, SCWD and other member agencies, and potential coordination with private entities.

The Seawater Desalination Research Study demonstrates that seawater desalination is a viable and adaptable option for enhancing regional water supply reliability under increasingly variable climate conditions. The three potential project sites represent a diverse cross-section of technical, regulatory, and partnership contexts that can guide future seawater desalination planning across Southern California. The Seawater Desalination Research Study indicates, at a planning level, that seawater desalination could be a viable and adaptable option for enhancing regional water supply reliability under increasingly variable climate conditions.

Moving forward, Metropolitan could continue coordinating with SCWD, which is serving as the Lead Agency for the Doheny Ocean Desalination Project (DODP), to monitor facility development and assess opportunities for regional collaboration. SCWD anticipates participation from two additional public agency partners that would invest in and receive water supplied from the project. Metropolitan could evaluate potential policy alignment, regional integration considerations, and any future cost-sharing or wheeling roles as appropriate.

For the potential Port Hueneme seawater desalination project, additional research could refine the feasibility of subsurface slant wells through hydrogeologic investigation and evaluate alternative intake concepts such as offshore desalination in collaboration with Calleguas and the U.S. Navy. For the potential El Segundo seawater desalination project, Metropolitan could monitor progress on the City of Los Angeles' PWLA program to assess evolving conditions at the Hyperion WWTP outfall that may influence future desalination permitting and blending options.

These continued research and partnership efforts will provide valuable data and policy insight to guide Metropolitan's long-term planning for potential seawater desalination and regional water-supply diversification.

1.0 Introduction

1.1 Metropolitan's Service Area and Water Supply Reliability

Metropolitan is a regional wholesale water provider that delivers treated and untreated water to 26 member agencies serving nearly 19 million people across Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties. Metropolitan imports water primarily from two major sources: the Colorado River via its CRA and the Delta via California's SWP system. These imported supplies have historically provided the backbone of Southern California's water reliability. However, both sources face increasing stress from more frequent and severe droughts, shifts in precipitation patterns, reduced mountain snowpack, and rising temperatures, all of which are likely to be exacerbated by climate change. At the same time, population growth and evolving regulatory requirements further challenge supply reliability.

To address these issues, Metropolitan has developed long-term planning strategies that emphasize water supply diversification and resiliency. The Integrated Resources Plan (IRP) set the foundation for evaluating existing and new local and regional supplies, and CAMP4W builds on this foundation by identifying projects and programs to enhance resiliency and adaptation. Seawater desalination is one of the potential supply options under consideration for Metropolitan's CAMP4W, complementing its investments in a diversified portfolio such as water use efficiency, recycled water, groundwater recovery, water transfers/banking, and storage.

In alignment with state efforts to diversify and strengthen water supply reliability, the California Seawater Desalination Interagency Group released the "Seawater Desalination Siting and Streamlining Report to Expedite Permitting" (California Environmental Protection Agency 2023). This report provides recommended siting criteria and identifies pathways to streamline permitting processes for seawater desalination facilities under California's regulatory framework. Consistent with these state-led streamlining efforts, a key priority of the research study was to identify and evaluate potential projects that align with the report's recommended siting principles and permitting considerations. Its findings reinforce the importance of thoughtful siting, environmental protection, and integrated water resource planning in advancing seawater desalination as a local supply option.

1.2 Objectives

The primary objective of this study is to evaluate the potential role of seawater desalination in enhancing the long-term reliability of Metropolitan's water supply portfolio. Specifically, the study seeks to:

- Review prior seawater desalination work by Metropolitan and other parties to inform this project
- Summarize emerging desalination and related technologies that may influence future project feasibility, performance, and sustainability.
- Identify and evaluate potential sites for seawater desalination facilities within Metropolitan's service area using MCDA that considers water supply benefits, cost-effectiveness, permitting

feasibility, environmental and social justice impacts, technology readiness, system integration, and sea level rise vulnerabilities to short-list three top projects.

- Assess treatment requirements and finished water quality, including blending considerations and re-mineralization strategies, to confirm compatibility with Metropolitan's existing treated water distribution system.
- Define system integration approaches for delivering desalinated water into Metropolitan's and its member agencies' systems, including conveyance alignments, pumping requirements, and storage needs.
- Characterize regulatory and permitting pathways that apply to the three potential seawater desalination projects, including intake, outfall, treatment, and distribution considerations.
- Develop planning-level cost estimates and schedules for the three best-suited projects, including capital cost opinions of probable construction cost (OPCC), parametric cost factors, and implementation timelines.
- Explore funding mechanisms, partnership opportunities and alternate project delivery methods that could support project delivery and implementation.

Together, these objectives provide a comprehensive foundation for Metropolitan to assess seawater desalination as a potential component of its CAMP4W and to guide decisions on whether, where, and how to pursue such projects in the future.

This study is intended to support strategic planning and policy discussions under CAMP4W. Analyses were conducted at a conceptual, planning level appropriate for comparative screening and feasibility evaluation. Further technical investigation, environmental review, stakeholder coordination, and detailed engineering would be required prior to advancing any site toward implementation.

1.3 Project Overview

Metropolitan retained CDM Smith to conduct a multi-phase research study on seawater desalination as part of the CAMP4W. The study was organized into discrete tasks, each addressing a critical aspect of project feasibility, and documented through a series of technical memoranda (TMs). Together, these TMs form the technical foundation of this final report.

The work completed under the study included the following:

- TM 1.1 Siting Evaluation: Identified and screened eight potential general sites for seawater desalination in Metropolitan's service area. Using a MCDA framework, sites were evaluated for water supply benefit, cost-effectiveness, permitting ease, environmental and social justice impact, technology readiness, system integration, and sea level rise. Three sites were recommended for further evaluation:
  - Doheny State Beach (10 mgd)
  - Port Hueneme (20 mgd)
  - El Segundo (10 mgd)

- TM 1.2 Literature Review: Summarized global and California seawater desalination practices, including lessons learned from past studies. Topics included intake and outfall technologies, permitting challenges, energy use, and operational considerations.
- TM 1.3 Regulatory Requirements: Assessed regulatory and permitting requirements applicable to seawater desalination in California, including state and federal agency processes, SWRCB's Ocean Plan provisions, CCC, CEQA, greenhouse gas considerations, and site-specific permitting pathways.
- TM 1.4 Cost Estimate: Developed OPCCs for the three recommended sites, with an AACE Class 5 level of accuracy. Included basis of estimate assumptions, site-specific factors, and development of parametric cost factors for application to other sites.
- TM 1.5 Schedule: Prepared planning-level implementation schedules for the three recommended sites. Schedules covered planning, permitting, design, procurement, construction, commissioning, and startup activities.
- TM 2.1-2.3 Partnerships and Financing: Evaluated potential partnership structures, project delivery models, and financing approaches for the three recommended sites. The evaluation reviewed alternative project delivery methods, public-private partnership options, ownership and risk allocation considerations, potential exchange opportunities, and funding mechanisms including grants, loans, and financing. Site-specific partnering strategies were developed for Doheny, El Segundo, and Port Hueneme to inform implementation feasibility and risk management.
- TM 2.4 System Integration and Water Quality: Evaluated how desalinated water could be conveyed and integrated into Metropolitan's distribution system and those of its member agencies from the three recommended sites. The work included pipeline alignment options, pump station design criteria, storage and surge mitigation requirements, and analysis of imported water demands in each service area.
- TM 2.4 Water Quality (Water Quality & Treatment Solutions [WQTS] Sub-Study): Conducted a desktop analysis of re-mineralization requirements for desalinated water at each site. The evaluation identified chemical treatment schemes to restore alkalinity, hardness, and pH, ensuring compatibility with existing Metropolitan treated water and customer plumbing materials.
- TM 3.1 Emerging Technologies: Reviewed innovative and emerging desalination-related technologies, including offshore and floating desalination concepts, alternative treatment processes, brine minimization and valorization, energy recovery advancements, subsurface intakes, and new outfall designs. Each was assigned a TRL to gauge maturity and future applicability.

The work performed under this effort was limited to desktop evaluations, literature review, conceptual engineering assessments, and planning-level cost and schedule development. No field investigations, environmental studies, or preliminary design activities were conducted as part of this research study.

1.4 Structure of Report

This final report compiles and synthesizes the findings from all technical memoranda prepared under the seawater desalination research study. It is organized into the following sections:

Section 1 provides background on Metropolitan's service area and water supply reliability, states the objectives of the study, summarizes the tasks undertaken, and outlines the structure of the report.

Section 2 summarizes global and California desalination practices and key lessons learned from past studies.

Section 3 reviews emerging technologies that may influence future desalination projects.

Section 4 describes the site screening and evaluation process, the criteria used for comparison, and the overall ranking of potential seawater desalination sites.

Section 5 presents the expected quality of desalinated seawater, re-mineralization requirements, and blending considerations and describes how desalinated water could be integrated into Metropolitan's and its member agencies' systems, including conveyance and pumping requirements.

Section 6 reviews the regulatory framework governing seawater desalination projects, including intake, treatment, and outfall requirements, as well as CEQA, greenhouse gas considerations, and site-specific permitting timelines.

Section 7 provides planning-level OPCCs for the recommended sites and outlines estimated project schedules, including permitting, design, procurement, and construction phases.

Section 8 discusses potential partnerships, funding and financing opportunities, and delivery approaches to support implementation of seawater desalination projects.

Section 9 summarizes cost implications, regulatory complexity, system integration considerations, funding opportunities, and potential partnerships, and provides recommendations for Metropolitan's next steps.

2.0 Literature Review

2.1 Literature Review of Seawater Desalination Practices

To support the evaluation of potential future projects, a literature review was conducted to assess and categorize available information on seawater desalination relevant to Metropolitan's service area and broader California and global practices. The review focused on three primary areas:

- Prior studies that evaluated seawater desalination in or adjacent to Metropolitan's service area;
- Seawater desalination projects that have come before the CCC for approval since adoption of the SWRCB's Ocean Plan requirements; and
- Metropolitan's 1993 seawater integration study, which provided insight into the location of key facilities that could potentially be utilized for outfalls and co-located energy sources.

In total, 21 reports were identified and reviewed. Key findings from these studies were compiled and are summarized in **Appendix A**. Of particular relevance to this report are lessons learned regarding energy consumption, siting constraints, major environmental considerations, and subsurface intake technologies. The findings from this literature review provide a foundation for the evaluation of siting alternatives, cost estimation, and regulatory considerations discussed in this report.

2.2 Key Lessons Learned from Past Studies

2.2.1 Intake and Discharge Technologies

A recurring theme throughout past studies and pilot projects is the critical role of intake and discharge design in determining the environmental feasibility and regulatory acceptability of seawater desalination facilities. California's Ocean Plan places strong emphasis on minimizing impacts on marine life, leading to a regulatory preference for subsurface intakes such as slant wells or infiltration galleries where feasible. Pilot studies, including long-term testing at Doheny State Beach, have demonstrated that slant wells can reliably produce high-quality source water with low turbidity and silt density index, although elevated iron and manganese concentrations have presented treatment challenges. At other sites, evaluations of subsurface intakes at scales required for full-size plants have highlighted constructability constraints, limited precedent, and site-specific hydrogeologic challenges.

Where subsurface intakes are not technically feasible, open-ocean intakes with wedgewire screens have been tested as an alternative. Studies at Carlsbad and elsewhere found that while active wedgewire screens can reduce biofouling and improve reliability, they still pose challenges in terms of benthic habitat loss, long-term performance uncertainty, and higher costs. Discharge management is another key issue, with studies consistently emphasizing the need for diffuser systems or commingling with treated wastewater to reduce salinity impacts on marine ecosystems. Collectively, the body of work reviewed demonstrates that intake and discharge remain among the most significant technical, environmental, and permitting considerations for advancing seawater desalination in California.

Key lessons learned from past intake and discharge studies include:

- Slant wells can provide reliable source water quality but may introduce iron and manganese treatment challenges.
- Subsurface intakes face constructability and site-specific feasibility limitations at larger scales.
- Wedgewire screens can control biofouling when actively managed but are costly and raise ecological concerns.
- Brine discharges require careful management through commingling or diffuser systems to minimize salinity and ecological impacts.

2.2.2 Environmental and Permitting Challenges

Environmental impacts and permitting requirements have consistently been major hurdles for seawater desalination projects in California. Regulatory reviews emphasize potential impacts to marine life from intake and discharge systems, energy use, greenhouse gas emissions, and brine disposal. Projects have also encountered permitting delays related to aesthetics, coastal land use, and proximity to sensitive habitats or threatened and endangered species. Coordination among multiple agencies, including the CCC, SWRCB, and Regional Water Quality Control Boards (RWQCBs), adds further complexity to the permitting process.

Recent statewide efforts, such as the California Seawater Desalination Interagency Group's "Seawater Desalination Siting and Streamlining Report to Expedite Permitting" (California EPA 2023), have sought to improve clarity and efficiency by encouraging concurrent agency review and integrated water resource management. Even so, experience from past projects shows that seawater desalination facilities that do not clearly demonstrate need, address environmental justice concerns, and proactively engage stakeholders often face extended permitting timelines or project permit rejection. Collectively, the literature highlights that environmental and permitting considerations remain central to the viability of future projects.

Key lessons learned from past environmental and permitting reviews include:

- Early and meaningful stakeholder engagement is critical to reduce opposition and delays.
- Projects near sensitive habitats face heightened scrutiny and longer review timelines.
- Demonstrating an identified water supply need facilitates regulatory approval.
- Environmental justice considerations, such as water affordability and community impacts, are increasingly important in permitting decisions.
- Coordination among multiple agencies can delay approvals unless concurrent review is pursued.

2.2.3 Energy Use and Operational Considerations

Energy demand remains one of the most significant factors influencing the cost and sustainability of seawater desalination. RO systems are energy intensive compared to other supply options, and energy costs have historically represented a large portion of overall production costs. Pilot studies and collaborative research programs, such as the Affordable Desalination Collaboration (ADC), have demonstrated that advances in energy recovery devices, improved membrane performance, and optimized system recovery can substantially reduce energy consumption and lower costs. Other

innovative approaches, including two-pass nanofiltration (NF) and offshore desalination concepts, have been investigated to further enhance efficiency and reduce greenhouse gas emissions.

Operational considerations also play a key role in long-term performance and cost-effectiveness. Pretreatment design has been shown to influence membrane fouling rates, with red tide events and biological activity posing challenges for maintaining stable operations. Integration with existing distribution systems requires careful planning of blending strategies, post-treatment conditioning, and hydraulic compatibility to maintain water quality and operational flexibility. Collectively, these findings underscore that while desalination energy demands have improved over time, operational complexity and integration challenges remain important considerations for future projects.

Key lessons learned from energy use and operational studies include:

- Energy recovery devices and optimized membrane technologies can significantly reduce operating costs.
- Two-pass or alternative treatment configurations can improve water quality but may increase energy consumption.
- Operational challenges, such as algal blooms and variable source water quality, require robust pretreatment systems.
- Careful planning of blending and post-treatment is important for maintaining distribution system water quality, including addressing corrosion control, disinfectant stability, disinfectant by-product formation, temperature differentials, aesthetic impacts, and microbial stability during water quality studies and pilot testing.
- Integration strategies must account for both hydraulic performance and long-term operational flexibility.

3.0 Emerging Technologies

As part of this study, research was conducted to evaluate seawater desalination technologies that are either in development or at an early stage of implementation. The goal was to identify advancements that may influence the feasibility, cost, or sustainability of future projects within the region. Technologies were assessed across a range of process areas, including intake and pretreatment systems, membrane improvements, energy recovery devices, concentrate management approaches, and alternative power integration.

Numerous technologies were identified and evaluated as part of this review. The technologies were distributed into the following seven overarching categories:

- Offshore Desalination
- Alternative Desalination Technologies
- Brine Minimization/ Mining
- Energy Recovery and Pumping
- Subsurface Seawater Intakes
- Outfalls
- Artificial Intelligence

As part of this evaluation, each technology was provided with a TRL score based on scoring criteria established by National Aeronautics and Space Administration (NASA) to define the maturity level of a particular technology, presented below in **Figure 3.1**. The TRL approach assigns a numerical score based on the stage of development, ranging from initial concept validation (TRL 1) through full-scale commercial application (TRL 9). This scoring allows emerging technologies to be compared on both their potential benefits and their readiness for pilot testing or near-term adoption. Key information and scoring for each technology are presented in **Appendix B**.

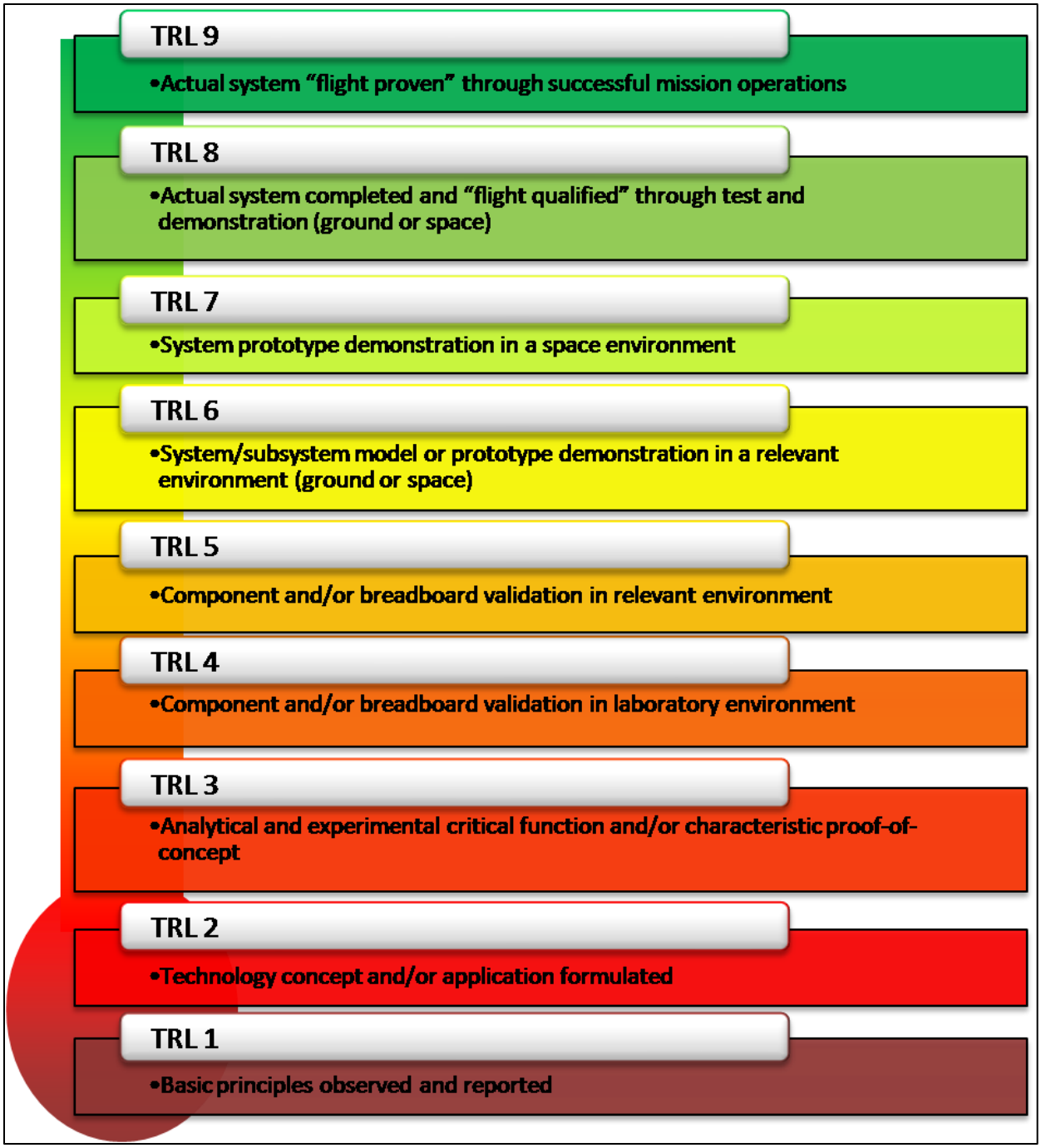


Figure 3.1 NASA Technology Readiness Level (TRL) Definitions

3.1 Technology Summaries

A brief summary of each technology is provided in this section, with each categorized according to the technology type.

3.1.1 Offshore Technologies

3.1.1.1 Summary from the 2024 Metropolitan White Paper on Offshore Seawater Desalination Technologies

In California, the potential benefits of land-based seawater desalination have gone mostly unrealized due to high costs and environmental concerns. Offshore seawater desalination offers an avenue that significantly reduces or eliminates many of the characteristics of land-based desalination that can be problematic in California. A January 2024 Metropolitan white paper, titled Offshore Seawater Desalination: New Technology and Opportunities, provided a comprehensive summary of emerging offshore technologies, evaluating their potential benefit for use in supplementing the municipal water supply in southern California.

The paper utilized the same TRL scoring system covered in this report to evaluate the maturity level of each offshore technology. In some cases, multiple companies/developers were assessed within each offshore technology. As a result, some of the technologies had higher or lower TRL ratings depending on the level of readiness of the specific company's proprietary approach and/ or equipment. The offshore technologies and their range of TRL ratings from that report were as follows:

- Ship/barge-based desalination had products with a TRL ranging from 2 to 9.
- Submerged offshore desalination had products with a TRL ranging from 5 to 7.
- Floating ocean buoys for wave and non-wave-powered desalination had products with a TRL ranging from 3 to 7.
- Integrated offshore wind energy desalination which was given a TRL of 5.

Not assessed in the white paper was the possibility of constructing small desalination facilities on de-commissioned oil platforms. While this has not been done to date, it would only require commercially available equipment to be installed on the platform. No TRL rating was assigned to this option, however, it is identified here to round out the discussion on offshore technologies.

The paper highlighted three upcoming demonstration or pilot projects being carried out in California using offshore technologies. Each of these technologies is described briefly below, with an update provided on the status of the projects:

OceanWell Submerged Seawater Desalination

The Los Angeles-based company plans to use modular treatment pods anchored to the seabed, with dozens of pods manifolded into a large-scale water farm. The pods would be located within the aphotic zone of the ocean (greater than 650 ft depth), where marine life abundance is low and environmental impacts are expected to be reduced. The desalination process will be driven by hydraulic pressure from the ocean; however, pumping will still be needed to convey desalinated water to the shore and to return concentrated brine back to the ocean. The manufacturer claims the process will use 40 percent less energy than conventional seawater desalination. Reviewing the information available on the process, these savings seem to be coming from the elimination of pretreatment, the minimization of pumping needs for the brine, and operation at extremely low fluxes. Information provided by OceanWell indicates that they are targeting a water depth of 1,300-1,500 feet, which would provide up

to 652 pounds per square inch (psi) of driving head, or 300 psi beyond the background osmotic pressure of the ocean at 4 degrees Celsius (°C). This driving head would allow the system to operate at a flux of up to 3.5 gallons per day per square foot (gfd). Operation at low flux can have a negative impact on product water quality, creating challenges with meeting typical boron or chloride targets, however, the colder temperatures increase salt rejection, and a recovery below 20 percent would allow for similar boron and chloride concentrations as a conventional desalination facility. Operation at low flux rates will also require significantly more reverse osmosis (RO) membranes compared with a land-based project.

Overall, the concept of submerged seawater desalination has considerable merit, however, real life demonstrations are needed to confirm the operational reliability of large offshore equipment arrays, product water quality limitations, and the challenges of performing regular maintenance on equipment housed at significant ocean depths. Permitting challenges are also somewhat unknown, and regulatory reviews will need to be adapted for the offshore location and unconventional water supply approach. Concept art for a submerged offshore seawater desalination facility is included as **Figure 3.2**.

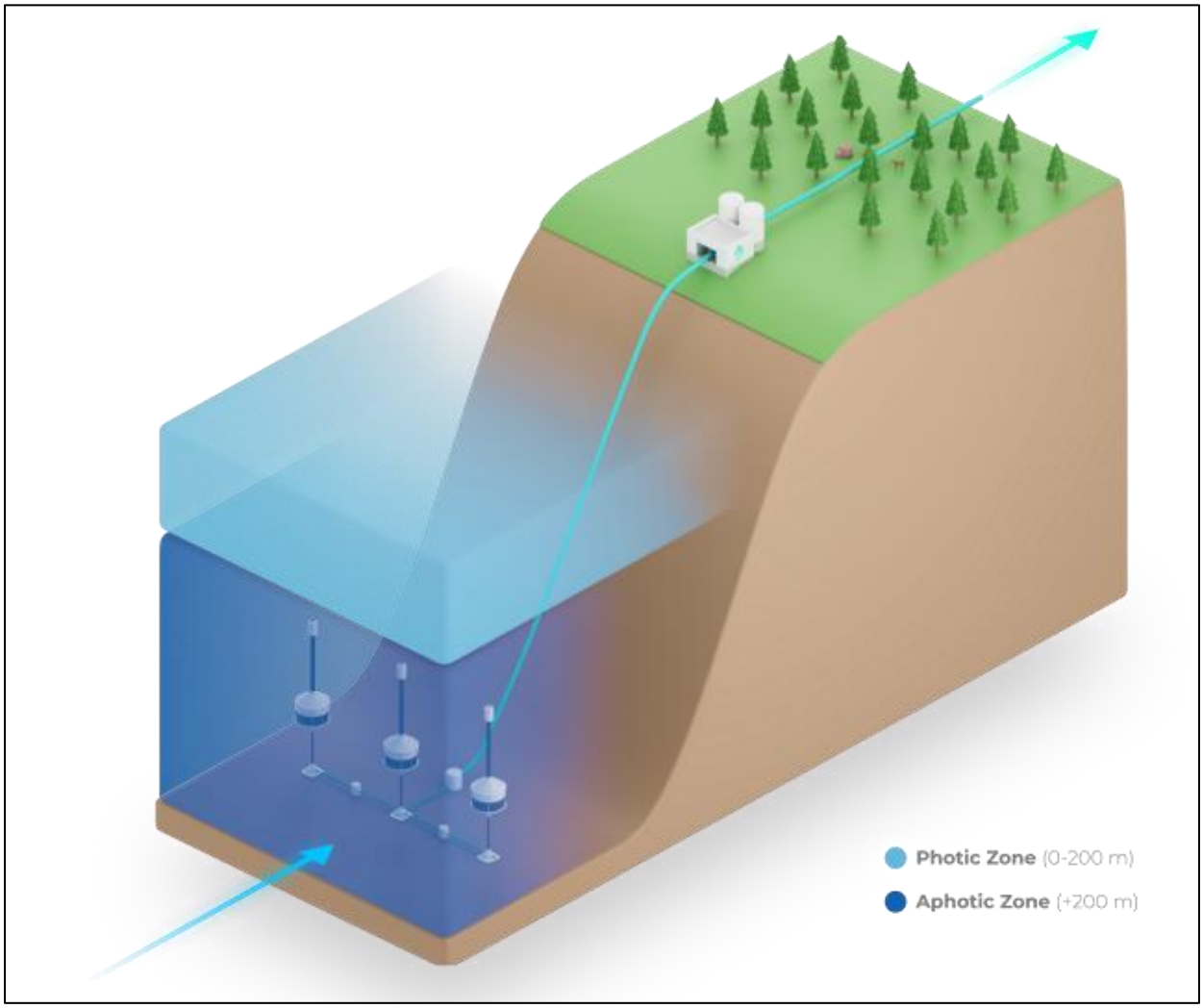


Figure 3.2 Concept Art for Submerged Offshore Desalination System (Courtesy of OceanWell)

OceanWell, a water technology company, has partnered with the Las Virgenes Municipal Water District (LVMWD) and a consortium of six additional California water agencies to advance Water Farm 1 (WF1), proposed as the first commercial-scale subsea RO desalination project in the United States. WF1 would be located approximately 4.5 miles offshore in Santa Monica Bay at depths of approximately 400 meters (1,300 feet) and is anticipated to produce up to 60 mgd of potable water by 2030. The concept relies on modular subsea pods that utilize natural hydrostatic pressure to reduce energy consumption and minimize surface infrastructure.

WF1 follows OceanWell's pilot program with LVMWD, which began in March 2025 in the Las Virgenes Reservoir, receiving a grant from the U.S. Bureau of Reclamation as well as a Future Supply Actions Funding grant from Metropolitan to demonstrate the operability and performance of its submerged membrane system under bio-active conditions. The reservoir-based pilot is testing a single pod and serves as a proof of concept for system hydraulics, intake performance, and treatment reliability. While the pilot provides important operational data, full validation of long-term performance, environmental impacts, and constructability under ocean conditions at the targeted depths (750-1,500 feet) should be completed before considering a full-scale project of this type.

It should also be considered that OceanWell, as with many of the other offshore seawater desalination technology developers, is currently targeting a build-own-operate approach to their projects, selling water to municipal customers, rather than selling equipment for the municipalities to operate. They are reported to be in discussions with nine water agencies in Southern California about a potential large-scale water farm in the area.

OceanWell has been assigned a TRL of 5 in the original siting analysis. Since completion of the siting evaluation, additional pilot testing at the Las Virgenes Reservoir has been completed and based on the demonstrated progress in system validation under bio-active conditions, the technology's maturity would now reasonably be characterized as TRL 6. However, because the siting analysis rankings were finalized prior to the completion of this testing, the updated TRL assessment does not change the comparative scoring or overall rankings presented in this study. Similar subsea desalination concepts are being advanced internationally, including by Flocean, which announced plans in June 2025 to launch what it describes as the first commercial subsea desalination plant in Mongstad, Norway. Flocean has also entered into an agreement with Alver Municipality to explore supplying water to municipal, industrial and consumer customers and to assess integration into existing water infrastructure. These efforts indicate that offshore desalination developers are moving beyond pilot-scale testing toward early commercial deployment and utility integration discussions. Other Norwegian companies, such as Waterise Solutions (TRL 6) and FSubsea (TRL 7), are also planning subsea desalination systems; however, no planned testing or deployment of these systems in California has been reported to date.

Seawell Floating Buoy Desalination

The Santa Barbara based company plans to supply 21-foot diameter floating buoys that desalinate seawater offshore and then pump the treated water to additional treatment and conveyance facilities onshore. **Figure 3.3** includes a rendering of a floating buoy seawater desalination system. Seawater desalination would be done using conventional RO membranes, utilizing similar pumping and energy recovery configurations as land-based facilities. Each of their buoys is expected to produce 1 mgd of desalinated water, with concentrate returned to the ocean. Limited information is available on the type

of pretreatment envisioned, apart from the use of 1-millimeter wedge wire screens and a reference to filters in their press kit, however, the process is said to be chemical free, which would limit both the type of pretreatment that can be used and the ability to chemically clean membranes to maintain production. The RO is expected to operate at low fluxes, reducing operating costs, but increasing the number of membranes and overall size of the treatment equipment.

Seawell is currently testing components of their system at the Naval Seawater Desalination Test Facility in Port Hueneme. Once complete, the system will be tested offshore of the Vandenberg Space Force Base, north of Santa Barbara. The Vandenberg Base is in the planning stages of a full-scale desalination project, using the Seawell system as a primary water supply for the base.

Advantages of the system include direct access to seawater desalination equipment, located near the ocean surface, simplifying plant maintenance; use of proven technologies and process configurations; lower operating costs from low flux operation; and option to purchase equipment directly rather than purchasing water from a private provider.

Potential challenges with the system include: the 1 mgd unit size would require a large area to produce the flows needed for a large-scale project; the near surface intake could be impacted by algae and other water quality excursions, making the limited pretreatment difficult to operate reliably; energy footprint would only be moderately lower than a land-based facility; offshore location would be considerably more difficult to maintain than a land-based facility and could be damaged or destroyed by heavy storms. Seawell has been assigned a TRL of 3.

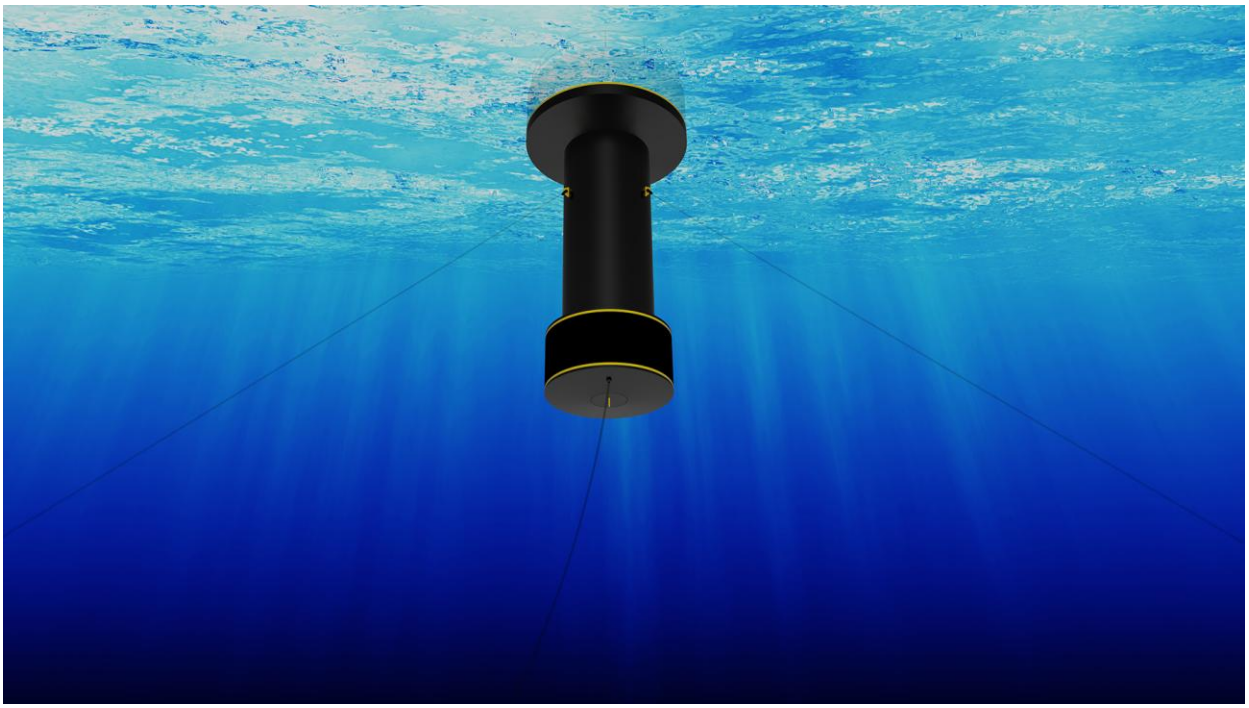


Figure 3.3 Floating Buoy Offshore Desalination Facility (Courtesy of Seawell)

Oneka Wave Powered Desalination

The Canadian based company has developed a wave-powered offshore seawater desalination system configured onto a floating buoy. The largest unit (Glacier-class) will reportedly produce 130,000 gallons per day (gpd) of freshwater without the need for any land-based energy input. This differs from the OceanWell and Seawell technologies in that the energy used for both the desalination and conveyance is entirely renewable. The technology was developed primarily for smaller water users, such as hotels, industrial users and small coastal communities, and the limited capacity of its largest unit would make it difficult to incorporate into a project targeting large-scale water supply. **Figure 3.4** presents a photo of an Oneka desalination system.

Many of the advantages and drawbacks to the Oneka system are similar to the Seawell system, however, the company's business model involves selling water to utilities and other users rather than selling equipment directly.

Figure 3.4 Wave Powered Offshore Desalination Facility (Courtesy of Oneka)

The City of Fort Bragg, located between San Francisco and Eureka, is planning to conduct a one-year test of the technology with potential to incorporate this into their long-term water supply. The proposed pilot facility is expected to produce approximately 13,200 gpd and is funded by a $1.5 million state grant through the Department of Water Resources (DWR). The system would be located approximately 0.1 to 0.3 miles offshore in water depths ranging from 43 to 98 feet. The City previously completed an initial

Study/Mitigated Negative Declaration for the pilot test, and the CCC approved Coastal Development Permit Application No. 9-25-0512 at its December 10-12, 2025 meeting, as documented in the Notice of Decision filed December 18,2025. If successful, the city plans to enter into a purchase agreement with the company, purchasing desalinated water from the company. Oneka has been assigned a TRL of 7.

3.1.2 Alternative Seawater Desalination Technologies

3.1.2.1 High Recovery Reverse Osmosis Processes

Both Dupont's Closed-Circuit Reverse Osmosis (CCRO) and Rotec's Flow Reversal Reverse Osmosis (FRRO) are proprietary RO treatment processes that have been commercialized primarily to support high recovery applications (greater than 90 percent). While their technical approaches are different, both CCRO and FRRO leverage the kinetics of scale formation to push beyond the thermodynamic restrictions which limit conventional RO. While these technologies have found favor within the industrial sector and are starting to be used in some municipal groundwater desalination facilities (e.g. CCRO at Marine Corps Air Ground Combat Center's Twentynine Palms WTP, FRRO at City of Santa Monica's Arcadia WTP), they are not ideal for seawater applications where recoveries are generally limited to less than 50 percent, due to the resulting operating pressures seen with higher recoveries. Under the lower recovery conditions used in seawater reverse osmosis (SWRO), neither FRRO nor CCRO provide competitive benefits over conventional configurations. Given this lack of suitability, neither of these technologies was assigned a TRL for this study.

3.1.2.2 Forward Osmosis

Forward osmosis (FO) uses a membrane to separate feed water from product water, but unlike RO, which uses hydraulic pressure to push water through the membrane, FO uses inherent osmotic pressure to pull water across. Since FO can only pull water from a low salinity side of a membrane to a high salinity side, another separation method must be used to produce low salinity water from the high salinity draw solution. One alternative is to use an ammonium carbonate based (or other similarly volatilizable) draw solution, pulling feed water across the membrane without any outside energy input, and then volatilizing the ammonium carbonate through heat addition. The evaporated gases can be collected and reused to produce additional draw solution. This approach can be lower energy than SWRO, provided the minerals in the draw solution can be volatilized with sufficiently low energy input.

A different alternative is to use sodium chloride or magnesium sulfate as the draw solution, using RO to recover water from the draw. While this approach essentially requires twice the membrane area as a conventional SWRO facility, the FO has a lower fouling potential than a comparable SWRO system. In the case of magnesium sulfate, a looser RO membrane or nanofilter can be used to recover water from the draw solution, reducing the energy input, compared with conventional SWRO. This process is shown schematically in **Figure 3.5**.

A third approach, proposed originally by the Colorado School of Mines (Cath et al, 2010), is using seawater as a draw solution for wastewater effluent, recovering freshwater from the diluted seawater using RO. This hybrid FO-RO process would be combining direct potable reuse (DPR) with seawater desalination into a single plant. While the concept could potentially operate at lower energy and higher public health protection than separate treatment plants, the concept is purely conceptual at this stage,

requiring a long road of testing, demonstration, and permitting review before it could be credited as an alternative process within California's highly restrictive potable reuse regulations.

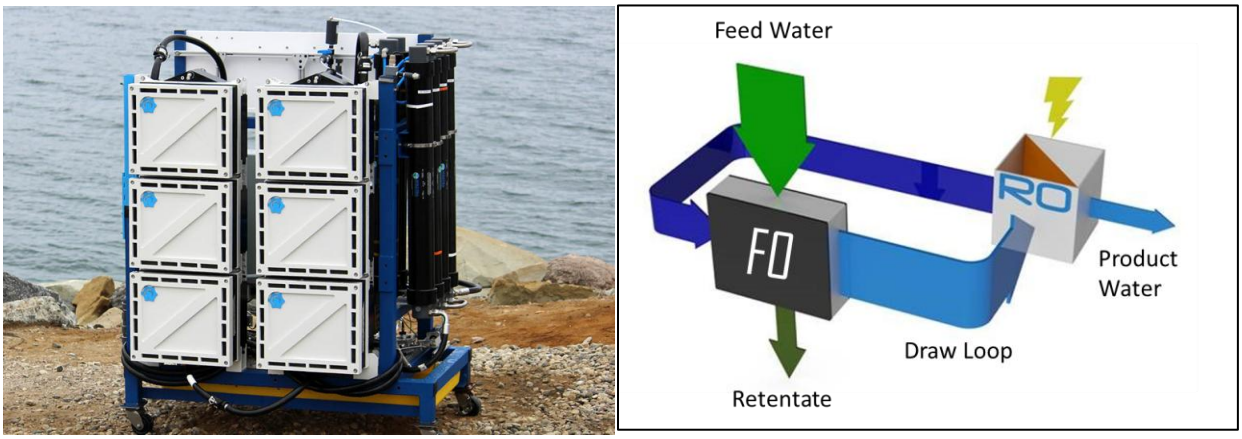


Figure 3.5 Forward Osmosis Membrane Stack and Process Diagram (Porifera, San Leandro, CA)

Challenges associated with FO include identification of appropriate draw solutions and development of efficient membranes given that commercial RO elements are not suited for FO. Draw solutions should feature the following:

- High osmotic efficiency (highly soluble in water and low molecular weight)
- Non-toxic
- Chemical compatibility of membrane
- Easy and economic separation from recovered water

Currently, FO is used in the food and beverage industry but is pre-commercial in use with high salinity water. Membrane vendors include names such as Porifera and Fluid Technology Solutions. Moving forward, development of semi-permeable FO membranes having high salt rejection and minimal internal concentration polarization to realize higher product water fluxes is critical for future development.

Because forward osmosis is still considered conceptual for use in seawater (high salinity) desalination applications, a TRL of 2 has been assigned. FO is discussed further in the energy recovery section of this memorandum in regard to its use with pressure retarded osmosis.

3.1.2.3 Membrane Distillation

Membrane distillation (MD) utilizes principles of both membrane separation and thermal distillation; MD involves evaporation of water from a saline solution and transport of the water vapor through the pores of a hydrophobic membrane. Clean water vapor is transported across the membrane by a thermal gradient that creates partial pressure across the membrane. The water vapor is then condensed within the membrane package or in a separate condenser system.

Unlike traditional pressure-driven membrane technologies, the driving force behind MD is the difference in vapor pressure of the liquid across the membrane. The efficiency of MD depends on feed water quality, system design, and heat recovery from the permeate stream. MD is more efficient at greater

liquid temperatures that increase vapor pressure and result in increased membrane penetration. MD has been reported to run at 70 °C (158 degrees Fahrenheit), allowing for beneficial use of waste heat or low-grade heat sources to successfully power the process.

Advantages of MD include beneficial use of otherwise low-grade heat, minimal pretreatment needs, and negligible scaling. Challenges include a reliance on the availability waste heat to promote economic feasibility, susceptibility to membrane fouling, and membrane degradation due to loss of hydrophobicity. An example pilot unit, manufactured by Aquastill (Netherlands) and a simplified process flow diagram are provided in **Figure 3.6**. Aquastill has had a pilot scale seawater desalination system (2,600 gpd) operational in Saudi Arabia since 2020. No information has yet been published on the performance of this system.

MD is currently in the development and demonstration phase. A variety of configurations can be used, all of which require feed water to directly contact the membrane. Various configurations are available for condensation:

- Air-Gap Membrane Distillation – provide an air gap after the membrane, followed by a cool surface for condensation. This configuration is the most common and versatile.
- Direct-Contact Membrane Distillation – cool condensing solution flows through the membrane, typically countercurrent to feed water, and condenses the clean water vapor as it passes through the membrane.
- Sweep-Gas Membrane Distillation – sweep gas pulls clean water vapor out of the membrane gap for subsequent condensation in a separate system.
- Vacuum Membrane Distillation – vacuum is applied to the membrane space to pull clean water vapor out of the system and condense in a separate system.

A TRL of 2 was assigned to this technology based on the conceptual stage of development.

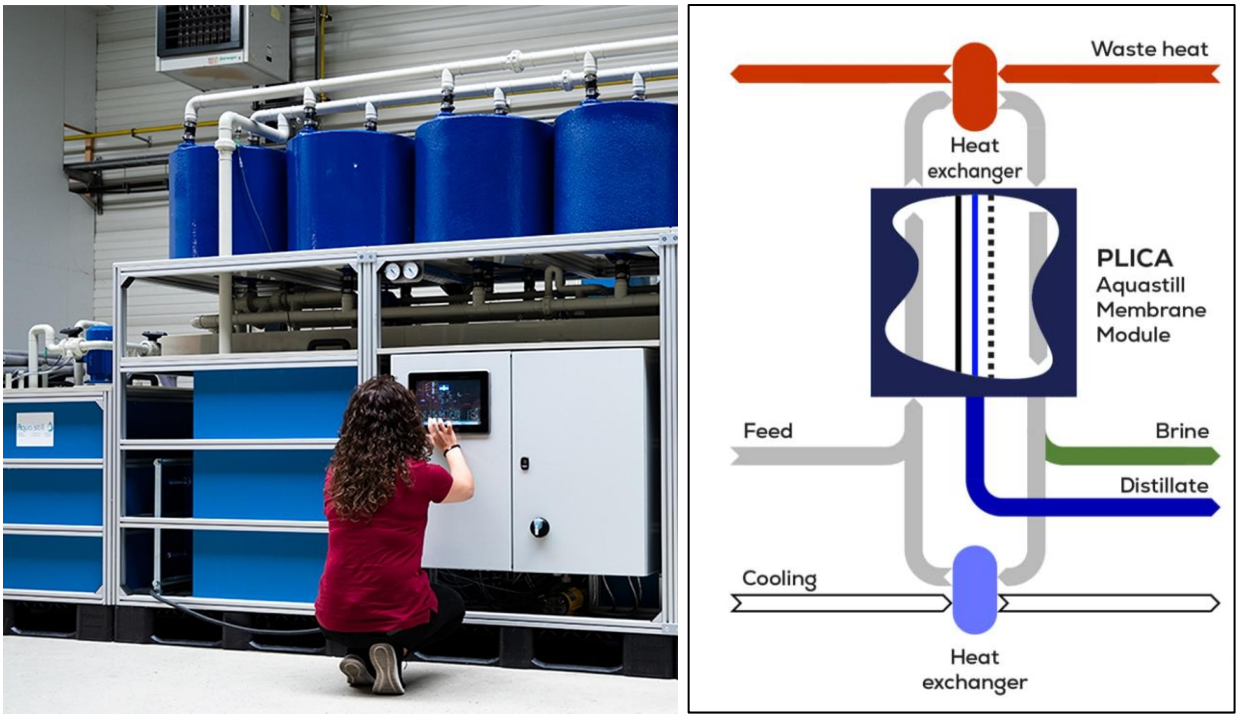


Figure 3.6 Pilot-scale Membrane Distillation System and Process Diagram (Courtesy of Aquastill, Netherlands)

3.1.2.4 Capacitive Deionization

Capacitive deionization (CDI) directs a saline solution between porous electrode pairs that adsorb ions by applying a low voltage electric field, producing deionized water. Upon removal, ions are desorbed from the surface of the electrodes by removing the induced electric field. This allows for regeneration of the electrodes without need for additional chemicals, marking a significant advantage compared to ion exchange (IX) technology. The efficiency of this process depends on surface properties of the electrodes such as surface area and adsorption properties.

Carbon aerogel is considered an ideal electrode and has been optimized through research beginning in the late 1980s. Despite this, challenges with CDI remain and include limited adsorption capacity of carbon aerogel electrodes, slow kinetics of transport of ions across electrodes, high cost of CDI modules, and fouling potential of the aerogel surface. Advantages include low energy requirement and simple construction. The technology is reported to have been adopted at full-scale cooling water facilities in China and Mongolia (see **Figure 3.7**), however, very limited information is available online for these facilities and links to the associated company website (www.estpure.com) are no longer active. Smaller CDI systems are marketed in the United States by Aqua Clear Water (Vista, CA); however, no information is available on existing installations.

Figure 3.7 Power Generating Facility in China Reported to be Using CDI to Desalinate Reclaimed Water (Courtesy of estpure.com via web.archive.org)

This technology is currently considered in the demonstration phase with a TRL of 7, however, very limited information is available on the success or failure of the demonstrations, and the technology has not yet been adapted to a seawater application.

3.1.2.5 Hydraulic Injection Desalination

There is limited scholarly or commercial information available on hydraulic injection desalination (HID), however, the technology is said to reduce energy consumption in desalination by over 30 percent. It is understood that the patented process works by lowering the influent pressure to a point where the liquid vaporizes and is later recaptured as condensate. The recovery rate is estimated to be lower than what is typically achieved with a conventional RO plant (45 to 50 percent), which if the case, would create challenges for larger facilities, due to the higher influent flow requirements. As plants get larger, the raw water pumping costs would eventually exceed the energy gains provided by this technology.

ACWA Power, a Saudi power developer, signed an agreement with Water Global Access (WGA), the owner of the patent, to integrate HID technology at scale. The agreement involves a HID pilot project to validate previous research which is purported to demonstrate the potential to lower energy consumption below 2 kilowatts per cubic meter (kW/m^3), approximately one-third below the consumption of a traditional seawater reverse osmosis process. In addition to the claims regarding energy use, it is also claimed that HID does not require chemical treatment of the feed water or produce a harmful brine.

Based on the limited information available to date HID, and the indication that the process will be demonstrated at pilot scale in the near future, a TRL of 4 has been assigned to this technology.

3.1.2.6 Halophytic Algae

Halophytic algae desalination, also referred to as bio-desalination, uses salt-tolerant algae to concentrate salt within the algal cells. The salt-laden algae can then be removed via traditional filtration processes and used as biofuel to offset energy inputs. A conceptual flow schematic for a halophytic algae desalination system is presented in **Figure 3.8**.

This technology is in the early stages of research development and has been shown to remove up to 30 percent of salt from saline solutions. While insufficient for producing drinking water, halophytic algae may serve as a first step for RO processes to reduce energy consumption and/or increase recovery.

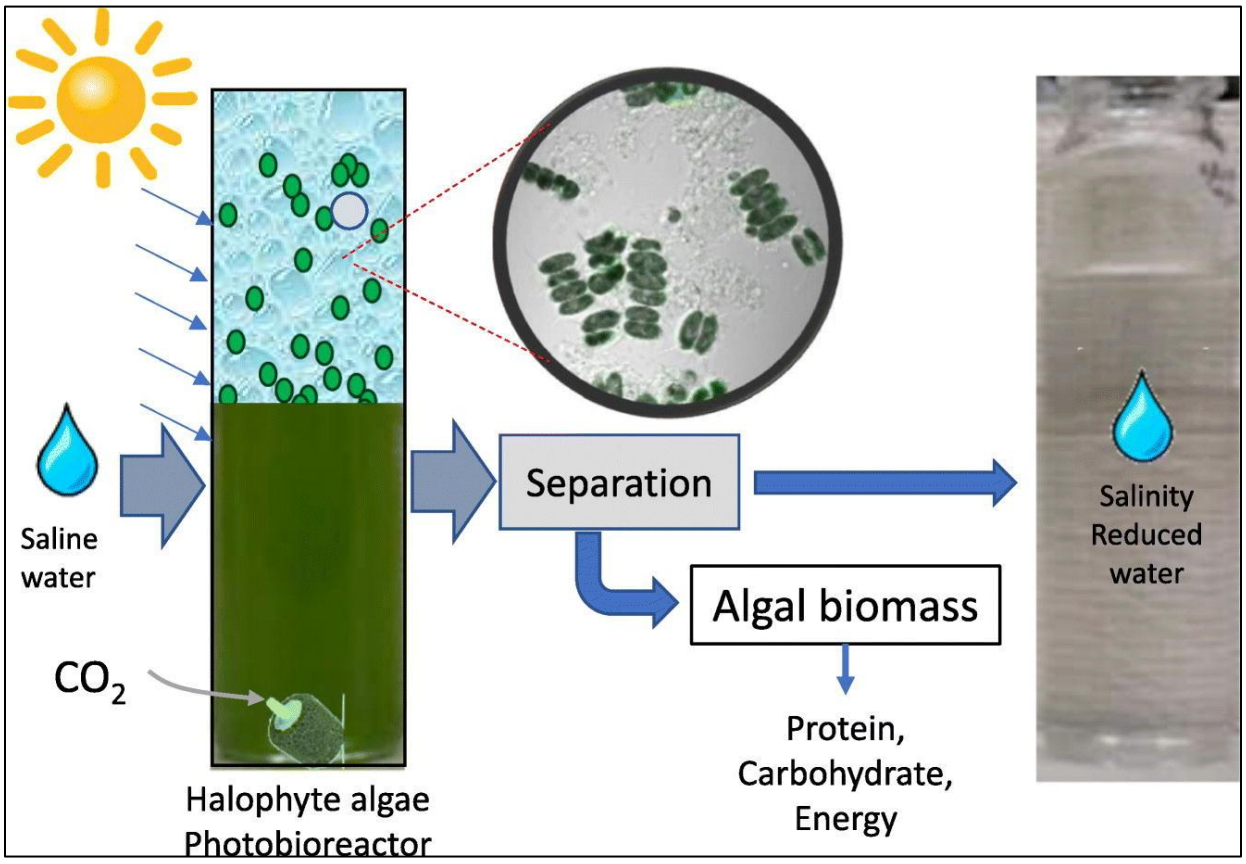


Figure 3.8 Basic Concept for Halophytic Algae Desalination (Sahle-Demessie et al, 2019)

This technology is currently considered theoretical with a TRL of 1.

3.1.2.7 Freeze/Thaw Desalination

Freeze/thaw desalination relies on phase change from liquid to solid to achieve separation. Ice crystals reject salt from their structure, allowing it to be separated from ice as a brine. The primary benefit to this process is that energy required is less than one-seventh the energy required for phase change from liquid to vapor (excluding multiple vessel thermal technologies such as multiple effect distillation [MED] and multi-stage flash [MSF] distillation, which require significantly less energy than the heat of

evaporation). The primary challenge with freeze/thaw desalination is washing and separation of ice crystals without melting and recontamination with salt. Direct freezing, and indirect freezing and absorption configurations have been developed for this technology thus far.

This technology is currently considered theoretical with a TRL of 1.

3.1.2.8 Solar Thermal Desalination

While simple solar stills for desalinating small volumes of water have been commercially available for decades, more recent approaches to solar thermal desalination (STD) combine conventional thermal desalination systems, such as MED and MSF, with a concentrated solar system. STD commonly employs thermal collectors or concentrated thermal collectors to extract the energy required to vaporize the seawater before collecting and condensing the resultant steam. STD is loosely defined and encompasses several methods to harness solar thermal radiation for desalination processes.

In 2018, the Middle East Desalination Research Center (MEDRC) in Oman awarded $450,000 in grants to three projects developing small-scale renewably powered desalination technologies. One of these, the Dutch SolarDew, utilizes membrane distillation with a solar still to supply desalinated water to off-grid communities. This system has a maximum capacity of 120 liters per day, making it infeasible for use in a large municipal application.

A Pasadena based company, Sunvapor, is developing an STD system that was recently selected as a semifinalist in the US Department of Energy (DOE) Solar Desalination Prize for their Solar Cascading Evaporation Process. The DOE competition focused on systems that can realistically achieve a levelized cost of water below $0.50 per cubic meter. This technology features the advantage of harnessing renewable solar energy, along with the added benefit of minimizing land-use requirements compared to traditional sun-powered thermal desalination. **Figure 3.9** provides a simplified process flow diagram for the Sunvapor system. There is considerable focus on the development of solar thermal desalination, including funding from DOE, MEDRC, the National Alliance for Water Innovation (NAWI) and a recently announced $119 million XPrize for desalination.

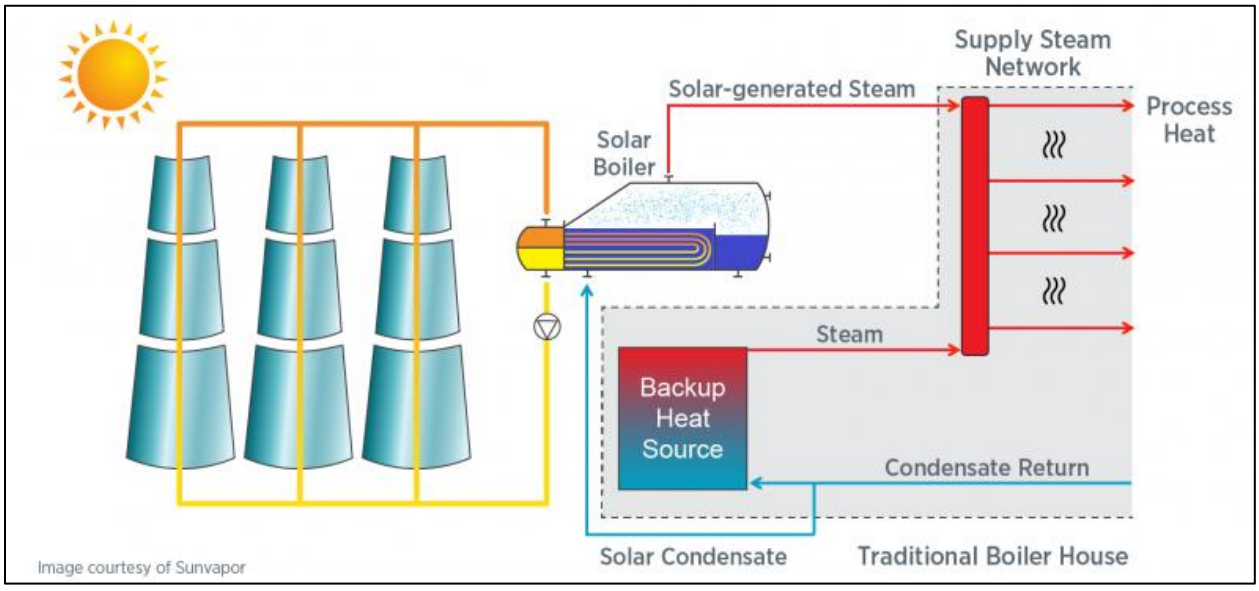


Figure 3.9 Solar Thermal Power Generation and Desalination Process (Sunvapor, Pasadena, CA)

This technology is currently considered early conceptualization with a TRL of 2.

3.1.2.9 Supercritical Water Desalination

Supercritical conditions occur at elevated pressures and temperatures, where the liquid and gas phases both exist and are indistinguishable (see **Figure 3.10**). Supercritical water is a poor solvent, allowing for separation of solid salt particles via precipitation and subsequent production of purified water. The purity of the finished product varies with temperature and pressure. While supercritical conditions take both high pressures and high temperatures to achieve, energy recovery devices and heat exchangers can be used to drastically reduce energy inputs. Once supercritical conditions are achieved, salts will settle out of solution, allowing extremely high water recovery rates to be achieved (greater than 99 percent), while collecting settled salts as potentially saleable product.

Supercritical water desalination is still in the development phase and has not been tested outside of the laboratory. This technology has been proposed as a pretreatment step for RO seawater desalination systems that can decrease salinity of the feed water, allowing for the use of low-pressure brackish water membranes that operate at higher recoveries and much lower feed pressures. The technology could also be utilized as part of a brine recovery process train, as it produces settled salts rather than concentrated brine. Research in this technology is being conducted at Wetsus in the Netherlands and by Cade Engineering in Spain, however, no commercial use has yet been reported.

This technology is currently considered theoretical with a TRL of 1.

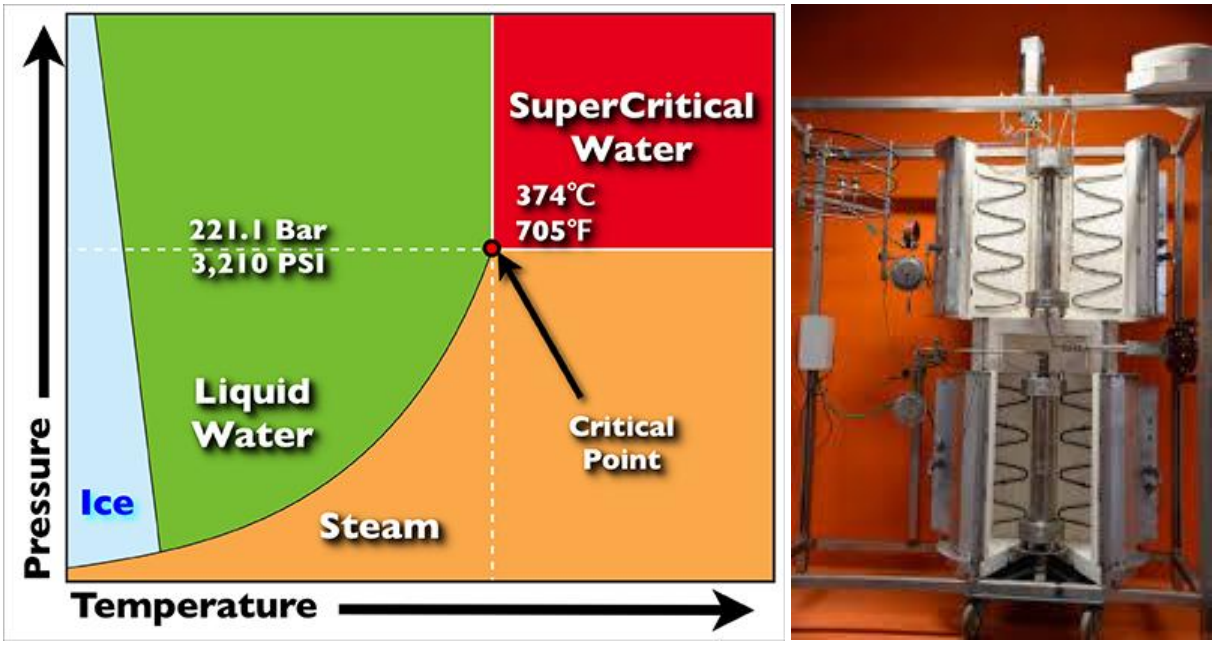


Figure 3.10 Supercritical Conditions and Pilot-Scale Desalination System (Courtesy of Wetsus)

3.1.3 Brine Minimization

The recovery, or the minimization, of the brine from the SWRO process by use of a high-recovery system (HRS) can help reduce brine disposal costs or provide a modest income from the sale of marketable

salts. The level of minimization or income is dictated by the brine quality, technological limitations, and the market prices in the immediate vicinity of the treatment plant. In some cases, brine minimization can also recover water, useable as either a desalinated product water or a supplement to desalination supply flows.

Approximately 97 percent of salt in typical seawater is comprised of sodium, chloride, sulfate, or magnesium, with sodium chloride making up the primary constituent. With high quantities of dissolved salts, alternatives for reducing or eliminating a brine discharge should consider recovery of saleable products from the brine stream. Available technologies for achieving this include NF, CCRO, FRRO, electrodialysis (ED), IX, crystallization, brine concentrators, and thermal desalination, with combinations of these technologies used to separate specific salts with potential market value. These technologies are used to varying degrees in full-scale zero-liquid discharge applications, as well as research evaluating recovery of saleable products, such as sodium hydroxide, sulfuric acid, gypsum, or Epsom salt. In addition, more traditional brine recovery methods are also possible, including natural evaporation and the production of sea salt.

HRSs are commonly used for brackish water and inland desalination facilities; however, their target has almost universally been to reduce the cost of brine disposal and maximize the use of the water source rather than to produce specific mineral products. Some mineral products can command a high price, making them attractive as mineral recovery alternatives, yet the level of purity required to obtain this higher price is often difficult to achieve using technologies developed more for the recovery of water. A commercial brine recovery facility was built by Enviro Water Mineral Company (EWM) in El Paso, Texas to recover minerals from the concentrate of an adjacent groundwater desalination plant (See **Figure 3.11**). The $65 million facility employed chemical softening, NF, ED and evaporative processes to recover saleable products, such as sodium hydroxide, hydrochloric acid, gypsum and magnesium hydroxide. Starting up in 2017, the facility was never able to operate reliably and was sold to Critical Materials Corporation.

Based on discussions with the local water utility, the facility has continued to struggle with operation, due in part to the variability of water quality coming from the groundwater desalination plant. After sale of the El Paso facility, EWM lead a feasibility study in Saudi Arabia, adapting brine recovery to seawater desalination. At this time, no such facility has yet been built, however public statements have been made that the Neom project will incorporate salt recovery in their planned seawater desalination project.

Figure 3.11 One-Million-Gallon-per-Day Mineral Recovery Facility in El Paso, TX (Enviro Water Minerals)

The lowest cost brine minimization approach considered feasible for large seawater desalination plants would be the installation of evaporation ponds for a small portion of the desalination brine, thus producing manageable quantities of sea salt that can be directly tied to a market, or used in onsite sodium hypochlorite generation. In this scenario, the majority of the brine would still be returned back to the ocean. It is not considered feasible to recover 100 percent of the SWRO brine using evaporation ponds due to the high capital cost of the ponds (and associated land), extensive land area required (including environmental impacts on this land), permitting challenges and commercial/market challenges associated with selling large volumes of a bulk commodity (salt).

Although several technologies for brine concentration are commercially available, the use of these technologies to produce a saleable product scale has not been successfully demonstrated to date. A TRL of 6 has been assigned, recognizing the construction and operation of the El Paso facility, however, a high degree of risk should be recognized, given the struggles this plant has had and the lack of any full-scale adaptations with seawater.

3.1.4 Energy Recovery and Pumping

3.1.4.1 Positive Displacement Pumps

For most seawater RO applications, and practically universally on large-scale facilities, centrifugal pumps are used for high pressure RO feed water pumping. This is based on a long track record of centrifugal pumps being used for this service, diverse product offerings from multiple suppliers, and general familiarity most end users have with this type of pump. While centrifugal pumps can be energy efficient (generally 80 to 85 percent within their preferred operating range), they lose efficiency when operated above or below their optimal flow and pressure, and they require variable frequency drives (VFD) to adapt to feed pressure variations, adding to the equipment cost and further reducing energy efficiency. In contrast, positive displacement (PD) pumps can achieve up to 92 percent efficiency, maintaining that

efficiency across a large variation in feed pressures, without the need for a VFD. This higher efficiency and opportunity to avoid VFDs could allow for significant energy savings and carbon footprint reduction when using PD pumps.

PD pumps are commonly used in the oil and gas industry due to their reputation for reliability and ability to function in harsh conditions. They are also common in this industry because their capacity is not affected by the operating pressures they pump against. Traditional PD pumps used in the oil and gas industry are reciprocating plunger style, manufactured by National Oilwell Varco (NOV) or Weatherford (both headquartered in Houston, TX). The pumps are generally low capacity (less than 1 mgd) and require both large footprints and considerable moving parts. While NOV pumps were installed at a small municipal desalination facility in Sand City, California (0.3 mgd), they are not commonly used in municipal applications.

A more recent innovation in PD pumps is the axial piston pump, manufactured by Danfoss (Denmark) and shown in **Figure 3.12**. This pump, designed specifically for the seawater desalination industry, is compact, with fewer moving parts and a single rotating axle. The pump operates at 92 percent efficiency, making it the highest efficiency high pressure pump in the industry. Since its introduction in 2005, the pump has been installed in dozens of small-scale desalination facilities around the globe. Currently, the largest model produces only 0.3 mgd, however, Danfoss has indicated a willingness to upscale their design for larger facilities.

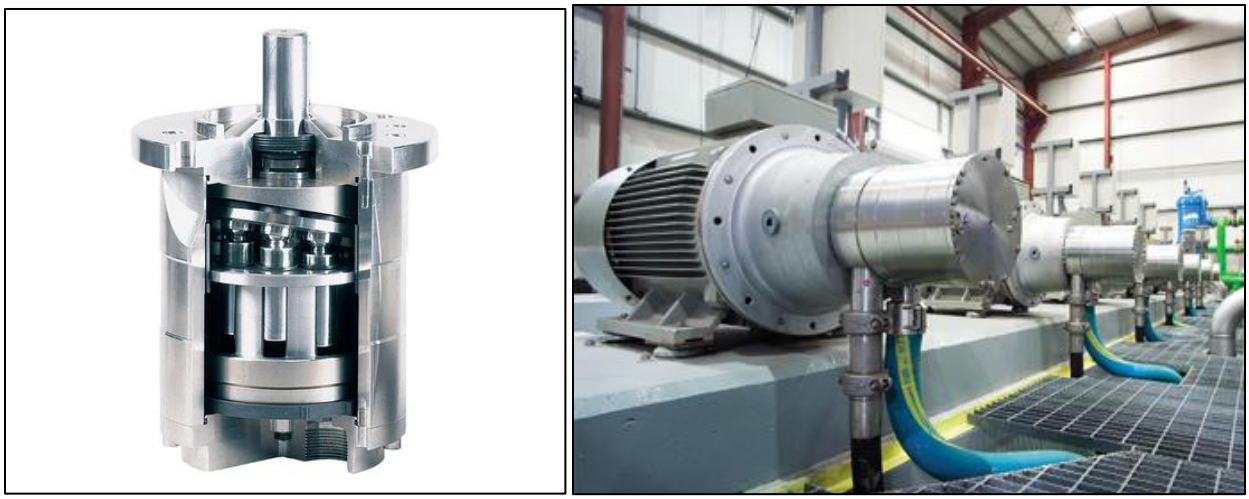


Figure 3.12 Axial Piston PD Pumps Operate at Efficiencies up to 92% (Courtesy of Danfoss)

While the technology underpinning positive displacement pumps is considered mature, due to the limited size range of this pump type, to date they have not been used on large seawater desalination facilities. This has less to do with any technical hurdles than market demand. This technology is therefore assigned a TRL of 8 to indicate that some degree of product development would be required by a PD pump manufacturer to bring a large capacity PD pump to market.

3.1.4.2 Pressure Exchange Type Energy Recovery

The introduction of pressure exchange (isobaric) type energy recovery devices (ERDs) into the desalination market in the early 2000s played a pivotal role in advancing the shift from thermal

desalination approaches to reverse osmosis membranes for large SWRO desalination facilities worldwide. ERDs revolutionized the energy efficiency of the pressure driven membrane desalination process, resulting in significant reductions in operational costs and environmental footprints. Whereas previous ERD technologies like Pelton Wheels and turbochargers operated at efficiencies around 70 to 90 percent (turbochargers being more efficient than Pelton wheels), isobaric ERDs provide approximately 95 to 97 percent efficiency in their design range.

Isobaric ERDs function by harnessing the energy from the high-pressure brine stream exiting the reverse osmosis membranes and transferring it to the incoming feedwater, thereby reducing the energy required for pressurization by approximately half. This energy recovery mechanism drastically improves the overall efficiency of the membrane seawater desalination process, resulting in a specific energy typically in the range of 3 to 4 kilowatt-hour per cubic meter (kWh/m^3) of water produced.

Energy Recovery Inc (ERI) and Flowserve are the two major manufacturers of isobaric ERDs with ERI's product installed in most of the large SWRO desalination facilities constructed during the past twenty years. Danfoss also manufactures an isobaric ERD with an integrated booster pump for use in desalination plants. A schematic of ERI's device is shown in **Figure 3.13**.

As a well proven technology with years of service in some treatment plants, a TRL of 9 was assigned.

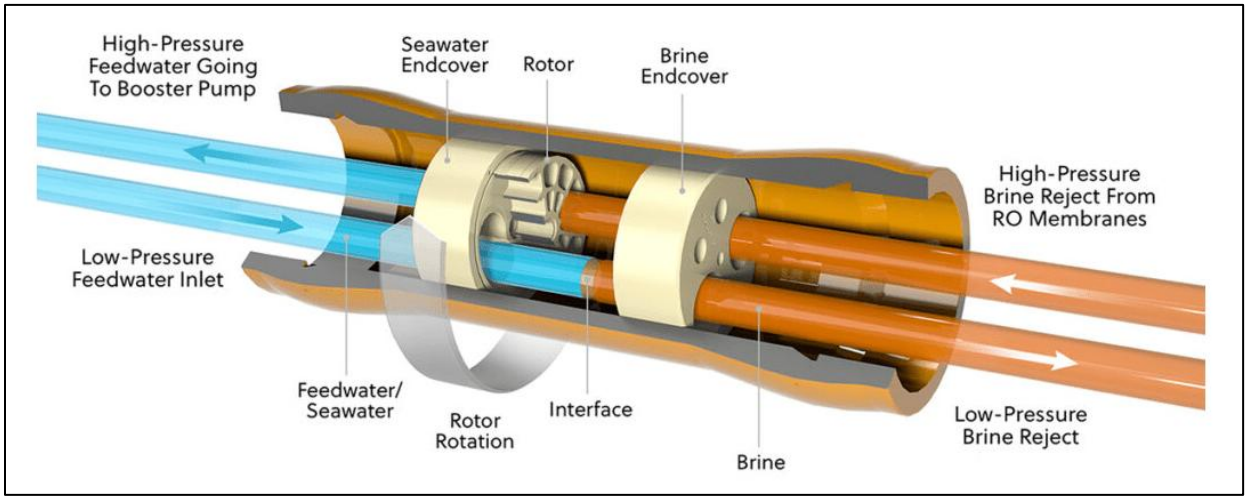


Figure 3.13 Pressure Exchange Energy Recovery Device (Courtesy of ERI, San Leandro, CA)

3.1.4.3 Pressure Retarded Reverse Osmosis

Pressure retarded reverse osmosis (PRO) is a process that would harness the osmotic pressure difference between two solutions of different salinities to generate power or perform work. It was first proposed by Sidney Loeb in 1976 as a potential energy generation alternative. In a seawater desalination application, the high salinity solution would be supplied by either seawater or the brine generated by the RO process, whereas the low salinity solution would be supplied by freshwater, sourced from a nearby natural water body or a wastewater outfall. In PRO, the flow of water across a semi-permeable membrane from the low-salinity solution to the high-salinity solution is driven by the osmotic pressure difference and could be harnessed to drive a turbine or generate electricity, partially offsetting the power required to operate the desalination facility.

A prototype PRO facility was built in Tofte, Norway by Statkraft, in 2009 (**Figure 3.14**). The facility used river water and seawater to create the osmotic pressure gradient for 10 kilowatts (kW) of power generation, achieving a power density of 1 Watt per square meter (W/m^2). Statkraft planned to expand this to a much larger production facility, however, in 2013 an announcement was made that the facility would be closed and further research discontinued. According to a press release, "the company recognizes that the technology will not be sufficiently developed to become competitive within the foreseeable future."

Shortly after the Statkraft facility went online, a smaller test facility was built by Kyowakiden Industry Company in Fukuoka, Japan. The Fukuoka prototype used brine from a desalination plant along with low salinity wastewater to create the osmotic pressure gradient. This approach effectively doubled the osmotic pressure gradient, compared with the Statkraft facility, bringing the technology closer to viability and reaching a power density of 10 W/m^2. Kyowakiden is currently operating a test facility in Nagasaki and is developing a 100-kW generation system to be commercialized. Pilot studies conducted in Singapore have been able to demonstrate power densities averaging 24 W/m^2, bringing the cost of PRO comparable with other renewable energy alternatives. It has been estimated, based on recent prototype testing results that PRO, when used between desalination brine and a fresh water supply, could produce enough power to offset 0.2 to 0.35 kWh/m^3 of the energy use at a desalination facility (Makabe et al, 2021).

One of the primary limitations with PRO has been finding an ideal FO membrane to use in the process. While commercial FO membranes are available from Toyobo and Porifera, the ideal membrane is still being pursued, with current membranes suffering from low permeability and high fouling. Considerable research is being done using carbon nanotubes in pursuit of a more efficient FO membrane. Recent research advancements into the development of FO and PRO membranes have been led by Jeffrey McCutcheon at University of Connecticut and John Lienhard at the Massachusetts Institute of Technology (MIT), with other research being carried out at Lawrence Berkeley National Laboratory and the NASA Ames Research Center.

Based on the testing and ongoing technology development in Japan, this technology is considered to have a TRL of 7.

Figure 3.14 Prototype PRO Facility in Tofte, Norway (Courtesy of Statkraft)

3.1.4.4 Depth Exposed Membrane for Water Extraction (DEMWAX)

The concept underpinning the DEMWAX technology is by utilizing natural water pressure created by elevation differences it is possible to drive a reverse osmosis process without supplementary pumping. The technology achieves this by installing membranes in deep well bores. The technology relies on piping in ocean water to the bore and providing a concentrate pipeline back to the ocean. To reduce the depth of the bore hole required to desalinate the seawater, the technology relies on operating at much lower pressure than traditional seawater reverse osmosis (estimated to be between 350 and 400 psi). To achieve these lower operating pressures, the DEMWAX relies on an operating recovery of 7 percent, compared with the 45 to 50 percent typical for most seawater desalination plants. As a result, the low operating flux, a DEMWAX system would require significantly more membranes to produce the same volume of water compared with a conventional design. Based on the available information, this technology is considered early conceptualization with a TRL of 2.

3.1.4.5 Wave Energy

A number of companies are focused on developing products that harness wave energy to provide clean energy which could be used by a nearby seawater desalination facility or fed into the electricity grid. Most of the products being developed work by harnessing the energy present in the movement of the ocean beyond the high energy surf zone.

Carnegie Clean Energy, an Australian company, has carried out several pilot projects of its CETO underwater buoy technology and is currently in the process of commercializing its latest model, the

CETO 6 (**Figure 3.15**). Two European companies, Waves4Power and CorPower Ocean, have floating buoy type technologies undergoing piloting with goals of commercializing their products over the next few years.

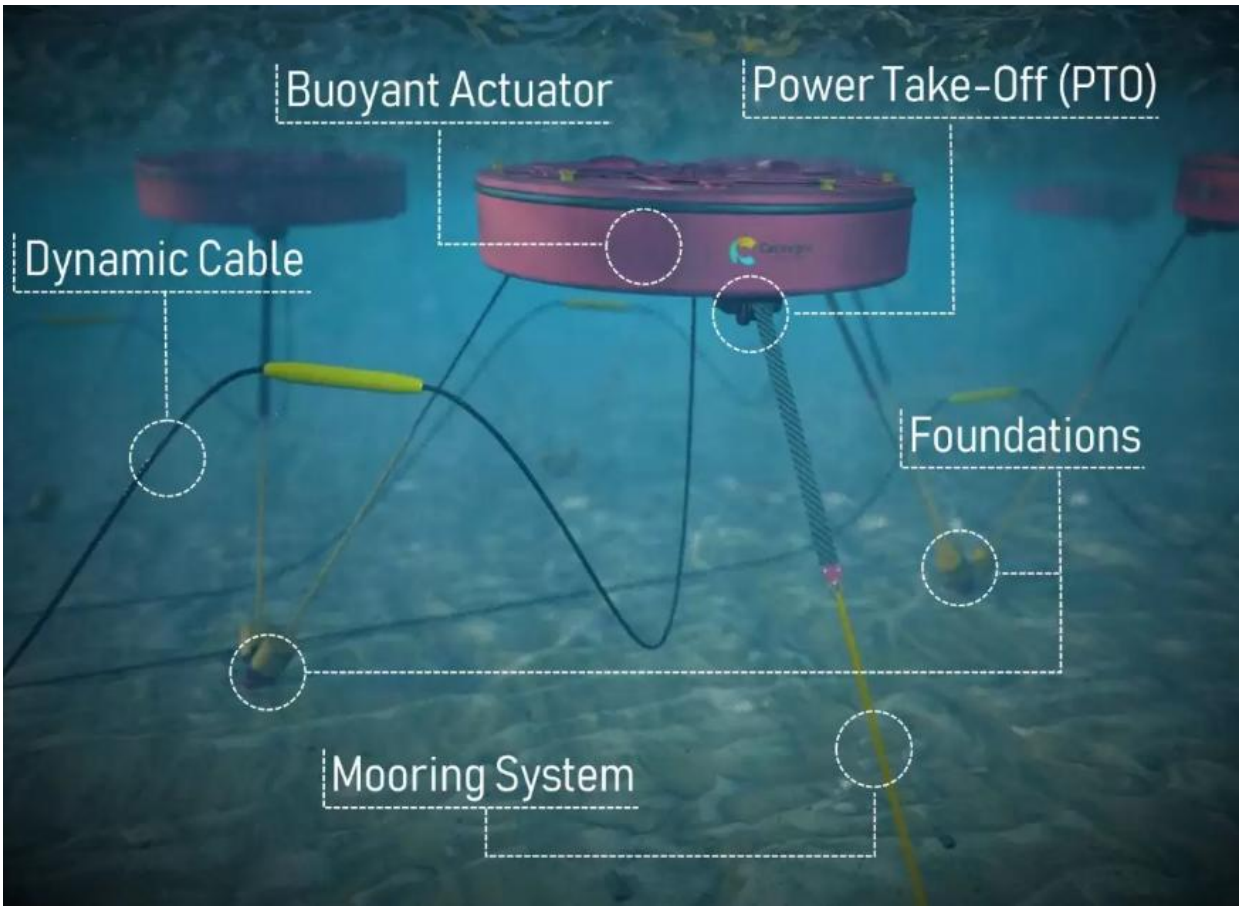


Figure 3.15 CETO 6 Wave Energy Technology (Carnegie Clean Energy, Freemantle, Australia)

A significant challenge with wave energy technologies is the considerable footprint needed for any power generation facility large enough to power a seawater desalination plant. This issue is made more challenging in Southern California by the need to avoid impacts to widely used shipping lanes, marine protected areas and the National Marine Sanctuary surrounding the Channel Islands.

This technology is currently considered late-stage prototype with a TRL of 6.

3.1.4.6 Seawater Pumped Storage with Desalination

This technical solution is based on the idea of pumping seawater to an elevated location during off-peak hours and releasing this water back to the ocean during peak energy tariffs to generate energy and power a conventional land-based seawater desalination plant. While the approach does not reduce the amount of energy required to operate the plant, it would assist with modulating the demand on the grid. One advantageous modification of the seawater pumped storage approach is the potential to power a large desalination project entirely by solar power, pumping pretreated water to the reservoir during daylight power production periods and allowing desalination to continue into the evenings using hydrostatic energy. While there is a loss of energy with the water being pumped, conveyed, stored, and

conveyed again, before being treated, much of the pumped energy can be recovered through high efficiency energy recovery devices. Raw water storage requirements would need to provide at least 12 hours of supply flow, meaning that a 25 mgd facility would need 25 million gallons of raw water storage (assuming 50 percent RO recovery).

The primary hurdle to implementation is having two available and proximate sites with sufficient elevation difference to generate the amount of hydraulic energy needed to power a desalination plant (typically 2,300 feet of elevation change). Additional hurdles include the cost, permitting challenges, and potential environmental concerns associated with constructing a large seawater reservoir in a coastal or inland environment, along with the land needs for a sufficiently sized solar or wind farm.

Oceanus is a California based company whose Integrated Pumped Hydro Reverse Osmosis System (IPHROCES) technology (**Figure 3.16**) was reviewed by Metropolitan in their Offshore Seawater Desalination white paper (2024). Oceanus is currently evaluating sites to test their technology which was assigned a TRL of 3.

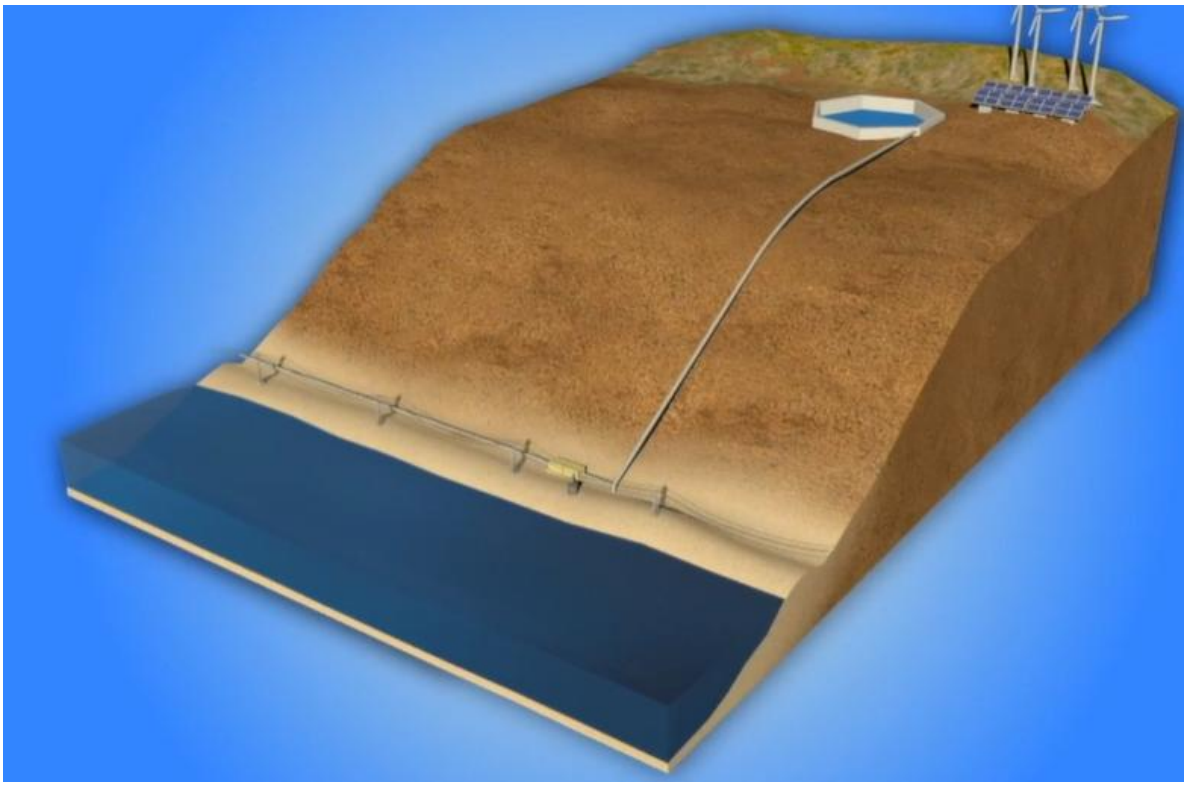


Figure 3.16 Seawater Pumped Storage with Desalination (Courtesy of Oceanus)

3.1.4.7 Off-site Renewable Energy

Several desalination plants have been constructed around the world with significant portions, or the entirety of the energy demand, offset by the construction and operation of renewable energy projects in off-site locations. In these arrangements, energy is fed into the grid to offset the energy consumed by the desalination facility rather than power the desalination facility directly. The advantages to constructing off-site renewable energy projects, rather than co-locating them with the desalination facility, include:

- Avoids the need for costly, and potentially environmentally sensitive, land near the coast, which could potentially limit the energy generation potential.
- As prime sites for renewable energy development are generally not the same as where the desalination plant is being located, it is possible to select the most favorable area for renewable energy generation.
- Permitting requirements are generally more streamlined when large-scale energy generation is removed from sensitive coastal/marine environments.

Many large-scale desalination projects have incorporated off-site renewable energy to offset more than half of their energy demand, including: 66 mgd Sydney Desalination Plant in Australia, 108 mgd Victoria Desalination Plant in Australia, 79 mgd Adelaide Desalination Plant in Australia, 40 mgd Binningup Desalination Plant in Perth, Australia, 33 mgd Gold Coast Desalination Plant near Brisbane, Australia, 15.9 mgd Al Khafji Desalination Plant in Saudi Arabia, 119 mgd Shuqaiq Desalination Plant in Saudi Arabia, 158 mgd Jubail Desalination Plant in Saudi Arabia, 21 mgd Sur Desalination Plant in Oman, and the 240 mgd Taweelah Desalination Plant in the United Arab Emirates. In addition to these projects, many smaller-scale renewable energy supplied projects are in operation and a number of large-scale projects are under development.

Of particular note is the Taweelah Desalination plant in Abu Dhabi, which is currently the largest membrane-based desalination plant in the world, with a production capacity of 240 mgd. This facility was designed and built by a consortium of Abengoa (Spain) and the Shandong Electric Power Construction Corporation III, which is a wholly owned subsidiary of the Power Construction Corporation of China. The plant is powered by a 70-megawatt (MW) photovoltaic solar farm (**Figure 3.17**) and supplies water purchased by ACWA Power and the Emirates Water and Electricity Company. While Abengoa filed for bankruptcy in 2021, facility construction continued, with the 120 mgd Phase I project reaching full production in mid-2022 and the final Phase II operation beginning in April 2023. The facility has a reported construction cost of $900 million and a reported cost-of-water of $1.85/kilogallon.

Off-site renewable energy projects utilize well proven technologies and are assigned a TRL of 9.

Figure 3.17 70-Megawatt Solar Farm Powering the Taweelah Desalination Plant (ACWA Power)

3.1.5 Subsurface Seawater Intakes

Traditional screened open ocean intakes collect seawater directly from the ocean via offshore inlet structures. The large majority of all large seawater desalination facilities around the world utilize this form of intake. However, because these intakes can impact marine life, the California Ocean Plan (last revised in 2019) established a strong preference for subsurface seawater intakes (SSIs), which collect water from beneath the seafloor, instead of open ocean intakes unless a site-specific evaluation determines SSIs are not feasible. If SSIs are not feasible, the affected Regional Water Board may approve an open ocean intake using best available technology to minimize entrainment and impingement. The feasibility definition in the context of the Ocean Plan is "…capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors." In California, this typically requires the use of fine-mesh wedge-wire screens designed to meet stringent approach velocity and slot-size criteria, which are generally more restrictive than intake screening standards used in other countries (e.g., Australia or the Middle East).

SSIs generally fall into two broad categories – wells and infiltration galleries. Wells (slant, vertical, horizontal, radial) have generally only been used for small-scale applications, with the majority of these being vertical (beach) wells.

3.1.5.1 Vertical, Slant, Horizontal, and Radial Collector Wells

Vertical (Beach) wells are commonly used on small seawater desalination facilities. The largest membrane-based seawater desalination facility in the world utilizing beach wells is the Sur plant in

Oman with a capacity of 80,000 m^3/day (approximately 21 mgd). The hydrogeology at this site is predominantly karstic (principally limestone and dolomite), making it more conducive to the use of beach wells, however, the facility has reported challenges with loss of capacity over time for their installed wells. Vertical beach wells were used to supply the 0.3 mgd Sand City desalination plant (**Figure 3.18**), the 0.6 mgd Morro Bay desalination plant, and the 0.33 mgd Avalon desalination plant on Catalina Island. One challenge with beach wells is the potential to impact inland groundwater levels, as the wells are typically located on land and pull equally from all directions.

A TRL rating of 9 has been assigned to vertical beach wells.

Figure 3.18 Vertical Beach Well at Sand City Desalination Plant

Slant wells differ from beach wells by facilitating the extraction of groundwater located further away from shore, which minimizes the potential for impacting seawater intrusion barriers created at the interface between seawater and groundwater aquifers. Slant wells have been successfully pilot-tested for the forthcoming DODP and are also proposed for the Monterey Peninsula Water Supply Project. Both of these projects have a capacity of approximately 5 mgd. A simplified diagram of a slant well is included as **Figure 3.19**.

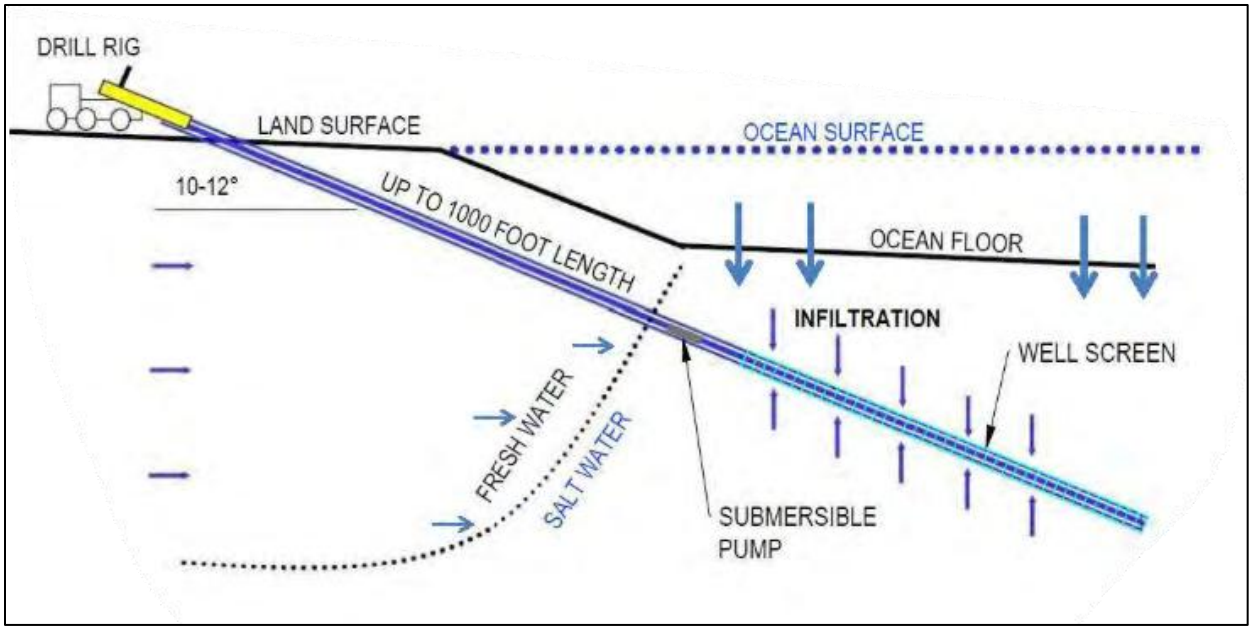


Figure 3.19 Doheny Slant Well Construction (Courtesy of Geoscience)

A TRL of 8 was assigned to slant wells to indicate that the technology has been tested in an operative environment. Although slant wells may prove to be suitable for small to medium size facilities, the high number of wells required to serve a large facility is expected to be cost prohibitive. Environmental impacts from large facilities could also create a challenge as wells need to be adequately spaced to avoid interference, resulting in long stretches of shoreline disturbed by well construction and periodic maintenance.

Radial (Ranney-type), and horizontal wells, with directionally drilled collectors, have been utilized at similar scales, though horizontal wells have fallen out of favor due to issues with clogging at some sites in Spain. Horizontal wells are therefore considered developmental and assigned a TRL of 6. Radial wells have reportedly been used for a desalination facility in Mexico with unknown performance records. A TRL of 7 has been assigned to this technology based on the lack of long-term performance data. A simplified diagram of a radial collector well system is included in **Figure 3.20**.

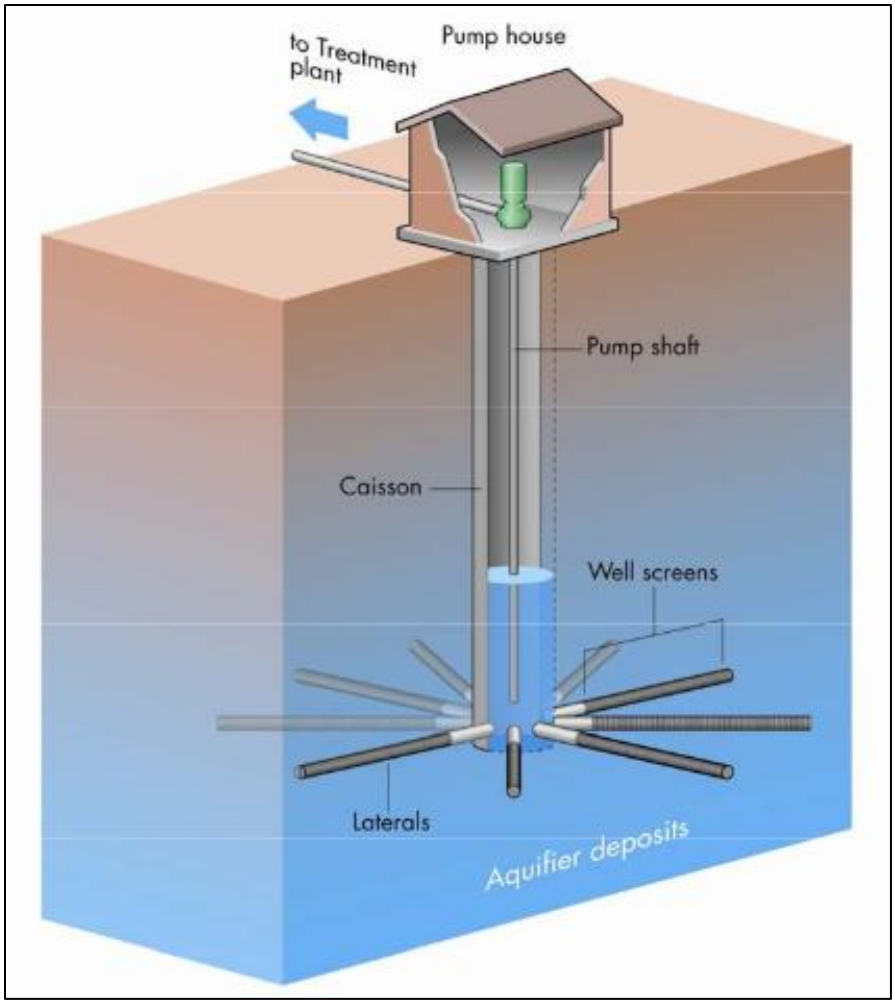


Figure 3.20 Radial (Ranney-type) Well (Courtesy of Water Globe Consulting)

A different approach to beach well design is the directionally drilled microporous pipe, marketed as the Neodren system, by the Spanish company Catalana de Perforacions. The Neodren system uses microporous HDPE pipe, directionally drilled from the shoreline under the ocean floor. Water from the well is collected at an onshore caisson or wetwell, and then pumped to the treatment facility, similar to the approach used by the Ranney well system. As with the Ranney wells, multiple collection pipes can be used with a common wetwell. Neodren intakes have been installed at multiple desalination facilities in Spain, including the 32 mgd Alicante plant on the Mediterranean coast. The oldest facility is near San Pedro del Pinatar and has been operating since 2003. A TRL rating of 9 has been assigned for the Neodren system, based on their established use in Spain.

3.1.5.2 Seabed/ Beach/ Deep Infiltration Gallery

Infiltration galleries have very little precedent for use on seawater desalination plants. There are two general types of galleries: beach (or surf zone) and seabed. The beach type infiltration gallery differs from the seabed type where the intake infrastructure is located. Seabed type galleries are located beyond the surf zone, in an area of lower energy, while beach types are located within the surf zone. The only known example of a functioning seabed infiltration gallery is the 27-mgd intake associated with

the Fukuoka desalination facility in Japan, which has been in service for almost 20 years. A diagram for a seabed type infiltration gallery is included as **Figure 3.21**. There are no known examples of a beach infiltration gallery in service, however, a demonstration project was constructed and operated in Long Beach, CA from 2008 to 2012 (**Figure 3.22**). This facility included a 3,100 ft^2 intake gallery and a 2,000 ft^2 discharge gallery connected by a 25-foot deep wetwell. The facility demonstrated a maximum sustained filtration rate of 0.15 gpm/ft^2, with significantly improved water quality compared with an open ocean intake (comparable to microfiltered seawater).

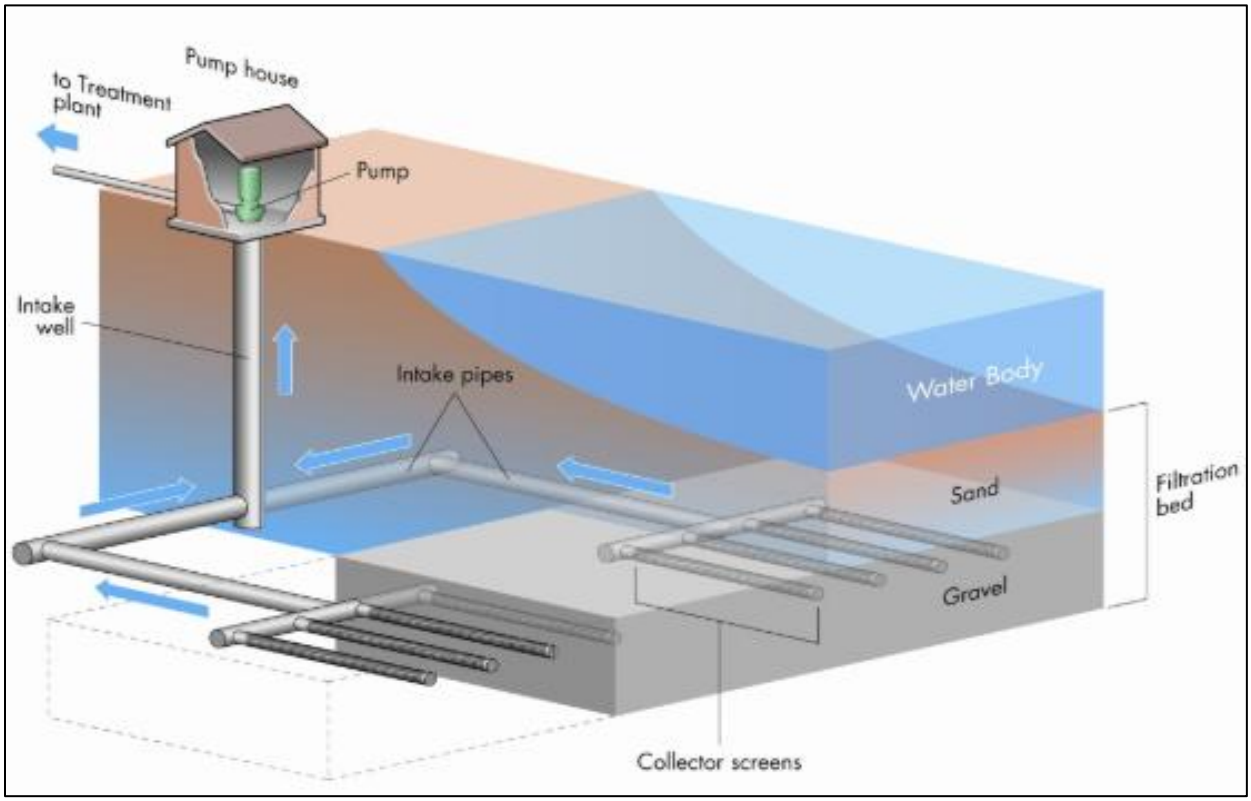


Figure 3.21 Seabed Infiltration Gallery (Courtesy of Water Globe Consulting)

Figure 3.22 Location of Long Beach Demonstration Infiltration Gallery

Deep infiltration galleries (or Water Tunnels) utilize a large horizontally drilled pipe (i.e. tunnel) which connects a series of vertical or radial collector wells to an onshore pump station. One such application of this approach has been used for several years to supply a portion of the raw water used by the Alicante II desalination facility in Spain.

The relatively limited data available to date for this technology, complex construction methods, and potential susceptibility to severe ocean/seismic events are all significant hurdles to adoption. A TRL rating of up to 9 has been assigned to seabed infiltration galleries based on the long-term experience at Fukuoka and the direct experience in Long Beach. Because the water tunnel has been successfully used at Alicante II for several years, a TRL of 9 has been assigned to this technology as well.

3.1.6 Outfalls

3.1.6.1 Venturi Mixers

Modern outfalls are equipped with diffuser systems to provide effective mixing of brine with the surrounding marine water body, mitigate brine plume formation, and minimize the extent of the mixing zone. Where outfalls are partially/ fully installed on the seafloor, it has become common to utilize duckbill valves (**Figure 3.23**) to generate the high exit velocities needed to meet modern brine mixing requirements. Most of the seawater desalination plants constructed in Australia, which prohibited the use of seabed installations on environmental concerns, utilize large diffuser structures located on the end of the outfall pipe to achieve the requisite mixing conditions.

Figure 3.23 Tideflex Duckbill Diffusers in Ocean Outfall (Courtesy of Red Valve)

One alternative to conventional brine discharges that has been tested at both the Mapalomas II (Canary Islands) and Gozo (Malta) seawater desalination plants is the use of venturi mixers (**Figure 3.24**) to produce dilution conditions which are measurably greater than what can generally be achieved with conventional duckbill diffusers. This greater dilution could be helpful, or necessary, when biological communities sensitive to salinity differences are found in the vicinity of the discharge.

The technology behind the venturi mixer is considered robust and well-proven, however, the use of venturi mixers are not wide-spread or commercial. The venturi mixers installed at Maspalomas II and Gozo appear to be ”one-off” custom designs, designed and fabricated by ECOS. On this basis, a TRL of 8 has been assigned to this technology.

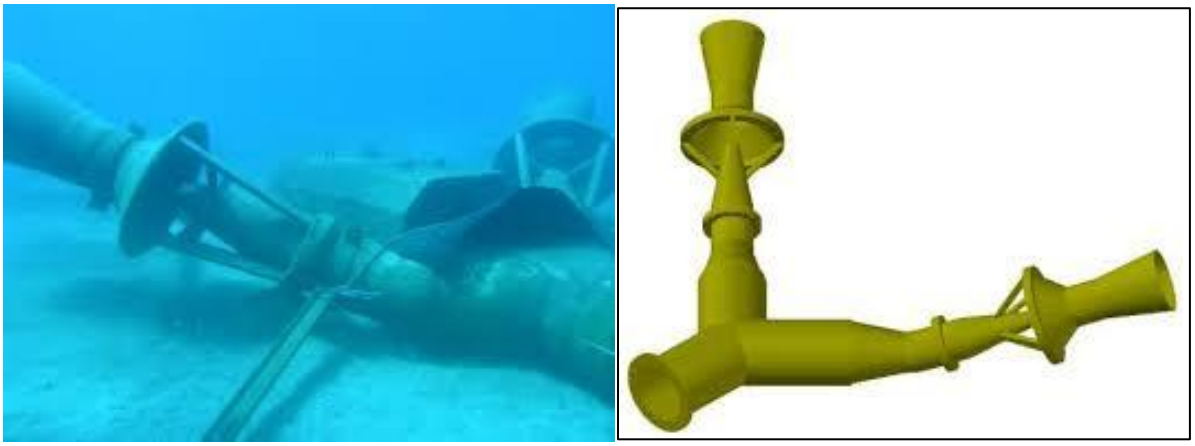


Figure 3.24 Venturi Diffusers Installed on Maspalomas II Brine Outfall (ECOS, Canary Islands, Spain)

3.1.6.2 Bio-Enhancing Concrete

Bio-enhancing concrete is a technology developed to improve marine ecosystems and provide mitigation for offshore construction. ECOncrete Tech LTD (Israel) developed a series of concrete mixes that provide suitable biological conditions for enhancement of diverse floral and faunal communities, while providing structural function in a marine environment. The technology was implemented in 2023 in the Port of Vigo in Spain. The concrete is said to have an 80 percent reduced carbon footprint

compared with conventional concrete, in addition to providing benefits to marine life. The concrete also claims to have seven times the carbon sequestration capacity of standard concrete, while improving biodiversity by a factor of two.

A three-year pilot project at the Port of San Diego was begun in 2021 on Harbor Island to demonstrate the ECOncrete CoastaLock tide pool armor product (**Figure 3.25**). Based on its full-scale implementation and successful demonstration in California's marine environment, Bio-enhancing concrete has been identified with a TRL of 8.

Figure 3.25 Bio-Enhancing Concrete Provides Mitigation Opportunity for Offshore Construction (ECOncrete Tech Ltd)

3.1.6.3 Carbon Sequestration

Various methods of carbon sequestration have been proposed to offset the impacts of greenhouse gas (GHG) emissions on the atmosphere. Two broad categories of carbon sequestration include ocean-based approaches and land-based approaches. Ocean alkalinity enhancement (OAE) has been proposed as an ocean-based method for reducing GHG from the atmosphere by either adding large amounts of pulverized silicate or carbonate rock directly to the ocean or adding dissolved flows of water that are high in these minerals. These alkalinity enhancing minerals promote carbon dioxide (CO_2) capture from the atmosphere into the ocean, with captured carbon settling to the ocean floor. This concept is presented schematically in **Figure 3.26**. OAE provides an added benefit of offsetting ocean acidification, which is threatening many marine ecosystems. In a seawater desalination plant, OAE could be accomplished by modifying plant operations to confirm the brine discharge has sufficiently high alkalinity to promote CO_2 capture in the immediate vicinity of the discharge.

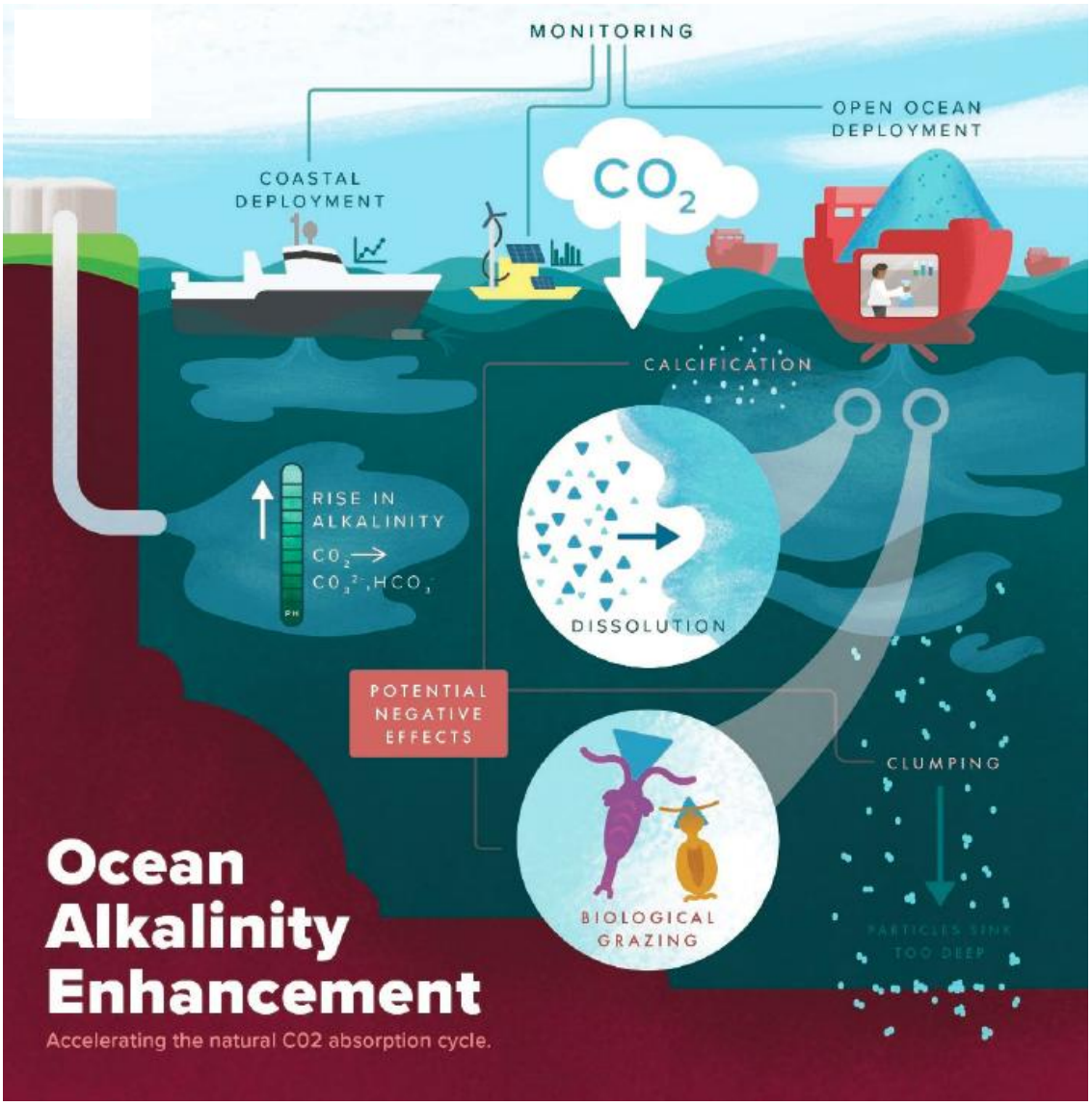


Figure 3.26 Concept for Ocean Alkalinity Enhancement (National Academies of Sciences, Engineering, and Medicine, 2021)

One study, led by MIT—Woods Hole Oceanographic Institution Joint Program, estimated that most marine locations can reach an uptake-efficiency of 0.3 to 0.4 tons of CO_2 sequestration per ton of alkalinity added to the ocean (Renforth, P. and G. Henderson 2017). While many seawater desalination plants employ ferric chloride or sulfuric acid in their pretreatment processes, lowering the pH and alkalinity of the water, a facility that avoided pH suppression, operating at an RO recovery of 50 percent, would be expected to have 65 to 75 percent higher alkalinity in the concentrate than in the ocean water supply. Based on an assumed CO_2 uptake efficiency of 0.3 tons of CO_2 per ton of alkalinity, and an average seawater alkalinity of approximately 130 mg/L as $CaCO_3$, a brine discharge could be expected to reduce atmospheric CO_2 by 230 pounds for every million gallons discharged. For a 25 mgd desalination facility, this would be over 1,000 tons of CO_2 sequestration per year. This represents approximately 3 percent of the carbon footprint for a typical seawater desalination plant powered by a petroleum-based electrical supply (assuming 2.5 kWh/m^3 desalination plant efficiency and 0.86 pounds of CO_2 per kWh of

electricity production) but could represent a more significant contribution for a desalination plant supplied by renewable power.

While carbon sequestration has not historically been a consideration for desalination brine outfalls, minor changes to plant operations could result in significant improvements in the CO_2 uptake potential of the brine and the resulting GHG footprint for the overall facility. As no new technology is required to generate the OAE process, a TRL of 9 is assigned.

A land-based approach to carbon sequestration has been developed by Captura (**Figure 3.27**), which utilizes ED to generate an acid and base stream from seawater. The acid generated by this process is added back to the seawater to reduce the pH and shift the dissolved inorganic carbon present in the seawater to CO_2, which can be subsequently separated from the seawater using downstream submerged membrane degasifiers. The captured CO_2 can either be used by industry or permanently stored.

Captura's process has been piloted at two different scales (1 ton CO_2 per year and 100 ton CO_2 per year). They are currently preparing to operate a final pilot of 1,000 ton CO_2 per year in partnership with Equinor in Norway. A TRL of 7 has been assigned to this technology.

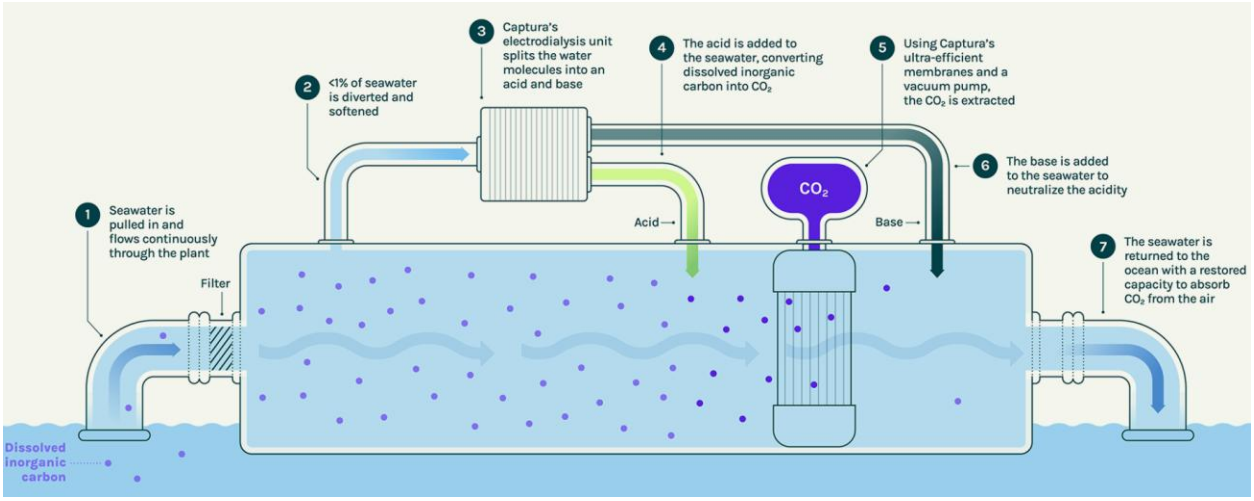


Figure 3.27 Direct Ocean Capture CO2 Sequestration System (Courtesy of Captura)

3.1.7 Artificial Intelligence

In the coming decades, artificial intelligence (AI) is expected to play an increasingly significant role in the operation and maintenance of membrane-based seawater desalination plants which are technically complex to run, as well as being large users of electrical power. Technology providers from across the industry are actively developing and promoting products focused on the areas of energy efficiency, as well as equipment and process reliability.

Key areas of focus for AI include:

- Energy Efficiency: Optimizing energy consumption by dynamically adjusting operational parameters for rotating equipment (pumps). Aquasight (Michigan) and Synauta (now part of

Boston-based Gradiant) are two software providers with product offerings that focus on delivering energy efficiency.

- Membrane Performance Monitoring: Analyzing data on RO feed water quality, normalized performance parameters and pressure differentials to monitor RO performance and recommend corrective actions such as chemical cleaning to maintain membrane permeability and maximize the membrane lifespan. Synauta/Gradiant (Massachusetts), Veolia (France), and IOSight (Israel) are some of the companies who provide software-based services that focus on optimizing membrane performance. The IOSight product is currently being used at the Carlsbad Desalination Plant to optimize energy efficiency and chemical use with their membrane system.
- Optimized Pretreatment: Analyzing data on raw water quality and adjusting pretreatment operating parameters, including chemical dosing, to improve filtered water quality. See list of providers noted in Membrane Performance Monitoring.
- Predictive Maintenance: By utilizing real-time data from sensors embedded in the plant equipment, AI can be used to predict when, and what, maintenance is needed. AI offers the potential to detect potential issues early and improve the planning of maintenance such that downtime is minimized and the working life and reliability of the equipment are maximized. Senseye by Siemens, Augury, and Uptake are some of the software providers with product offerings that focus on optimizing predictive maintenance.

There are AI software solutions on the market from many providers across the industry that aim to improve operations and maintenance across a range of industrial sectors, including the desalination market. As such, a TRL of 9 is assigned to this technology category based on the degree of commercially available products in the market.

3.1.8 Conclusions and Recommendations

The technology assessments presented herein are intended to inform long-term planning considerations. Technology readiness levels and associated conclusions reflect current information and do not constitute endorsement, selection, or advancement of any specific technology for implementation. Many of the technologies discussed in this section are not yet developed sufficiently to consider including in a large-scale seawater desalination project in California. Some of the technologies, in contrast, have become sufficiently established, with proven benefits, and should be considered in any desalination facility planning efforts. Still other technologies may require additional refinement and real-world demonstration but show sufficient promise that Metropolitan would benefit from partnering in some of the research to prove the technologies out. Technologies falling into these latter two categories are highlighted below.

3.1.8.1 Technologies Sufficiently Established for Near Term Adoption

While the desalination industry is rapidly evolving, many of the recent technological advances have been sufficiently demonstrated to be considered in planning efforts for future desalination projects in Southern California. These technologies include:

- Offsite Renewable Energy – The inclusion of offsite renewable energy, primarily from wind or solar, has become standard for many of the recent, large-scale desalination projects. With the

increasingly competitive pricing of renewable energy, its incorporation into a desalination project has potential to offset operating costs by more than 50 percent, while drastically reducing the carbon footprint of the facility.

- Pressure Exchangers – The development of pressure exchange or isobaric energy recovery devices revolutionized seawater desalination in the early 2000's. With an increasing number of vendors now offering the technology (ERI, Flowserve, Danfoss), it has become an essential tool that should be considered in any new desalination project.
- Positive Displacement Pumps – Large positive displacement pumps have long been incorporated into the oil and gas industry, however, the introduction of the Danfoss axial piston pump to the desalination industry has provided an opportunity to significantly improve pumping efficiency over centrifugal pumps, while eliminating the need for VFDs when addressing feed pressure variations. While this technology has become established for smaller facilities (up to 1 mgd), more product development is needed to adapt it to large-scale projects.
- Subsurface Intake Technologies – Various forms of subsurface intakes, including vertical wells, slant wells, radial collector wells, and infiltration galleries, have been successfully demonstrated in desalination and other water supply projects. These are identified as a preferred technology in the 2019 update to the California Ocean Plan. While their usage may not prove feasible for every desalination project, the Ocean Plan effectively requires their evaluation and use unless demonstrated to be infeasible.
- Outfall Diffuser Technologies – Both the duckbill diffuser (Red Valve) and the more novel venturi diffuser system have been successfully incorporated into seawater desalination projects to improve brine dispersion and reduce the environmental impacts of the outfall. Where RO concentrate cannot be blended with lower salinity flows, diffuser technologies should always be considered.
- Bio-Enhancing Concrete – Bio-enhancing concrete is a recently developed technology that has been successfully incorporated into offshore marine structures to enhance marine biodiversity. The concrete material offers a lower carbon footprint, while providing mitigation opportunities built into essential project structures. This technology should be considered for offshore intake or outfall structures where concrete is utilized.
- Artificial Intelligence – AI is a rapidly evolving field offering opportunities for improved plant efficiency, reduced energy demands, and lower operating costs. These technologies have been successfully demonstrated at full-scale desalination and water supply projects and should be considered in the planning of any desalination project. Vendors offering AI for desalination projects include Aquasight, Gradiant (Synauta), IOSight, and Veolia, however, the field is rapidly changing, and new technologies and suppliers should be anticipated before any future desalination project moves forward. Considerable care should be taken in maintaining data security when incorporating AI into a water supply project.

3.1.8.2 Technologies Warranting Research Consideration

Several technologies that are less established may provide sufficient opportunities for improved efficiencies or environmental benefits to warrant Metropolitan involvement in ongoing or future research. These technologies include:

- Pressure Retarded Osmosis – While PRO has not yet been commercialized, it has been successfully demonstrated to provide significant power generation when blending desalination brine and low salinity wastewater effluent. Recent studies have suggested that as much as 0.35 kWh/m^3 of the power used in desalination can be offset through PRO power production, achieving power densities as high as 24 W/m^2. Kyowakiden Industry Company in Japan is developing a commercial PRO system, and PRO membranes are currently available from Toyobo (Japan) and Porifera (California). While the technology has been successfully demonstrated in Japan and other international facilities, it has not yet been proven out in the United States market. Metropolitan would benefit from continuing to track advancements in this technology and should consider opportunities to partner with the technology providers in demonstrating its use in a California desalination application.
- Offshore Submerged Desalination – While offshore submerged desalination has not yet been implemented in a full-scale facility, there is considerable interest in the technology and several companies have commercially available products that offer potential environmental benefits, reduced energy demand, and reduced operating costs compared with conventional onshore desalination approaches. Two of these companies, Waterise and OceanWell, are actively pursuing desalination projects in California and have developed systems that could be incorporated into a large offshore desalination project. While business models for both companies involve selling water to utilities rather than selling equipment, the technical approaches being proposed are sufficiently novel that they warrant further validation. At this time, neither vendor has tested their equipment at the ocean depths being targeted, and questions remain on the efficiency, reliability, regulatory uncertainty, and ease of access for their systems. Metropolitan would benefit from continuing to track these technologies as well as potential consideration of partnering on planned demonstration projects.
- Carbon sequestration – Both ocean-based and land-based carbon sequestration approaches have potential to be employed as mitigating measures to GHG emissions, potentially providing a net benefit to the environment from the desalination facility. Ocean alkalinity enhancement (OAE) could be accomplished by modifying the desalination plant operations to maximize the alkalinity of the brine in the outfall, thus contributing to local CO_2 capture by the ocean. While this has been proposed as a theoretical method for using desalination brine to benefit the environment, no studies have been completed looking at the impacts of targeting high brine alkalinity on the efficiency and reliability of a desalination plant. Direct modeling is also needed for the impact of a high alkalinity brine outfall on CO_2 uptake in a California coastal environment. Metropolitan involvement in these types of studies could help establish opportunities for carbon credits associated with a seawater desalination facility.
- Optimizing established technologies – While positive displacement pumps and artificial intelligence are both established technologies that have been utilized in existing desalination

plants, there are opportunities for further enhancements of these technologies, which could benefit a future project in Southern California. Metropolitan should continue to track advancements in these technologies, while looking for opportunities to partner in future research studies.

4.0 Siting Evaluation

To focus on the seawater desalination opportunities that have the best chance of potential implementation, a siting analysis was conducted. The siting analysis utilized parametric evaluations to identify sites, conceptualize system alternatives for each site, and rank these alternatives to guide which ones warrant more detailed evaluation. The siting evaluation was conducted as a high-level screening exercise to compare potential alternatives using consistent planning-level criteria. The rankings presented are intended to inform future study prioritization and do not represent final site selection decisions.

A key factor in the ranking of sites is California's Ocean Plan, which was adopted by the State Water Board on May 6, 2015. The Ocean Plan provides guidance and preferences for the construction and operations of seawater desalination facilities to mitigate environmental impacts. The essence of the Ocean Plan is to use the best available site, design, technology, and mitigation measures feasible to minimize intake and mortality of all forms of marine life. Where impacts cannot be fully avoided through site selection and facility design, the Ocean Plan requires mitigation measures to address remaining effects. Preferences are to be given for subsurface intakes, use of existing intakes, and use of existing outfalls with sufficient blending water for brine disposal.

In addition to the Ocean Plan, the Seawater Desalination Siting and Streamlining Report to Expedite Permitting was also a key factor in the ranking of sites. This Siting and Permitting Report outlines criteria for site selection to streamline planning and mitigate effects on existing infrastructures and communities and offers recommendations to expedite permitting for desalination sites while balancing environmental and societal impacts.

4.1 Screening of Potential Seawater Desalination Sites

4.1.1 Hydrogeology Investigation

To identify sites that have the potential for subsurface intakes, CDM Smith's subconsultant, Geoscience, summarized previous work it had conducted along the coast of Southern California in order to estimate subsurface intake extraction capacities of various hydrogeologic areas. **Figure 4.1** shows these subsurface intake site locations, with the estimated maximum intake extraction capacities in mgd.

It is important to emphasize that these values represent theoretical hydrogeologic extraction capacities only and do not indicate overall project feasibility. Many of the mapped areas would be impractical or infeasible for development when considering broader environmental, regulatory, community, infrastructure, and resiliency constraints. In several cases, achieving the estimated capacity would require a large number of individual intake wells, resulting in significant construction footprint, operational complexity, and potential impacts to adjacent coastal communities.

Regional experience has demonstrated that desalination project viability depends on a comprehensive evaluation of cost, demonstrated need, environmental impacts, site constraints, and long-term resiliency, not solely on intake feasibility. For example, in May 2022, the CCC unanimously rejected the proposed 50-mgd Huntington Beach seawater desalination project after nearly 25 years of review,

concluding that the potential harms and project risks outweighed the anticipated benefits. Concerns cited in that decision included high projected water costs, lack of demonstrated local demand, potential impacts to marine life from screened ocean intakes, seismic and tsunami risks associated with the project location, and long-term sea level rise vulnerability. This illustrates that even large, technically feasible desalination projects may not be viable when evaluated against broader policy, environmental justice, and resiliency criteria.

Based on professional judgement, CDM Smith determined that the development and operation of more than 20 subsurface wells at a single site would be impractical due to potential impacts to adjacent beach communities and the operational complexity associated with constructing, operating, and maintaining a large number of wells. Accordingly, for planning-level evaluation purposes, the maximum number of subsurface intake wells in any one site serving a seawater desalination plant would be limited to 20.

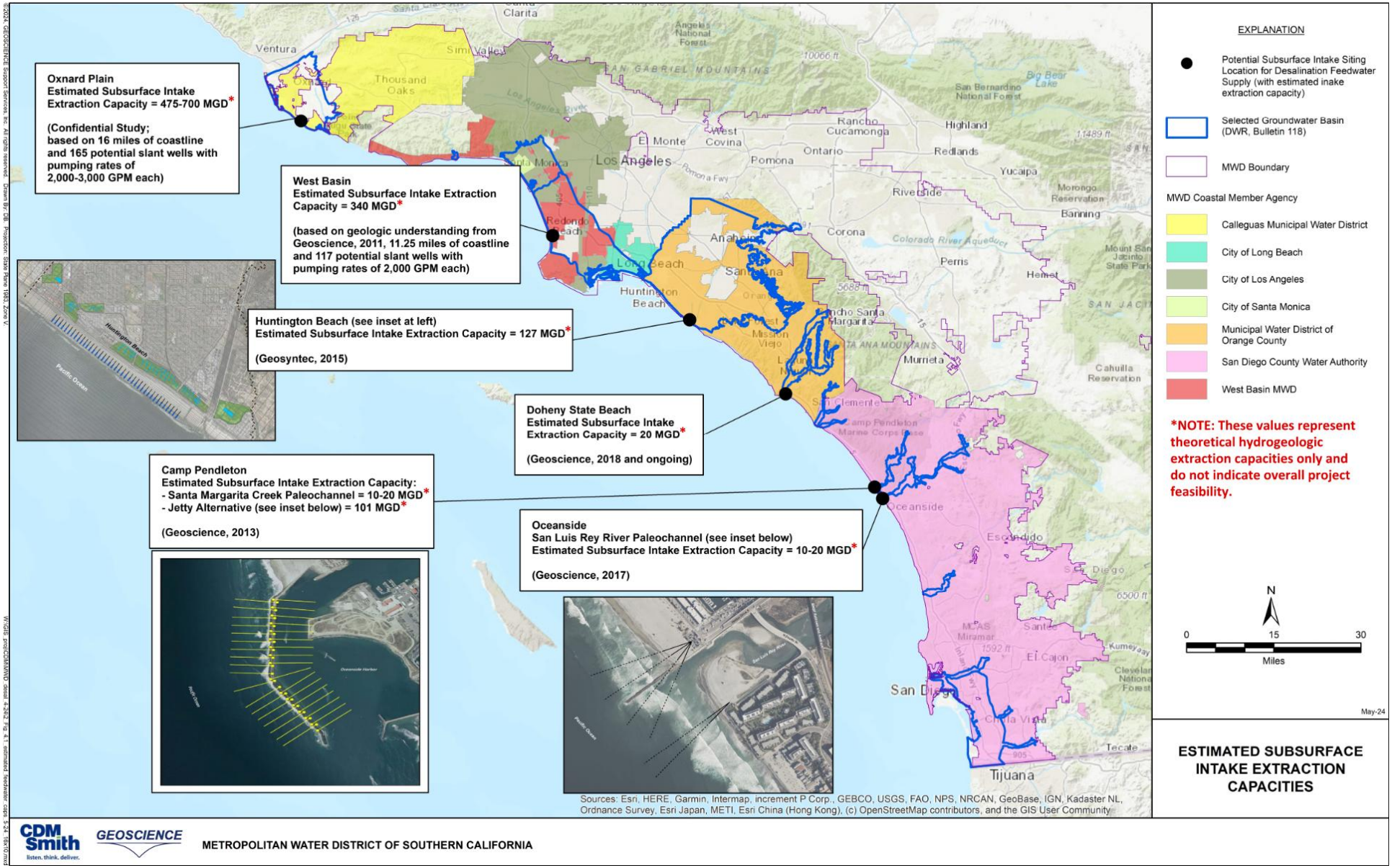


Figure 4.1 Hydrogeologic Map of Estimated Subsurface Intake Extraction Capacity (Courtesy of Geoscience)

4.1.2 Site Descriptions

In addition to potential subsurface intake extraction areas, CDM Smith identified existing power intakes and existing outfalls for wastewater and power to identify potential seawater desalination site locations. For this level of evaluation, CDM Smith made the following engineering assumptions:

- Seawater desalination facilities would operate at roughly 50 percent recovery, so a site's intake capacity would need to be double the water supply production, with remaining brine flows being sent to an outfall for disposal back to the ocean.
- A single subsurface well capacity is 2,000 gallons per minute (gpm).
- Slant wells would be grouped together in a well pod configuration, with 3-4 wells and their auxiliary facilities.
- A 25 percent standby capacity for slant wells is required to allow for well downtime.
- The maximum number of slant wells for a given site/seawater desalination facility would be 20 (including standby capacity), resulting in a maximum single site seawater desalination production capacity of 20 mgd for subsurface systems.
- One ocean seabed pod (new offshore technology) produces 1 mgd of product water, with a maximum of 20 seabed pods at any one site location.

Based on these assumptions and the desire to pick locations in each coastal county in Metropolitan's service area, a total of eight general seawater desalination sites were identified, with a total potential supply of 175 mgd. Four of the sites had two configurations of different specific locations, intake or outfall configurations, resulting in 12 site alternatives. **Figure 4.2** shows an overview map of these potential locations and their production capacities along the coast of Southern California.

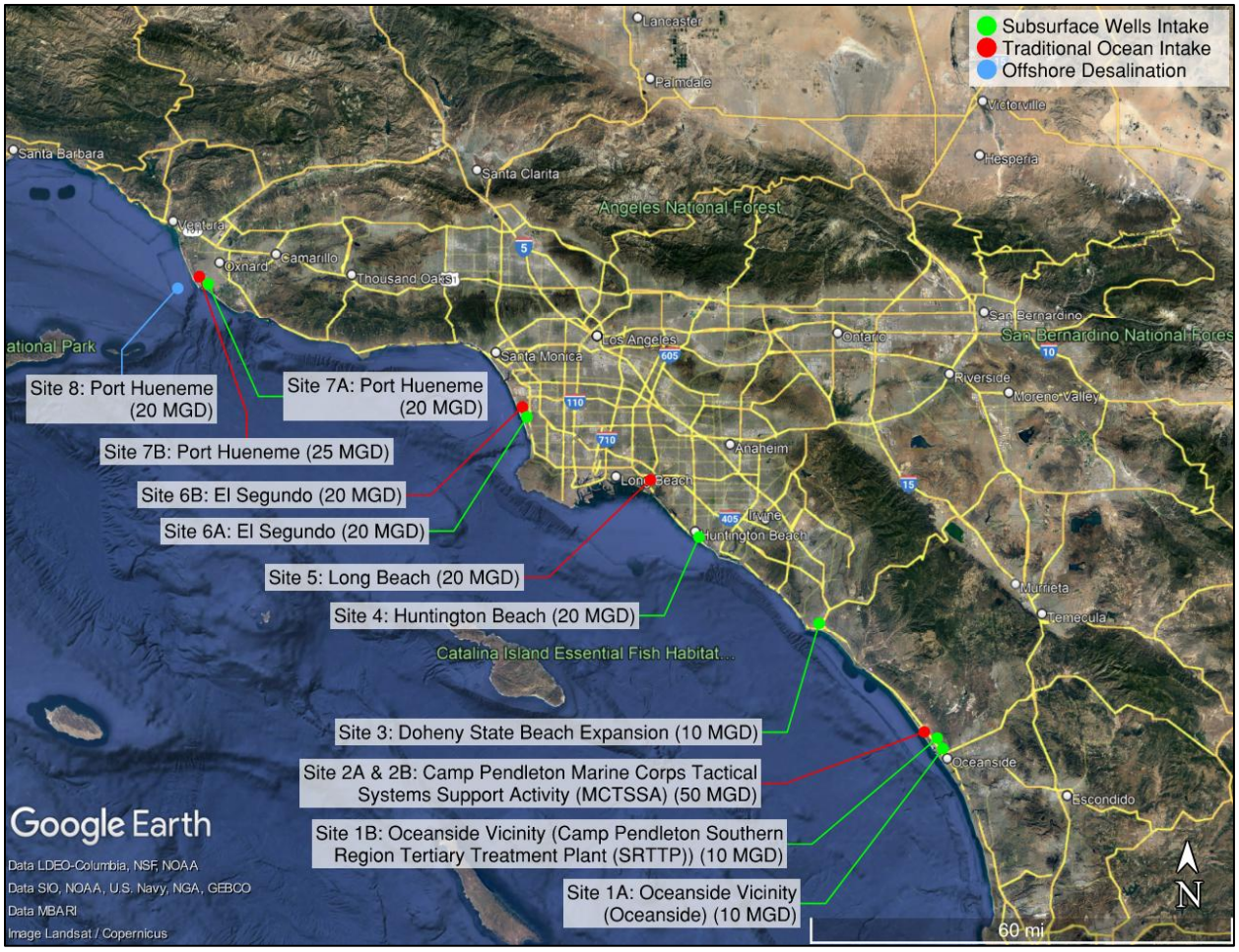


Figure 4.2 Potential Seawater Desalination Sites with Supply Production Values Shown in Parenthesis

Production capacities shown reflect initial screening assumptions. The refined El Segundo feasibility analysis evaluated a 10 mgd configuration.

The potential seawater desalination sites, along with intake, outfall and supply production capacities, are summarized in **Table 4.1.**

Table 4.1 Potential Seawater Desalination Site Summaries

Site #	Name	Intake	Outfall	Production Capacity (mgd)
1A	Oceanside Vicinity (Oceanside)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10
2A	Camp Pendleton MCTSSA	New Ocean Intake	Existing San Onofre Power Plant Outfall	50
2B	Camp Pendleton MCTSSA	New Ocean Intake	New Ocean Outfall	50
3	Doheny State Beach Expansion	Slant Wells (9)	Existing San Juan Creek WWTP Ocean Outfall	10
4	Huntington Beach	Slant Wells (20)	Existing AES Huntington Beach Generating Station Power Plant Outfall	20
5	Long Beach	New Ocean Intake	New Ocean Outfall	20
6A	El Segundo	Slant Wells (20)	Existing Hyperion WWTP Outfall	20[1]
6B	El Segundo	Converted Power Intake	Existing Hyperion WWTP Outfall	20[1]
7A	Port Hueneme	Slant Wells (20)	Existing Oxnard WWTP Outfall	20
7B	Port Hueneme	New Ocean Intake	Existing Oxnard WWTP Outfall	25
8	Port Hueneme (Offshore Desalination)	Seabed Pods	Seabed Pods	20

SRTTP = Camp Pendleton Southern Region Tertiary Treatment Plant
MCTSSA = Camp Pendleton Marine Corps Tactical Systems Support Activity Center

[1]The 20 mgd production capacity shown for Sites 6A and 6B reflects the initial capacity assumption used during the preliminary MCDA siting evaluation. Following subsequent coordination with NRG regarding site availability constraints, the refined planning-level cost estimate for the El Segundo alternative was reduced to 10 mgd. The 20 mgd capacity is retained in certain screening tables for consistency with the initial comparative evaluation framework.

4.1.2.1 Site 1A: Oceanside Vicinity (Oceanside)

This site is located on the Camp Pendleton Marine Corps Base property and in close proximity to the San Luis Rey River Paleochannel. Assuming 20 mgd of subsurface intake is needed for 10 mgd of product water, 9 slant wells (3 wellhead pods) would be required. The closest existing outfall to this site is the City of Oceanside Wastewater Outfall, approximately 3.3 miles south from the site. **Figure 4.3** shows the potential Oceanside treatment plant location which is outlined in green and within assessor's parcel number (APN) 1015201500 (San Diego County Geographic Information System [GIS] 2025[1]). Potential locations for the wellhead pods are shown in red and potential routing for intake conveyance is shown in blue. The total length of pipe to convey raw water from the wellhead pods to the treatment plant location is approximately 1.6 miles (Google Earth Pro 2025). The total site area, including treatment plant and wellhead pods, is approximately 15.5 acres (Google Earth Pro 2025).

Figure 4.3 Potential Oceanside Seawater Desalination Plant Location

4.1.2.2 Site 1B: Oceanside Vicinity (Camp Pendleton SRTTP)

This site is located on the Camp Pendleton Marine Corps Base property near SRTTP and is in close proximity to the Santa Margarita River Paleochannel. Assuming a 20 mgd of subsurface intake is needed

[1] https://gis-portal.sandiegocounty.gov/arcgis/home/webmap/viewer.html?webmap=f1b69ba9d3dd4940b8d1efcc9dac2ac4

for 10 mgd of product water, 9 slant wells (3 wellhead pods) would be required. The closest existing outfall to this site is the City of Oceanside Wastewater Outfall, approximately 4.8 miles south from the site. **Figure 4.4** shows the potential Camp Pendleton SRTTP location which is outlined in green and within APN 1015201500 (San Diego County GIS 2025[2]). The potential locations for the wellhead pods are shown in red, and potential routing for intake conveyance is shown in blue. The total length of pipe to convey raw water from the wellhead pods to the treatment plant location is approximately 1.6 miles (Google Earth Pro 2025). The total site area, including treatment plant and wellhead pods, is approximately 28.4 acres (Google Earth Pro 2025).

Figure 4.4 Potential Camp Pendleton SRTTP Site Location

4.1.2.3 Site 2A & 2B: Camp Pendleton MCTSSA

This site is located on the Camp Pendleton Marine Corps Base property near the MCTSSA Center. This location could potentially accommodate a new open ocean intake pipeline with an intake capacity of 100 mgd. There are two options for the expected 50 mgd brine discharge: Site 2A could potentially convey the brine in a 13-mile-long pipeline (Google Earth Pro 2025) to the existing San Onofre Outfall while Site 2B could potentially construct a new ocean outfall. **Figure 4.5** shows the potential Camp

[2] https://gis-portal.sandiegocounty.gov/arcgis/home/webmap/viewer.html?webmap=f1b69ba9d3dd4940b8d1efcc9dac2ac4

Pendleton MCTSSA treatment plant location which is outlined in green and within APN 1015201500 (San Diego County GIS 2025[3]). The total site area is approximately 20 acres (Google Earth Pro 2025).

Figure 4.5 Potential Camp Pendleton MCTSSA Site Location

4.1.2.4 Site 3: Doheny State Beach Expansion

This site is located north of the Doheny State Beach Campground. Currently, the first phase of the DODP is underway, with slant wells used to extract 10 mgd of raw water and a seawater desalination plant that will produce 5 mgd of potable supply. The potential expansion evaluated in this study would add an additional 10 mgd of desalinated product water to the existing 5 mgd facility, resulting in an ultimate plant capacity of 15 mgd. To support this additional 10 mgd of production, approximately 9 new slant wells (3 wellhead pods) would be required. In addition, the site presents a potential opportunity to integrate or co-develop up to 5 mgd of potable reuse supply, subject to further feasibility evaluation and coordination with regional wastewater and regulatory agencies.

The conveyance distances and routing assumptions presented herein reflect a planning level siting analysis conducted prior to finalization of the Phase 1 microtunneling alignment and raw water routing configuration. As such, the conceptual raw water conveyance layout shown in **Figure 4.6** represents a

[3] https://gis-portal.sandiegocounty.gov/arcgis/home/webmap/viewer.html?webmap=f1b69ba9d3dd4940b8d1efcc9dac2ac4

screening level assumption developed for comparative purposes and may not reflect infrastructure that will ultimately be incorporated as part of the Phase 1 project or any other future phases.

The closest existing outfall to this site is the San Juan Creek Ocean Outfall (SJCOO). **Figure 4.6** shows the Doheny location outlined in green within APNs 668-281-04, 668-261-13, and 668-261-11 (Orange County GIS 2025[4]). The potential locations for the wellhead pods are shown in red, existing wellhead pods are shown in orange, and potential routing for intake conveyance is shown in blue. Based on these screening level assumptions, the total length of pipe to convey raw water from the wellhead pods to the treatment plant location is approximately 1.6 miles (Google Earth Pro 2025). The total site area for the 3 additional wellhead pods is approximately 0.4 acres (Google Earth Pro 2025).

Figure 4.6 Doheny State Beach Site Location

4.1.2.5 Site 4: Huntington Beach

This site is located adjacent to the AES Power Station and in close proximity to Huntington State Beach. Assuming a 40 mgd of subsurface intake is needed for 20 mgd of product water, 20 slant wells (5 wellhead pods) would be required. The closest existing outfall to this site is the AES Huntington Beach Generating Power Plant Outfall. **Figure 4.7** shows the potential Huntington Beach parcel location

[4] https://data-ocpw.opendata.arcgis.com/datasets/e2c8332606da4e51ad941cacfd2c24ed_0/explore

outlined in green within APNs 114-152-01, 114-152-02, and 114-152-20 (Orange County GIS 2025[5]). The potential locations for the wellhead pods are shown in red and potential routing for intake conveyance are shown in blue. The total length of pipe to convey raw water from the wellhead pods to the treatment plant location is approximately 1.5 miles (Google Earth Pro 2025). The total site area, including treatment plant and wellhead pods, is approximately 20 acres (Google Earth Pro 2025).

Figure 4.7 Potential Huntington Beach Site Location

4.1.2.6 Site 5: Long Beach

This site is located on the property of the Alamitos Energy Center, which is scheduled to be decommissioned in 2026. This location could potentially construct a new open ocean intake pipeline with an intake capacity of 20 mgd and a new ocean outfall. **Figure 4.8** shows the potential Long Beach parcel location outlined in green within APNs 7237-019-810 and 7237-019-008 (Los Angeles County GIS[6]). The total site area is approximately 18.4 acres (Google Earth Pro 2025).

Although an existing power plant cooling water intake is located nearby, it was not considered a viable option for this project. Use of the existing intake would likely require substantial modifications to meet

[5] https://data-ocpw.opendata.arcgis.com/datasets/e2c8332606da4e51ad941cacfd2c24ed_0/explore
[6] https://maps.assessor.lacounty.gov/m/

current regulatory requirements, including installation of modern screening technology. In addition, the intake is located within the highly trafficked Port of Long Beach, where marine navigation constraints, limited construction access, and complex permitting would make retrofit or expansion activities logistically challenging and potentially infeasible. As a result, development assumptions for this site were based on construction of a new dedicated intake and outfall rather than reuse of existing power plant infrastructure.

Figure 4.8 Potential Long Beach Site Location

4.1.2.7 Site 6A & 6B: El Segundo

This site is located on the property of the partially decommissioned El Segundo Power Plant and near El Segundo Beach. This site has two options for intake: Site 6A could potentially use subsurface slant wells and Site 6B could potentially convert the existing El Segundo Power Plant intake.

At a planning level, the subsurface slant well option (Site 6A) appears technically viable from a hydrogeologic perspective, provided that sufficient aquifer transmissivity and raw seawater yield can be confirmed through site-specific investigation. However, achieving a 20 mgd production capacity would require approximately 20 slant wells (5 wellhead pods), representing a relatively high well count. While technically feasible, this scale of development could present construction complexity, staging constraints, high capital cost, and operational considerations compared to lower-well-count facilities.

Long-term performance reliability would need to be confirmed through pilot testing and aquifer characterization.

The existing intake conversion option (Site 6B) may offer potential capital cost and construction advantages by leveraging existing infrastructure and minimizing new marine construction. However, this alternative presents greater regulatory uncertainty. Under current California Ocean Plan requirements, open ocean intakes are generally not permitted unless subsurface intake infeasibility can be demonstrated through a site-specific evaluation. As a result, while physically viable from an infrastructure standpoint, the regulatory pathway for converting the existing intake would likely involve more extensive permitting review, demonstration of best available technology, and potential mitigation requirements.

Accordingly, both intake alternatives appear technically achievable at a conceptual level, but they present different risk profiles: Site 6A carries a greater construction and operational complexity risk, whereas Site 6B carries greater regulatory and permitting risk. Further site-specific engineering, hydrogeologic testing, and regulatory coordination would be required to confirm the ultimate viability of either approach.

The closest existing desirable outfall to this site is the Hyperion Wastewater Outfall. **Figure 4.9** shows the potential El Segundo parcel location outlined in green within APNs 4138-029-804, 4138-029-805, 4138-029-005, 4138-029-006, 4138-029-800, and 4138-029-004 (Los Angeles County GIS[7]). The potential locations for the wellhead pods are shown in red and potential routing for intake conveyance is shown in blue. The total length of pipe to convey raw water from the wellhead pods to the treatment plant location is approximately 1 mile (Google Earth Pro 2025). The total site area, including treatment plant and wellhead pods, is approximately 32.8 acres (Google Earth Pro 2025).

[7] https://maps.assessor.lacounty.gov/m/

Figure 4.9 Potential El Segundo Site Location

4.1.2.8 Site 7A & 7B: Port Hueneme

This site is located on the property of the Naval Base Ventura County – Port Hueneme (Port Hueneme Naval Base) and in the Oxnard Plain. This site has two options for intake: Site 7A could potentially use subsurface slant wells and Site 7B could potentially construct a new open ocean intake pipeline. Assuming a 20 mgd plant production capacity, 20 slant wells (5 wellhead pods) would be required for the subsurface intake option. The closest existing outfall to this site is the Oxnard Wastewater Outfall. The Calleguas Salinity Management Pipeline (SMP) outfall is also located in close proximity but was not selected due to the state's preference for comingled discharge. **Figure 4.10** shows the potential Port Hueneme parcel location outlined in green within APN 206001017 (Ventura County GIS[8]). The potential locations for the wellhead pods are shown in red, and potential routing for intake conveyance is shown in blue. The total length of pipe to convey raw water from the wellhead pods to the treatment plant location is approximately 3.2 miles (Google Earth Pro 2025). The total site area, including treatment plant and wellhead pods, is approximately 30 acres (Google Earth Pro 2025). The new ocean intake option would have a site area of 30 acres (Google Earth Pro 2025).

[8] https://maps.ventura.org/countyview/

Figure 4.10 Potential Port Hueneme Site Location

4.1.2.9 Site 8: Port Hueneme (Offshore Desalination)

In an attempt to capture a new offshore desalination option in this siting analysis, CDM Smith selected seabed pods as being the most likely offshore technology that could be permitted under the Ocean Plan. However, many unknowns still exist with this technology. The coast of Ventura County was identified as a potential site for seabed pods, approximately 4 miles offshore from Port Hueneme. Depending on final system configuration and hydraulic requirements, deployment would likely require placement in deep offshore waters to achieve sufficient hydrostatic pressure and avoid nearshore wave loading and coastal use conflicts. Preliminary review suggests that depths on the order of several hundred meters (approximately 750 to 1,500 feet) may be necessary, consistent with current proposed subsea RO concepts. A detailed ocean bathymetry survey and subseafloor geotechnical investigation would be required to accurately determine feasible pod placement, seabed stability, pipeline routing, and constructability constraints.

Assuming 20 mgd treatment plant production capacity, 20 seabed pods would be needed. **Figure 4.11** shows the approximate location of the seabed pods. To account for disinfection, stabilization, storage and pumping it was assumed an onshore facility would be also needed, which is shown on the map

outlined in green within APN 206001017 (Ventura County GIS[9]). The total site area is approximately 30 acres (Google Earth Pro 2025).

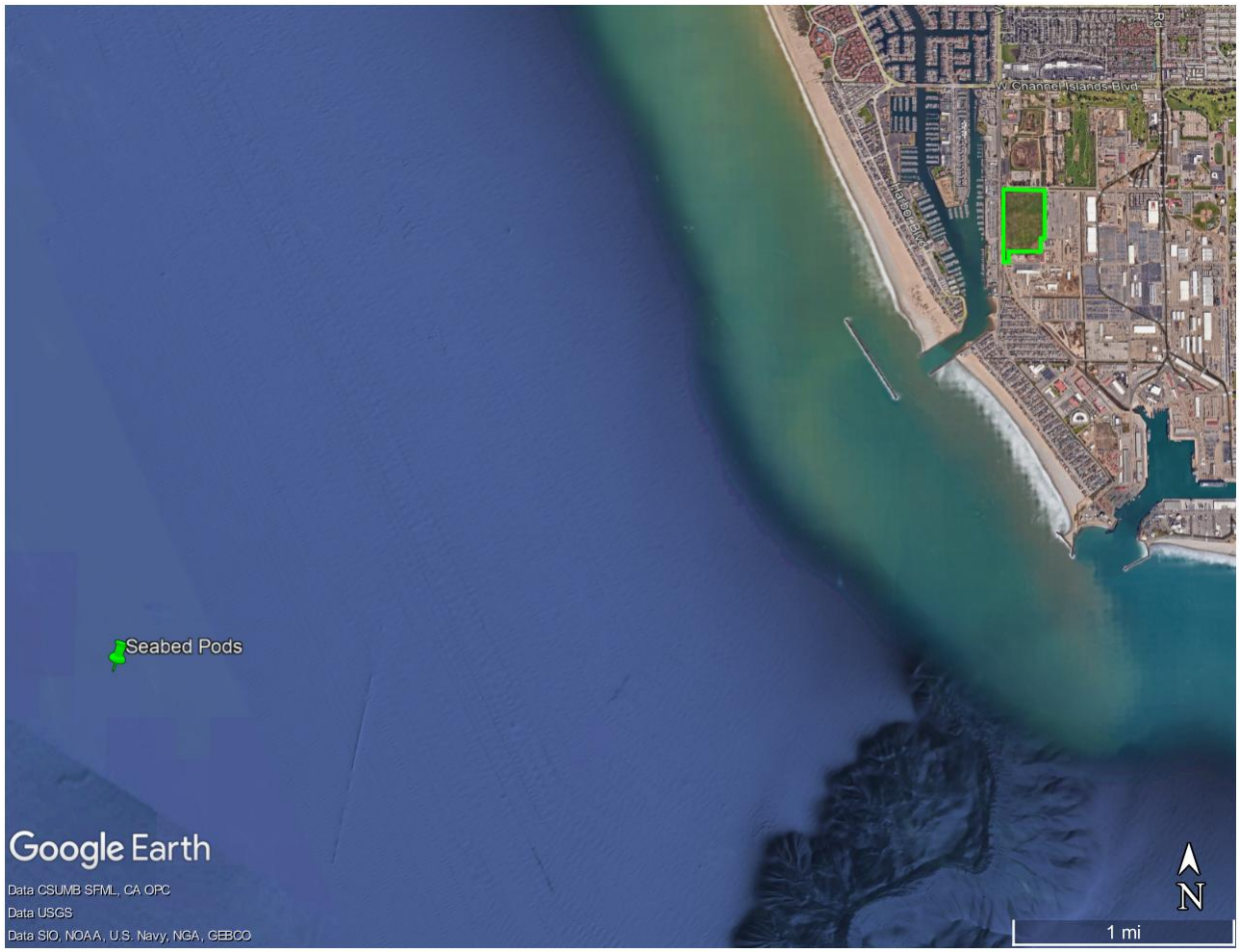


Figure 4.11 Potential Offshore Desalination Site Location

[9] https://maps.ventura.org/countyview/

4.2 Evaluation Criteria and Scoring

To evaluate each potential seawater desalination site, MCDA was utilized. MCDA requires the following:

- Defining the criteria.
- Determining how the criteria will be scored.
- Normalizing process for handling scores measured in different units.
- Establishing weights of importance for the criteria.

CDM Smith used the commercial software Criterium Decision Plus[10] in order to rank the seawater desalination sites for this effort.

Metropolitan staff and CDM Smith developed the criteria at the start of this research study for ranking potential seawater desalination sites. Several of the criteria were intentionally structured to reflect and remain consistent with evaluative considerations outlined in Metropolitan's CAMP4W framework, including supply reliability, cost-effectiveness, environmental stewardship, equity considerations, and implementation feasibility. The relative weights assigned to each criterion were discussed and agreed upon during a workshop held with Metropolitan staff on August 9, 2024. The resulting weighted score distribution of these criteria is as follows:

- Water Supply Benefit (20%)
- Permitting Ease (20%)
- Cost-Effectiveness (15%)
- Environmental and Social Justice Impact (15%)
- Technology Readiness (15%)
- System Integration (10%)
- Sea Level Rise (5%)

It should be noted that MCDA results are inherently sensitive to the weighting assumptions applied to each criterion. Alternative weighting scenarios could reasonably produce different relative rankings, particularly among sites with comparable composite scores. The rankings presented herein reflect the agreed-upon weighting structure and are intended to support comparative planning-level evaluation rather than establish definitive project prioritization.

These criteria, along with scoring definitions, are presented in **Table 4.2**.

[10] http://www.infoharvest.com/ihroot/index.asp

Table 4.2 Site Evaluation Criteria

Criteria	Score Definition
Water Supply Benefit	▪ Score of 1-5, reflecting the needs for alternative water supply of the surrounding area. ▪ Score of 5 indicates the highest need, generally in areas where there are little local water supplies, and where imported water can be severely limited due to seismic events or Metropolitan's SWP Dependent Areas during droughts. ▪ Score of 1 indicates the lowest need, generally in areas with low demand, abundant local water supplies, and multiple points of imported water delivery.
Permitting Ease	▪ Score of 1-5, reflecting the ease of permitting all of the required facilities for an ocean desalination plant (intakes, plant, and outfalls). ▪ Score of 5 indicates the highest expected permitting ease, generally those sites with subsurface intakes and use of an existing outfall with sufficient wastewater blend for brine disposal. ▪ Score of 1 indicates that both a new ocean intake and ocean outfall would be required, and/or there is no blend water for the outfall.
Cost-Effectiveness	▪ Unit cost of water supply, expressed as dollars per acre-foot ($/AF) with the lowest unit cost being most advantageous and, therefore, receiving a higher score. ▪ This metric reflects the capital and O&M (operations and maintenance) costs associated with intakes, treatment plant, and outfalls over a 30-year life. ▪ Land purchase costs and conveyance/distribution to specific demand areas were not included in this metric. Because conveyance and distribution infrastructure can represent a substantial portion of total lifecycle cost, the exclusion of these elements may materially affect relative cost-effectiveness comparisons among sites.
Environmental/ Social Impacts	▪ Score of 1-5, reflecting the impacts of construction and operations of the ocean desalination facilities on the environment, disadvantaged communities (DAC), and tribal resources. ▪ Score of 5 indicates the lowest impacts, generally those sites with few sensitive species or protected wildlife areas, no surrounding DAC areas, and little impact to tribal resources. ▪ Score of 1 indicates the highest impacts to the environment, DAC and tribal resources.
Technology Readiness	▪ Score of 1-9, reflecting TRL. ▪ Score of 9 indicates the most proven, replicable technology such as use of ocean intakes, traditional onshore treatment facilities, and ocean outfalls. ▪ Score of 1 indicates offshore desalination technologies only tested in laboratory settings, without pilots or demonstrations in real-world environments.
System Integration	▪ Score of 1-5, reflecting difficulty of delivery of desalinated water to customers. ▪ Score of 5 indicates the least amount of conveyance is required to deliver water to customers. ▪ Score of 1 indicates the greatest amount of conveyance is required to deliver water to customers.
Sea Level Rise Impacts	▪ Score of 1-5, reflecting the risk of sea level rise inundation to intake and plant facilities by the year 2080. Screening was conducted using NOAA's Sea Level Rise Viewer under the "Intermediate High" relative sea level rise scenario, assuming no shoreline accretion. This scenario represents a mid-to-upper range projection of relative sea level rise incorporating regional land motion and accelerated ice sheet contributions. ▪ A score of 5 indicates no risk of sea level rise on facilities by the year 2080. ▪ Score of 1 indicates significant risk of sea level rise on facilities by the year 2080.

4.2.1 Water Supply Benefit

Evaluating the state of a region's current water supply is essential for determining the necessity and feasibility of a seawater desalination plant. Factors such as existing water sources, reliability during natural disasters, and vulnerability to droughts play a critical role in this assessment. A score of 1-5 was assigned to each site based on CDM Smith's water supply planning experience in Metropolitan's service area, with 5 being the best score (i.e., indicating the highest need) and 1 being the worst score (see **Table 4.3**).

Table 4.3 Water Supply Benefit Scoring

Site #	Name	Score	Score Reasoning
1A	Oceanside Vicinity (Oceanside)	3	This area of San Diego can receive imported water, as well as desalinated water from SDCWA's water purchase agreement with Poseidon's Carlsbad Desalination Plant.
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	3	This area of San Diego can receive imported water, as well as desalinated water from SDCWA's water purchase agreement with Poseidon's Carlsbad Desalination Plant.
2A	Camp Pendleton MCTSSA	2	▪ The local demand area for this quantity of water would have to extend to Riverside County. ▪ The combined San Diego/Riverside area can receive imported water from multiple delivery points, as well as local groundwater and desalinated water from SDCWA's water purchase agreement with Poseidon's Carlsbad Desalination Plant.
2B	Camp Pendleton MCTSSA	2	▪ The local demand area for this quantity of water would have to extend to Riverside County. ▪ The combined San Diego/Riverside area can receive imported water from multiple delivery points, as well as local groundwater and desalinated water from SDCWA's water purchase agreement with Poseidon's Carlsbad Desalination Plant.
3	Doheny State Beach Expansion	5	▪ This area of South Orange County has very little local groundwater and is 90% reliant on imported supply. ▪ This area is vulnerable to imported water interruption during a seismic event that can significantly limit delivery of treated water from Metropolitan.
4	Huntington Beach	1	This area of Orange County has access to significant groundwater, which has been enhanced by purified reuse for groundwater replenishment, and multiple points of delivery of imported water.
5	Long Beach	4	▪ Long Beach has an "exclusive" imported water zone that has had issues when planned/unplanned Metropolitan system outages have occurred, which could be eliminated with a new local source of water supply. ▪ As it is expected that the City of Long Beach alone will not have sufficient overlaying water demands for a 20 mgd desalination supply, Metropolitan would also need additional conveyance to deliver water to neighboring member agencies that could include: City of Compton, City of Torrance, West Basin Municipal Water District, Central Basin Municipal Water District, and Municipal Water District of Orange County.
6A	El Segundo	3	This coastal area of Los Angeles County has more limited access to groundwater due to constraints in water rights and pumping capacities but has multiple points of delivery of imported water.
6B	El Segundo	3	This coastal area of Los Angeles County has more limited access to groundwater due to constraints in water rights and pumping capacities but has multiple points of delivery of imported water.
7A	Port Hueneme	5	Ventura County is in Metropolitan's SWP Dependent Area for Metropolitan making it very susceptible to droughts and seismic events that impact the SWP system.
7B	Port Hueneme	5	Ventura County is in Metropolitan's SWP Dependent Area for Metropolitan making it very susceptible to droughts and seismic events that impact the SWP system.
8	Port Hueneme (Offshore Desalination)	5	Ventura County is in Metropolitan's SWP Dependent Area for Metropolitan making it very susceptible to droughts and seismic events that impact the SWP system.

4.2.2 Permitting Ease

Projects with clearer and more predictable permitting pathways are generally less susceptible to regulatory disputes, third-party litigation, and associated schedule delays, which can significantly reduce development risk and long-term cost uncertainty. Each site's ease of permitting was determined by evaluating a combination of the intake and outfall options. For intake types, the permitting ease scoring was informed by the SWRCB's Ocean Plan, which prioritizes subsurface intakes and requires a comparative demonstration of infeasibility before a surface intake is approved.

Three intake options were investigated for this siting analysis: traditional open ocean intakes, subsurface extraction slant wells, and seabed pods. For open ocean intake, either a new intake pipeline would be required, or an existing decommissioned power plant cooling water intake pipeline would be converted to a seawater desalination pipeline. Subsurface extraction slant wells would be located along the coastline and below the ground surface. Wellhead pods contain 3-4 wells. Wellhead pods are recommended to be a minimum of 1,500 feet apart along the shoreline. Seabed pods are submerged seawater desalination units located in the aphotic zone, at approximately 1,500-foot depth. They use hydraulic pressure from the water depth to operate at 3.5 gfd production rate. Subsurface intakes were given a permitting ease score of 5, offshore seabed pods a score of 4 (to account for permitting uncertainty), converted power ocean intakes a score of 3, and new ocean intakes a score of 1.

In this siting analysis, we prioritized site locations near existing outfalls to the extent possible. Permit ease scoring for outfalls was determined by the approximate assumed discharge blend ratios. For example, outfalls having higher ratios of wastewater available to blend with the desalination brine were given higher scores. These ratios were calculated from the outfall's current wastewater discharges (as stated in their National Pollutant Discharge Elimination System (NPDES) permit), anticipated future wastewater discharges as a result of planned Pure Water Programs, and assumed desalination brine discharge. A summary of each site's outfall score and score reasoning is outlined in **Table 4.4**.

Table 4.4 Outfall Scoring

Site #	Name	Outfall	Assumed Discharge Blend	Score	Score Reasoning
1A	Oceanside Vicinity (Oceanside)	Existing Oceanside WWTP Outfall	2.56 mgd wastewater (WW) effluent (17.6%)* 2 mgd WW reuse brine (13.7%) 10 mgd desalination brine (68.7%)	3	The use of the Oceanside WW Outfall would have approximately 70% of the effluent makeup as desalination brine and the other 30% as WW reuse brine.
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Existing Oceanside WWTP Outfall	2.56 mgd WW effluent (17.6%)* 2 mgd WW reuse brine (13.7%) 10 mgd desalination brine (68.7%)	3	Using Oceanside's WW Outfall would have approximately 70% of the effluent makeup as desalination brine and the other 30% as WW reuse brine.
2A	Camp Pendleton MCTSSA	Existing San Onofre PP Outfall	50 mgd desalination brine (100%)	1	Utilizing San Onofre's existing outfall would result in effluent being 100% desalination brine.
2B	Camp Pendleton MCTSSA	New Ocean Outfall	50 mgd desalination brine (100%)	1	A new ocean outfall for desalination would be the most difficult to permit.

Site #	Name	Outfall	Assumed Discharge Blend	Score	Score Reasoning
3	Doheny State Beach Expansion	Existing San Juan Creek WW Ocean Outfall	10.5 mgd WW effluent (40.6%) 15 mgd desalination brine - initial and new phases (58.1%) 0.33 mgd GW desalination brine (1.3%)	4	While utilizing the San Juan Creek WW Ocean Outfall would have more than 40% desalination brine, the Doheny plant already has a permit for discharging desalination brine.
4	Huntington Beach	Existing AES Huntington Beach Power Outfall	20 mgd desalination brine (15.9%) 105.5 mgd PP cooling water (84.1%)	2	The AES Huntington Beach Power Outfall is all seawater and adding desalination brine would make it more concentrated.
5	Long Beach	New Ocean Outfall	20 mgd desalination brine (100%)	1	A new ocean outfall for desalination would be the most difficult to permit.
6A	El Segundo	Existing Hyperion WWTP Outfall	34.9 mgd WW reuse brine (63.6%)** 20 mgd desalination brine (36.4%)	4	Using Hyperion's WW Outfall would result in approximately 40% desalination brine and 60% wastewater discharge.
6B	El Segundo	Existing Hyperion WWTP Outfall	34.9 mgd WW reuse brine (63.6%)** 20 mgd desalination brine (36.4%)	4	Using Hyperion's WW Outfall would result in approximately 40% desalination brine and 60% wastewater discharge.
7A	Port Hueneme	Existing Oxnard WWTP Outfall	18.5 mgd WW effluent (44.5%) 3.1 mgd Advanced Water Purification Facility (AWPF) brine (7.5%) 20 mgd desalination brine (48.0%)	4	Using Oxnard's WW Outfall would result in approximately 50% desalination brine and 50% wastewater discharge.
7B	Port Hueneme	Existing Oxnard WWTP Outfall	18.5 mgd WW effluent (44.5%) 3.1 mgd AWPF brine (7.5%) 20 mgd desalination brine (48.0%)	4	Using Oxnard's WW Outfall would result in approximately 50% desalination brine and 50% wastewater discharge.
8	Port Hueneme (Offshore Desalination)	None	N/A	4	Brine disposal/disbursement is not proven for this technology, but low recoveries would limit the salinity of the brine.

*Based on planned Pure Water Oceanside.

**Pure Water LA (formerly Operation NEXT) intends to reuse all water from the Hyperion WWTP. This number represents the estimated amount of wastewater reuse brine, which assumes that Hyperion will produce up to 174 mgd and the reuse process being 85% efficient.[11]

The total permitting ease score was calculated by taking the average of the intake and outfall scores. **Table 4.5** summarizes the intake score, outfall score, and total permitting ease score for each potential site.

[11] https://www.ladwp.com/sites/default/files/documents/LASAN_Hyperion_2035_Program_Fact_Sheet.pdf

Table 4.5 Permitting Ease Scoring

Site #	Name	Intake Score	Outfall Score	Total Score
1A	Oceanside Vicinity (Oceanside)	5	3	4
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	5	3	4
2A	Camp Pendleton MCTSSA	1	1	1
2B	Camp Pendleton MCTSSA	1	1	1
3	Doheny State Beach Expansion	5	4	4.5
4	Huntington Beach	5	2	3.5
5	Long Beach	1	1	1
6A	El Segundo	5	4	4.5
6B	El Segundo	3	4	3.5
7A	Port Hueneme	5	5	5
7B	Port Hueneme	1	5	3
8	Port Hueneme (Offshore Desalination)	4	4	4

4.2.3 Cost Effectiveness of Treatment and Disposal

For this level of siting evaluation, intake, treatment, and outfall costs were estimated using an AACE Class 5 parametric analysis, that is to say that published reports/guidance manuals were used to develop unit capital and O&M costs for required facilities. The unit costs were then scaled to the various capacity sizes of the sites as summarized previously. Because energy use is a major driver of seawater desalination O&M cost, two key assumptions were applied consistently across the siting analysis: an assumed electricity cost of $0.2975/kWh and a specific energy consumption of 4,900 kWh/AF for RO treatment. For sites using subsurface intakes, cost components included: slant wells, pipes to network wells to treatment plants, treatment plants and pipes to existing outfalls. For sites that required modified existing seawater intakes at power plants, cost components included: new 1-mm intake screens for minimizing marine life mortality, treatment plants, and pipes to existing outfalls. For sites that required new intakes or new outfalls, cost components included: new intakes, treatment plants, and new outfalls. Intake and outfall costs assume that tunneling would be used to minimize marine impacts.

For offshore desalination, cost estimates were requested from two equipment suppliers (OceanWell and Waterise), however, to be more conservative capital costs presented here were developed based on unit costs for onshore treatment, inflated to account for larger membrane areas (2.7 times more membranes) and more costly materials needed for the deep-sea environment. O&M costs for offshore desalination presented here reflect reduced costs (compared to onshore treatment) for energy and chemicals, but increased costs for membrane replacement and more challenging underwater maintenance.

Land acquisition costs, distribution conveyance costs from treatment plants to water customers, and GHG mitigation costs were not included in this siting-level evaluation. These exclusions represent potentially significant cost components and should be clearly considered when interpreting the total

capital cost results presented herein. Estimating land and distribution conveyance costs would have required site-specific property ownership research, routing studies, and coordination with landowners and agencies, which were beyond the scope and budget of this planning-level study. As a result, the cost estimates and relative rankings reflect facility-level costs only and do not represent full program-level implementation costs. Inclusion of land acquisition, regional distribution infrastructure, and emissions mitigation measures could materially affect total project cost and, in some cases, comparative cost-effectiveness among sites. These elements will be critical considerations in subsequent project phases when site-specific design, permitting, routing, financing, and compliance strategies are more fully developed. Similarly, emissions reduction and compliance costs were excluded because all alternatives would be subject to California greenhouse gas regulations and would require some level of emissions mitigation as an implementation requirement. As such, emissions-related costs were considered a common requirement across all alternatives and not a differentiating factor at this screening-level analysis. Land acquisition, distribution conveyance, and emissions mitigation costs will be important considerations in subsequent project phases, when site-specific design, permitting, routing, and compliance strategies are more fully developed.

All costs were inflated from the year of the parametric estimate to 2024 dollars using the appropriate indices for capital equipment, energy, chemicals, labor, etc. Costs also include 20 percent for engineering and permitting, and 30 percent for contingency—appropriate for high-level planning. Capital costs were annualized over 30 years, using a 5 percent interest rate. Annualized capital costs were added to annual O&M costs, then divided by the supply yield in order to arrive at a unit cost of $/AF. No future escalation of costs was made. The unit costs are presented in **Table 4.6**.

Table 4.6 Cost Summary[1]

Site #	Name	Intake/Outfall	Produced Water (mgd)	Total Annualized Cost ($M)	Unit Cost ($/AF)
1A	Oceanside Vicinity (Oceanside)	New Slant Wells, Existing Outfall	10	$49.8	$4,400
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	New Slant Wells, Existing Outfall	10	$50.6	$4,500
2A	Camp Pendleton MCTSSA	New Ocean Intake, Existing Outfall	50	$329.8	$5,900
2B	Camp Pendleton MCTSSA	New Ocean Intake and Outfall	50	$353.1	$6,300
3	Doheny State Beach Expansion	New Slant Wells, Existing Outfall	10	$48.1	$4,300
4	Huntington Beach	New Slant Wells, Existing Outfall	20	$93.8	$4,200
5	Long Beach	New Ocean Intake and Outfall	20	$144.5	$6,400
6A	El Segundo	New Slant Wells, Existing Outfall	20[2]	$93.3	$4,200
6B	El Segundo	Converted Intake, Existing Outfall	20[2]	$89.1	$4,000
7A	Port Hueneme	New Slant Wells, Existing Outfall	20	$98.5	$4,400

Site #	Name	Intake/Outfall	Produced Water (mgd)	Total Annualized Cost ($M)	Unit Cost ($/AF)
7B	Port Hueneme	New Ocean Intake, Existing Outfall	25	$164.8	$5,900
8	Port Hueneme (Offshore Desalination)	Seabed Pods	20	$110.5	$4,900

[1]Unit costs exclude land acquisition (except where noted) and distribution/conveyance infrastructure beyond the treatment plant tie-in point.

[2]The 20 mgd production capacity shown for Sites 6A and 6B reflects the initial capacity assumption used during the preliminary MCDA siting evaluation. Following subsequent coordination with NRG regarding site availability constraints, the refined planning-level cost estimate for the El Segundo alternative was reduced to 10 mgd. The 20 mgd capacity is retained in certain screening tables for consistency with the initial comparative evaluation framework.

For more details on cost assumptions, see **Appendix C**.

4.2.4 Environmental and Social Justice Impact

A wide variety of factors influence environmental and social justice impacts. Any new seawater desalination facility would be required to undergo extensive environmental analysis in compliance with CEQA and may require compliance with the National Environmental Policy Act (NEPA). The analysis performed for this memorandum evaluated environmental and social justice impacts comparatively across the sites. A high score indicates the lowest impacts compared to the other sites; it is not an absolute value that indicates the overall environmental or social justice impacts of a particular site.

This screening-level evaluation is preliminary in nature and does not substitute for formal CEQA/NEPA environmental review, detailed technical studies, tribal consultation, or robust community engagement processes that would be required prior to project implementation.

For purposes of this screening level analysis, three factors were considered in determining the comparative environmental and social justice impacts of the various sites relative to one another:

- Location within/proximity to a California Marine Protected Area (MPA), which was used as an initial screening for all the sites.
- Potential for site development to affect a sensitive species or critical habitat, as determined by the National Oceanic and Atmospheric Administration (NOAA) Environmentally Sensitive Index (ESI) geodatabase and California's Offshore Wind Data Basin, respectively.
- Location of the site with respect to archeological and tribal cultural resources.
- Location of the site with respect to a DAC based on the Environmental Protection Agency's (EPA) online EJScreen tool[12].

[12] Note that environmental and social justice impacts were determined by a desktop review. No site visits were conducted as part of this analysis. Moreover, as noted, a limited number of databases were reviewed for this analysis. A broader review of additional information sources may yield different or more refined information regarding environmental and social justice impacts.

Environmental implications of brine discharge as well as intake option are considered under permitting ease. Once permitting is achieved, the environmental score herein is based on construction and operational impacts to the environment.

4.2.4.1 Environmental Impact

California's MPAs have become a crucial instrument in safeguarding the state's marine habitat against overfishing, pollution, climate change, and the loss of native habitat. The South Coast Region spans from the U.S./Mexico border to Santa Barabara County. An initial screening of each site was conducted against the South Coast Region MPAs to confirm that none of the potential sites would interfere with an MPA. This evaluation is shown in Figure 4.12[13].

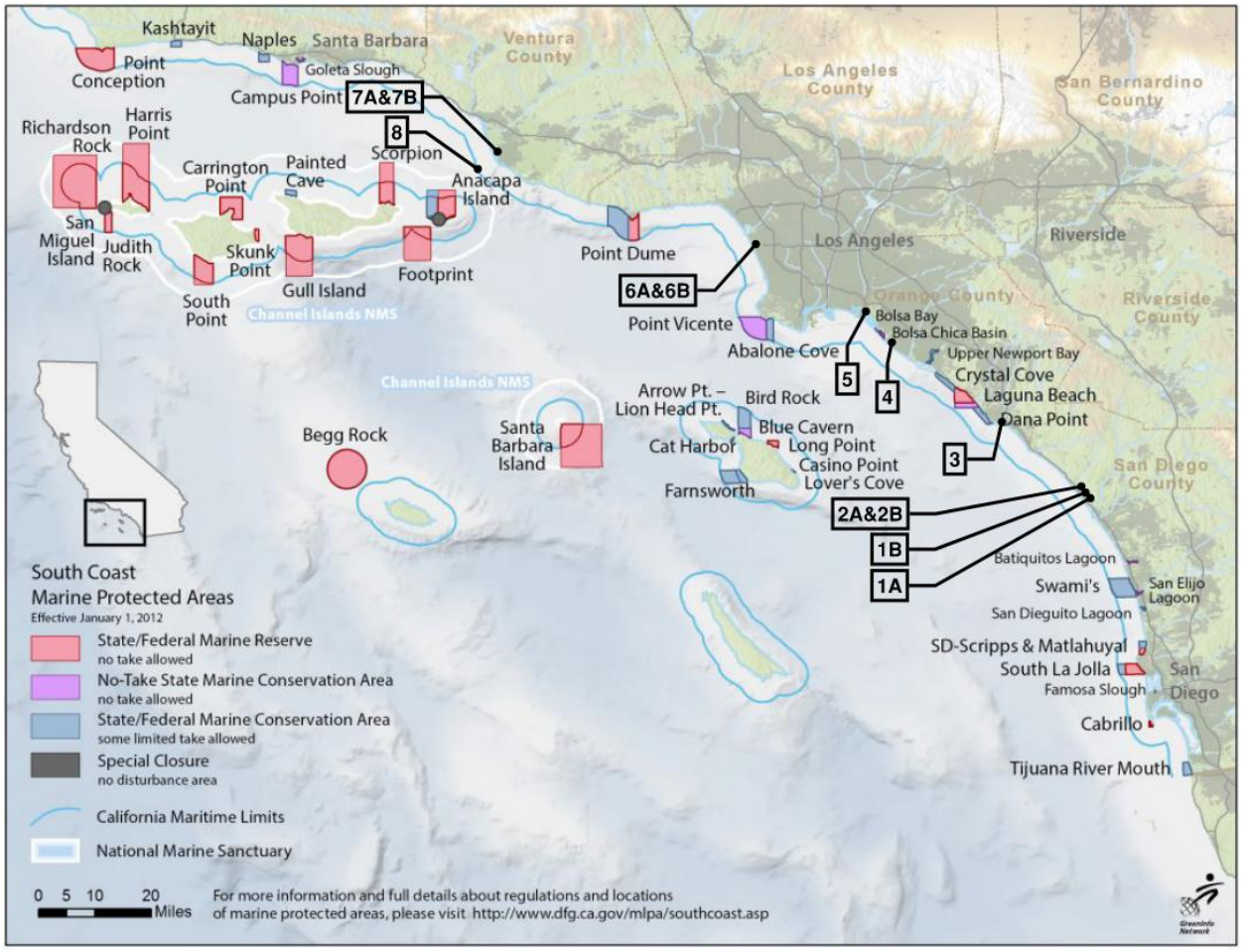


Figure 4.12 South Coast Region Marine Protected Areas (MPAs)

The locations of sensitive species were obtained from the NOAA ESI geodatabase and critical habitats were obtained from the California Offshore Wind Data Basin. Critical habitats that were evaluated included those of the killer whale, western snowy plover, humpback whale, leatherback turtle, and Steller sea lion. Figure 4.13 displays an overview map of the site locations with the environmental impact data. Affected sensitive species include: (1) California Grunion, which spawns March through

[13] Source: https://californiampas.org/mpa-regions/south-coast-region

August, (2) California Least Tern, which nests April through September, (3) Western Snowy Plover, which nests March through September, (4) Belding's Savannah Sparrow, which nests March through May, (5) California Pocket Mouse, (6) Bald Eagle, and (7) Peregrine Falcon. Construction activities may be impacted during the spawning and nesting seasons of these species. Only one critical habitat was affected, which was the Western Snowy Plover. Any sites that may permanently affect a critical habitat were given a score of 1. **Appendix D** contains detailed maps of the environmental impact of each site.

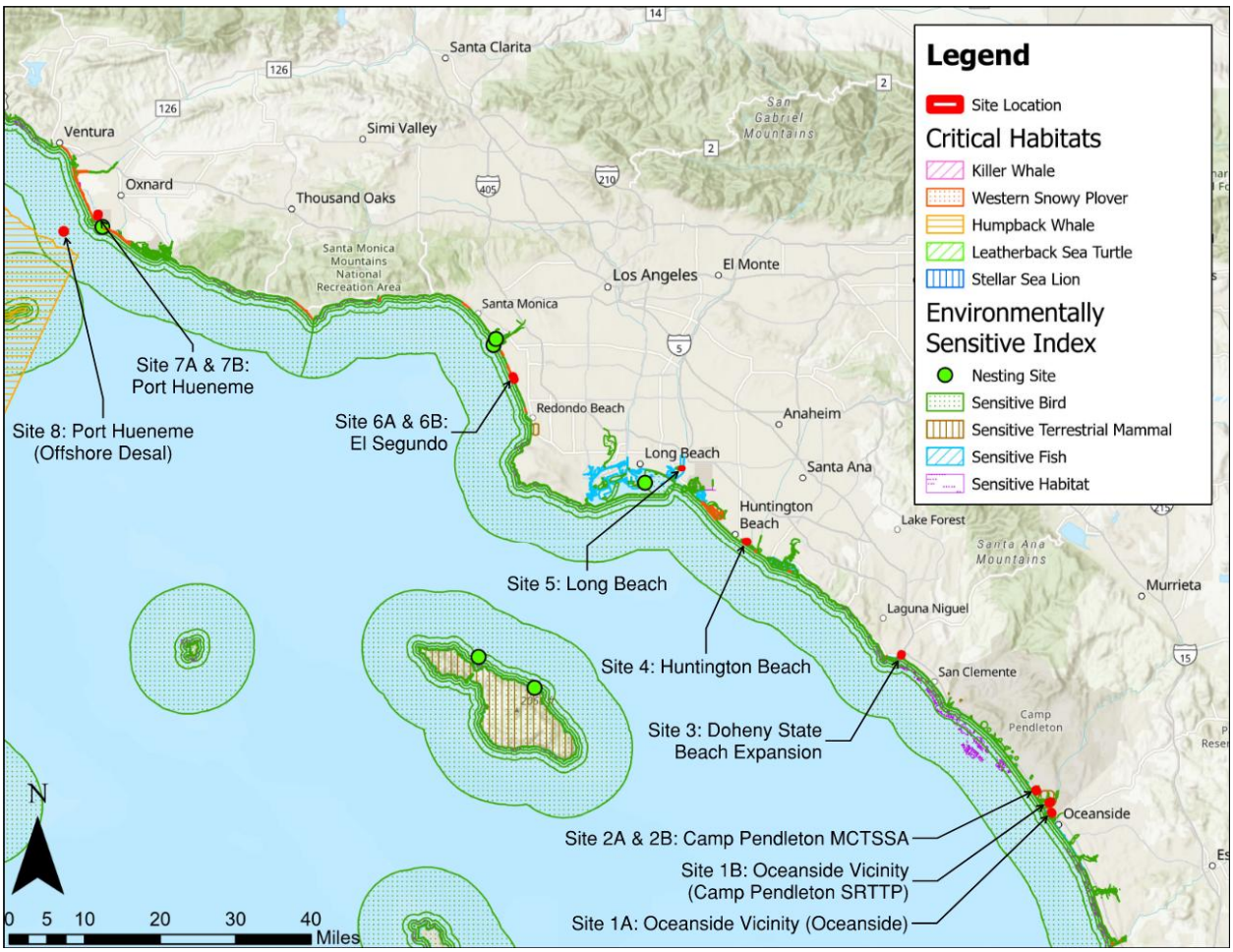


Figure 4.13 Environmental Impact Overview Map

In addition to evaluating the environmental impact on sensitive species and critical habitats, the environmental impact from intake structures was also taken into consideration. Open ocean intakes are historically known to impinge, entrain, and entrap marine organisms, making them potentially damaging to aquatic life (WateReuse Association 2011). However, under the Ocean Plan, newly constructed open ocean intakes are required to possess wedgewire screens, which have been shown to minimize impingement and entrapment and to reduce the entrainment of fish larvae and eggs in some cases (USEPA 2004). For example, the Logan Generating Station in New Jersey showed 90 percent less entrainment of larvae and eggs through the 1-millimeter wedgewire screens than the conventional screens (WateReuse Association 2011).

Site 1A: Oceanside Vicinity (Oceanside)

The Oceanside treatment plant site does not interfere with environmentally sensitive species or critical habitats. However, two of the three wellhead pods may interfere with a sensitive fish species and bird species, the California Grunion and California Least Tern. This site was given an environmental impact score of 4 due to potential impacts to construction activities for two of the three wellhead pods.

Site 1B: Oceanside Vicinity (Camp Pendleton SRTTP)

The Camp Pendleton SRTTP treatment plant site and all three of the wellhead pods may interfere with a sensitive terrestrial mammal species, the California Pocket Mouse. Additionally, all three of the wellhead pods may interfere with sensitive fish species, the California Grunion, and sensitive bird species, the Western Snowy Plover and the Belding's Savannah Sparrow. This site was given an environmental impact score of 2 due to the potential impacts to construction activities at the treatment plant site as well as all three of the wellhead pods.

Site 2A & 2B: Camp Pendleton MCTSSA

The Camp Pendleton MCTSSA treatment plant site does not interfere with environmentally sensitive species or critical habitats. This site was given an environmental impact score of 4 due to potential mitigation of environmental impact from wedgewire screens required on open ocean intake structures under the Ocean Plan.

Site 3: Doheny State Beach Expansion

The Doheny treatment plant site does not interfere with environmentally sensitive species or critical habitats. However, all three of the wellhead pods may interfere with a sensitive fish species, the California Grunion, and two of the wellhead pods may interfere with a sensitive bird species, the Bald Eagle. This site was given an environmental impact score of 3 due to the potential impacts to construction activities at all three of the wellhead pods.

Site 4: Huntington Beach

The Huntington Beach treatment plant site does not interfere with environmentally sensitive species or critical habitats. However, all five of the wellhead pods may interfere with a sensitive fish and bird species, the California Grunion and Western Snowy Plover. This site was given an environmental impact score of 3 due to the potential impacts to construction activities at all five of the wellhead pods.

Site 5: Long Beach

The Long Beach treatment plant site does not interfere with environmentally sensitive species or critical habitats. This site was given an environmental impact score of 4 due to potential mitigation of environmental impact from wedgewire screens required on open ocean intake structures under the Ocean Plan.

Site 6A: El Segundo

The El Segundo treatment plant site does not interfere with environmentally sensitive species or critical habitats. However, three of the five wellhead pods may interfere with a sensitive fish species, the California Grunion, and all five of the wellhead pods may interfere with sensitive bird species, the Peregrine Falcon and Western Snowy Plover. Additionally, three of the five wellhead pods are in the

critical habitat of the Western Snowy Plover. This site was given an environmental impact score of 1 due to the potential impact of some of the wellhead pods on a critical habitat.

Site 6B: El Segundo

The El Segundo treatment plant site does not interfere with environmentally sensitive species or critical habitats. This site was given an environmental impact score of 4 due to potential mitigation of environmental impact from wedgewire screens on open ocean intake structures.

Site 7A: Port Hueneme (Slant Wells)

The Port Hueneme treatment plant site does not interfere with environmentally sensitive species or critical habitats. However, three of the five wellhead pods may interfere with a sensitive fish species, the California Grunion. Additionally, four of the five wellhead pods are in the critical habitat of the Western Snowy Plover. This site was given an environmental impact score of 1 due to potential impacts of some of the wellhead pods on a critical habitat.

Site 7B: Port Hueneme (Screened Intake)

The Port Hueneme treatment plant site does not interfere with environmentally sensitive species or critical habitats. This site was given an environmental impact score of 4 due to potential mitigation of environmental impact from wedgewire screens on open ocean intake structures.

Site 8: Port Hueneme (Offshore Desalination)

Based on our GIS analysis, the Port Hueneme Offshore Desalination option does not interfere with any of the listed environmentally sensitive species or critical habitats that were evaluated. However, since offshore desalination has not been implemented at a full scale, it is unknown what impacts the Port Hueneme Offshore Desalination option would have on other species that occupy major ocean depths. Additionally, it is unknown what impacts the system's operation and maintenance may have on marine mammals regarding noise, cables, and anchorages. This site was given an environmental impact score of 4.

4.2.4.2 Tribal Impact

The tribal impact score was determined by evaluating whether the site would interfere with archeological or tribal cultural resources. From correspondence with Metropolitan, all sites along the coast are considered sensitive for either archeological or tribal cultural resources. Due to this implication:

- Sites along the coast with subsurface slant wells were given a score of 3,
- Sites along the coast with open ocean intakes were given a score of 4, and
- The site with offshore desalination was given a score of 5.

4.2.4.3 Disadvantaged Community Impact

The community impact for each potential site was evaluated by determining how severely the site location would interfere with DACs. The locations of DACs were obtained from the EPA online EJScreen

tool[14]. EJScreen is the EPA's environmental justice screening and mapping tool which uses standard and nationally consistent data to identify areas with potentially higher environmental burdens and vulnerable populations. The demographic index was utilized to determine community impact. The demographic index in EJScreen is a combination of percent low-income and percent people of color, the two socioeconomic factors that were explicitly named in Executive Order 12898 on Environmental Justice. For each Census block group, these two numbers are simply averaged together. The formula is as follows: demographic index = (% low-income + % people of color) / 2.

Demographic index data on the EJScreen tool is displayed as percentiles. A percentile is a measure indicating the value below which a given percentage of observations in a group of observations fall. For example, if a given area is in the 90th percentile of the demographic index, this indicates that the area has more low-income and people of color than 90% of the areas in the state. DAC impact scoring was determined as follows:

- Score of 1: Site falls within 80-100 percentile of demographic index.
- Score of 2: Site falls within 60-80 percentile of demographic index.
- Score of 3: Site falls within 40-60 percentile of demographic index.
- Score of 4: Site falls within 20-40 percentile of demographic index.
- Score of 5: Site falls within less than 20 percentile of demographic index.

To evaluate the DAC impact at each site, a pin was dropped on the treatment plant site and a 1-mile ring was placed around the pin. Figure 4.14 shows the demographic index state percentiles within a 1-mile radius of each of the sites.

[14] https://ejscreen.epa.gov/mapper/

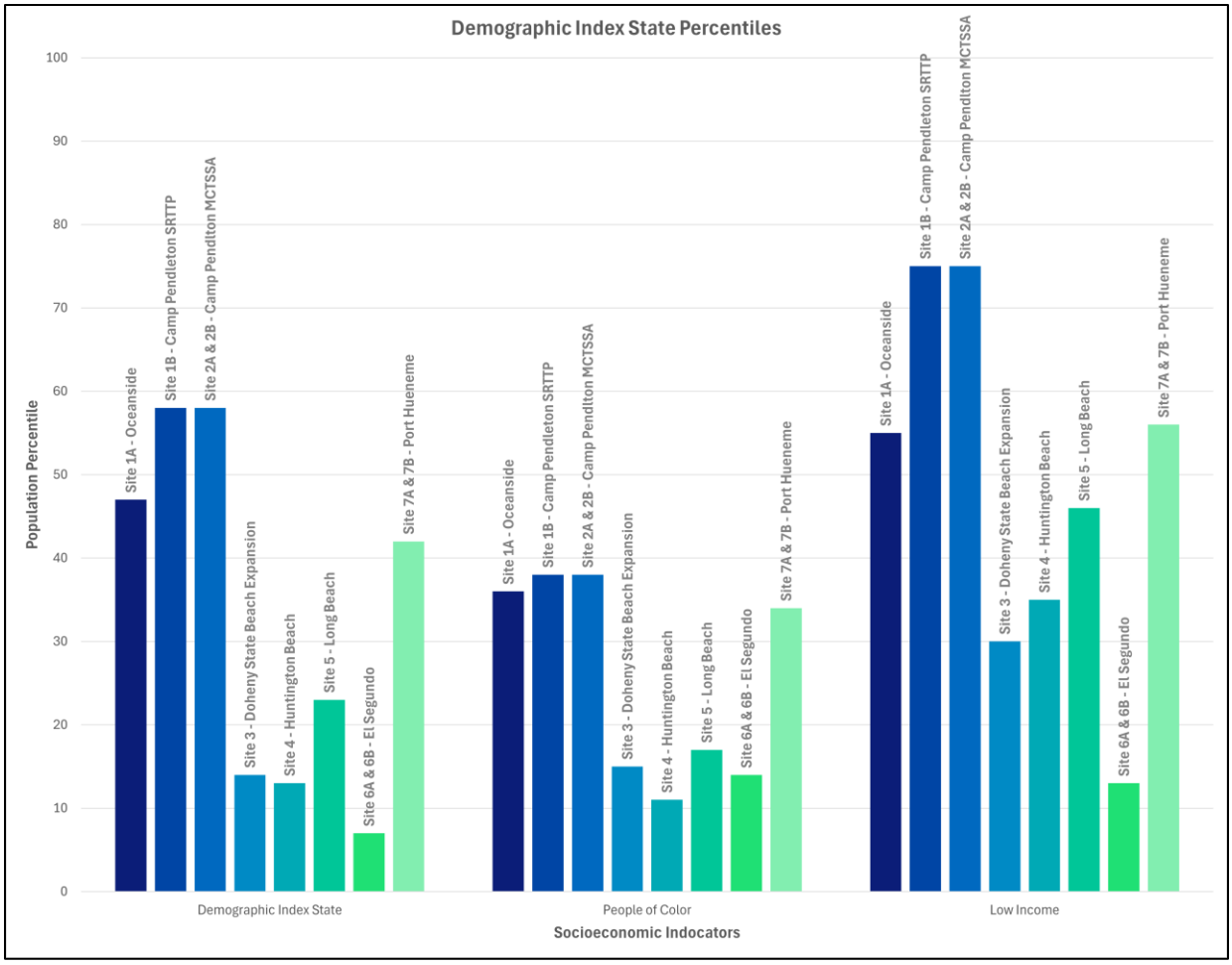


Figure 4.14 Comparison of Demographic Index National Percentiles

The total Environmental and Social Justice Impact score was calculated by averaging the environmental, tribal, and DAC impact scores. The environmental impact score was determined by evaluating whether the site interfered with an environmentally sensitive species or critical habitats. The tribal impact score was determined by evaluating whether the site interfered with an archeological or tribal resource area. The DAC impact score was determined by identifying the percentile socioeconomic demographic index the site falls into. **Table 4.7** summarizes the environmental impact score, social justice impact score, DAC impact score, and total score for each potential site.

Table 4.7 Environmental and Social Justice Impact Scoring

Site #	Name	Environmental Impact Score	Tribal Impact Score	DAC Impact Score	Total Score
1A	Oceanside Vicinity (Oceanside)	4	3	3	3.3
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	2	3	3	2.7
2A	Camp Pendleton MCTSSA	4	4	3	3.7
2B	Camp Pendleton MCTSSA	4	4	3	3.7
3	Doheny State Beach Expansion	3	3	5	3.7
4	Huntington Beach	3	3	5	3.7
5	Long Beach	4	4	4	4.0
6A	El Segundo	1	3	5	3.0
6B	El Segundo	4	4	5	4.3
7A	Port Hueneme	1	3	3	2.3
7B	Port Hueneme	4	4	3	3.7
8	Port Hueneme (Offshore Desalination)	4	5	5	4.7

4.2.5 Technology Readiness

Technology readiness was evaluated by scoring the technological feasibility of each of intake options considered: traditional open ocean intake, existing power plant cooling water intake, subsurface slant wells, and seabed pods. The TRL Scoring system established by NASA is used to define the maturity level of each technology. The nine-tiered scoring system defines each TRL score as a technology's ability to be implemented, predicated on past use of each technology. A one-rating refers to technologies in a preliminary research stage whose results are beginning to move forward into additional research and development. Alternatively, a nine-rating refers to technology that has been "flight proven" and has been implemented successfully. Seabed Pods have the lowest TRL score of the potential technologies with a TRL 5 referring to a technology that must require additional rigorous testing simulating realistic environmental conditions. New Ocean Intake and Converted Power Intake share the highest score with a TRL 9 reflecting their successful implementations in past projects.

Table 4.8 summarizes the intake type and score for each potential site.

Table 4.8 Technology Readiness Scoring

Site #	Name	Intake	TRL Score
1A	Oceanside Vicinity (Oceanside)	Slant Wells	8
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells	8
2A	Camp Pendleton MCTSSA	New Ocean Intake	9
2B	Camp Pendleton MCTSSA	New Ocean Intake	9
3	Doheny State Beach Expansion	Slant Wells	8
4	Huntington Beach	Slant Wells	8
5	Long Beach	New Ocean Intake	9
6A	El Segundo	Slant Wells	8
6B	El Segundo	Converted Power Intake	9
7A	Port Hueneme	Slant Wells	8
7B	Port Hueneme	New Ocean Intake	9
8	Port Hueneme (Offshore Desalination)	Seabed Pods	5

4.2.5.1 Open Ocean Intake

An open ocean intake uses piping that extends hundreds to thousands of meters into the ocean. It is the most common approach for seawater desalination plants globally (Kennedy/Jenks, 2016). To reduce risk to marine life, velocity caps and screens are used to decrease the velocity of the water in order to prevent aquatic life from entering the pipelines. Velocity caps are currently being phased out of modern designs and replaced with screened open intakes to reduce entrainment of aquatic organisms. Using an open ocean intake is the most common approach for seawater desalination plants globally, with a TRL of 9.

4.2.5.2 Existing Power Plant Cooling Water Intake

Using open ocean intake tunnels from existing power plants can often be an economically favorable intake option. In an ocean water desalination program master plan done in 2013, Arcadis found that utilizing existing intake tunnels with diffusers was the most cost-effective solution for the potential facility. Additionally, a feasibility study done by the San Diego County Water Authority (SDCWA) considered Rosarito Beach an advantageous site due to potential access to the CFE power plant intake facilities. Using a converted power plant intake is a very common approach for seawater desalination plants globally, with a TRL of 9.

4.2.5.3 Subsurface Slant Wells

Slant wells are wells drilled at a 10-to-25-degree angle originating on the shore and utilizing aquifers below the ocean. A slant well intake system was recommended in Dana Point, CA and technical reports from the Municipal Water District of Orange County (MWDOC) showed slant wells as the most cost-effective intake for the desired location. Over two years of testing, the wells produced water that had

low turbidity, bacteriological activity, and SDI leading to a low fouling potential. Subsurface slant wells are also less harmful to marine life compared to ocean intakes and typically more cost effective. They can provide natural sand filtration and are a buffer to changing ocean water quality. However, high levels of dissolved iron and manganese were found in the marine groundwater in Dana Point. Different pretreatment methods have been considered to remove these heavy metals such as granular media filtration (GMF), aeration, and a combination of chlorination, flocculation, and sedimentation. CDM Smith's Task 3 Memo rated subsurface slant wells as a TRL of 8. A simplified diagram of a slant well is included as **Figure 4.15**.

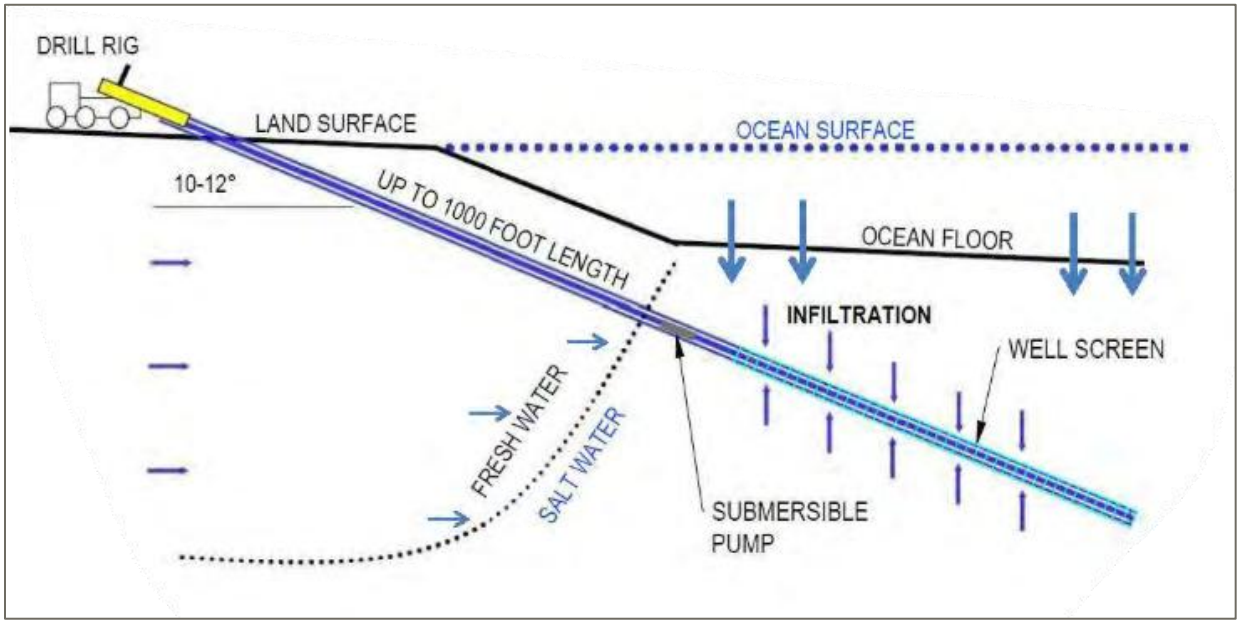


Figure 4.15 Doheny Slant Well Construction (Courtesy of Geoscience)

4.2.5.4 Offshore Submerged Desalination

The Los Angeles-based company, OceanWell, is the developer of the Seabed Pods, which are one alternative among multiple submerged offshore desalination technologies. While the discussion in this memorandum refers to Seabed Pods, the siting, costing, and other analyses are equally applicable to other seafloor technologies from Waterise and FSubsea. The submerged desalination technology is comprised of an array of modular treatment pods anchored to the seabed that is manifolded into a large-scale modular system. The seabed pods are designed to be implemented well within the ocean (1,000 to 1,500-ft depth) to limit environmental impacts as marine life abundance is low. Additionally, it is anticipated that the desalination process would use 40 percent less energy than conventional desalination due to its reduction of pretreatment and elimination of high-pressure feed pumps. Some pumping would still be needed to return concentrate to the ocean and pump desalinated water to the shore. OceanWell began piloting a seabed pod in collaboration with the LVMWD in March 2025. Although the concept of submerged offshore desalination has considerable merit; questions remain on the efficiency, reliability, and ease of access for the large offshore equipment arrays; this technology has been assigned a TRL of 5. **Figure 4.16** shows the OceanWell concept art for a Seabed Pod desalination facility.

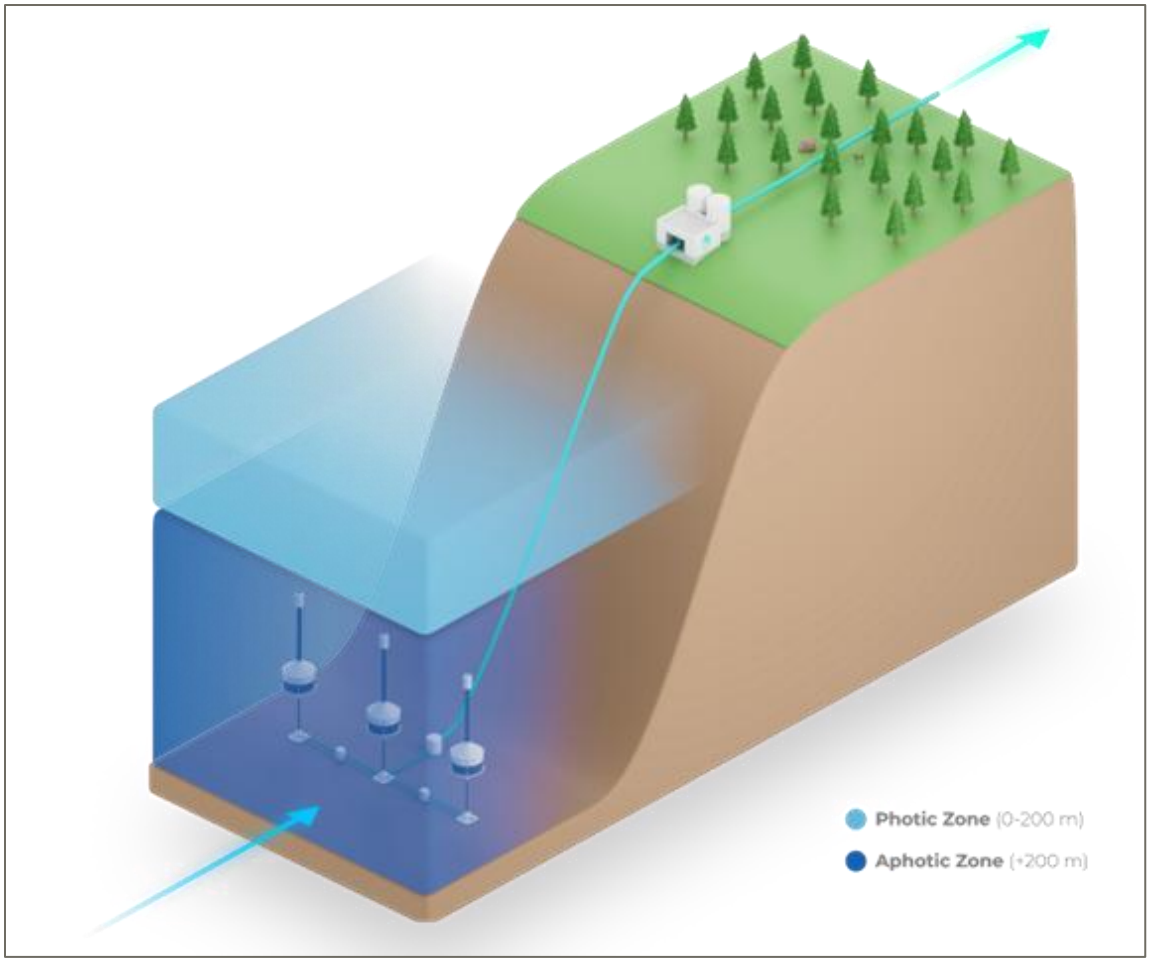


Figure 4.16 Concept Art for Submerged Offshore Desalination System (Courtesy of OceanWell)

4.2.6 System Integration

For this siting analysis, a system integration score was developed to be a proxy for conveyance from the seawater desalination plant to water demand areas. This score makes qualitative assessment of relative distance and elevation gain. In the more detailed, subsequent analysis of top-ranked sites, hydraulic modeling will be used to estimate the actual conveyance (including pumping) of desalinated water to existing water supply systems of either Metropolitan or retail water providers. A summary of each site's system integration score and score reasoning is outlined in **Table 4.9**.

4.2.7 Sea Level Rise Impact

Sea level rise (SLR) refers to the gradual increase in the average level of the world's oceans, primarily due to the melting of ice sheets and glaciers, as well as the thermal expansion of seawater as it warms[15]. Evaluating sea level rise is crucial when performing a siting analysis in coastal regions because it can significantly impact the design, safety, and sustainability of infrastructure. Rising sea levels can lead to increased flooding, erosion, and saltwater intrusion, which can compromise the structural integrity of buildings and roads, disrupt ecosystems, and affect the livelihoods of communities. Therefore,

[15] Source: NOAA Sea Level Rise Viewer

understanding and planning for sea level rise is essential to confirm that new developments can withstand future conditions and protect both the environment and human populations.

To assess the potential impact of sea level rise on each site, NOAA's Sea Level Rise Viewer[15] was utilized. Screening was conducted using the 2022 NOAA relative sea level rise projections under the "Intermediate High" scenario for the year 2080, assuming no shoreline accretion. The Intermediate High scenario represents a mid-to-upper range projection of relative sea level rise, incorporating regional land motion and accelerated ice sheet contributions. The Mean Higher High Water (MHHW) tidal datum was selected from the closest tidal gauge to each site. MHHW represents the average of the higher high-water height observed each tidal day over the National Tidal Datum Epoch and provides a conservative benchmark for evaluating potential inundation risk.

Each site was then assigned a quantitative score ranging from 1 to 5, with a score of 1 indicating significant projected inundation risk by 2080 under the selected scenario and a score of 5 indicating minimal or no projected inundation risk. Independent sea level rise maps for each site can be found in **Appendix E**. A summary of each site's SLR impact score and score reasoning is outlined in **Table 4.10**.

Table 4.9 System Integration Scoring

Site #	Name	Production Capacity (mgd)	Score	Score Reasoning
1A	Oceanside Vicinity (Oceanside)	10	3	This supply would be conveyed to the SDCWA to maximize this desalinated water via a connection to SDCWA's treated water aqueduct.
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	10	3	This supply would be conveyed to the SDCWA to maximize this desalinated water via a connection to SDCWA's treated water aqueduct.
2A	Camp Pendleton MCTSSA	50	1	▪ Without an exchange of Colorado River water with the Federal Government, significant conveyance would be required to utilize this amount of desalinated water in Riverside County. ▪ The member agencies that would utilize this supply include Eastern Municipal Water District and Western Municipal Water District.
2B	Camp Pendleton MCTSSA	50	1	▪ Without an exchange of Colorado River water with the Federal Government, significant conveyance would be required to utilize this amount of desalinated water in Riverside County. ▪ The member agencies that would utilize this supply include Eastern Municipal Water District and Western Municipal Water District.
3	Doheny State Beach Expansion	10	4	▪ For this expansion, there would be additional conveyance to regional water supply systems needed in order to serve other South Orange County water agencies. ▪ The member agency served by this supply would be the Municipal Water District of Orange County.
4	Huntington Beach	20	3	▪ There is not adequate coastal demand for this quantity of water and a moderate amount of conveyance would be needed. ▪ The member agency served by this supply would be the Municipal Water District of Orange County.

Site #	Name	Production Capacity (mgd)	Score	Score Reasoning
5	Long Beach	20	4	▪ Small to moderate amount of conveyance would be needed to deliver coastal desalinated water to exclusive imported water zone. ▪ The member agency served by this supply would be the City of Long Beach; however, full utilization of the 20 mgd supply would likely require distribution to adjacent member agencies.
6A	El Segundo	20[1]	3	▪ There is not adequate coastal demand for this quantity of water and a moderate amount of conveyance would be needed. ▪ The member agency served by this supply would be the West Basin Municipal Water District.
6B	El Segundo	20[1]	3	▪ There is not adequate coastal demand for this quantity of water and a moderate amount of conveyance would be needed. ▪ The member agency served by this supply would be the West Basin Municipal Water District.
7A	Port Hueneme	20	4	▪ Small to moderate amount of conveyance would be needed to deliver coastal desalinated water to nearby communities. ▪ The member agency serviced by this supply would be the Calleguas Municipal Water District.
7B	Port Hueneme	25	4	▪ Small to moderate amount of conveyance would be needed to deliver coastal desalinated water to nearby communities. ▪ The member agency serviced by this supply would be the Calleguas Municipal Water District.
8	Port Hueneme (Offshore Desalination)	20	4	▪ Small to moderate amount of conveyance would be needed to deliver coastal desalinated water to nearby communities. ▪ The member agency serviced by this supply would be the Calleguas Municipal Water District.

[1] The 20 mgd production capacity shown for Sites 6A and 6B reflects the initial capacity assumption used during the preliminary MCDA siting evaluation. Following subsequent coordination with NRG regarding site availability constraints, the refined planning-level cost estimate for the El Segundo alternative was reduced to 10 mgd. The 20 mgd capacity is retained in certain screening tables for consistency with the initial comparative evaluation framework.

Table 4.10 Sea Level Rise Impact Scoring

Site #	Name	Score	Score Reasoning
1A	Oceanside Vicinity (Oceanside)	4	▪ The southmost wellhead pod at this site would be affected by SLR due to the flooding of the San Luis Rey River. ▪ The remaining areas surrounding this site and the site itself would not be affected by SLR.
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	2	The treatment plant site would not be affected by SLR, but all three of the shown wellhead pods would be affected by SLR.
2A	Camp Pendleton MCTSSA	5	This site would not be affected by SLR.
2B	Camp Pendleton MCTSSA	5	This site would not be affected by SLR.
3	Doheny State Beach Expansion	4	The site itself would not be affected by SLR, but the three wellhead pods will be near a low-laying area.

Site #	Name	Score	Score Reasoning
4	Huntington Beach	2	▪ While the site itself and the wellhead pods would not be affected by SLR, the entire surrounding area will be flooded by SLR. ▪ This would make it very difficult to access the site, and lead to many problems on the site.
5	Long Beach	5	This site would not be affected by SLR.
6A	El Segundo	5	This site and its wellhead pods would not be affected by SLR, despite its proximity to the beach.
6B	El Segundo	5	This site would not be affected by SLR, despite its proximity to the beach.
7A	Port Hueneme	4	The site and the wellhead pods would be unaffected by SLR, but part of the site would become a low-lying area.
7B	Port Hueneme	4	The site would be unaffected by SLR, but part of the site would become a low-lying area.
8	Port Hueneme (Offshore Desalination)	5	This site would not be affected by SLR.

4.3 Overall Scoring and Site Rankings

The overall scoring of the seawater desalination sites was based on several criteria previously mentioned throughout this section, including water supply needs, cost-effectiveness, permitting ease, environmental and social justice impact, technology readiness, system integration, and sea level rise impact. Overall scoring is summarized in **Table 4.11**.

Table 4.11 Overall Scoring

Site #	Name	Product Water (mgd)	Intake	Outfall	Water Supply Benefit (Score 1-5)	Permitting Ease (Score 1-5)	Total Cost ($/AF)	Environmental/ Social Impacts (Score 1-5)	Technology Readiness Level (Score 1-9)	System Integration (Score 1-5)	Sea Level Rise in Year 2080 (Score 1-5)
1A	Oceanside Vicinity (Oceanside)	10	Slant Wells (9)	Existing Oceanside WWTP Outfall	3	4	$4,400	3.3	8	3	4
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	10	Slant Wells (9)	Existing Oceanside WWTP Outfall	3	4	$4,500	2.7	8	3	2
2A	Camp Pendleton MCTSSA	50	New Ocean Intake	Existing San Onofre Power Plant Outfall	2	1	$5,900	3.7	9	1	5
2B	Camp Pendleton MCTSSA	50	New Ocean Intake	New Ocean Outfall	2	1	$6,300	3.7	9	1	5
3	Doheny State Beach Expansion	10	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	5	4.5	$4,300	3.7	8	4	4
4	Huntington Beach	20	Slant Wells (20)	Existing AES Huntington Beach Power Plant Outfall	1	3.5	$4,200	3.7	8	3	2
5	Long Beach	20	New Ocean Intake	New Ocean Outfall	4	1	$6,400	4	9	4	5
6A	El Segundo	20[1]	Slant Wells (20)	Existing Hyperion WWTP Outfall	3	4.5	$4,200	3	8	3	5
6B	El Segundo	20[1]	Converted Power Intake	Existing Hyperion WWTP Outfall	3	3.5	$4,000	4.3	9	3	5
7A	Port Hueneme	20	Slant Wells (20)	Existing Oxnard WWTP Outfall	5	5	$4,400	2.3	8	4	4
7B	Port Hueneme	25	New Ocean Intake	Existing Oxnard WWTP Outfall	5	3	$5,900	3.7	9	4	4
8	Port Hueneme (Offshore Desalination)	20	N/A	N/A	5	4	$4,900	4.7	5	4	5

[1] The 20 mgd production capacity shown for Sites 6A and 6B reflects the initial capacity assumption used during the preliminary MCDA siting evaluation. Following subsequent coordination with NRG regarding site availability constraints, the refined planning-level cost estimate for the El Segundo alternative was reduced to 10 mgd. The 20 mgd capacity is retained in certain screening tables for consistency with the initial comparative evaluation framework.

4.3.1 MCDA Methodology

The MCDA software used by CDM Smith to rank seawater desalination sites can handle criteria scores measured in different native units (e.g., 1-5 for Water Supply Benefit, $/AF for Cost-Effectiveness, or 1-9 for Technology Readiness). The software does this by using a positive or negative utility function that establishes the low and high boundary of native score units, aligned to a standard metric from 0.0 to 1.0, with 1.0 being the best. Thus, for a criterion that uses a native score from 1-5, a positive utility function is used where a native score of 5 would be translated into a metric of 1.0. All the criteria, except Cost-Effectiveness, used a positive utility function to convert native scores. For Cost-Effectiveness, the lowest $/AF native score is converted to the highest standard metric of 1.0. These standard metrics for the criteria can then be weighted and added together to produce an overall metric score from 0.0 to 1.0. Those sites with an overall metric score approaching 1.0 will be higher in rank than those sites with a metric score closer to 0.0.

Weights for each criterion were developed with Metropolitan staff and were established based on siting criteria report factors, Ocean Plan requirements, standard planning principles, and the desire not to weigh cost too greatly. Because the System Integration and Sea Level Rise Impacts were proxy criteria for additional costs (which will be estimated in subsequent tasks for this study), they were given lower weights than the other criteria so as not to give too much weight to cost-related concerns.

The weights for each criterion are as follows:

- Water Supply Benefit (20%)
- Permitting Ease (20%)
- Cost Effectiveness of Treatment and Disposal (15%)
- Technology Readiness (15%)
- Environmental and Social Justice Impact (15%)
- System Integration (10%)
- Sea Level Rise Impact (5%)

4.3.2 Overall Scoring and Site Ranking

The results of the MCDA for seawater desalination sites are shown in **Figure 4.17**. The longer the color segmented bars, the better the performance. The criteria weights are shown in the legend, indicating the maximum metric a given criterion can achieve. For example, Technology Readiness is given a weight of 15%, so the maximum a site can receive for that criterion is 0.15 (which would be a TRL = 9). This ranking methodology allows decision makers to clearly see trade-offs between alternatives and criteria performance. The MCDA results reflect assumptions and weighting factors appropriate for this planning-level analysis. Additional stakeholder input, refined technical data, environmental studies, and regulatory coordination could influence future evaluation outcomes.

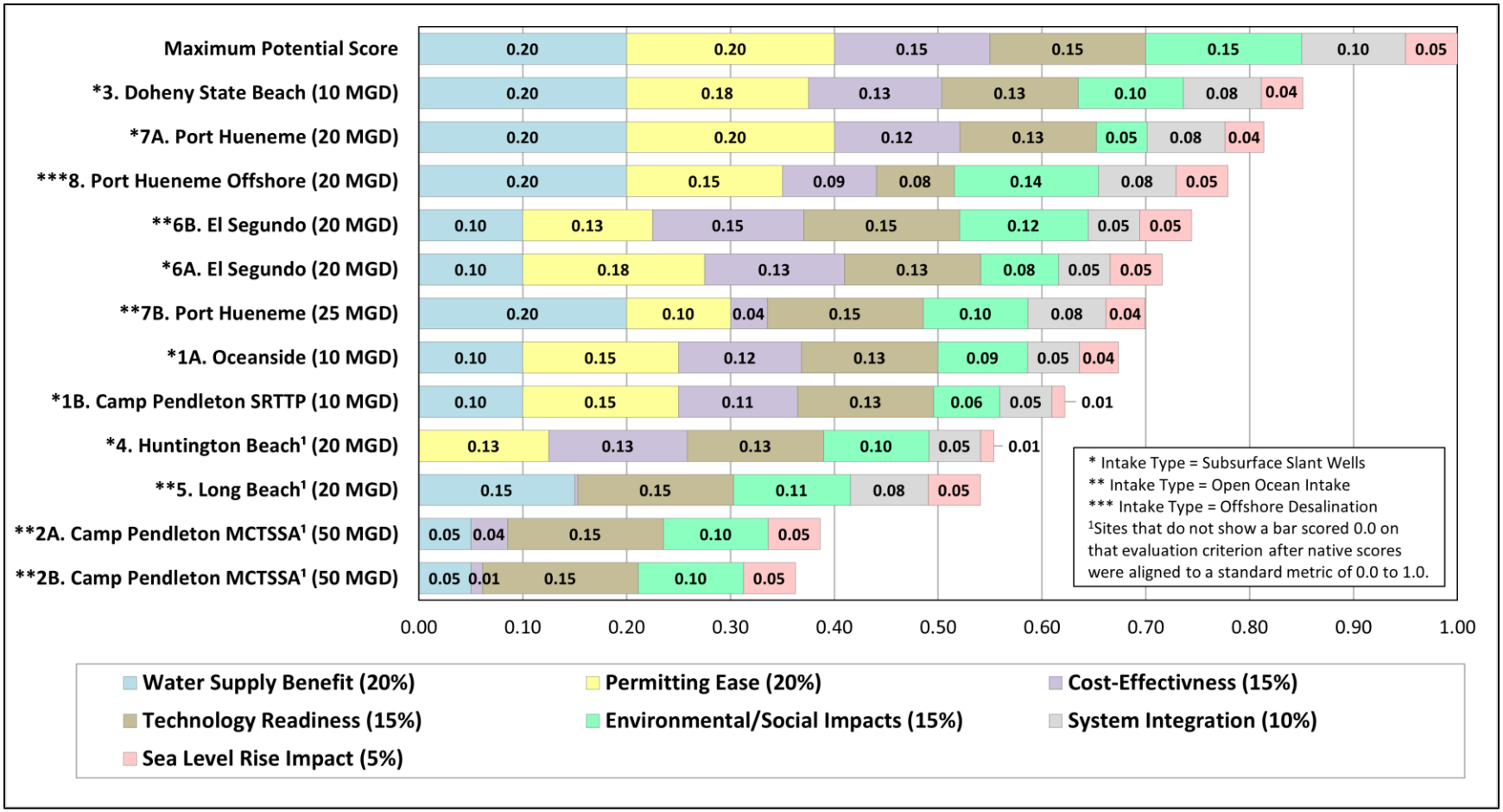


Figure 4.17 Ranking of Seawater Desalination Sites

Note: The larger the color bar, the better it scores for the criteria shown. If a bar segment is not shown, then the criteria performance was zero.

The results of this ranking analysis indicate that four highest ranked sights are:

- **Site 3:** Doheny State Beach Expansion of the Planned 5-mgd Plant with Additional Subsurface Slant Wells and Use of Existing Wastewater Outfall (10 mgd)
- **Site 7A:** Port Hueneme with Subsurface Slant Wells and Use of Existing Wastewater Outfall (20 mgd)
- **Site 8:** Port Hueneme with Offshore Seabed Pods (20 mgd)
- **Site 6B:** El Segundo with Existing Power Intake and Use of Existing Wastewater Outfall (20 mgd)

While the offshore technology using seabed pods off the coast of Port Hueneme Ranked #3 and looks promising, this is still an emerging technology. As such, it received a TRL score of 5, which signifies it is mid-stage in development and would require further piloting and performance validation prior to consideration for large-scale deployment. As there are planned efforts for full demonstration of this technology in the coming years, it is recommended that Metropolitan revisit this siting analysis if the technology meets regulatory and permitting requirements.

During refinement of the El Segundo alternative, Site 6A was advanced over Site 6B based on updated information regarding property availability and intake feasibility. Subsequent coordination indicated that the previously considered intake and site footprint would not be available for long-term desalination development, limiting the viability of Site 6B. As a result, the project configuration was shifted to the alternate Site 6A location. Due to the smaller footprint at this site, the assumed facility capacity was reduced from 20 mgd to 10 mgd to maintain a feasible plant layout.

Among the sites with proven technology, three locations were identified as most suitable for more detailed evaluation. These sites form the focus of the remainder of this report:

- **Site 3:** Doheny State Beach Expansion of the Planned 5-mgd Plant with Additional Subsurface Slant Wells and Use of Existing Wastewater Outfall (10 mgd)
- **Site 7A:** Port Hueneme with Subsurface Slant Wells and Use of Existing Wastewater Outfall (20 mgd)
- **Site 6A:** El Segundo with Subsurface Slant Wells and Use of Existing Wastewater Outfall (10 mgd)

5.0 Water Quality and System Integration

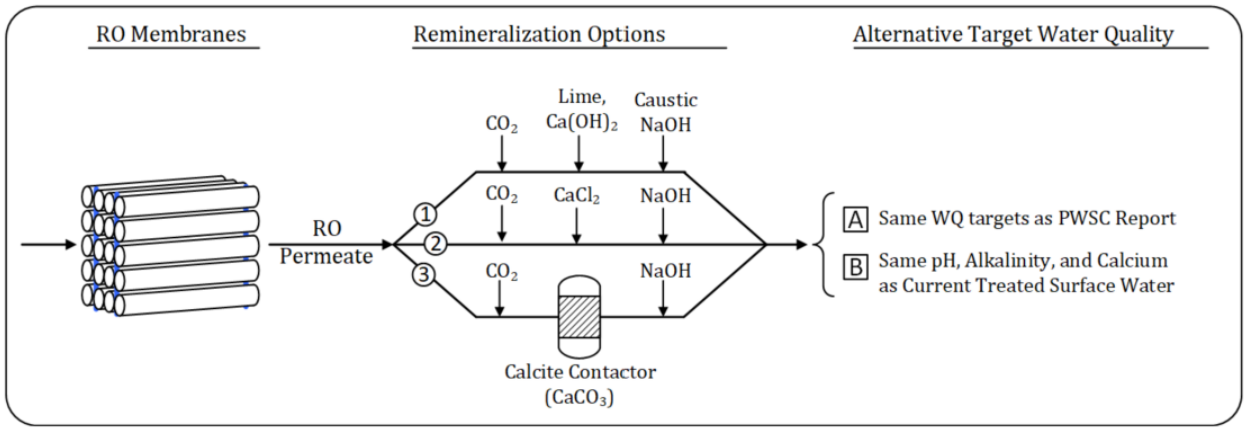
5.1 Water Quality and Blending Considerations

Since seawater RO desalination removes virtually all of the alkalinity and hardness from the water, introducing the RO permeate water into a distribution system and premise plumbing without additional chemical conditioning would cause significant corrosion of metal pipes and cement surfaces in the system. Hence, re-mineralization of desalinated water or blending with a higher hardness water source is necessary with the goal of restoring the alkalinity, pH, and hardness of the water to levels protective of the distribution system and premise plumbing material.

Water Quality & Treatment Solutions Inc. (WQTS) was tasked with conducting a desktop study to identify the chemical treatment schemes that could be applied to properly re-mineralize the water at each of the three seawater desalination plants. This section includes the specifics and outcome of the desktop study. Water quality analyses were conducted using desktop modeling and representative assumptions. Site-specific pilot testing, operational studies, and coordination with member agencies would be required to confirm these findings during the project development phases.

The objective of the evaluation was to identify the re-mineralization chemical treatment scheme required at each of the three seawater desalination plants to generate treated water quality that is compatible with the distribution system material currently served by treated surface water from Metropolitan's surface water treatment plants. In this evaluation, compatibility is defined as having water quality conditions that do not cause dissolution or precipitation of chemical constituents in the seawater desalination plant service area that are unacceptably different from that caused by the treated surface water currently served to that area.

To achieve the goal of this evaluation, three pieces of information were required. The first piece of information required is the quality of the RO permeate water entering the remineralization process. The second is the range of re-mineralization strategies to be considered, and the third is the target water quality parameters that achieve the compatibility goal as defined in this section. **Figure 5.1** presents a schematic of the framework of this evaluation that ties the three pieces of information together. The subsequent subsections discuss each component in **Figure 5.1**.



PWSC = Pure Water Southern California

Figure 5.1 Conceptual Schematic of the Evaluation Framework

While blending could also be used to provide hardness and alkalinity to the water, reducing the chemical doses required to reach stable water quality, the higher chemical doses would still be required when sufficient blend water is not available. This evaluation therefore focused on a conservative approach, confirming the conditions needed to reach product water stability without blending, and also considering potential negative impacts that could arise when blending the stabilized desalinated water with existing water supplies (including impacts on chloramine stability and lead corrosion).

At sites with subsurface intakes (e.g., Port Hueneme and Doheny), naturally occurring iron and manganese may oxidize and precipitate when exposed to oxygen, creating a fouling risk to downstream filtration/RO if unmanaged. Projects with similar intake settings have included pretreatment filtration with optional oxidant addition (e.g., sodium hypochlorite) ahead of cartridge filters. Final pretreatment selection is site-specific; incorporating flexibility (run-with/without oxidant) allows operators to mitigate iron/manganese if present at elevated levels.

5.1.1 Reverse Osmosis Permeate Water Quality

The chemical quality of the permeate water from a seawater desalination RO process can vary with varying influent water quality to the RO process, membrane material type and age, RO staging design, and RO process operation. The Port Hueneme, Doheny, and El Segundo seawater desalination plants are expected to employ subsurface slant well intakes (SSI). However, for this analysis, an open-ocean intake scenario was also modeled for the El Segundo site to provide a broader understanding of potential permeate quality variations and to inform future site-specific design considerations. The type of intake is expected to slightly impact the quality of the RO permeate generated by the RO process due to the potential impact of subsurface groundwater on the influent water to the plant. While the base case for El Segundo assumes SSI, the open intake results are retained for reference and beneficial insight into potential influent variability. Based on RO process modeling conducted by CDM Smith, **Table 5.1** lists the minimum and maximum values of various water quality parameters anticipated in the permeate water from a RO seawater desalination plant using either a subsurface intake structure or an open intake structure. As expected, the primary constituents in the permeate water are sodium and chloride resulting in a Total Dissolved Solids (TDS) concentration ranging from 29 mg/L to 67 mg/L. The remaining

constituents of alkalinity, calcium, sulfate, potassium, and fluoride are all present at negligibly low levels. Of particular concern in the RO permeate water is bromide (Br^-), which is projected to range from a low of 0.094 mg/L to a high of 0.220 mg/L in the permeate water. While the concentration of bromide is not relevant to the re-mineralization discussion, it can have a negative effect on the stability of chloramine in the distribution system as discussed later in **Section 5.1.5.4**.

Table 5.1 Anticipated Minimum and Maximum RO Permeate Water Quality for Seawater Desalination Plants with a Subsurface Intake or Open Intake

Parameter	Unit	Subsurface Intake (Port Hueneme & Doheny)		Open Intake (El Segundo)	
		Minimum	Maximum	Minimum	Maximum
TDS	mg/L	34	63	29	67
Temperature	deg C	12	20	10	21
Alkalinity	mg/L as $CaCO_3$	0.35	0.9	0.74	0.93
Calcium	mg/L	0.047	0.083	0.045	0.101
Magnesium	mg/L	0.15	0.26	0.14	0.3
Sodium	mg/L	12.4	23.1	10.4	24.4
Potassium	mg/L	0.58	1.1	0.52	1.2
Barium	mg/L	0.0	0.0	0.0	0.0
Strontium	mg/L	0.001	0.002	0.001	0.002
Sulfate	mg/L	0.65	1.2	0.53	1.2
Chloride	mg/L	20	36	16	38
Fluoride	mg/L	0.003	0.005	0.002	0.004
Bromide	mg/L	0.097	0.180	0.094	0.220
Boron	mg/L	0.19	0.44	0.15	0.46
pH	--	6.3	6.6	6.3	6.6

5.1.2 Re-mineralization Options

Three re-mineralization options were considered at each seawater desalination plant and are presented in **Figure 5.1**. They include the following combinations of chemicals:

- CO_2, lime ($Ca(OH)_2$), and caustic soda (NaOH)
- CO_2, calcium chloride ($CaCl_2$), and NaOH
- CO_2, NaOH, and a calcite contactor (which dissolves calcium carbonate ($CaCO_3$) into the water)

Each of these options has the proper chemicals needed to raise the calcium, alkalinity, and pH of the water to meet specific target water quality criteria in the treated water. The analysis presented in the next section identifies the individual chemical doses under each option that would be required to meet each of the two treated water criteria. The ultimate selection between the three options will depend on several factors including economies of scale, capital and operational costs, and possibly other factors.

5.1.3 Target Treated Water Quality

The chemical doses under any of the three re-mineralization options can be selected to meet specific targets of pH, alkalinity, and calcium concentration. However, there are infinite combinations of these

three water quality parameters that are likely to produce desalinated water that is compatible with the existing distribution system and home plumbing in each plant's service area. Therefore, a more defined water quality goal is needed.

Two treated water quality criteria were considered to help identify the target pH, alkalinity, and calcium concentrations, which then set the chemical doses required. The first criteria were those recommended by the PWSC analysis commissioned by Metropolitan for its PWSC program since that treatment system includes 100% RO treatment. (Stantec et al. 2024) In that analysis, the following criteria were recommended for the re-mineralized treated water:

- pH = 8.0 ± 0.2
- Alkalinity ≥ 50 mg/L as $CaCO_3$
- Langelier Saturation Index (LSI) > 0

The above criteria will be referred to herein as the PWSC treated water quality criteria. While the criteria did not specifically identify a target calcium concentration, setting the LSI at >0 along with the target pH and alkalinity in essence defines a fixed calcium concentration. Assuming a TDS of 150 mg/L and a water temperature of 20 °C, the calcium concentration resulting in an LSI >0 at pH 8.0 and alkalinity of 50 mg/L as $CaCO_3$ is 48 mg/L.

The second approach to setting the treated water quality criteria is to select the chemical doses that result in pH, alkalinity, and calcium concentrations in the treated water that are equal to the average values of these parameters in the treated surface water currently serving the area to be served by the three seawater desalination plants. In the development of this approach, the project team requested input from Metropolitan staff on identifying which Metropolitan water treatment plant currently serves each of the areas to be served by each of the three seawater desalination plants. Metropolitan staff indicated the following:

- The Port Hueneme seawater desalination plant service area is currently served by water from the Jensen plant.
- The Doheny seawater desalination plant service area is currently served by water from the Diemer plant.
- The El Segundo seawater desalination plant service area is currently served by water from either the Jensen plant or the Weymouth plant.

For the El Segundo plant, since its service area is compatible with both the Jensen plant treated water quality and that of the Weymouth plant, selecting either of them satisfies the objective of this analysis. For no specific reason, the Jensen plant effluent water quality was used to set the chemical doses for the El Segundo seawater desalination plant.

The next step was to identify the water quality produced by each of the Jensen and Diemer plants, which Metropolitan already generates as part of its monthly water quality monitoring and reporting program to its member agencies (Metropolitan Table D). **Table 5.2** presents the values of the water quality parameters monitored by Metropolitan staff in the effluents of the Jensen and Diemer plants

between 2005 and 2018. The values listed include the average and the range of 5th percentile to 95th percentile for pH, alkalinity, and calcium concentrations in the effluent of each plant, as well as those of other general water quality parameters. For the purpose of this analysis, the remineralization chemical doses at each seawater desalination plant were set at the values required to achieve the same combination of average pH, alkalinity, and calcium values in the effluent of the surface water plant currently serving that seawater desalination plant service area.

Table 5.2 Average and Range (5th-95th Percentile) Values of Water Quality Parameters in the Effluents of the Jensen and Diemer Water Treatment Plants (2005-2018)

Parameter	Unit	Jensen WTP		Diemer WTP	
		Average	Range	Average	Range
pH	--	8/3	8.1 – 8.4	8.1	7.9 – 8.3
Alkalinity	mg/L as $CaCO_3$	85	74 – 94	101	71 – 127
Calcium	mg/L	28	22 – 36	55	30 – 76
TDS	mg/L	308	237 – 417	505	310 – 657
Magnesium	mg/L	12	10 – 14	22	13 – 28
Sodium	mg/L	62	42 – 93	84	56 – 104
Sulfate	mg/L	65	44 – 105	186	89 – 261
Chloride	mg/L	71	48 – 94	85	55 – 102
Bromide	mg/L	200	130 – 260	110	42 – 189
Temperature	deg C	19	14 – 24	21	14 – 28

5.1.4 Supplemental Treated Water Quality Analysis

When selecting the remineralization chemical doses, the focus is typically on the precipitation of $CaCO_3$ with the goal of maintaining positive LSI and Calcium Carbonate Precipitation Potential (CCPP) values in the treated water. However, the pH and alkalinity values of the treated water also affect the solubility of metal oxides commonly present on the surface of home plumbing, specifically copper pipes and lead-containing surfaces such as old solder or brass fixtures.

As elemental copper is oxidized by chlorine or oxygen to cuprous ions (Cu^+) and cupric ions (Cu^{2+}), it forms various oxide precipitates including reddish-brown cuprite ($Cu_2O_{(s)}$), blue-green malachite, ($Cu_2(OH_2)CO_{3(s)}$), or black tenorite ($CuO_{(s)}$):

$$2Cu^{+} + 2OH^{-} \rightarrow Cu_2O_{(s)} + H_2O \quad (1)$$

$$2Cu^{2+} + CO_3^{2-} + 2OH^{-} \rightarrow Cu_2\left(OH\right)_2 CO_{3_{(s)}} \quad (2)$$

$$2Cu^{2+} + 2OH^{-} \rightarrow 2CuO_{(s)} + H_2O \quad (3)$$

If complete oxidation of copper to Cu^{2+} is assumed, then the formation of $Cu_2O_{(s)}$ shown in Reaction 1 above would be minimal. The remaining dominant forms are malachite and tenorite. Depending on the quality of the water passing through the copper pipes, predominantly pH and alkalinity, malachite and tenorite will either precipitate or dissolve in the water. Based on chemical principles, knowing the pH and alkalinity of treated water can identify the maximum copper that can be present in the water when

it is in equilibrium with either precipitate. The commercially available program WaterPro® was used to calculate the maximum copper solubility for each treated water quality in the effluent of each seawater desalination plant and then was compared to the maximum copper solubility in the current treated surface water serving the distribution system.

The analysis also quantified the maximum lead solubility based on the precipitation or dissolution of lead carbonate cerussite, $PbCO_3$, or of the basic lead carbonate, hydrocerussite, $Pb_3(CO_3)_2(OH)_2$. The maximum potential lead concentration is driven by the least soluble lead precipitate. Since cerussite is significantly more soluble than hydrocerussite, the latter controls the maximum solubility of lead concentration in the water in the presence of oxidants, carbonate, and hydroxide ions. The model WaterPro® was used to calculate the maximum lead that can dissolve into the water if in contact indefinitely with an infinite quantity of the solid hydrocerussite, $Pb_3(CO_3)_2(OH)_{2(s)}$. This maximum lead solubility was calculated in the resulting treated water under each remineralization scenario and then compared to the maximum lead solubility in the current treated surface waters produced by Metropolitan's Jensen and Diemer WTPs.

Finally, the analysis also calculated the Chloride-to-Sulfate Mass Ratio (CSMR) in the product water and compared it to that in the current treated surface water served into the system. Some researchers believe that a higher CSMR value suggests a higher propensity for lead corrosion in premise plumbing (Nguyen et al. 2010). However, it is WQTS' opinion that the chloride concentration is more relevant than the CSMR. Specifically, WQTS believes that a significant increase in the chloride concentration in water exposed to metal pipes with an existing stable corrosion scale may result in a significant increase in the release of metals from those pipes into the water. Nonetheless, the CSMR values are calculated for each treated water condition evaluated herein.

5.1.5 Chemical Doses Required to Achieve Target Treated Water Quality

Calculations of the chemical doses required to achieve a target combination of pH, alkalinity, and calcium concentrations were conducted using WQTS' internal water chemistry model. The model also determines the resulting water quality conditions, specifically related to the two $CaCO_3$ precipitation indices: LSI, and the CCPP. While both LSI and CCPP are related to the precipitation of $CaCO_3$, they differ in their meaning since the LSI is a measure of the degree by which the water is oversaturated or under-saturated with $CaCO_3$ while the CCPP is a measure of the quantity of $CaCO_3$ that will precipitate (or dissolve) if the water is allowed to get reach equilibrium (i.e., given infinite time). As noted in the previous section, WaterPro® was used to calculate the maximum copper and lead solubilities under each water quality condition. This section presents the outcome of the analysis for each of the three seawater desalination plants.

5.1.5.1 Doheny Seawater Desalination Plant

The same chemical dose calculations were conducted for the Doheny seawater desalination plant using the same approach applied for the Port Hueneme plant. Table 5.3 presents the calculated chemical doses required under each of the three re-mineralization options to meet the pH, alkalinity, and LSI criteria set for the PWSC effluent along with the resulting treated water quality. **Table 5.4** presents the same parameters under the goal of meeting the average pH, alkalinity, and calcium content of the Diemer WTP effluent, which is currently served into the Doheny plant service area. Since both the

Doheny plant and the Port Hueneme plant would utilize a subsurface intake resulting in the same permeate water quality, then the chemical doses required at the two plants are the same and the resulting water quality is the same. However, since the Diemer WTP effluent contains a higher average concentration of calcium (55 mg/L) compared to that in the Jensen WTP effluent (28 mg/L), the chemical doses required to meet the Diemer WTP effluent water quality are significantly higher than those required to meet the Jensen WTP effluent water quality. For example, under option 1, the lime dose required at the Doheny plant is projected at 102 mg/L (**Table 5.4**), while that required at the Port Hueneme plant was projected at 52 mg/L (**Table 5.6**).

Table 5.3 Chemical Doses Required Under the Three Remineralization Options to Meet the PWSC Treated Water Quality Criteria at the Doheny Seawater Desalination Plant, and the Resulting Water Quality Compared to that Recommended for the PWSC Effluent

Chemical	Unit	Option 1	Option 2	Option 3	Goal (PWSC)
Chemical Doses					
Lime	mg/L $Ca(OH)_2$	59 – 65	--	--	--
Calcium Chloride	mg/L $CaCl_2$	--	97 – 125	--	--
Calcite	mg/L $CaCO_3$	--	--	80 – 87	--
Caustic Soda	mg/L NaOH	0	59 – 60	0	--
Carbon Dioxide	mg/L CO_2	71 – 78	66 – 67	36 – 40	--
Treated Water Quality					
pH	--	8.0	8.0	8.0	8.0 ± 0.2
Alkalinity	mg/L as $CaCO_3$	81 – 88	75	81 – 88	≥50
Calcium	mg/L	32 – 35	35 – 45	32 – 35	--
TDS	mg/L	99 – 122	218 – 219	121 – 143	--
Temperature	deg C	12 – 20	12 – 20	12 – 20	--
Sodium	mg/L	12 – 23	54 – 65	12 – 23	--
Chloride	mg/L	20 – 36	98 – 100	20 – 36	--
Magnesium	mg/L	0.15 – 0.26	0.15 – 0.26	0.15 – 0.26	--
Sulfate	mg/L	0.65 – 1.2	0.65 – 1.2	0.65 – 1.2	--
LSI	--	0.02 – 0.05	0.01 – 0.02	0.01 – 0.04	>0
CCPP	mg/L as $CaCO_3$	0.21 – 0.5	0.08 – 0.17	0.08 – 0.40	--
Copper Solubility	µg/L (Tenorite)	20 – 37	18 – 32	20 – 37	--
Copper Solubility	µg /L (Malachite)	38 – 52	36 – 48	38 – 52	--
Lead Solubility	µg /L (hydrocerussite)	156 – 196	159 – 198	156 – 196	--
CSMR	mg/mg	30 – 31	82 – 154	30 – 31	--

It is also noted that the copper and lead solubility values under each re-mineralization option are within close proximity of their average values in the Diemer WTP effluent water. In fact, the projected lead solubility in the Doheny plant re-mineralized water is lower than that projected in Diemer WTP effluent water for all re-mineralization options. The “solubility” values are reported in **Table 5.3** and others refer to the theoretical maximum dissolved concentration expected under the stated water quality conditions.

Finally, **Table 5.4** shows that the chloride concentrations in the re-mineralized water under option 2 are projected to be higher than that in the Diemer WTP effluent, primarily due to the high $CaCl_2$ dose required under that option (152 mg/L). The chloride concentration projected under options 1 and 3 (20 to 36 mg/L) is significantly lower than that in Diemer effluent (55 to 102 mg/L). However, if the CSMR were to be used as an indicator of lead corrosion potential, then the introduction of the re-mineralized desalinated water from the Doheny plant will result in a very significant increase in the CSMR value from a range of 0.38 to 0.64 mg/mg in Diemer WTP effluent to a range of 30 to 31 mg/mg under re-mineralization options 1 and 3, and up to a range of 111 to 181 mg/mg under re-mineralization option 2. This is caused by the fact that the sulfate concentration in the Diemer WTP effluent is much higher than that in the seawater RO desalinated water.

Table 5.4 Chemical Doses Required Under the Three Remineralization Options to Meet the Diemer Treated Water Quality Criteria at the Doheny Seawater Desalination Plant, and the Resulting Water Quality Compared to that of the Diemer WTP Effluent Water

Chemical	Unit	Option 1	Option 2	Option 3	Diemer WTP
Chemical Doses					
Lime	mg/L $Ca(OH)_2$	102	--	--	--
Calcium Chloride	mg/L $CaCl_2$	--	152	--	--
Calcite	mg/L $CaCO_3$	--	--	137	--
Caustic Soda	mg/L NaOH	0	81	0	--
Carbon Dioxide	mg/L CO_2	122	89	62	--
Treated Water Quality					
pH	--	8.1	8.1	8.1	7.9 – 8.3
Alkalinity	mg/L as $CaCO_3$	138	101	138	71 – 127
Calcium	mg/L	55	55	55	30 – 76
TDS	mg/L	136 – 165	267 – 295	171 – 200	310 – 657
Temperature	deg C	12 – 20	12 – 20	12 – 20	14 – 28
Sodium	mg/L	12 – 23	69 – 79	12 – 23	56 – 104
Chloride	mg/L	20 – 36	118 – 133	20 – 36	55 – 102
Magnesium	mg/L	0.15 – 0.26	0.15 – 0.26	0.15 – 0.26	13 – 28
Sulfate	mg/L	0.65 – 1.2	0.65 – 1.2	0.65 – 1.2	89 – 261
LSI	--	0.49 – 0.60	0.31 – 0.42	0.48 – 0.59	0.147 – 0.64
CCPP	mg/L as $CaCO_3$	9.65 – 11.7	4.0 – 5.4	9.2 – 11.3	4.8 (Ave.)
Copper Solubility	µg/L (Tenorite)	27 – 46	20 – 33	27 – 46	18 (Ave.)
Copper Solubility	µg /L (Malachite)	45 – 58	38 – 50	45 – 58	36 (Ave.)
Lead Solubility	µg /L (hydrocerussite)	152 – 192	155 – 194	153 – 192	201 (Ave.)
CSMR	mg/mg	30 – 31	111 – 181	30 – 31	0.38 – 0.64

5.1.5.2 Port Hueneme Seawater Desalination Plant

For the Port Hueneme seawater desalination plant, the minimum and maximum values of the permeate water quality parameters listed in **Table 5.1** for a subsurface intake were used to calculate the chemical doses required under each re-mineralization option to achieve the PWSC treated-water goal or to match the average pH, alkalinity, and calcium concentrations in the effluent of the Jensen plant. **Table 5.5** presents the results of the analysis for meeting the PWSC treated water goals.

Under re-mineralization option 1, a lime dose of 59 to 65 mg/L as $Ca(OH)_2$ is required along with a carbon dioxide dose of 71 to 78 mg/L, with no caustic addition required. The range reflects the range of permeate water quality. The resulting water quality includes a pH of 8.0, an alkalinity ranging from 81 to 88 mg/L as $CaCO_3$, and a calcium concentration ranging from 32 to 35 mg/L. The reason the actual alkalinity is significantly higher than the target of 50 mg/L as $CaCO_3$ is driven by the fact that the lime dose had to be increased to meet the LSI goal while maintaining the pH at 8.0.

Table 5.5 Chemical Doses Required Under the Three Remineralization Options to Meet the PWSC Treated Water Quality Criteria at the Port Hueneme Seawater Desalination Plant, and the Resulting Water Quality Compared to that Recommended for the PWSC Effluent

Chemical	Unit	Remineralization Options			Goal (PWSC)
		Option 1	Option 2	Option 3	
Chemical Doses					
Lime	mg/L $Ca(OH)_2$	59 – 65	--	--	--
Calcium Chloride	mg/L $CaCl_2$	--	97 – 125	--	--
Calcite	mg/L $CaCO_3$	--	--	80 – 87	--
Caustic Soda	mg/L NaOH	0	60	0	--
Carbon Dioxide	mg/L CO_2	71 – 78	67	36 – 40	--
Treated Water Quality					
pH	--	8.0	8.0	8.0	8.0 ± 0.2
Alkalinity	mg/L as $CaCO_3$	81 – 88	75	81 – 88	≥50
Calcium	mg/L	32 – 35	35 – 45	32 – 35	--
TDS	mg/L	99 – 122	218 – 219	121 – 143	--
Temperature	deg C	12 – 20	12 – 20	12 – 20	--
Sodium	mg/L	12 – 23	54 – 65	12 – 23	--
Chloride	mg/L	20 – 36	98 – 100	20 – 36	--
Magnesium	mg/L	0.15 – 0.26	0.15 – 0.26	0.15 – 0.26	--
Sulfate	mg/L	0.65 – 1.2	0.65 – 1.2	0.65 – 1.2	--
LSI	--	0.02 – 0.05	0.01 – 0.02	0.01 – 0.04	>0
CCPP	mg/L as $CaCO_3$	0.21 – 0.50	0.08 – 0.17	0.08 – 0.4	--
Copper Solubility	µg/L (Tenorite)	20 – 37	18 – 32	20 – 37	--
Copper Solubility	µg /L (Malachite)	38 – 52	36 – 48	38 – 52	--
Lead Solubility	µg /L (hydrocerussite)	156 – 196	159 – 198	156 – 196	--
CSMR	mg/mg	30 – 31	82 – 154	30 – 31	--

Under re-mineralization option 2, since lime is substituted with $CaCl_2$ for calcium addition, a high caustic dose of 60 mg/L is required coupled with a $CaCl_2$ dose of 97 to 125 mg/L and a CO_2 dose of 67 mg/L to meet the treated water goals. As shown in the re-mineralization water quality values, the use of $CaCl_2$ results in a significant increase in the chloride and TDS concentrations compared to those calculated under re-mineralization option 1.

Under re-mineralization option 3, calcium is added to the water by dissolving $CaCO_3$ from a calcite granular media contactor. The estimated $CaCO_3$ dose is projected at 80 to 87 mg/L, and is supplemented

with a CO_2 dose of 36 mg/L to 40 mg/L. No caustic addition is required since the alkalinity target is met by the carbonate added with calcite.Table 5.6 presents a similar analysis with the treated water goal of matching the average pH (8.3), alkalinity (85 mg/L as $CaCO_3$), and calcium (28 mg/L) in the effluent of the Jensen WTP. The chemical doses required under each re-mineralization option evaluated are listed first, followed by the resulting water quality parameters compared to the range of values for those parameters in the Jensen WTP effluent. It is emphasized that the reference to a "range" implies that from the 5th percentile value to the 95th percentile value.

Under re-mineralization option 1, a lime dose of 52 mg/L as $Ca(OH)_2$ is required along with a carbon dioxide dose of 74 mg/L, along with a caustic soda dose of 12 mg/L. Under option 2, the calcium chloride dose required is 78 mg/L, while that of caustic soda is 68 mg/L and the CO_2 dose is 74 mg/L. Finally, under option 3, a $CaCO_3$ dose of 70 mg/L is required combined with a caustic dose of 12 mg/L and a CO_2 dose of 44 mg/L. Any of these combinations is projected to generate water quality with the same precipitation potential of $CaCO_3$ as demonstrated by the LSI and CCPP values, as well as the copper and lead solubilities compared to those calculated for the Jensen WTP effluent water. However, due to the much higher sulfate concentration in the Jensen WTP effluent compared to that in the seawater RO desalinated water, the CSMR in the re-mineralized desalinated water is orders of magnitude higher than that in the Jensen WTP effluent. However, it is unlikely that lead solubility will increase in the water since the chloride concentration in the re-mineralized seawater desalination water is similar to that in the Jensen WTP effluent.

Table 5.6 Chemical Doses Required Under the Three Remineralization Options to Meet the Average Jensen Treated Water Quality Criteria at the Port Hueneme Seawater Desalination Plant, and the Resulting Water Quality Compared to that of the Jensen WTP Effluent Water

Chemical	Unit	Option 1	Option 2	Option 3	Jensen WTP
Chemical Doses					
Lime	mg/L $Ca(OH)_2$	52	--	--	--
Calcium Chloride	mg/L $CaCl_2$	--	78	--	--
Calcite	mg/L $CaCO_3$	--	--	70	--
Caustic Soda	mg/L NaOH	12	68	12	--
Carbon Dioxide	mg/L CO_2	74	74	44	--
Treated Water Quality					
pH	--	8.3	8.3	8.3	8.1 – 8.4
Alkalinity	mg/L as $CaCO_3$	85	85	85	74 – 94
Calcium	mg/L	28	28	28	22 – 36
TDS	mg/L	98 – 126	179 – 208	116 – 144	237 – 417
Temperature	deg C	12 – 20	12 – 20	12 – 20	14 – 24
Sodium	mg/L	20 – 31	60 – 70	21 – 31	42 – 93
Chloride	mg/L	20 – 36	70 – 86	20 – 36	48 – 94
Magnesium	mg/L	0.15 – 0.26	0.15 – 0.26	0.15 – 0.26	10 – 14
Sulfate	mg/L	0.65 – 1.2	0.65 – 1.2	0.65 – 1.2	44 – 105
LSI	--	0.21 – 0.31	0.17 – 0.28	0.20 – 0.30	0.11 – 0.36
CCPP	mg/L as $CaCO_3$	1.7 – 2.6	1.4 – 2.3	1.6 – 2.5	1.9 (Ave.)
Copper Solubility	µg/L (Tenorite)	11 – 19	11 – 18	11 – 18	11 (Ave.)

Chemical	Unit	Option 1	Option 2	Option 3	Jensen WTP
Copper Solubility	µg /L (Malachite)	28 – 37	28 – 37	28 – 38	29 (Ave.)
Lead Solubility	µg /L (hydrocerussite)	157 – 213	158 – 213	157 – 213	214 (Ave.)
CSMR	mg/mg	30 – 31	71 – 107	30 – 31	0.66 – 1.7

5.1.5.3 El Segundo Seawater Desalination Plant

For the El Segundo plant, SSI are also anticipated, consistent with the Port Hueneme and Doheny sites. Because an earlier phase of this study evaluated an open intake scenario for comparison, both subsurface and open intake cases are summarized here. The open intake results provide beneficial information that helps illustrate potential variations in RO permeate quality and confirm the robustness of the remineralization analysis. The treated water quality goals are the same as those of the Port Hueneme plant which are either the PWSC goals or the Jensen WTP effluent pH, alkalinity, and calcium. The chemical dose calculations were conducted similar to the two other plants, and because the El Segundo subsurface intake would yield permeate quality comparable to Port Hueneme, the required chemical doses to achieve the PWSC or Jensen targets are effectively identical to those listed for Port Hueneme in Tables 5.3 and 5.4. Results for the open intake scenario are also presented in **Table 5.7** for meeting the PWSC treated water goals, and in

Table 5.8 for achieving the average pH, alkalinity, and calcium of the Jensen WTP effluent water. The chemical doses required under all re-mineralization options are similar to those anticipated for the Port Hueneme plant because they share the same target water quality values, and the resulting treated water quality is also similar as that projected from the Port Hueneme plant whether meeting the PWSC water quality goals (**Table 5.7**) or the Jensen WTP effluent water quality (

Table 5.8).

Table 5.7 Chemical Doses Required Under the Three Remineralization Options to Meet the PWSC Treated Water Quality Criteria at the El Segundo Seawater Desalination Plant, and the Resulting Water Quality Compared to that Recommended for the PWSC Effluent

Chemical	Unit	Option 1	Option 2	Option 3	Goal (PWSC)
Chemical Doses					
Lime	mg/L $Ca(OH)_2$	55 – 67	--	--	--
Calcium Chloride	mg/L $CaCl_2$	--	97 – 139	--	--
Calcite	mg/L $CaCO_3$	--	--	80 – 92	--
Caustic Soda	mg/L NaOH	0	59	0	--
Carbon Dioxide	mg/L CO_2	66 – 80	66	36 – 42	--
Treated Water Quality					
pH	--	8.0	8.0	8.0	8.0 ± 0.2
Alkalinity	mg/L as $CaCO_3$	76 – 91	75	81 – 93	≥50
Calcium	mg/L	30 – 36	35 – 50	32 – 37	--
TDS	mg/L	96 – 122	223 – 227	121 – 147	--
Temperature	deg C	10 – 21	10 – 21	10 – 21	--
Sodium	mg/L	10 – 24	52 – 66	10 – 24	--
Chloride	mg/L	16 – 38	100 – 105	16 – 38	--

Chemical	Unit	Option 1	Option 2	Option 3	Goal (PWSC)
Magnesium	mg/L	0.14 – 0.30	0.14 – 0.30	0.14 – 0.30	--
Sulfate	mg/L	0.53 – 1.2	0.53 – 1.2	0.53 – 1.2	--
LSI	--	0.01 – 0.02	0.02 – 0.03	0.03 – 0.06	>0
CCPP	mg/L as $CaCO_3$	0.10 – 0.19	0.20 – 0.28	0.31 – 0.52	--
Copper Solubility	µg/L (Tenorite)	18 – 44	17 – 36	19 – 45	--
Copper Solubility	µg /L (Malachite)	35 – 57	35 – 52	36 – 57	--
Lead Solubility	µg /L (hydrocerussite)	147 – 202	151 – 203	147 – 201	--
CSMR	mg/mg	30 – 32	83 – 197	30 – 32	--

Table 5.8 Chemical Doses Required Under the Three Remineralization Options to Meet the Jensen Treated Water Quality Criteria at the El Segundo Seawater Desalination Plant, and the Resulting Water Quality Compared to that Recommended for the Jensen WTP Effluent Water

Chemical	Unit	Option 1	Option 2	Option 3	Jensen WTP
Chemical Doses					
Lime	mg/L $Ca(OH)_2$	52	--	--	--
Calcium Chloride	mg/L $CaCl_2$	--	77 – 78	--	--
Calcite	mg/L $CaCO_3$	--	--	70	--
Caustic Soda	mg/L NaOH	11	67	11	--
Carbon Dioxide	mg/L CO_2	73 – 74	73 – 74	43	--
Treated Water Quality					
pH	--	8.3	8.3	8.3	8.1 – 8.4
Alkalinity	mg/L as $CaCO_3$	85	85	85	74 – 94
Calcium	mg/L	28	28	28	22 – 36
TDS	mg/L	92 – 130	174 – 212	110 – 148	237 – 417
Temperature	deg C	10 – 21	10 – 21	10 – 21	14 – 24
Sodium	mg/L	18 – 32	58 – 72	18 – 32	42 – 93
Chloride	mg/L	16 – 38	66 – 88	16 – 38	48 – 94
Magnesium	mg/L	0.14 – 0.30	0.14 – 0.30	0.14 – 0.30	10 – 14
Sulfate	mg/L	0.53 – 1.2	0.53 – 1.2	0.53 – 1.2	44 – 105
LSI	--	0.18 – 0.32	0.14 – 0.29	0.17 – 0.32	0.11 – 0.36
CCPP	mg/L as $CaCO_3$	1.4 – 2.7	1.1 – 2.4	1.4 – 2.6	1.9 (Ave.)
Copper Solubility	µg/L (Tenorite)	10 – 21	10 – 21	10 – 21	11 (Ave.)
Copper Solubility	µg /L (Malachite)	28 – 40	27 – 40	27 – 40	29 (Ave.)
Lead Solubility	µg /L (hydrocerussite)	149 – 212	149 – 211	149 – 212	214 (Ave.)
CSMR	mg/mg	30 – 32	73 – 124	30 – 32	0.66 – 1.7

5.1.5.4 Chloramine Stability

The shift from treated surface water to treated desalinated water has its water quality advantages, with the main one being the very low organic content, which results in the formation of very low concentrations of the two regulated disinfection by-products (DBPs): trihalomethanes (THMs) and haloacetic acids (HAAs). As an example, the City of Santa Barbara's seawater desalination plant produces water with a Total Organic Carbon (TOC) concentration between 0.15 and 0.27 mg/L. In addition, such

low organic content would greatly reduce the rate of decay of chloramine in the distribution system, which in turn would reduce the probability of occurrence of nitrification in the seawater desalination plant's service area.

However, one water constituent in the desalinated water that may create challenges to Metropolitan is bromide. Typical bromide concentrations in seawater range predominantly from 65 to 80 mg/L, which may result in permeate bromide concentrations ranging from 0.250 to more than 0.60 mg/L depending on several design and operational factors. When chlorine is added to permeate water containing bromide, hypochlorous acid, *HOCl*, reacts rapidly with bromide to form hypobromous acid, *HOBr*, as shown by Reaction 4:

$$HOCl + Br^{-} \rightarrow HOBr + Cl^{-} \quad (4)$$

When ammonia is then added downstream to form chloramine, the *HOBr* formed by reaction 4 reacts with the added ammonia to form monobromamine, NH_2Br:

$$HOBr + NH_3 \rightarrow NH_2Br + H_2O \quad (5)$$

The formed monobromamine will be part of the total chlorine measurement. However, monobromamine is less stable than monochloramine in water and will decay at a higher rate resulting in a more rapid decay of total chlorine in the distribution system.

Figure 5.2 presents the results of bench-scale testing conducted previously by WQTS to evaluate the impact of bromide on chloramine decay in water. One water was re-mineralized distilled water, while the other was re-mineralized RO-desalinated seawater. Both waters were re-mineralized to an alkalinity of 62 mg/L as $CaCO_3$, pH of 8.3, and 26 mg/L of Calcium. Neither water contained detectable TOC concentrations. The re-mineralized distilled water contained no detectable bromide, while the re-mineralized desalinated seawater contained 0.433 mg/L bromide. Both water samples were spiked with 0.55 mg/L ammonia-nitrogen and 2.5 mg/L chlorine and then monitored for total chlorine concentration over 72 hours.

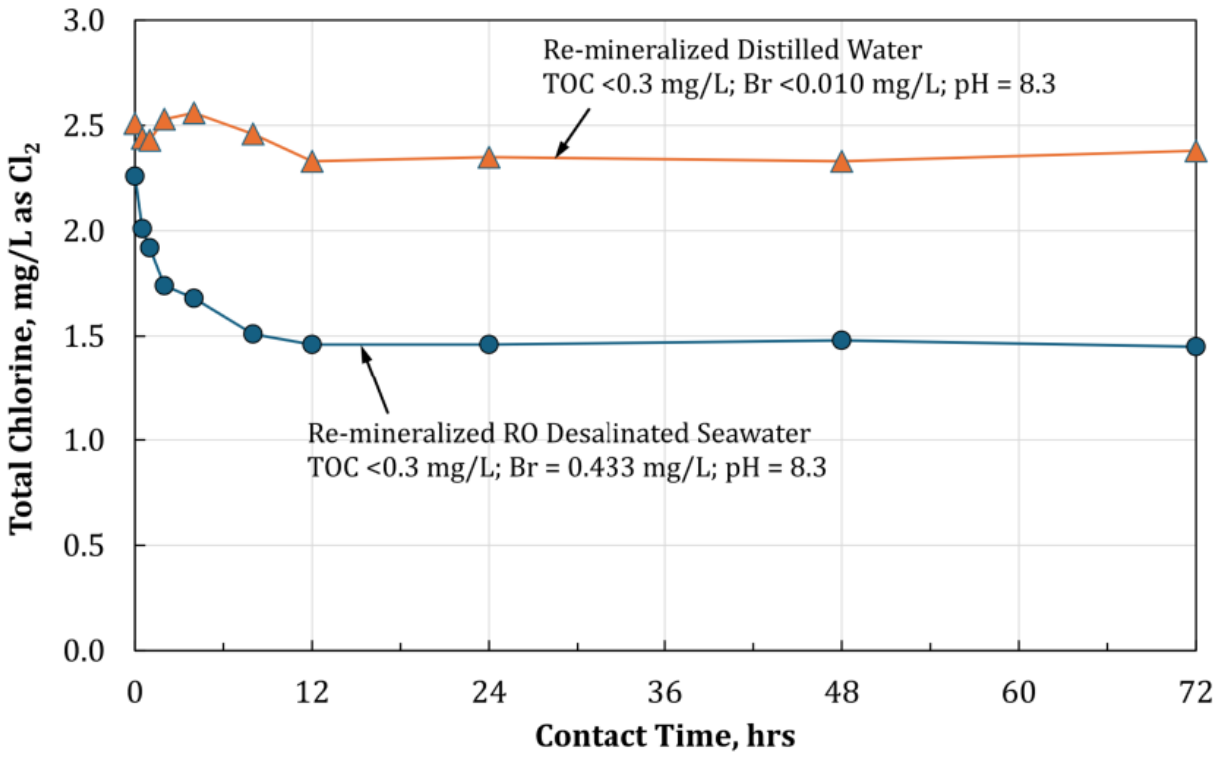


Figure 5.2 Impact of Bromide on the Decay of Total Chlorine in Buffered TOC-Free Water

The results show that the total chlorine concentration was relatively stable in the distilled water over the 72-hour period. However, in the desalinated water, total chlorine decayed at a high rate during the initial 12 hours before it stabilized for the rest of the contact time. The result was a loss of approximately 1 mg/L of total chlorine as a result of the presence of 0.433 mg/L bromide in the water.

Table 5.9 lists the expected bromide concentration in the permeate water from the three seawater desalination plants (**Table 5.1**) compared to those reported in the effluent of the Jensen and Diemer WTPs. If these values are validated, then the shift to desalinated water should not result in a significant change in total chlorine decay since the bromide concentrations in the desalinated water are expected to be in the same range as those in the surface WTP effluents.

Table 5.9 Comparison in the Bromide Concentration Between Seawater Desalination Plants Effluents and those of the Jensen and Diemer WTPs

Water Source	Bromide, mg/L
Port Hueneme & Doheny Seawater Desalination Plants	0.097 – 0.180
El Segundo Seawater Desalination Plant	0.094 – 0.220
Jensen WTP	0.130 – 0.260
Diemer WTP	0.042 – 0.189

However, WQTS' experience, and reported literature, suggest that the bromide concentration in the desalinated plant effluents could be higher than those reported in **Table 5.9**. To increase the confidence in the projected bromide concentration, WQTS recommends that a survey of existing seawater desalination plants be conducted. In this survey, Metropolitan should avoid measurements made using

chlorinated treated water samples because the bromide analytical methods employed by most laboratories under-estimate the bromide concentration in the water in the presence of chlorine. The reason is likely due to the conversion of a significant portion of the bromide ion, Br^-, to *HOBr* which may not picked up by the bromide analytical method.

5.1.6 Summary

This desktop study aimed at estimating the chemical doses required to re-mineralize the RO desalinated water at three potential seawater desalination plants in Ventura, Los Angeles, and Orange counties. The goal of re-mineralization is to produce treated water that is compatible with the distribution system material.

Starting with baseline RO permeate water quality, two target water quality criteria were evaluated for each plant, which are listed in **Table 5.10**. The first was the pH, alkalinity, and LSI values recommended for the effluent of the PWSC plant. These criteria were applied to all three plants. The second was the pH, alkalinity, and calcium concentration in the effluent of the surface WTP currently serving the same service area of each seawater desalination plant. For the Port Hueneme and El Segundo seawater desalination plants, the target conditions were those in the effluent of the Jensen WTP, while those in the effluent of the Diemer plant were used for the Doheny seawater desalination plant. It is noted that the LSI value under the Jensen and Diemer WTP effluents are not listed because they were not specific target water quality values under these scenarios.

Table 5.10 Water Quality Targets Considered in this Evaluation for Each Seawater Desalination Plant

Chemical	Unit	PWSC Targets	Jensen WTP Effluent	Diemer WTP Effluent
Seawater Desalination Plant		All	Port Hueneme & El Segundo	Doheny
pH	--	8.0 ± 0.2	8.3	8.1
Alkalinity	mg/L CaCO3	>50	85	101
Calcium	mg/L	--	28	55
LSI	--	>0	--	--

Three chemical re-mineralization options were evaluated for each seawater desalination plant. The three options were as follows:

- Option 1 – $Ca(OH)_2$ + NaOH + CO_2
- Option 2 – $CaCl_2$ + NaOH + CO_2
- Option 3 – Calcite ($CaCO_3$) + NaOH + CO_2

Using chemical equilibrium modeling, the chemical doses required to meet the target water quality conditions under each re-mineralization option were determined for each seawater desalination plant. **Table 5.11** lists the chemical doses required to meet the recommended PWSC effluent water quality at all three seawater desalination plants. While minor differences between the plants as discussed in the body of the report, the values listed in **Table 5.11** are reasonably applicable to all three plants.

Table 5.11 Chemical Doses Required Under the Three Re-mineralization Options at All Three Seawater Desalination Plants to Meet PWSC Treated Water Quality Goals

Chemical	Unit	Option 1	Option 2	Option 3
Lime	mg/L Ca(OH)2	55 – 67	--	--
Calcium Chloride	mg/L CaCl2	--	97 – 139	--
Calcite	mg/L CaCO3	--	--	80 – 92
Caustic Soda	mg/L NaOH	0	60	0
Carbon Dioxide	mg/L CO2	66 – 80	67	36 – 42

If the seawater desalination plants are required to produce water with the same pH, alkalinity, and calcium concentration as those present in the waters currently serving their respective service areas, then the chemical doses required under each re-mineralization option are listed in **Table 5.12**. For the Port Hueneme and El Segundo seawater desalination plants, the chemical doses are virtually the same since their service areas are currently served by the Jensen WTP. For the Doheny seawater desalination plant, the chemical doses under each option are higher because its service area is currently served by the Diemer WTP which has a higher alkalinity and higher calcium concentrations than those in the Jensen WTP effluent.

Table 5.12 Chemical Doses Required Under the Three Re-mineralization Options at the Three Seawater Desalination Plants to Meet Current Treated Water Quality in Their Respective Service Areas

Chemical	Unit	Option 1	Option 2	Option 3
Port Hueneme & El Segundo Seawater Desalination Plants (Jensen WTP Service Area)				
Lime	mg/L $Ca(OH)_2$	52	--	--
Calcium Chloride	mg/L $CaCl_2$	--	78	--
Calcite	mg/L $CaCO_3$	--	--	70
Caustic Soda	mg/L NaOH	12	68	12
Carbon Dioxide	mg/L CO_2	74	74	44
Doheny Seawater Desalination Plant (Diemer WTP Service Area)				
Lime	mg/L Ca(OH)2	102	--	--
Calcium Chloride	mg/L CaCl2	--	152	--
Calcite	mg/L CaCO3	--	--	137
Caustic Soda	mg/L NaOH	0	81	0
Carbon Dioxide	mg/L CO2	122	89	62

The analysis also estimated the $CaCO_3^-$ precipitation indices LSI and CCPP, as well as the maximum solubilities of lead and copper. Under all re-mineralization conditions, the LSI and CCPP are positive, and the lead and copper solubilities are well within the range of values predicted under the current treated surface water qualities in the effluents of both the Jensen and Diemer WTPs.

The lack of sulfate in the desalinated water results in high CSMR values under all re-mineralization conditions compared to the CSMR values in the current treated surface water. However, the chloride concentration in the re-mineralized waters is within the values measured in the current treated surface

waters with the exception of the quality produced under re-mineralization Option 2 which utilizes $CaCl_2$ for calcium addition. The resulting chloride concentration in the re-mineralized water under Option 2 is projected to be twice that in the re-mineralized waters under Options 1 and 3. However, the chloride concentrations projected under Option 2 are still close to those present in the treated surface water served by Metropolitan.

All three candidate sites (Port Hueneme, Doheny, and El Segundo) can be effectively integrated with Metropolitan's system using multiple remineralization approaches, with Option 1 (lime/CO_2/NaOH) and Option 3 (calcite/CO_2/NaOH) generally preferred over Option 2 ($CaCl_2$/NaOH/CO_2) due to lower chloride addition and lower CSMR.

5.1.7 Blending Considerations

The following are recommended considerations based on the analysis presented herein.

CSMR – Some researchers have promoted the idea that a CSMR greater than 0.5 is expected to result in significant leaching of lead from lead-containing solder in contact with copper pipes (Edwards and Triantafyllidou, 2007). The CSMR values in the re-mineralized water are between 30 and 32 with Options 1 and 3, and greater than 71 with Option 2. If Metropolitan is concerned about the high CSMR values, avoiding re-mineralization Option 2 would keep the CSMR below 32, which is still substantially higher than the surface water CSMR, but lower than the values with option 2. Maintaining the CSMR value in desalinated water at 0.5 requires the addition of high doses of a sulfate salt. Alternatively, CO_2 could be replaced with sulfuric acid, H_2SO_4, to increase the concentration of sulfate in the water.

Bromide – The bromide concentration in the permeate water is projected to be between 0.097 to 0.180 mg/L in the effluents of the Port Hueneme and Doheny seawater desalination plants, and between 0.094 and 0.220 mg/L in the effluent of the El Segundo seawater desalination plant. These levels are significantly lower than those reported in the literature. Higher bromide in the desalinated water can result in a higher rate of decay of total chlorine in the distribution system. Metropolitan can benefit from a survey of operating RO seawater desalination plants to gain a better understanding of the actual bromide concentration to be expected in the effluent of its seawater desalination plants. However, WQTS' experience suggests that bromide measurements in water containing chlorine underestimates the bromide concentration due to possible interference from formed HOBr. If Metropolitan solicits data from operating plants, it is important that the samples evaluated be collected from the RO permeate water before chlorine addition at those plants.

5.2 System Integration Considerations

Based on the results of the ranking analysis and subsequent investigations, the top three potential desalination projects recommended for further evaluation are as follows and as presented in **Figure 5.3**:

- Doheny State Beach Expansion with subsurface slant wells and use of existing wastewater outfall (10 mgd)
- Port Hueneme with subsurface slant wells and use of existing wastewater outfall (20 mgd)
- El Segundo with subsurface slant wells and use of existing wastewater outfall (10 mgd)

During refinement of the El Segundo alternative, Site 6A was advanced over the previously evaluated Site 6B based on updated information regarding property availability and intake feasibility. Subsequent coordination indicated that the intake location and overall site footprint previously considered for long-term desalination development at Site 6B would not be available, limiting its viability. As a result, the project configuration was shifted to the alternate Site 6A location. Due to the smaller available footprint at Site 6A and associated layout constraints, the assumed facility capacity was reduced from 20 mgd (as evaluated during the initial siting screening analysis) to 10 mgd in order to maintain a feasible plant layout.

For consistency, figures and tables in earlier sections that reference a 20-mgd El Segundo configuration reflect the initial screening-level evaluation prior to refinement of site constraints. The 10-mgd capacity represents the refined planning-level configuration advanced for further evaluation in this study.

This section identifies potential locations to tie into Metropolitan's and its member agencies' distribution systems for each site, and considers the imported water demands in each of the three areas. A high-level evaluation of system integration is considered for each potential seawater desalination plant, including potential treated water pipeline alignments and additional infrastructure, where necessary, such as pump stations, break tanks, and hydropneumatic surge tanks (also called a surge tank). This strategy is designed to balance the ability of each seawater desalination plant to supplement Metropolitan's regional water supplies, meet the direct demands of coastal member agencies through their local treated water distribution systems, and consider options for brine disposal. This comprehensive approach supports that the seawater desalination projects would contribute effectively to the region's water supply reliability while addressing environmental and operational considerations. Conveyance alignments, pump station configurations, and system integration concepts presented are conceptual in nature and were developed solely for planning-level comparison purposes.

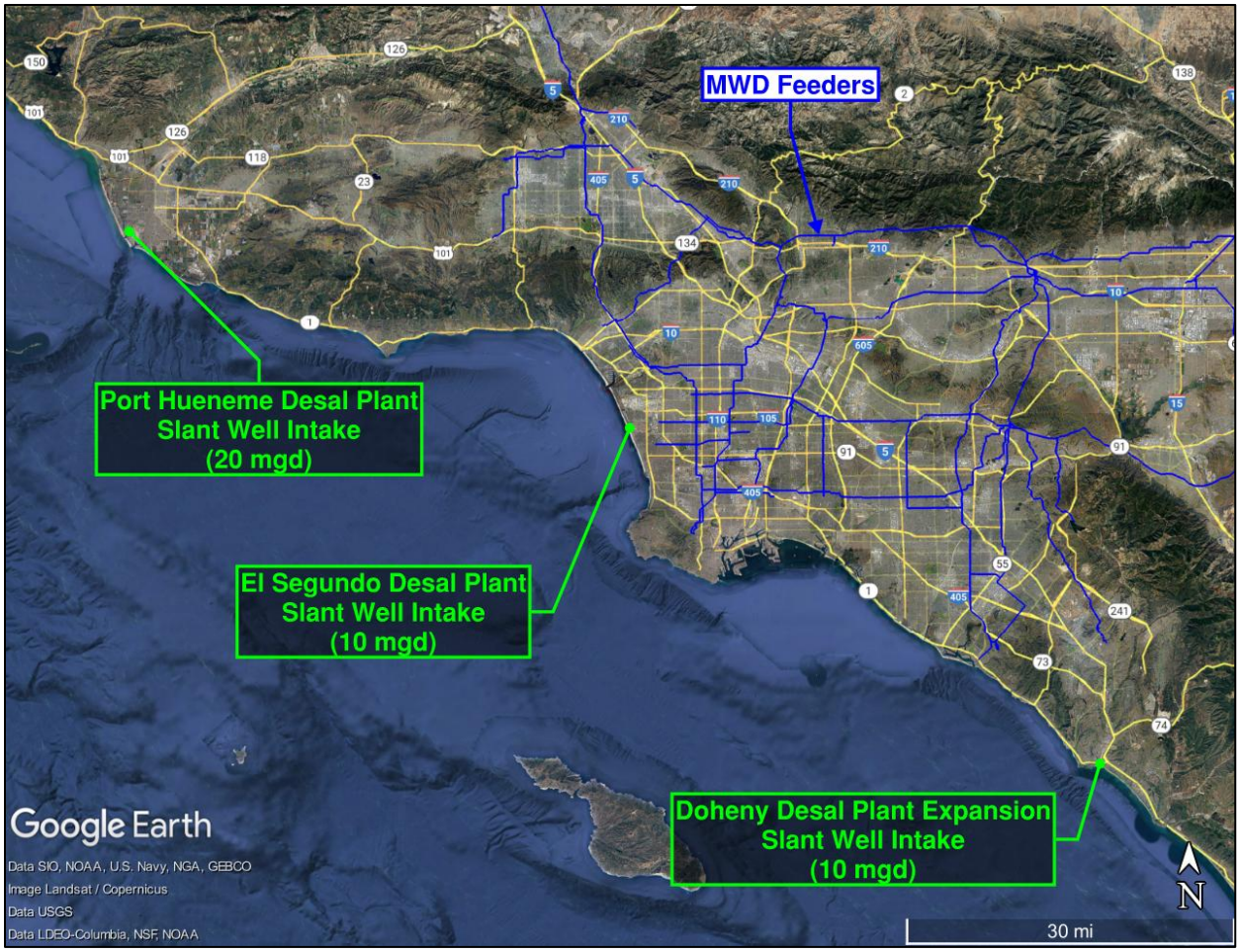


Figure 5.3 Map of Potential Seawater Desalination Facilities

5.2.1 Doheny Seawater Desalination Plant

This section presents an overview of the potential Doheny seawater desalination facility integration of treated desalinated water into the MWDOC system. Included is an analysis of imported water demands, a description of the project area, a review of the potential tie-in locations, flow and pressure control strategies, and potential impacts to existing conveyance and storage infrastructure. Although DPR is being considered as a future supply for this area, evaluation of potential co-development with an integrated DPR project was beyond the scope of this planning-level analysis; however, such opportunities could be explored in subsequent studies to assess potential operational, infrastructure, and water supply reliability benefits.

5.2.1.1 Imported Water Demand

Product water from the potential expansion to the Doheny seawater desalination facility would serve MWDOC's service area. To determine the estimated minimum water demands that could be offset, CDM Smith analyzed historical imported water data for eight retail agencies in the vicinity of the potential seawater desalination plant. Historical data was provided by MWDOC (**Figure 5.4**) from July 2015 through June 2024. The eight retail agencies included El Toro Water District, Laguna Beach County

Water District, Moulton Niguel Water District, City of San Clemente, City of San Juan Capistrano, Santa Margarita Water District, South Coast Water District, and Trabuco Canyon Water District.

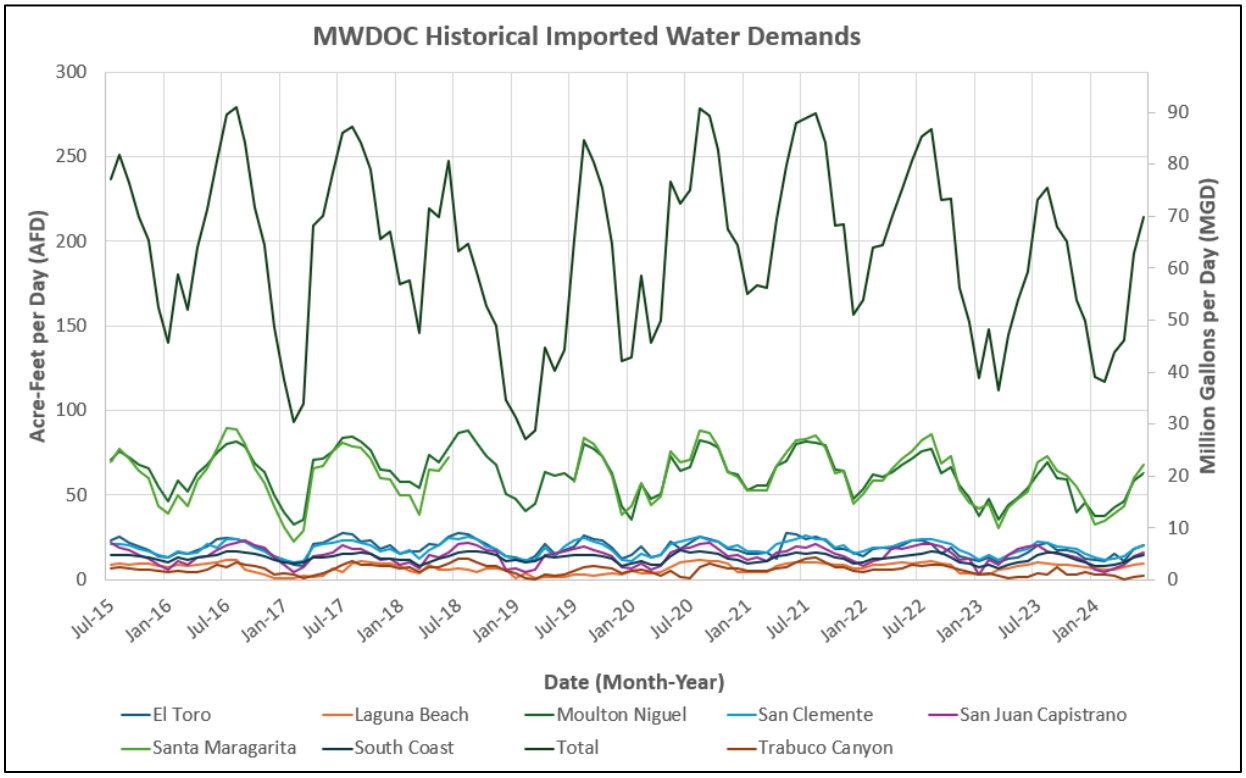


Figure 5.4 Historical Monthly Imported Water Demand of Municipal Water District of Orange County Retail Agencies

Historically imported water data from MWDOC can be used to predict how much treated desalinated water can be sent to the surrounding area to offset the district's reliance on imported water. This analysis revealed that the minimum imported water demand over the past eight years was 27 mgd. These results confirm that the potential 15 mgd capacity of an expanded Doheny seawater desalination plant could be fully used, even during periods of the system's lowest demands. This analysis validates that the seawater desalination facility could play a crucial role in meeting the water needs of MWDOC, enhancing water supply reliability, and reducing dependency on imported water sources.

To further illustrate the geographic distribution of demand and identify which retail agencies could benefit most directly from the potential expanded facility, **Figure 5.5** presents a map of the eight retail agencies and their corresponding estimated average daily imported water demands. This visual highlights the spatial relationship between demand centers and the seawater desalination facility, supporting the rationale for its integration into the MWDOC system.

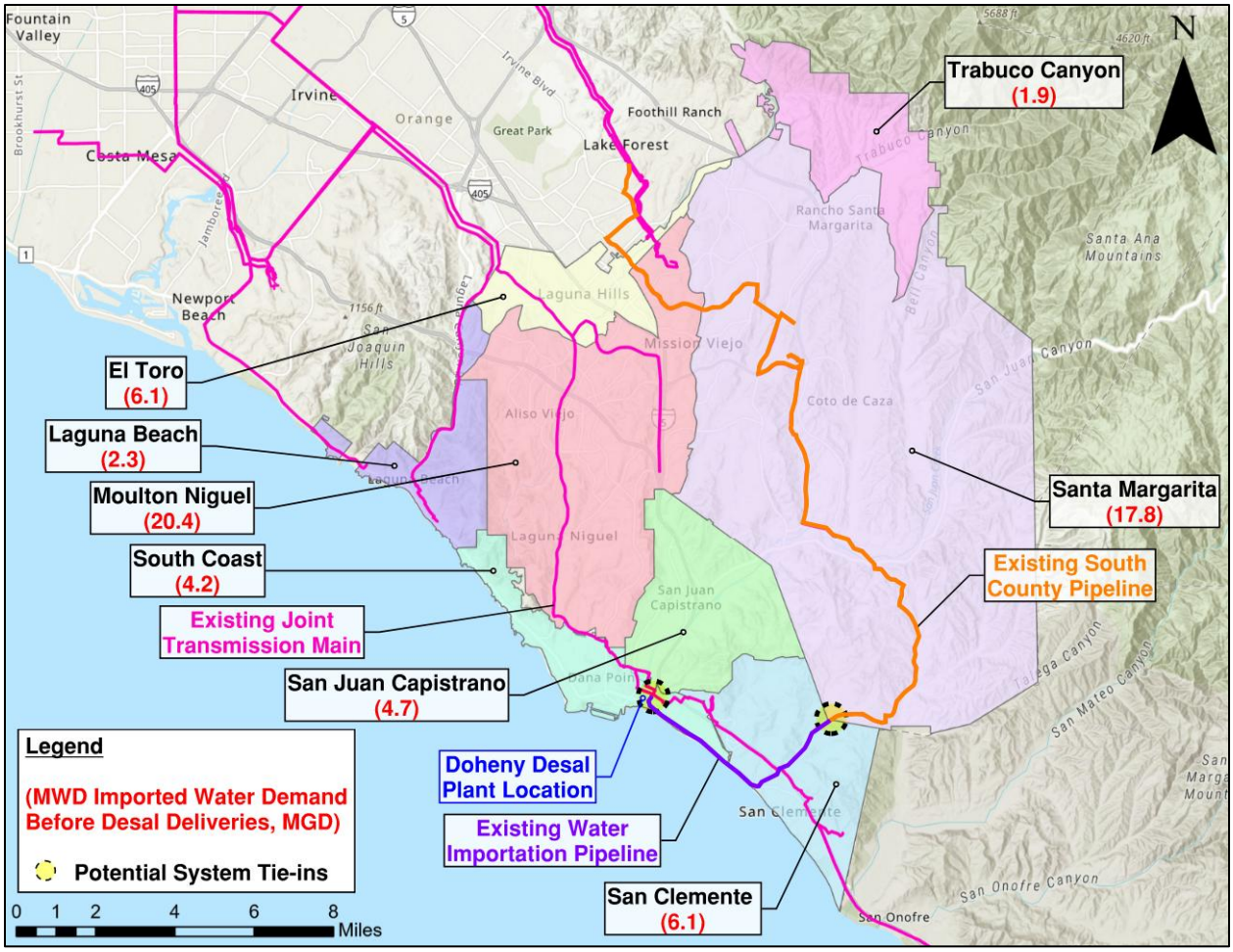


Figure 5.5 Estimated Average Imported Water Demands for Municipal Water District of Orange County Retail Agencies

5.2.1.2 System Integration and Storage

The potential expansion to the Doheny seawater desalination plant would provide an additional 10 mgd of production capacity and is located north of the Doheny State Beach Campground. The additional wells as shown are currently planned in the day-use area. However, as noted in **Figure 5.6**, offshore drilling is needed to validate paleochannel depths and extents offshore of the new locations as well as potential locations from the campground. **Figure 5.5** shows the location of four to six potential additional wells originating from the day use area. An MPA is located near the project, north of the proposed expansion area; however, the site is outside of the MPA boundary and relies on subsurface slant wells originating onshore, with no open ocean intake structures or in-water construction proposed within the MPA. Based on this planning-level configuration, the MPA would not be directly affected.

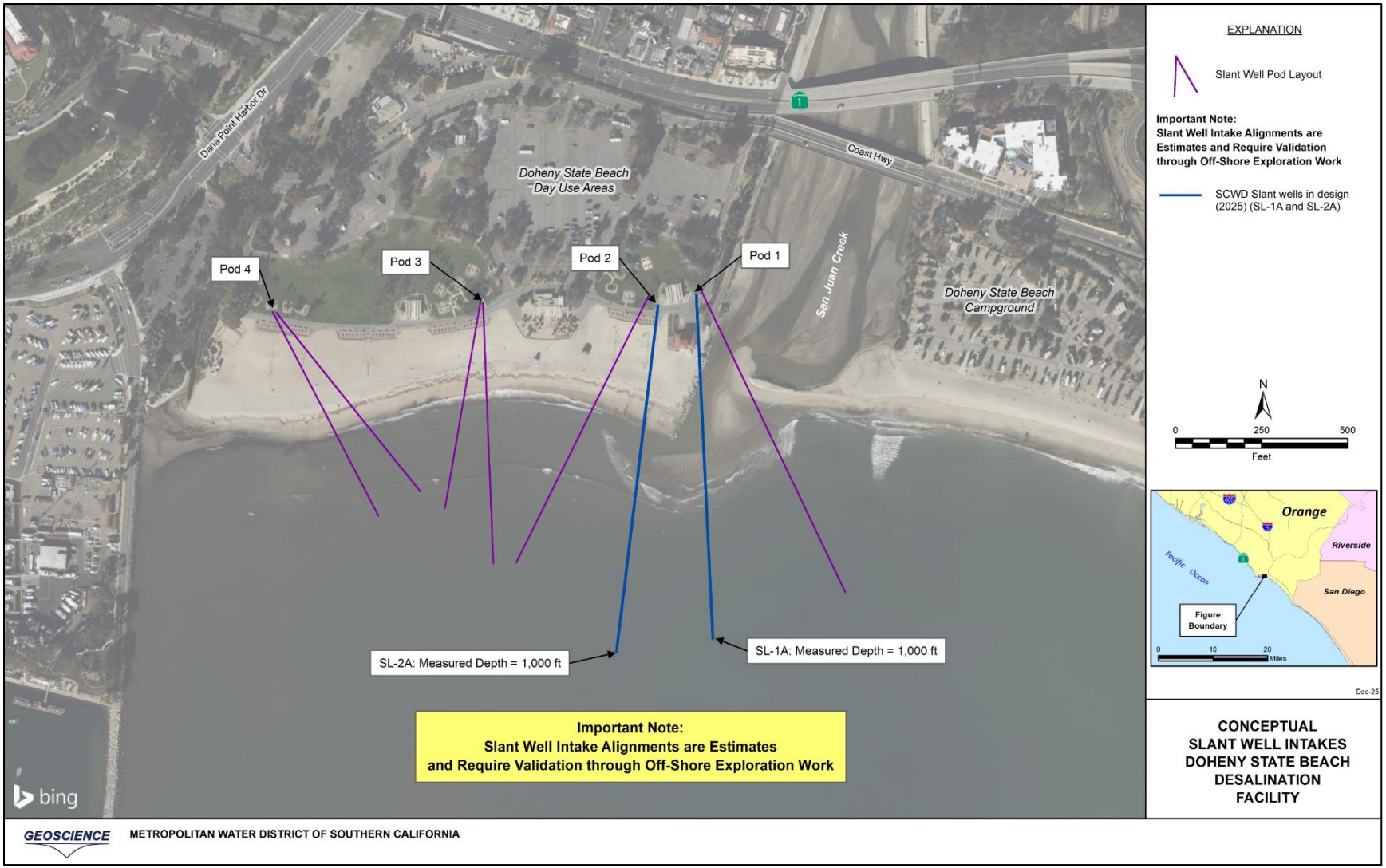


Figure 5.6 Slant Well Intakes for the Potential Expansion to the Doheny Seawater Desalination Facility (Courtesy of Geoscience)

There are two options for tie-in locations to pump product water from the seawater desalination facility into existing transmission systems. In both integration options, treated water may travel considerable distance through existing transmission pipelines to reach end users, potentially resulting in extended residence times. To mitigate water quality degradation due to chlorine decay over time, Metropolitan proposes to boost chlorine residual at strategic locations within the system. Residual monitoring stations and chemical injection points should be evaluated during future studies to maintain appropriate disinfection levels throughout the potential system, especially under low-demand or variable-flow conditions.

Tie-in Option 1 to Send Treated Water Northwest

This option includes two pump stations co-located at the seawater desalination plant, one of which would tie-in to the existing Joint Transmission Main (JTM) and the other to the existing Water Importation Pipeline (WIP) to allow water to be directed to either pipeline or both pipelines. The potential alignments from the seawater desalination facility to the two tie-in points include a total of approximately 3,400 LF of new pipe and one trenchless crossing (associated with railroad crossing). Each pump station is equipped with five pumps (four duty, one standby) with a capacity of 2.5 mgd per pump. **Table 5.13** summarizes design criteria for the potential pump stations in Option 1. Additional details of the pump stations are described below.

Table 5.13 Option 1 – Doheny Pump Station Design Criteria

Pump Station Name	Pump Station Description	Pump Station Design Flow (mgd)	Number of Pumps	Length of New Piping (feet)	Total Head (feet)	Discharge Pressure (psi)	Motor Size per Pump (hp)
DH-PS1	Doheny Desal Plant to JTM	10	4 Duty, 1 Standby at 2.5 mgd each	1,400 LF of new 30-inch pipe	445	183	260
DH-PS2	Doheny Desal Plant to WIP	10	4 Duty, 1 Standby at 2.5 mgd each	1,000 LF of new 27-inch pipe	565	235	330

Co-Located Doheny Pump Stations 1 and 2 (DH-PS1 and DH-PS2)

The potential DH-PS1 would draw from the finished water storage tank of the expanded Doheny seawater desalination plant. The pump station is sized to deliver 10 mgd to the JTM at a discharge HGL of 445 feet, corresponding to a pressure of 183 psi at an elevation of 20 feet. This discharge HGL is 22 feet higher than the JTM operating HGL of 420 feet to accommodate pump station and pipeline friction losses. Flow would be conveyed through approximately 1,400 feet of new 30-inch pipeline to the JTM connection. Depending on JTM hydraulic conditions, flow from DH-PS1 could travel either north or south along the JTM, assuming the JTM operates at an HGL of 420 feet or lower.

The potential DH-PS2 would also draw from the finished water storage tank at the expanded Doheny seawater desalination plant. This pump station is sized to deliver 10 mgd to the WIP at a discharge HGL of 565 feet, equivalent to a discharge pressure of 235 psi at an elevation of 20 feet. The discharge HGL is

22 feet above the WIP operating HGL of 540 feet to allow for pump station and pipeline friction losses. Flow would be conveyed through approximately 1,000 feet of new 27-inch pipeline to the WIP connection. Flow from DH-PS2 may travel north or south along the WIP depending on system hydraulic condition, assuming the WIP operates at an HGL of 565 feet or lower. Southbound flow would extend to, but not pass through, the Tri-Cities PRV, as the downstream system operates at a higher HGL.

The alignments and tie-in locations shown in this evaluation represent alternate routes from the Phase 1 DODP alignments. For the purposes of this planning-level analysis, it was assumed that the Phase 1 conveyance alignments and tie-in facilities may not have sufficient hydraulic capacity to accommodate an additional 10 mgd of production. Therefore, separate alignments and tie-in configurations to both the JTM and WIP were conceptually evaluated to account for adequate capacity for the expanded facility. Future planning studies should evaluate the feasibility of constructing new alignments versus increasing the capacity of the existing Phase 1 alignments.

To manage pressure transients, such as power outages during full-speed operation, two 25,000-gallon surge tanks would be required for each pump station discharge. The two surge tanks are estimated for each pump station.

Minimum parcel size assumed for this pump station location was determined based on the required facilities at the location. Two pump stations, a finished water storage tank that provides suction for both pump stations, and four surge tanks (two surge tanks per pump station) would require a parcel of approximately 1.6 acres. This parcel size was based on an approximate co-located pump station size of 180 feet by 90 feet, storage tank diameter of 65 feet, and two surge tank pads sized 45 feet by 50 feet to hold two surge tanks each.

Figure 5.7 illustrates the potential Doheny seawater desalination plant site, potential Option 1 alignments and tie-in locations, two co-located pump stations, finished water storage tank, and two surge tank pads for the four surge tanks.

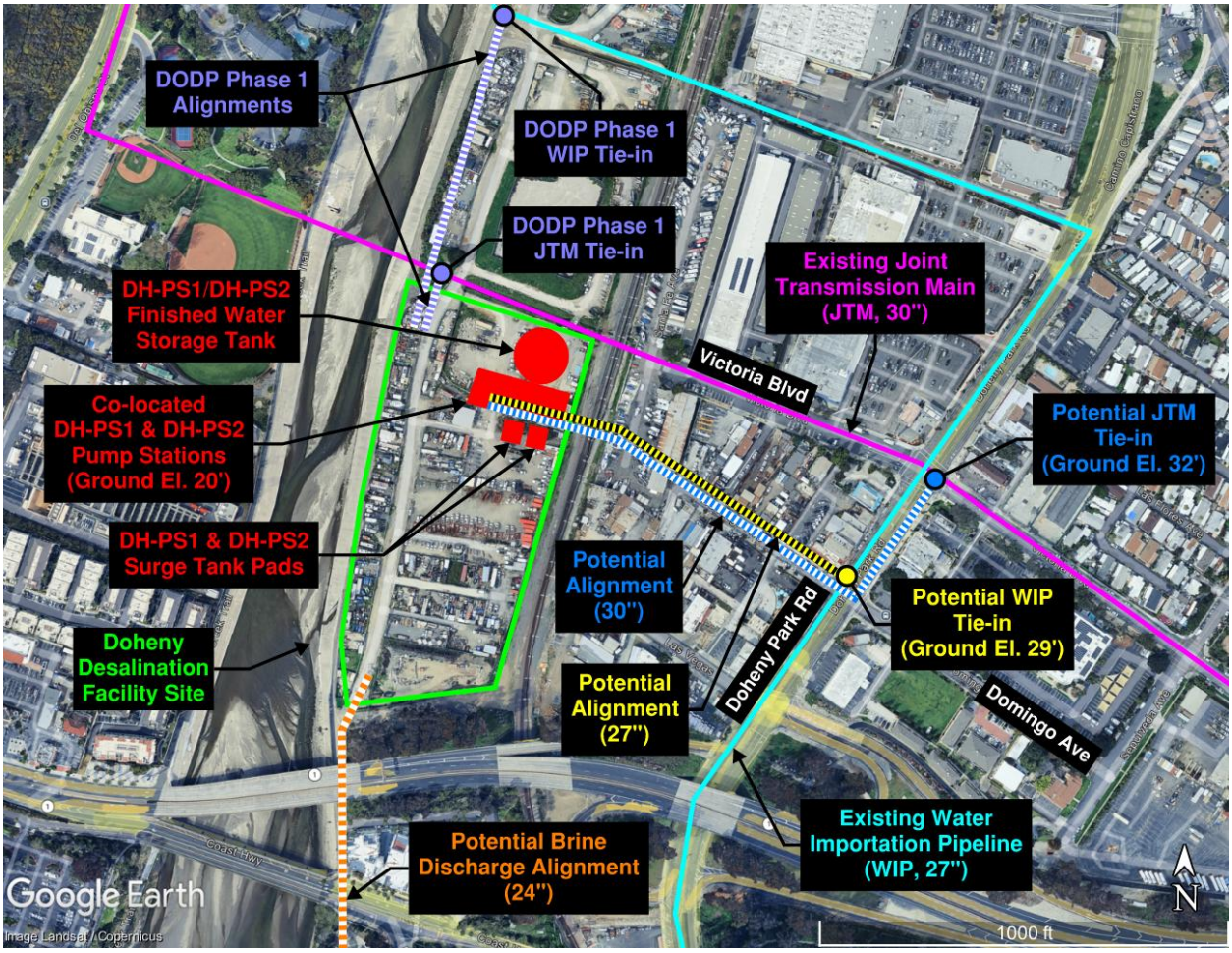


Figure 5.7 Option 1 – Potential Alignments for Doheny Seawater Desalination Facility

Tie-in Option 2 to Send Treated Water Northeast

This option would allow the new supply to be conveyed to the JTM, the WIP, and the South County Pipeline which is accessed through the WIP pipeline. Three new pump stations would be required, including two pump stations co-located at the seawater desalination facility and one new pump station near the Tri-Cities Pressure Regulating Station (PRS).

One new pump station, DH-PS1, at the seawater desalination facility would be the same size and capacity as the DH-PS1 pump station described in Tie-in Option 1 and would tie-in to the existing JTM. Flow would be delivered to the JTM via 1,400 LF of new 30-inch piping.

A second new pump station, DH-PS3, at the seawater desalination facility would tie-in to the existing 27-inch WIP pipeline east of the seawater desalination facility along Doheny Park Road and would deliver supply into the WIP via 1,000 LF of new piping. Flow would be conveyed through approximately 24,000 feet of existing 27-inch WIP pipeline which extends in the southeasterly direction along the coast, then that pipe diameter increases to 33-inch and follows Avenida Pico in the northeasterly direction for approximately 8,000 feet before increasing a final time to 36-inches for approximately 100 feet to the existing Tri-Cities PRS.

A flow control valve would be needed on the existing WIP north of the seawater desalination plant tie-in to balance desalinated supply flowing southward toward the Tri-Cities PRS with supply flowing northward along the WIP.

At the south end of the WIP, near the Tri-Cities PRS, a new break tank and pump station, DH-PS4, would be required. Flow into the break tank would be controlled with a pressure sustaining valve to maintain pressure in the WIP.

The Tri-Cities PRS normally flows from the South County Pipeline, which is higher in pressure, to the WIP which is lower in pressure. To convey flow in the opposite direction, or from the WIP into the South County Pipeline, the new pump station, DH-PS4, is required near the Tri-Cities PRS. The Tri-Cities PRS is located on Avenida Pico about 1,000 feet north of Avenida La Pata. An undeveloped and relatively flat area of land on Avenida La Pata, about 1,000 feet north of Avenida Pico was selected as the potential site of the new pump station for this exercise. About 2,500 LF of new piping would be needed to complete the new pump station and bypass Tri-Cities PRV.

The potential new alignments from the seawater desalination plant to the two tie-in points include a total of approximately 3,400 LF of new pipe and one trenchless crossing (associated with railroad crossing) near the new desal facility. Additionally, 2,500 LF of new pipe and no trenchless crossings would be needed to build the new pump station DH-PS4 and bypass around the Tri-Cities PRS. **Figure 5.8** shows the Doheny seawater desalination plant site, potential alignments and tie-in locations for Option 2, and potential locations of pump stations.

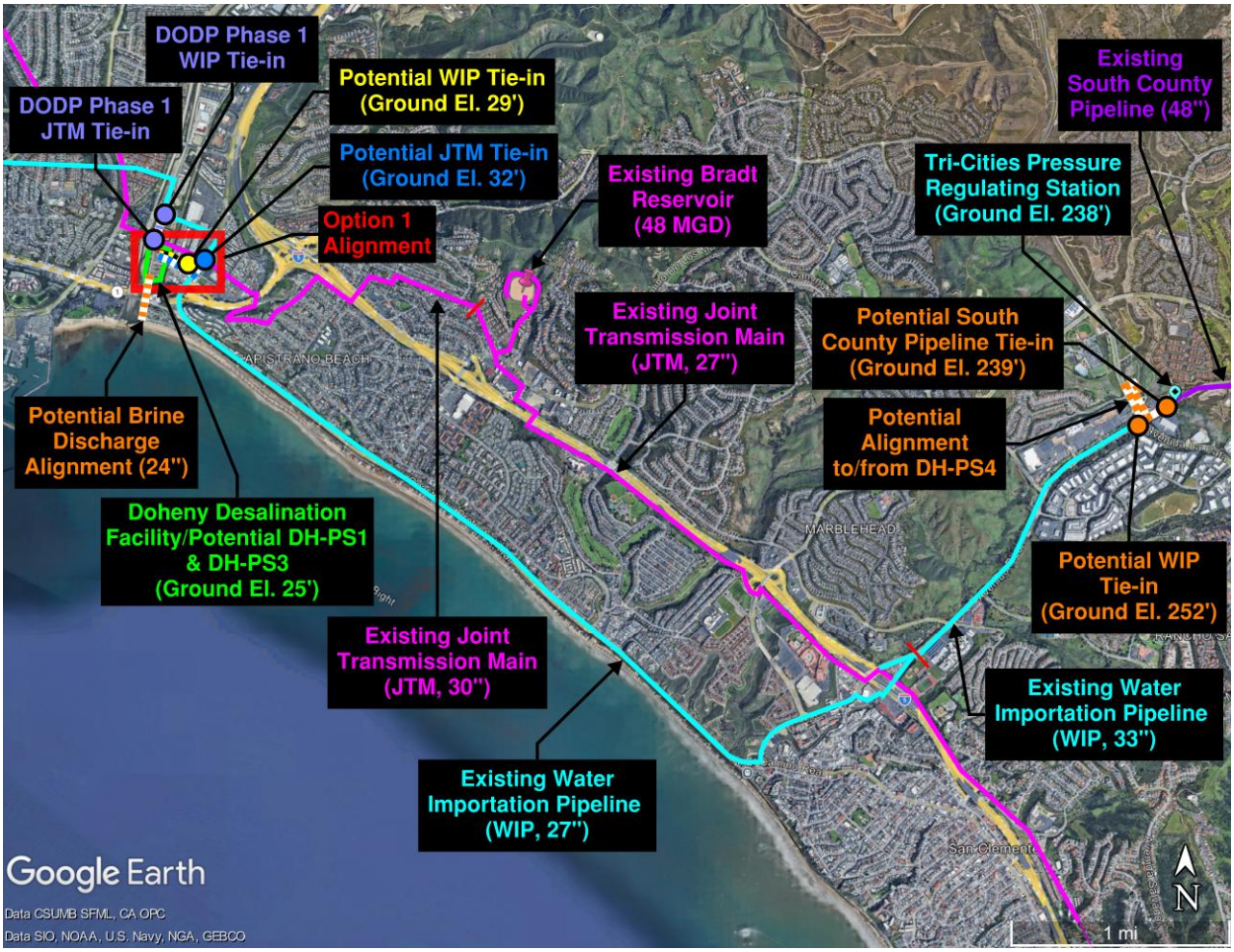


Figure 5.8 Option 2 – Potential Alignments for Doheny State Beach Expansion Seawater Desalination Facility

Each pump station would be equipped with five pumps (four duty, one standby) with a capacity of 2.5 mgd per pump. **Table 5.14** summarizes design criteria for the potential pump stations in Option 2. Additional details of the pump stations are described below.

Co-Located Doheny Pump Stations 1 and 3 (DH-PS1 and DH-PS3)

The potential DH-PS1 would draw from the finished water storage tank of the expanded Doheny seawater desalination plant and discharge into the JTM. The estimated discharge pressure is 183 psi at 20 feet elevation based on a flow of 10 mgd into the JTM, which operates at a HGL of 420 feet. The flow would travel through approximately 1,400 feet of 30-inch pipeline.

Table 5.14 Option 2 – Doheny Pump Station Design Criteria

Pump Station Name	Pump Station Description	Pump Station Design Flow (mgd)	Number of Pumps	Length of New Piping (feet)	Total Head (feet)	Discharge Pressure (psi)	Motor Size Per Pump (hp)
DH-PS1	Doheny Desal Plant to JTM	10	4 Duty, 1 Standby at 2.5 mgd each	1,400 LF of new 30-inch pipe	445	183	260
DH-PS3	Doheny Desal Plant to WIP	10	4 Duty, 1 Standby at 2.5 mgd each	1,000 LF of new 27-inch pipe	630	264	370
DH-PS4	Booster PS at Tri-Cities PRV	10	4 Duty, 1 Standby at 2.5 mgd each	2,500 LF of new 30-inch pipe	905	391	530

The potential DH-PS3 would draw from the finished water storage tank of the expanded Doheny seawater desalination plant and discharge into the WIP which operates at an HGL of 540 feet. The pump station would fill a ground-level break tank located at the new DH-PS4, which is at a ground elevation of 270 feet. The inlet to this break tank would have a pressure sustaining valve to maintain a HGL of 540 feet in the WIP. Discharge pressure of DH-PS3 would be approximately 264 psi at pump station elevation 20 feet, based on headlosses from 10 mgd of flow through approximately 24,000 LF of the 27-inch WIP and 8,000 LF of the 33-inch WIP between the desalination facility and Tri-Cities PRS, and a minimum HGL of 540 feet in the WIP.

To manage pressure transients, such as power outages during full-speed operation, two 25,000-gallon surge tanks are estimated to be required for each pump station discharge.

Minimum parcel sizes assumed for each pump station location were determined based on the required facilities at the location. For example, two pump stations with a storage tank and two surge tanks would require a parcel of approximately 1.6 acres. A pump station with two surge tanks and a break tank would require approximately 0.6 acres. These parcel sizes were based on an approximate pump station size of 90 feet by 90 feet, storage tank diameter of 92 feet, and surge tank pad size of 45 feet by 50 feet.

Figure 5.9 illustrates the potential approach to an expanded Doheny seawater desalination plant site, Option 2 alignments and tie-in locations, two co-located pump stations, finished water storage tank, and surge tank pad for the two surge tanks.

Doheny Pump Station 4 (DH-PS4)

The potential location for the new DH-PS4 is near the existing Tri-Cities PRS. A new 0.5 million-gallon (MG) break tank would provide a consistent suction HGL for the new pump station and is sized to provide a shutdown time of 30 minutes flowing at 10 mgd, with additional volume included for dead volume and freeboard.

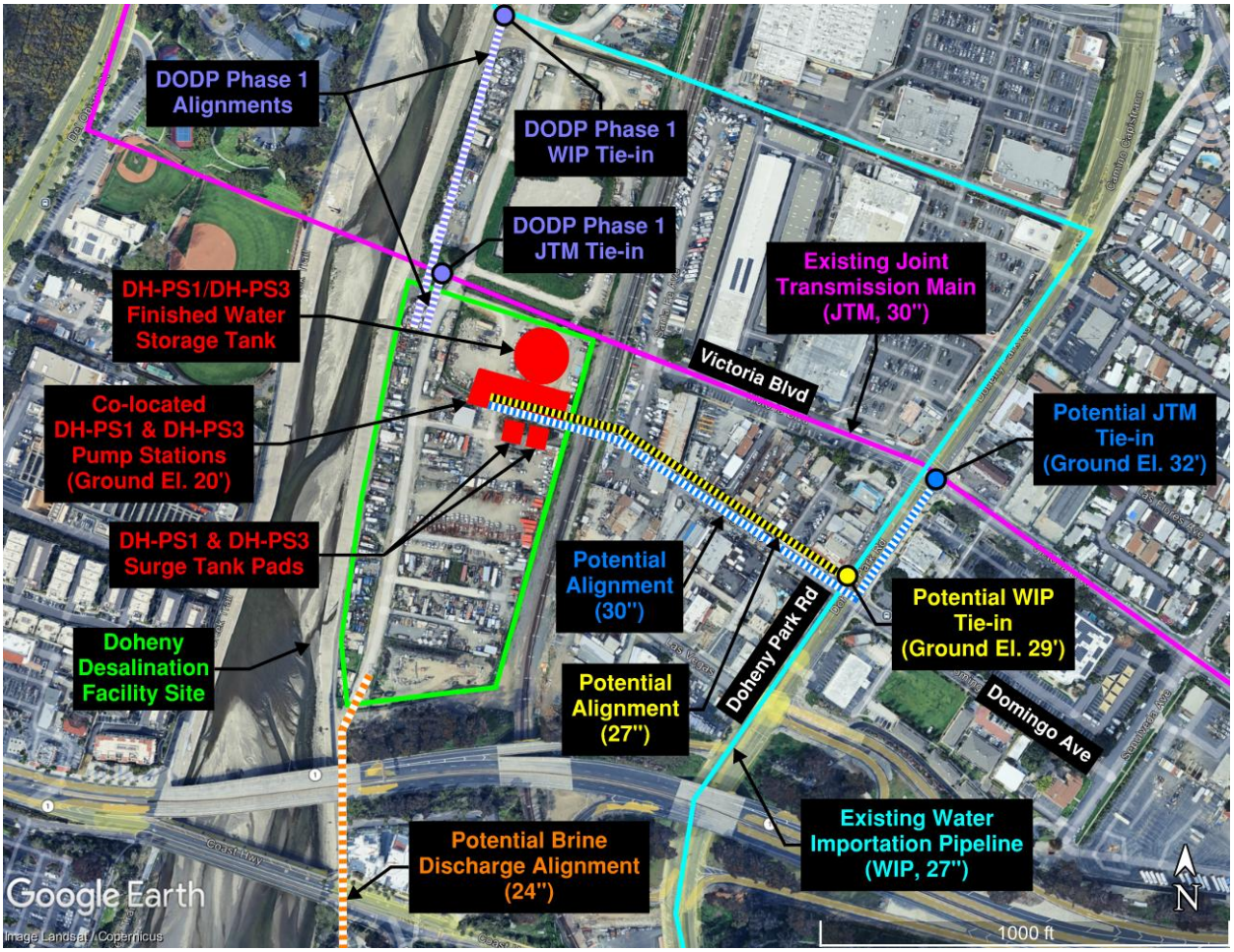


Figure 5.9 Doheny Pump Station 1, Doheny Pump Station 3, Storage Tank, and Surge Tank Pad Potential Locations

DH-PS4 would draw from a new break tank and discharge into the South County pipeline which runs north to south through Santa Margarita Water District. The South County pipeline is conservatively estimated to have a maximum elevation of 665 feet and a pressure of 200 psi at the high point, or an estimated HGL of 1,150 feet. The estimated HGL of the South County pipeline used for this report is an estimate as the actual range of HGL was not available.

The estimated discharge pressure of DH-PS4 is 391 psi at 270 feet elevation, or 1,173 feet HGL (based on 1,150 feet estimated HGL of the South County pipeline plus 23 feet in station and pumping losses). This station would require two 25,000-gallon surge tanks to 1) maintain a constant HGL and 2) provide surge mitigation.

Figure 5.10 illustrates the potential location for the booster pump station, break tank, and surge tank pad near the existing Tri-Cities PRS.

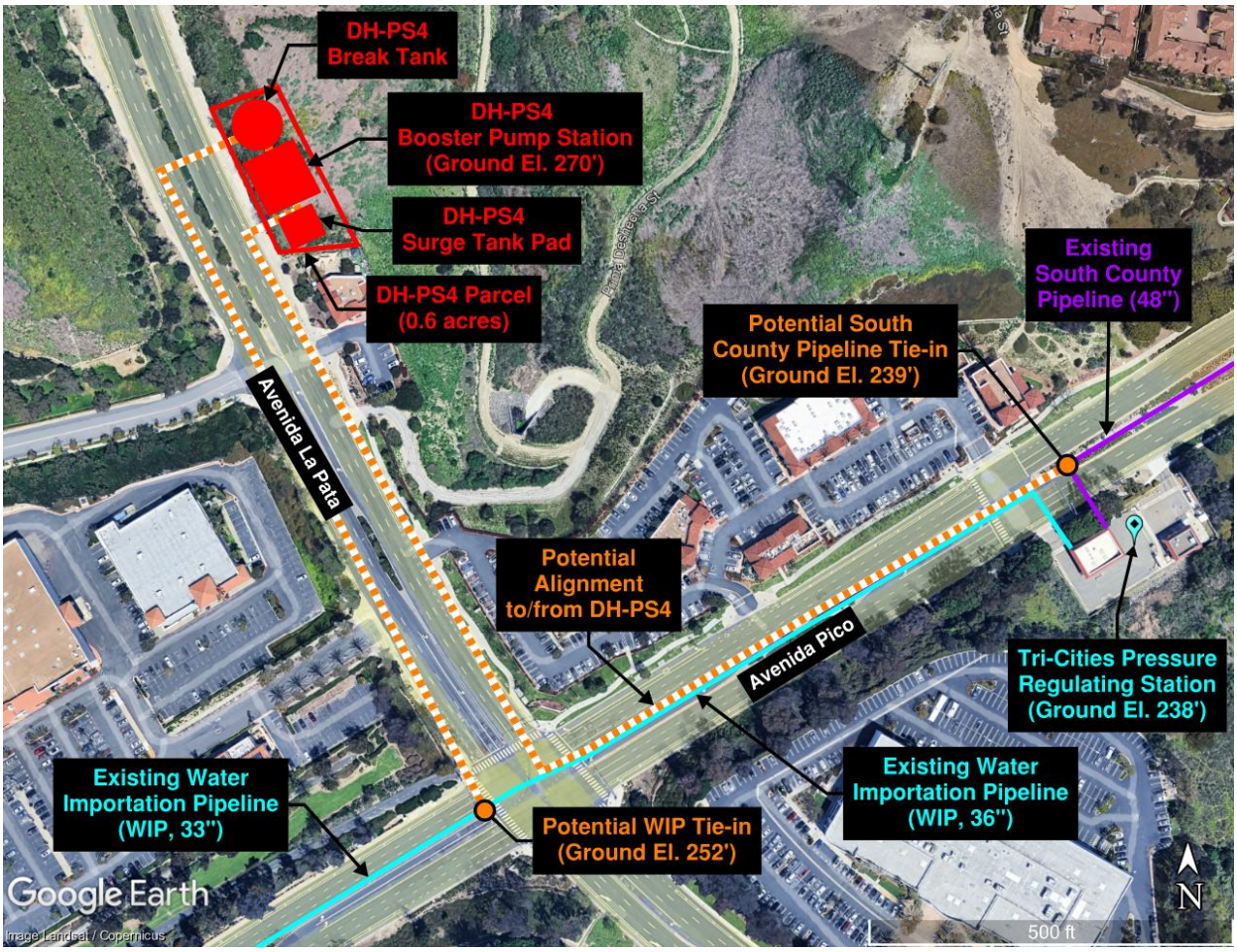


Figure 5.10 Doheny Pump Station 4, Break Tank, and Surge Tank Pad Potential Location

An alternative configuration for **DH-PS4** would be to operate the pump station as an inline booster station, drawing suction directly from the WIP and discharging into the South County Pipeline. This configuration would eliminate the break tank and avoid the inefficiency associated with reducing WIP pressure from approximately 540 feet HGL to about 270 feet HGL (a difference of 270 feet, equivalent to 117 psi pressure loss), followed by repumping into the South County Pipeline. Implementing an inline booster configuration would reduce pumping energy requirements, allow for smaller pump sizing at DH-PS4, decrease site footprint and capital cost by eliminating the break tank, and eliminate associated water age issues. Surge tanks on both the suction and discharge pipelines may need to be larger for an inline booster configuration than for a break tank configuration and would be evaluated during subsequent design phases. Operation of this configuration would require coordinated use of variable frequency drives at **DH-PS3** and **DH-PS4**, along with control logic at the new flow control valve on the WIP north of DH-PS3, to maintain appropriate system pressures and flows.

The primary advantage of the break tank configuration is improved operational simplicity. With a break tank, DH-PS4 would operate over a narrower range of suction pressures and would be less susceptible to hydraulic transients and control challenges commonly associated with inline booster stations with long suction pipelines. Accordingly, for conservative costing and comparative evaluation, the break tank configuration for DH-PS4 was assumed in this study.

5.2.1.3 Brine Disposal Considerations

The potential site for the Doheny seawater desalination plant is adjacent to the J.B. Latham Wastewater Treatment Plant operated by the South Orange County Wastewater Authority (SOCWA). The wastewater facility has a peak flow of 13 mgd and average flow of 6 mgd, discharging secondary treated effluent through a 2.2-mile outfall (SJCOO) off Doheny State Beach. It is recommended that this existing outfall be utilized for desalination brine disposal, comingling the effluent with the desalination brine, which would comply with the Ocean Plan Amendment.

The existing Waste Discharge requirements for the SJCOO (Order R902022-005) include consideration of comingling with brine from a future seawater desalination plant. The outfall currently receives RO concentrate from the South Coast Water District Groundwater Recovery Facility and San Juan Capistrano Groundwater Treatment Plant, as well as treated effluent from several water reclamation plants beyond the J.B. Latham facility. The SJCOO includes multi-port diffusers with 107 separate diffuser ports. Rated capacity of the SJCOO is 24 mgd for gravity flow and 80 mgd for pumped flow. The permit references a contribution of up to 9.4 mgd from a future Doheny Project, therefore, an amendment to the permit may be required for this project depending on the final expanded capacity and future status of SJCOO.

5.2.2 Port Hueneme Seawater Desalination Plant

This section presents an approach to integrate the potential Port Hueneme seawater desalination facility's desalinated water into the Calleguas system. Included is an analysis of imported water demands, a description of the potential project area and tie-in locations, flow and pressure control strategies, and potential impacts to existing conveyance and storage infrastructure.

5.2.2.1 Imported Water Demand

Product water from the potential Port Hueneme seawater desalination plant could support the water supply needs of Calleguas. To determine the estimated minimum imported water demands that could be offset, CDM Smith analyzed historical imported water demand data provided by Calleguas (**Figure 5.11**) from December 2015 through February 2024.

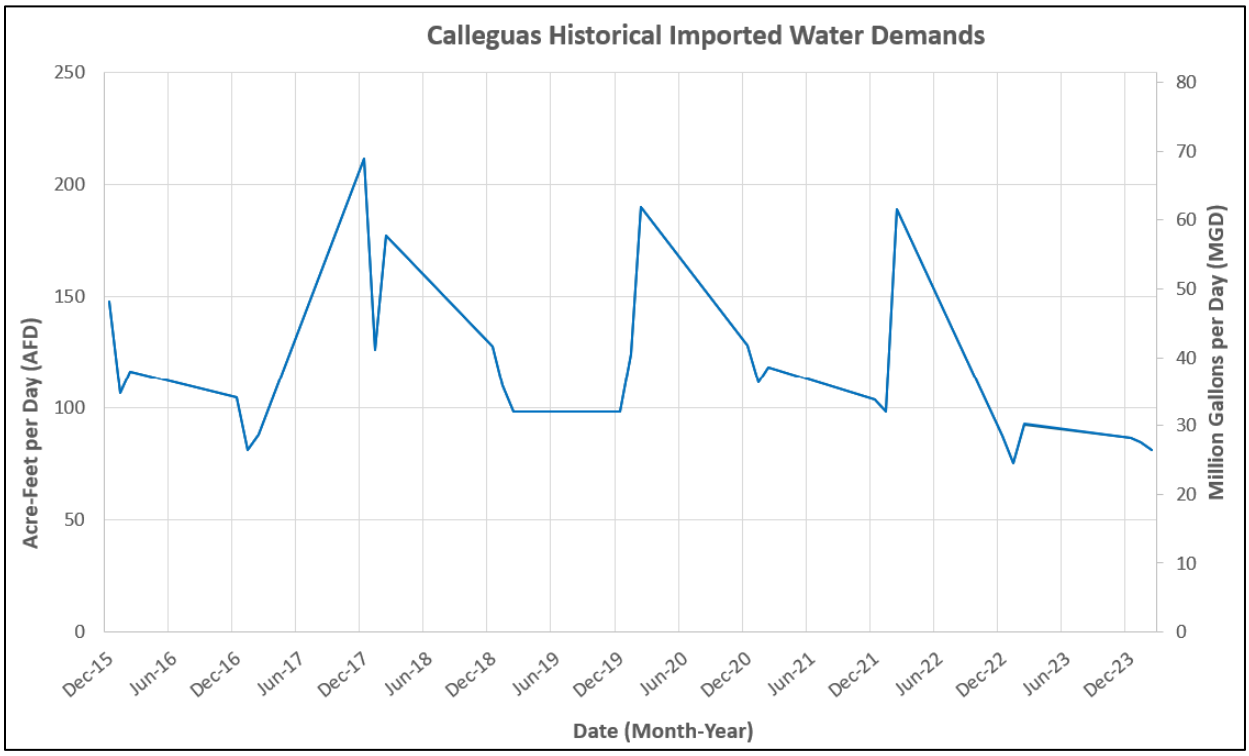


Figure 5.11 Historical Imported Water Demand of Calleguas Municipal Water District

Historical imported water data from Calleguas can be used to predict how much treated desalinated water can be sent to the surrounding area to offset the District's reliance on imported water. This analysis revealed that the minimum imported water demand over the past eight years was 25 mgd. These results indicate that the full 20 mgd of product water that could be provided by the potential Port Hueneme seawater desalination plant could likely be fully used, even during periods of the system's lowest demands. This analysis validates that the potential seawater desalination facility could play a crucial role in meeting the water needs of Calleguas, enhancing water supply reliability, and reducing dependency on imported water sources.

5.2.2.2 System Integration and Storage

As identified through discussions with Calleguas, treated desalinated water could be conveyed to the Lake Bard Water Filtration Plant (LBWFP) clearwells, from which it could be distributed across the Upper and Lower Zones of the Calleguas system. This central distribution strategy maximizes the utility of the treated desalinated water supply by allowing delivery to a wide range of retail water providers throughout the CWMD distribution system.

In addition to the primary integration path, two key interconnections (shown in **Figure 5.12**) provide backup conveyance capacity and operational flexibility. The existing LVMWD interconnection, located in the Upper Zone, provides an additional pathway for managing supply and demand fluctuations. Similarly, the Ventura interconnection, currently at 90 percent design and located in the Lower Zone, would enhance system redundancy by allowing supplies to enter the Lower Zone during emergency circumstances such as scheduled or unscheduled outages. While this conceptual evaluation recognizes

the potential for future coordination to expand operational flexibility, under existing agreements, the Ventura interconnection may only be utilized for emergency purposes and not for routine operational balancing of supplies.*

*Use of the Ventura interconnection for non-emergency supply transfers is not permitted under the current agreements between Metropolitan, Calleguas, and Ventura. Any expanded operational use would require new or modified agreements, the feasibility of which has not been determined.

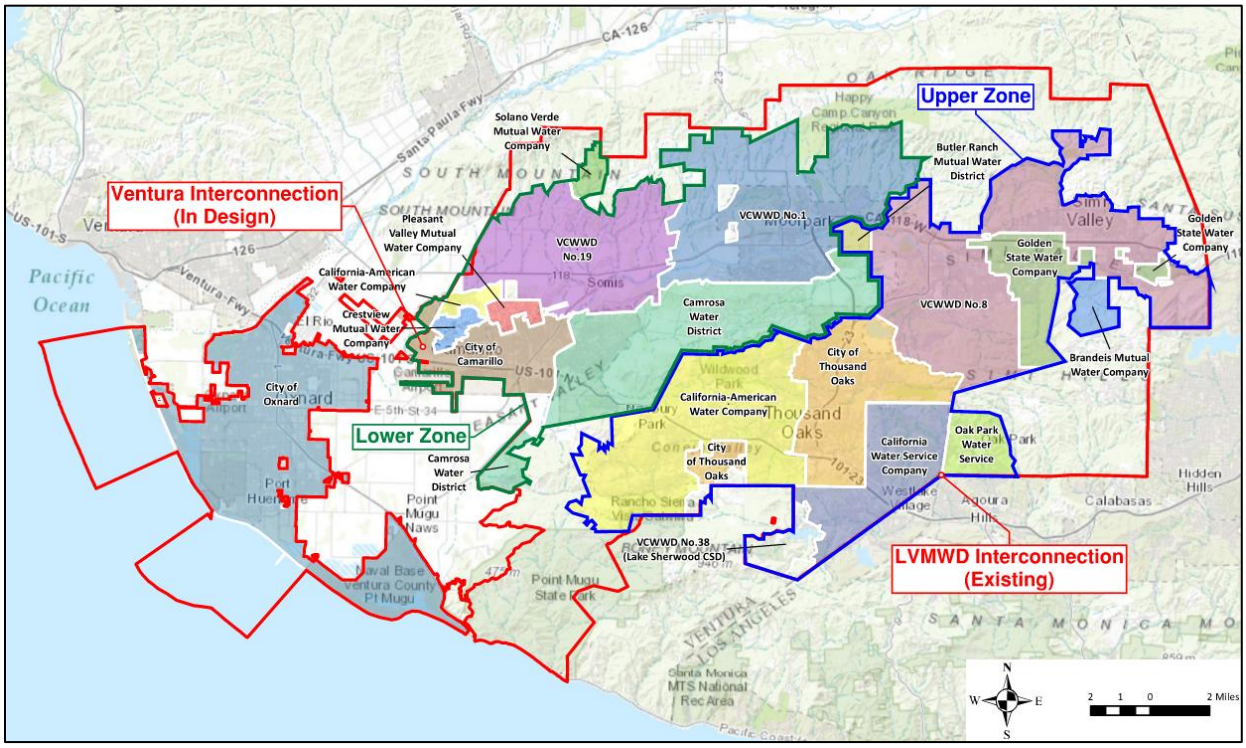


Figure 5.12 Las Virgenes Municipal Water District and Ventura Interconnections

Slant well configuration needs to consider the presence of subsea aquifers extending seaward from the coast along the entire coastline of the Oxnard Plain. Aquifers consist of the Oxnard and Mugu aquifers and have traditionally yielded groundwater supplies inland. However, due to historical inland pumping, seawater has been drawn into the aquifers resulting in seawater intrusion. **Figure 5.13** shows conceptual layout of subsurface intakes using slant wells along with the potential to expand the wellfield to the north.

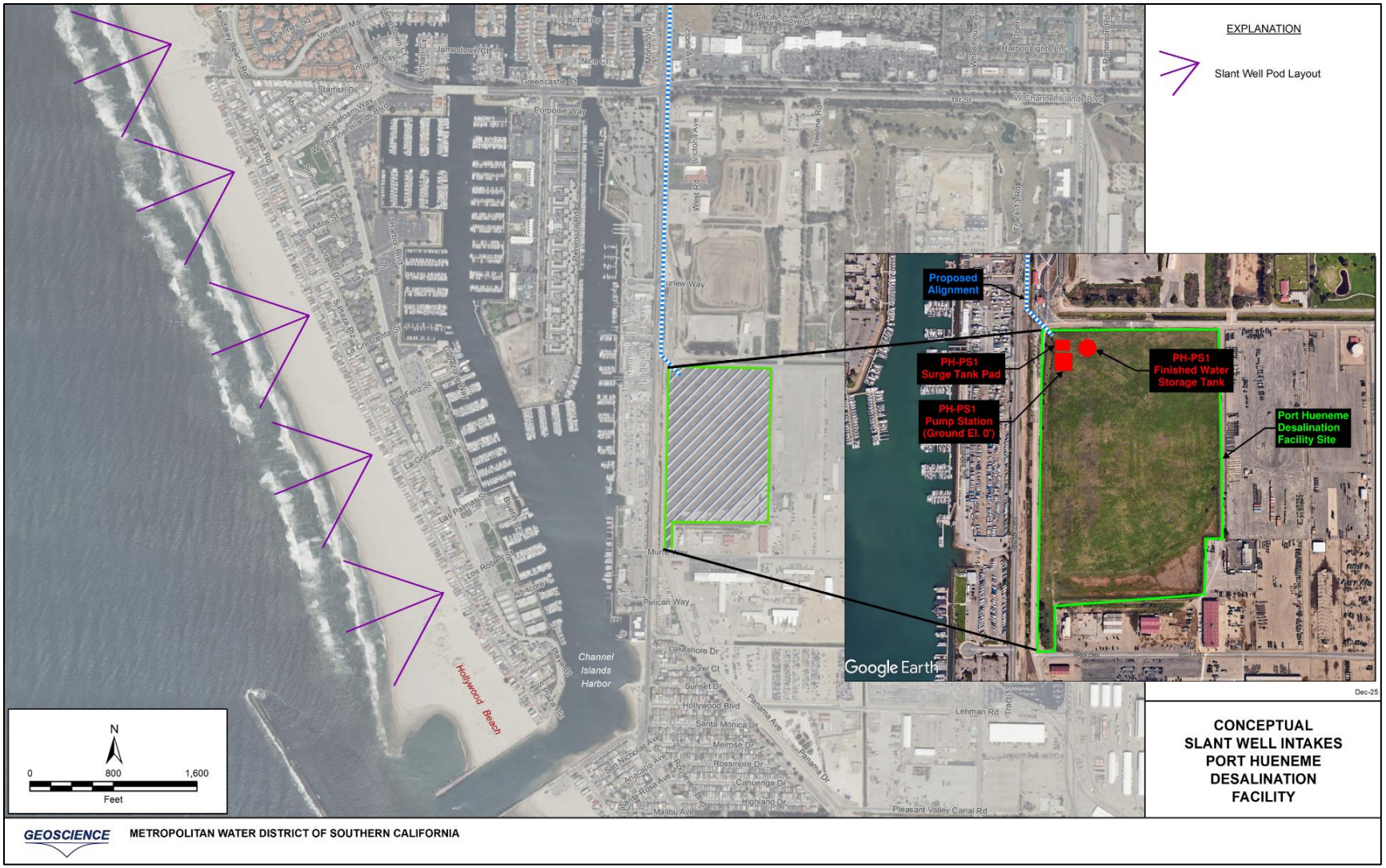


Figure 5.13 Slant Well Intakes for the Potential Port Hueneme Seawater Desalination Facility (Courtesy of Geoscience)

Figure 5.14 shows the potential Port Hueneme seawater desalination plant, potential pipeline alignments from the facility to the LBWFP clearwells, and the potential pump stations along the potential alignment. The potential alignment from the seawater desalination plant to the LBWFP clearwells includes approximately 153,100 linear feet (LF) of new 40-inch pipe, 7,800 LF of existing 66-inch pipe, and ten trenchless crossings (associated with the crossing of railroads, highways, and major intersections along the potential alignment).

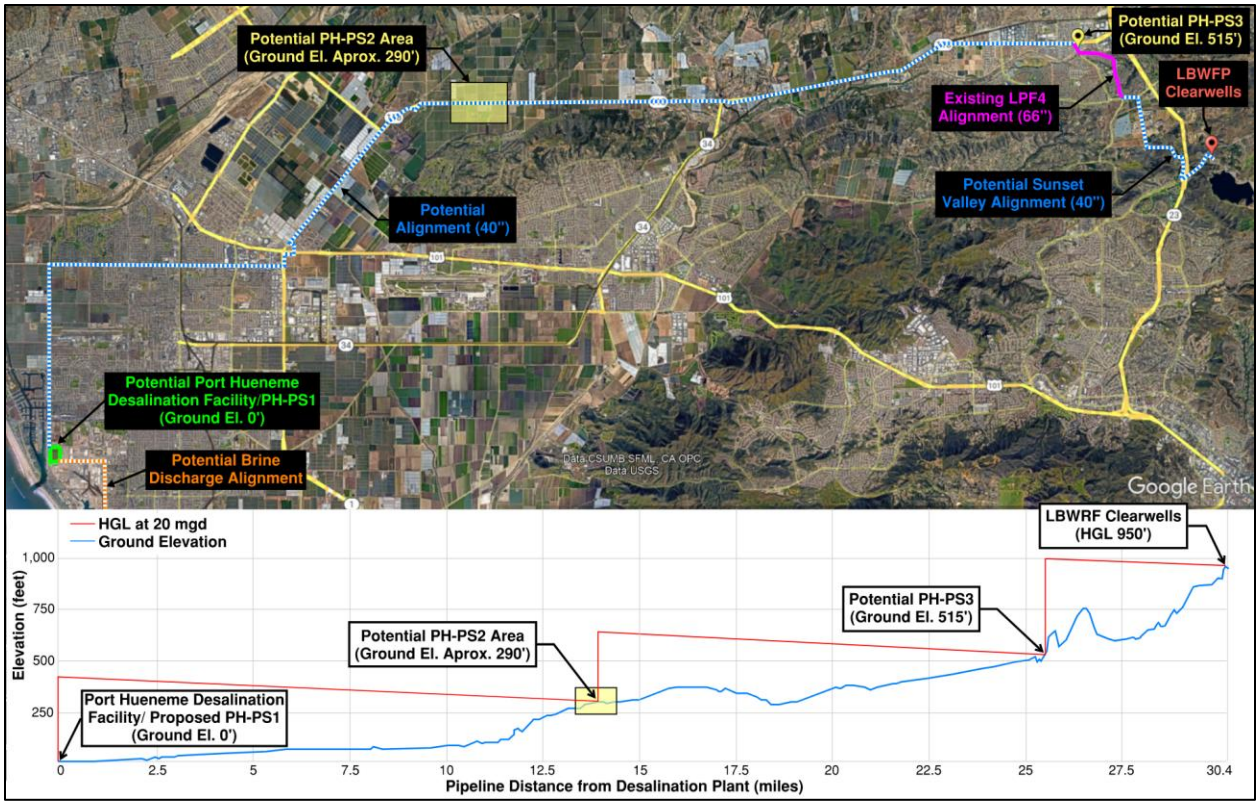


Figure 5.14 Port Hueneme Seawater Desalination Facility Potential Alignment

This approach would require a total of three pump stations. Approximate locations for each of the three pump stations are shown in **Figure 5.14.** Each pump station is assumed to be equipped with five pumps (four duty, one standby) with a capacity of 5 mgd per pump. **Table 5.15** summarizes the design criteria for the assumed pump stations. Pump Station 2 (PH-PS2) is shown about midway along the potential alignment of the new 40-inch transmission pipe. This location is flexible from a hydraulic pumping and transmission standpoint. Moving Pump Station 2 upstream along the alignment would reduce the size of pumps at Pump Station 1, while increasing size of Pump Station 2, and vice versa.

Each of the three pump stations draws from a suction-side reservoir at the pump station and discharges to a downstream reservoir at the end of the transmission line. Operation is relatively straightforward, as all pumps can be fixed-speed units controlled to start and stop based on downstream reservoir levels. Level setpoints can be staggered to establish lead and lag pump operation.

Table 5.15 Port Hueneme Pump Station Design Criteria

Pump Station Name	Pump Station Description	Pump Station Design Flow (mgd)	Number of Pumps	Transmission Pipe Length (feet)	Total Head (feet)	Discharge Pressure (psi)	Horsepower per Pump (hp)
PH-PS1	Port Hueneme Desal Plant to PH-PS2 Tank	20	4 Duty, 1 Standby at 5 mgd each	71,300 LF of new 40-inch pipe	408	177	480
PH-PS2	PH-PS2 Tank to PH-PS3 Tank	20	4 Duty, 1 Standby at 5 mgd each	63,900 LF of new 40-inch pipe	335	145	400
PH-PS3	PH-PS3 Tank to LBWFP Clearwells	20	4 Duty, 1 Standby at 5 mgd each	7,800 LF of existing 66-inch pipe (LPF4) and 17,900 LF of new 40-inch pipe, or 25,700 LF total	475	206	560

Port Hueneme Pump Station 1 (PH-PS1)

The potential Port Hueneme Pump Station 1 (PH-PS1) would draw from the finished water storage tank of the potential Port Hueneme seawater desalination plant and discharge to a new ground-level tank near ground level (about 290 feet) located at the potential Port Hueneme Pump Station 2 (PH-PS2) site. The estimated discharge pressure at PH-PS1 is 177 psi at 0 feet ground elevation assuming a Hazen-Williams friction factor, C-value, of 110 and 71,300 feet of 40-inch pipeline between PH-PS1 and PH-PS2.

To mitigate from potentially damaging pressure transients, such as a power outage while operating at design capacity, surge tanks would likely be required at the pump station discharge. Because this is a potable water system, maintaining positive pressure during a transient event is essential to prevent the possibility of drawing in contaminants from outside the pipe. Combination air and vacuum valves and vacuum relief valves are standard appurtenances on potable water pipelines and are necessary for air release and vacuum protection under normal operating conditions. However, these devices are designed to admit air during negative pressure conditions and therefore do not, by themselves, maintain positive pressure in the system during a severe transient event. As such, additional surge mitigation methods such as hydropneumatic surge tanks or other engineered transient mitigation systems, would likely be required to prevent negative pressures and protect water quality.

A surge tank, along with a power generator, would likely be needed to provide sufficient surge mitigation. A preliminary sizing of the surge tank was based on an estimated need to provide 3.5 minutes of operation at a maximum flow of 20 mgd after pump shutdown or power outage. A detailed surge evaluation of the pump station and transmission pipeline would be required to more accurately size the surge tank. Assuming the tank requires the same volume of air as water, a total surge tank volume of 100,000 gallons was estimated. Two 50,000-gallon surge tanks are recommended under these conditions so one can be taken offline for maintenance while the other tank continues to remain in service, though it would be providing a reduced level of surge mitigation. Assuming a surge tank diameter of 12 feet, each of the 50,000-gallon tanks would have a length of 57 feet. Two 50,000 gallon surge tanks are estimated to require a footprint or concrete pad of 50 feet by 70 feet. A more detailed surge evaluation would be needed as the design progresses to determine surge mitigation equipment and sizing.

Minimum parcel sizes for the potential pump stations were determined based on the required facilities at each location. For example, a pump station with a storage tank or break tank and two surge tanks would require a parcel of approximately 1 acre. This parcel size was based on an approximate pump station size of 90 feet by 90 feet, a storage or break tank diameter of 92 feet, and a concrete pad size of 50 feet by 70 feet for two 50,000 gallon surge tanks.

Port Hueneme Pump Station 2 (PH-PS2)

The potential Port Hueneme Pump Station 2 (PH-PS2) would draw from a new 1-million-gallon break tank at or near ground level (about 290 feet) to provide a consistent suction-side Hydraulic Grade Line (HGL) for the pumps. The pump station would convey water through approximately 63,900 feet of 40-inch pipeline and discharge into a ground-level tank located at the potential Port Hueneme Pump Station 3 (PH-PS3), which would be at a ground elevation of approximately 515 feet. The tank at PH-PS3 would maintain the hydraulic grade line in the transmission pipe.

The potential tank would be sized to provide a 30-minute shutdown window at a flow of 20 mgd, with added volume allowances for freeboard and dead storage. To prevent water quality degradation due to stagnation during periods of reduced operation, the pumps would be cycled periodically to maintain adequate turnover (e.g., operating at 4 mgd for 3 hours every 4 days to limit residence time to less than 4 days).

Pump station PH-PS2 requires surge tanks to provide surge mitigation due to pump station transients as described in the section for PH-PS1. The static discharge-side HGL at the potential PH-PS2 when the pump station is off would be 535 feet, or 106 psi at elevation 290 feet. When pumping at 20 mgd, the predicted discharge HGL would be 625 feet, or 145 psi at elevation 290 feet.

Port Hueneme Pump Station 3 (PH-PS3)

The potential PH-PS3 would be located adjacent to the existing Grandsen pump station and serve as the third pump station in series to convey treated desalinated water from Port Hueneme to the Upper Zone on the east side of Calleguas's system. This pump station was previously identified and evaluated in detail as part of the 2023 West to East Transmission (WET) Study to convey flow from the lower zones in the west to the upper zones in the east using a combination of existing and potential pipelines.

PH-PS3 would draw from a tank located at or near ground level (approximately 515 feet) and pump directly into the existing Las Posas Feeder Unit 4 (LPF4), a 66-inch pipeline owned by Calleguas but not currently in use. The suction side tank at PH-PS3 would be sized and function similarly to the tank described in the PH-PS2 section.

From there, a new Sunset Valley pipeline would extend the alignment eastward. This new potential pipeline would continue from the terminus of LPF4, extend down Sunset Valley Road, then east along Read Road, and ultimately connect to the LBWFP clearwells. From the LBWFP clearwells, treated desalinated water can be conveyed as needed throughout the Upper Zone.

To mitigate against pressure transients associated with pump station startup or power loss, two 50,000-gallon surge tanks are recommended. These surge tanks would help maintain system pressure and protect the infrastructure from hydraulic surges. The static discharge-side HGL at the potential PH-PS3

when the pump station is off would be 950 feet, or 188 psi at elevation 515 feet. When pumping at 20 mgd, the predicted discharge HGL would be 999 feet, or 209 psi at elevation 515 feet.

5.2.2.3 Brine Disposal Considerations

The potential site for the Port Hueneme seawater desalination plant is three miles northwest of the Oxnard Wastewater Treatment Facility, operated by the City of Oxnard. The wastewater facility is a conventional treatment plant with secondary treatment, a peak capacity of 31.7 mgd and average flow of approximately 20 mgd. The facility currently supplies a 12.5 mgd advanced water purification facility (AWPF), with up to 3.1 mgd of RO concentrate from the AWPF returned to the wastewater treatment facility and blended into the ocean outfall. The existing 48-inch diameter outfall discharges 6,000 feet offshore. To comply with recommendations of the Ocean Plan Amendment, it is recommended that a seawater desalination facility at the Port Hueneme site utilize this existing outfall, comingling with the current discharge. With a 20-mgd desalination brine flow added to the existing discharge flows (7.5 mgd wastewater effluent and 3.1 mgd of AWPF concentrate), the total flow would remain below the permitted capacity of 31.7 mgd. Future plans for expansion of the AWPF would further decrease wastewater effluent discharge flows, while increasing the RO concentrate flows. The existing outfall includes multiport diffusers with 170 separate diffuser ports, which would comply with the Ocean Plan Amendment recommended discharge approach.

The Calleguas SMP outfall is also located in close proximity to this potential site. However, the California Ocean Plan requires desalination project proponents to evaluate opportunities to commingle brine with existing wastewater effluent to reduce brine salinity and achieve neutral or positive buoyancy. In addition, both the Ocean Plan and the State's permit streamlining guidance identify commingled discharge as the preferred approach for concentrate management. Consistent with these requirements and policy preferences, the Oxnard wastewater outfall was selected as the preferred discharge location.

5.2.3 El Segundo Seawater Desalination Plant

This section presents an overview of integration of treated desalinated water from the potential El Segundo seawater desalination plant into the Metropolitan system. Included is a description of system demands, a description of the project area, a review of the potential tie-in location, flow and pressure control strategies, and potential impacts to existing conveyance and storage infrastructure.

5.2.3.1 Potential Seawater Desalination Plant Locations

Initial planning assumed that the El Segundo Power Plant site would be decommissioned and available for redevelopment. However, updated information from the landowner, NRG Energy, revealed that this site is still in operation. After exploring the potential to integrate a seawater desalination plant on the unused portion of the site, NRG Energy indicated this will not be feasible to consider at this time.

Turning to other potential sites, West Basin Municipal Water District (WBMWD) previously evaluated various locations for a seawater desalination plant at the Scattergood Generating Station and the Chevron Refinery. Four of the locations were identified as potential suitable alternative locations for the potential El Segundo seawater desalination plant. These potential locations and their approximate lot sizes are shown in .

Figure 5.15 Potential Locations for Potential El Segundo Seawater Desalination Facility

For the purposes of this study, the Chevron Refinery Site B in Error! Reference source not found.**15** was s elected for further evaluation. The Chevron Refinery Site B corresponds to the refined El Segundo configuration identified as Site 6A in previous sections and represents the location advanced for system integration, regulatory evaluation, cost and scheduling evaluation, and funding and partnership evaluation. The Chevron Refinery Site B was selected based on its lot size, proximity to the potential distribution system tie in pipeline alignment, and relative feasibility compared to the other candidate parcels. Due to the smaller available land area at the Chevron Refinery Site B compared to the originally screened El Segundo site, the assumed plant capacity was reduced from 20 mgd to 10 mgd in order to maintain a feasible facility layout.

Unlike the originally screened El Segundo site, which assumed the existing cooling water intake for the El Segundo Power Plant would be available to convert to a raw water open ocean intake, the Chevron Refinery Site B in Error! Reference source not found.**15** does not have access to existing ocean intake infrastructure. As a result, the Chevron Refinery Site B configuration must rely on the construction of new subsurface slant wells to supply the seawater desalination facility.

Slant well configuration needs to consider subsea aquifers present extending seaward from the coast from El Segundo north to Marina Del Rey. Aquifers consist of the 200-ft Sand, 400-ft Gravel, Silverado, and Lower San Pedro Formation. These aquifers have traditionally yielded groundwater supplies inland. However, due to historical inland pumping, seawater has been drawn into the aquifers from the subsea portion of the aquifers to the onshore portion, making it necessary to construct the West Coast Barrier Project which is a seawater intrusion barrier located inland. **Figure 5.16** shows a conceptual layout of subsurface intakes using slant wells.

Figure 5.16 Slant Well Intakes for the Potential El Segundo Seawater Desalination Facility (Courtesy of Geoscience)

5.2.3.2 System Demand

System integration would rely on Metropolitan's regional conveyance capacity rather than on individual member agency demand. From a pipeline capacity perspective, the West Coast Feeder can accommodate 10 mgd, and the Common Pool has sufficient overall system demand to absorb this inflow without exceeding hydraulic capacities. **Figure 5.17** illustrates Metropolitan feeder alignments in the vicinity of the potential El Segundo seawater desalination plant. While capacity appears sufficient, future studies should evaluate additional factors including blending requirements, potential effects on water age, water quality and corrosion implications, pipeline material compatibility with desalinated water, and potential operational impacts on treatment plants or downstream facilities.

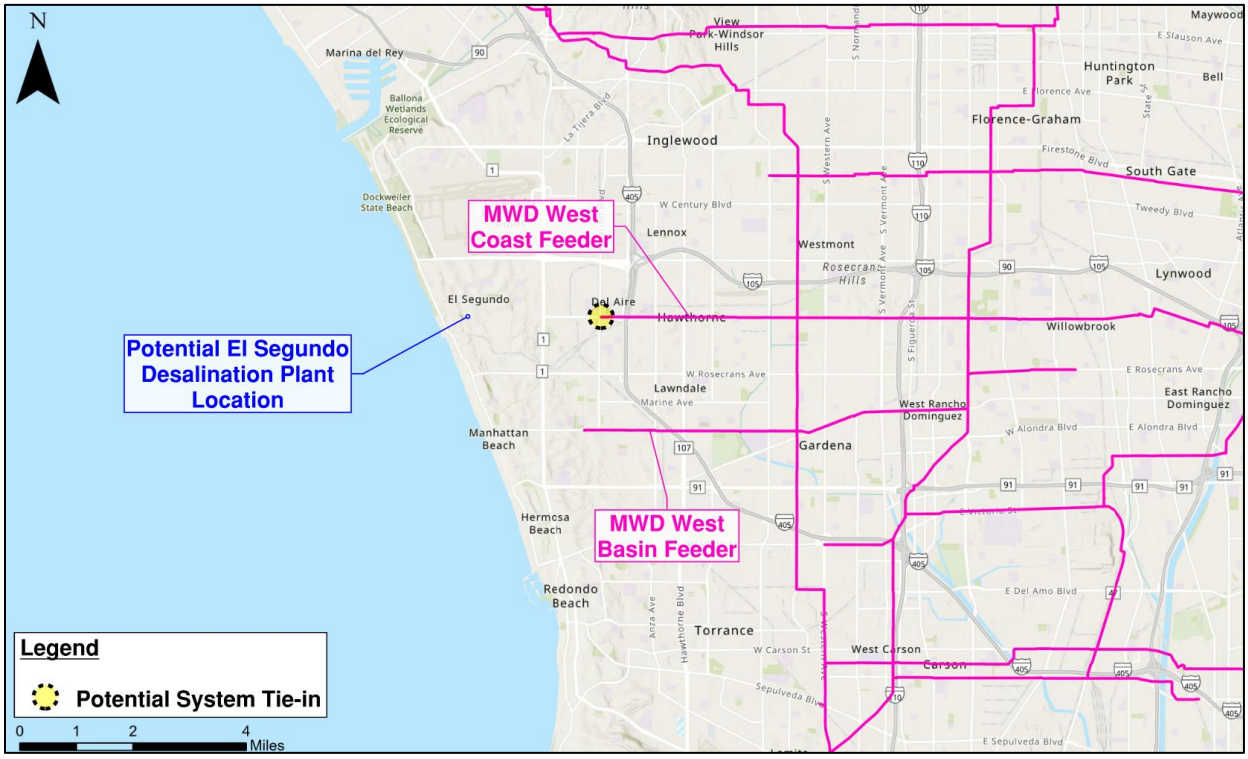


Figure 5.17 Metropolitan System Feeder Alignments Surrounding Potential El Segundo Seawater Desalination Plant Location

Metropolitan has confirmed that both the West Coast Feeder and Common Pool can readily accommodate an additional flow of 10 mgd, and the Common Pool's extensive service area provides flexibility to manage additional supplies without creating localized constraints. At this level of analysis, detailed member agency demand estimates are unnecessary, and Metropolitan's system has sufficient scale to absorb the added supply. Future evaluations would confirm system integration through detailed hydraulic modeling and assessment of blending, water quality stability, and operational impacts to confirm reliable, long-term incorporation of desalinated water into Metropolitan's regional network.

5.2.3.3 System Integration and Storage

The potential 10-mgd El Segundo seawater desalination plant would integrate with the Metropolitan system by delivering treated desalinated water into the existing Metropolitan West Coast Feeder.

Figure 5.18 shows the potential El Segundo seawater desalination plant, the potential pipeline alignment from the slant wells to the facility, the potential pipeline alignment from the facility to the tie-in point, and the potential tie-in point to the existing Metropolitan West Coast Feeder. The potential alignment from the seawater desalination facility to the tie-in point includes approximately 10,600 LF of new 24-inch pipe and five trenchless crossings (associated with the crossing of railroads, highways, and major intersections along the potential alignment).

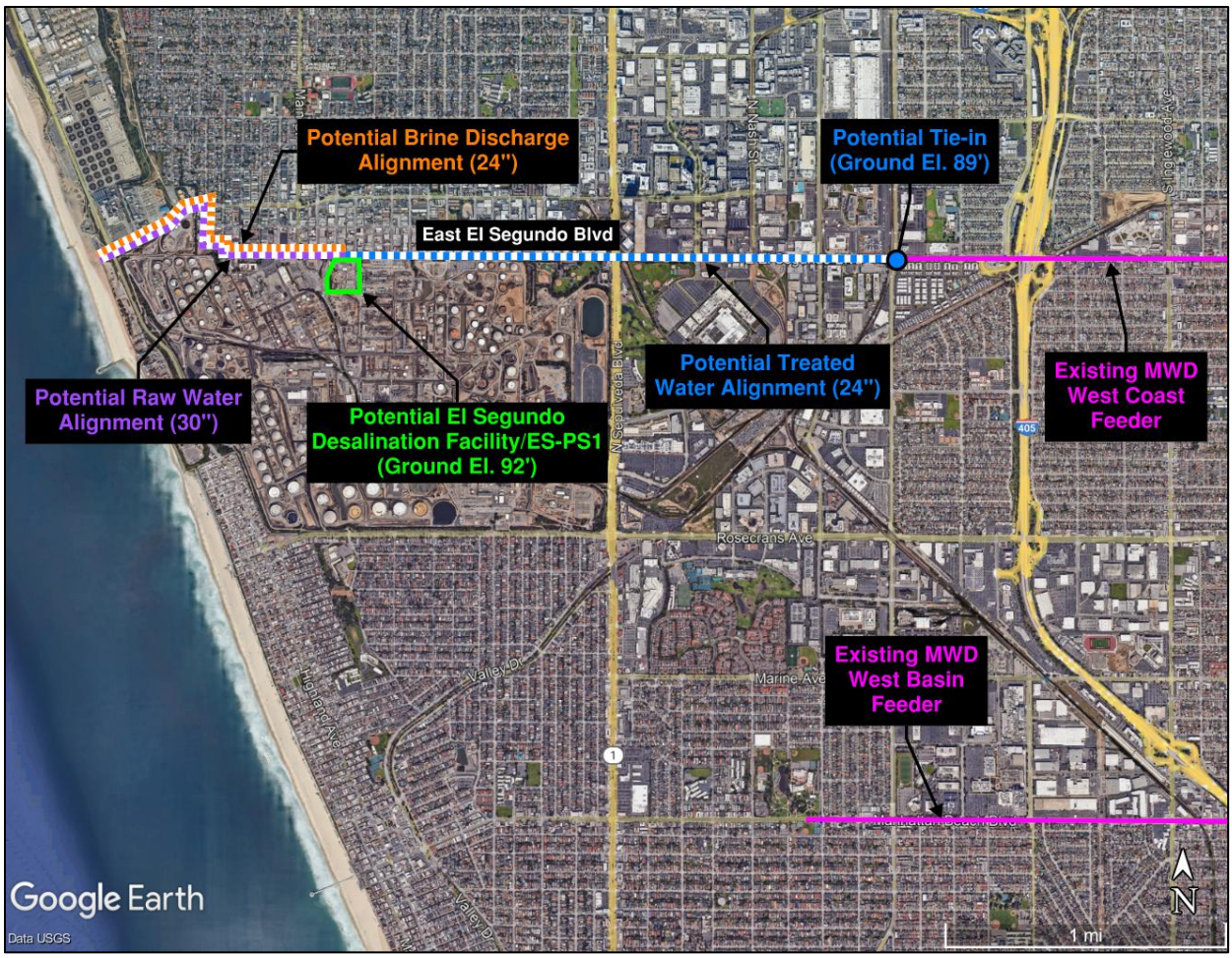


Figure 5.18 Potential El Segundo Seawater Desalination Facility Pipeline Alignments

This system integration approach requires one 10-mgd pump station. The pump station is equipped with five pumps (four duty, one standby) with a capacity of 2.5 mgd per pump. **Table 5.16** summarizes design criteria for the potential pump station.

The pump station is sized to deliver 10 mgd to the Metropolitan West Coast Feeder at its maximum operating HGL of 660 feet. Variable frequency drives are required to match pump output to the desalination facility production rate when delivering flow into the MWD system. Under existing conditions, flow in the West Coast Feeder is in the westerly direction; however, depending on turnout demands and system HGLs, injection of desalinated water could reduce westerly flow or result in flow reversal to the east.

Table 5.16 El Segundo Pump Station Design Criteria

Pump Station Name	Pump Station Description	Design Flow (mgd)	Number of Pumps	Length of New Piping (feet)	Total Head (feet)	Discharge Pressure (psi)	Motor Size per Pump (hp)
ES-PS1	El Segundo Desal Plant to Tie-in Point	10	4 Duty, 1 Standby at 2.5 mgd each	10,600 LF of new 24-inch pipe	720	275	420

El Segundo Pump Station 1 (ES-PS1)

The potential El Segundo Pump Station 1 (ES-PS1) would draw from the finished water storage tank of the new El Segundo seawater desalination plant. The estimated discharge HGL is 720 feet, or a pressure of 275 psi at 92 feet elevation based on a flow of 10 mgd into the existing West Coast Feeder, which operates at an HGL up to 660 feet. The ground elevation at the potential tie-in to the West Coast Feeder is 89 feet. Thus, at an HGL of 660 feet, the pressure at this location is 247 psi. If the El Segundo seawater desalination plant and pump station advance to a conceptual design phase, a detailed hydraulic evaluation, including surge and transient analysis, would be required to confirm infrastructure requirements and verify that no adverse hydraulic impacts occur to Metropolitan's existing system.

To manage pressure transients, such as power outages during full-speed operation, two 25,000-gallon surge tanks, or a total tank volume of 50,000 gallons, is estimated to be required for this pump station.

Minimum parcel size assumed for this pump station location was determined based on the required facilities at the location. A pump station with a storage tank and two surge tanks would require a parcel of approximately 0.6 acres. This parcel size was based on an approximate pump station size of 90 feet by 90 feet, storage tank diameter of 65 feet, and surge tank pad size of 45 feet by 50 feet.

Figure 5.19 illustrates the potential El Segundo seawater desalination plant site, ES-PS1 pump station, finished water storage tank, and surge tank pad for the two surge tanks.

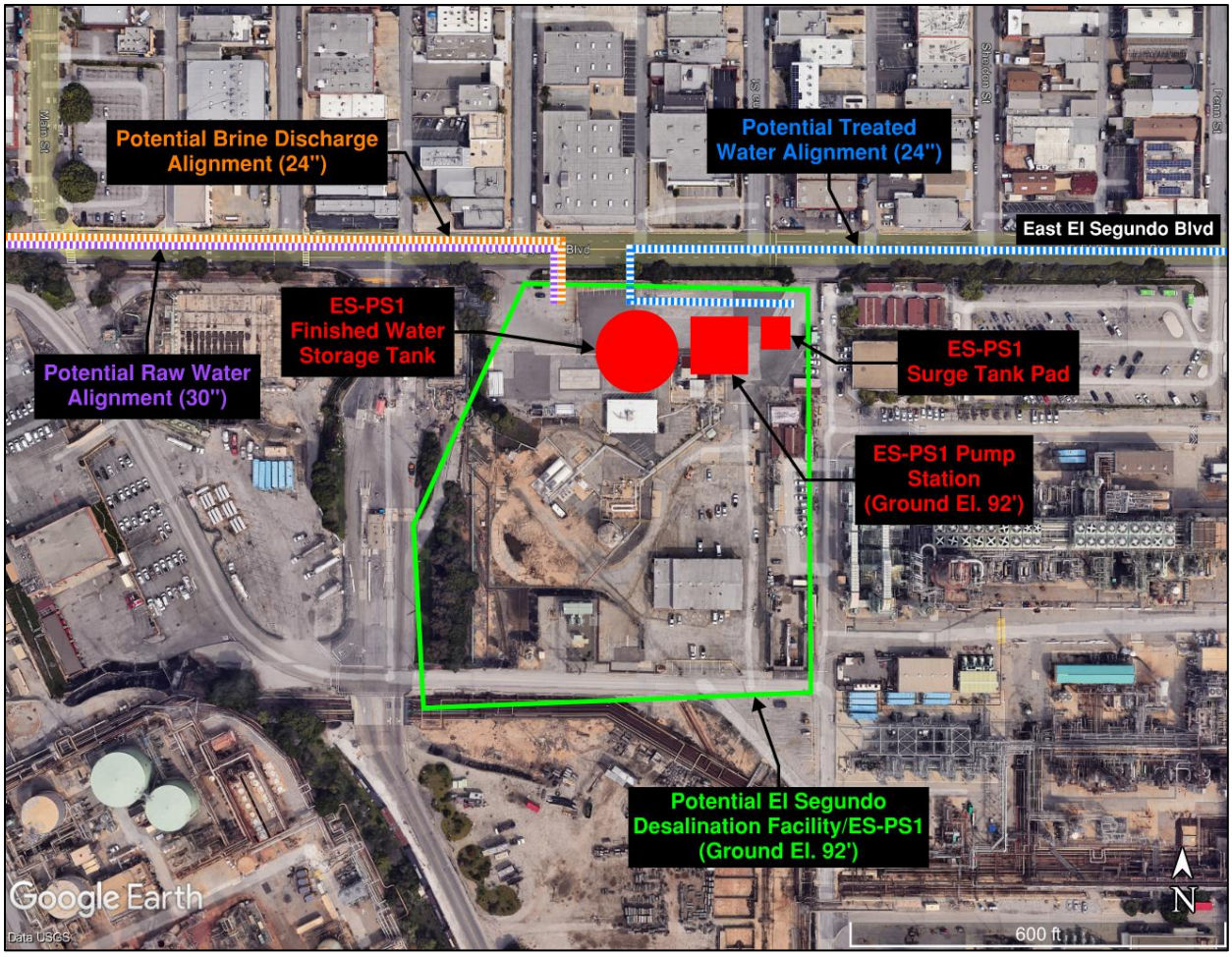


Figure 5.19 Potential El Segundo Seawater Desalination Plant Site Including El Segundo Pump Station 1, Storage Tank, and Surge Tank Pad Locations

5.2.3.4 Brine Disposal Considerations

The potential site for the El Segundo seawater desalination plant is less than one mile southeast of the Hyperion Water Reclamation Plant (Hyperion), operated by the Los Angeles Bureau of Sanitation (LASAN). This wastewater facility has a capacity of 450 mgd, average flow of 275 mgd and a rated wet weather capacity of 800 mgd. The facility supplies up to 40 mgd of secondary effluent to the WBMWD Edward C. Little Water Recycling Facility, with the remaining flow discharged to the Santa Monica Bay, using a 5-mile ocean outfall. LASAN is developing a large-scale potable reuse program, PWLA, which plans to recycle 210 mgd of the Hyperion effluent through potable reuse. Given the proximity to the potential seawater desalination site, it is recommended that the El Segundo seawater desalination plant utilize the existing ocean outfall at the Hyperion facility, comingling the 10 mgd of brine with the wastewater effluent, which would comply with recommendations of the Ocean Plan Amendment. As future wastewater flows are expected to decrease with the implementation of the PWLA project, future modifications to the outfall could be required, installing multiport diffusers for enhanced mixing.

Alternatives to the use of the Hyperion outfall include use of an existing or decommissioned outfall from a coastal power station. As an example, the Scattergood Generating Station (Scattergood) is adjacent to

the potential seawater desalination site and includes a 1,200-foot offshore discharge currently used for up to 380 mgd of cooling water effluent. Scattergood was originally slated for decommissioning; however, the Los Angeles Department of Water and Power now plans to modernize Units 1 and 2 as part of a facility upgrade. The modernization project includes transitioning away from once-through cooling and introducing a rapid-response combined-cycle generation system designed to operate on a blend of natural gas and green hydrogen. Similarly, the partially decommissioned El Segundo Power Plant, where the seawater desalination plant would be located, includes a 2,100-foot ocean outfall, which could potentially be repurposed. There is currently no wastewater flow associated with this outfall to comingle with desalination brine. It is not recommended that a seawater desalination plant at the El Segundo site utilize existing power plant outfalls due to regulatory issues related to brine concentration discharge limits.

6.0 Regulatory and Permitting Pathways

The regulatory evaluation presented herein is based on review of applicable statuses, regulations, and publicly available precedent projects. It does not constitute formal agency consultation or regulatory determination and is intended solely to inform comparative planning considerations. This section discusses the potential regulatory requirements associated with these three sites within the Metropolitan service area. Case studies to inform prior regulatory oversight of California desalination plants are discussed and include Dana Point, Monterey, Huntington Beach, Carlsbad, and Santa Catalina Island. These case studies and the potential MWD sites are depicted in **Figure 6.1.**

Although not an explicit regulatory impact, it is worth noting that the DWR has issued more than $123 million in funds for desalination research, design, and construction, and re-opened the Continuous Application Process for the Water Desalination Grant Program in September 2024 for construction and expansion of desalination facilities. State funding of desalination as a source of potable supply indicates that a broad level of regulatory support exists for desalination, despite the regulatory hurdles discussed in this document.

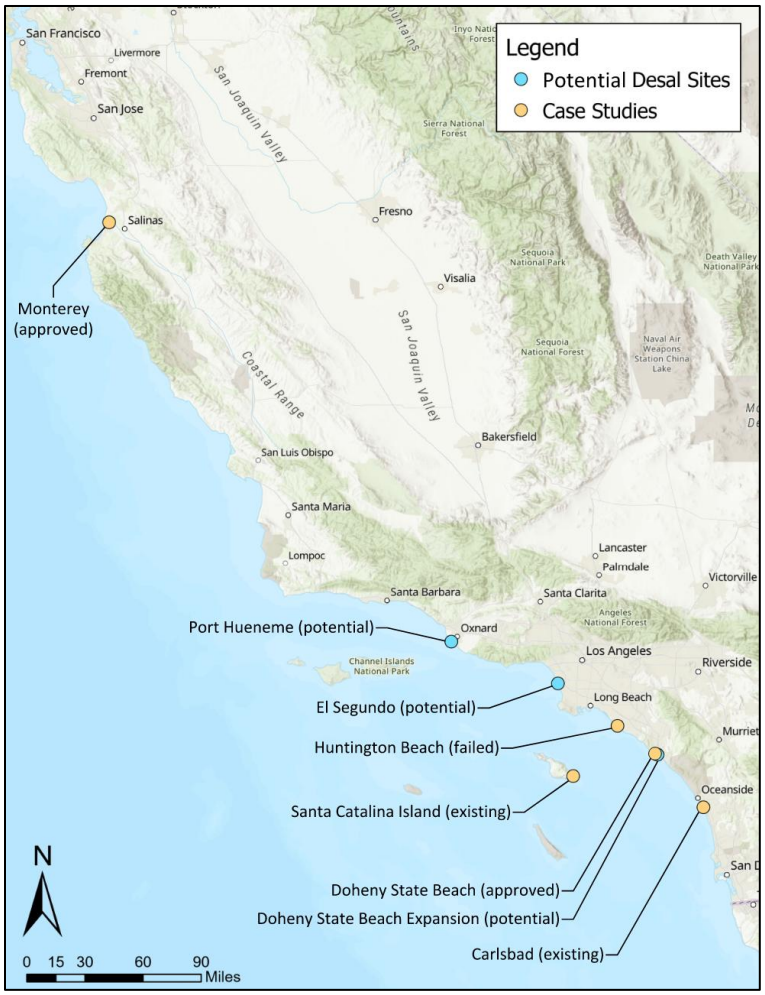


Figure 6.1 Map of Case Study Locations and Potential Desalination Facilities

6.1 Regulations Affecting Intake

6.1.1 Ocean Plan and Water Code Desalination Overview

The SWRCB adopted the *Water Quality Control Plan for Ocean Waters of California* (Ocean Plan) in 1972. The Ocean Plan is applicable to point source discharges to the ocean. Ocean Plan Chapter III.M "*Implementation Provisions for Desalination Facilities"* applies to desalination facilities using seawater. Chapter III.M was adopted by the SWRCB as an amendment to the Ocean Plan in 2015 and is sometimes referred to as the "desalination amendment" or "Ocean Plan amendment".

California Water Code section 13142.5(b) provides that:

> "For each new or expanded coastal power plant or other industrial installation using seawater for cooling, heating, or industrial processing, best available site, design, technology, and mitigation measures feasible shall be used to minimize the intake and mortality of all forms of marine life".

Seawater desalination project applicants are required to submit a request with supporting documentation to the RWQCBs for a Water Code section 13142.5(b) determination (Determination). Ocean Plan Chapter III.M.2 provides specific direction to the Regional Water Board for making Water Code section 13142.5(b) determinations. The Ocean Plan is implemented through NPDES permits or Waste Discharge Requirement (WDR) Orders issued by the applicable Regional Water Board in consultation with SWRCB staff.

Although Ocean Plan Chapter III.M is implemented through the Regional Water Boards, other state agencies would be consulted in the process. Per Chapter III.M.2.a.(4):

> "In conducting the Water Code section 13142.5(b) determination, the Regional Water Boards shall consult with other state agencies involved in the permitting of that facility, including, but not limited to: California Coastal Commission, California State Lands Commission, and California Department of Fish and Wildlife. The Regional Water Board shall consider project-specific decisions made by other state agencies; however, the Regional Water Board is not limited to project-specific requirements set forth by other agencies and may include additional requirements in a Water Code section 13142.5(b) determination."

This section identifies these agencies and their potential roles in this Ocean Plan specified determination process. The "Seawater Desalination Siting and Streamlining Report to Expedite Permitting" (California Environmental Protection Agency 2023) provided recommendations on coordinating agencies submittals and reviews.

Ocean Plan Chapter III.M.2.a.(2) specifies how a Regional Water Board is to identify the best available feasible site, design, technology, and mitigation measures in an independent iterative manner as part of the Determination process as stated below:

> "The Regional Water Board shall first analyze separately as independent considerations a range of feasible alternatives for the best available site, the best available design, the best available technology, and the best available mitigation measures to minimize intake and mortality of all forms of marine life.

Then, the Regional Water Board shall consider all four factors collectively and determine the best combination of feasible alternatives to minimize intake and mortality of all forms of marine life."

One of the findings of the Report was that "Implementing this section of the Ocean Plan has been challenging because project proponents typically have a preferred site in mind when they approach Agencies." To streamline this process, the Report recommended that the State Water Board consider amending this provision in the Ocean Plan so that the Regional Water Board would identify the best available site first. Then, Agencies and project applicants could consider the best available design and technology feasible to minimize intake and mortality of all forms of marine life.

6.1.2 Entrainment and Impingement

The Ocean Plan mandates that the owner or operator of a potential seawater desalination facility site must evaluate the feasibility of subsurface intakes to minimize the intake and mortality of marine life. For this study's three evaluated sites, subsurface slant wells are the current intake assumption, including at El Segundo, given the unavailability of the power plant intake site that was initially considered. According to Chapter III.M.2.a.(2), the Regional Water Board, in consultation with the State Water Board staff, must require subsurface intakes unless a comparative analysis deems them infeasible. Factors to be considered in determining the feasibility of subsurface intakes include geotechnical data, hydrogeology, benthic topography, oceanographic conditions, presence of sensitive habitats and species, energy use for the entire facility, design constraints, and project life cycle cost. The project life cycle cost encompasses planning, design, land acquisition, construction, operations, maintenance, mitigation, equipment replacement, disposal over the facility's lifetime, and decommissioning costs. Subsurface intakes cannot be deemed economically infeasible solely because subsurface intakes may be more expensive than surface intakes. However, if the additional costs or reduced profitability associated with subsurface intakes render the seawater desalination facility economically unviable, they may be considered infeasible. Subsurface intakes could potentially make a project so expensive that the water is unaffordable for disadvantaged communities.

If subsurface intakes are not feasible, the Regional Water Board may approve a surface water intake under the following conditions:

- Surface water intakes must be screened, and the screens must be functional while the facility is withdrawing seawater.
- To reduce entrainment, all surface water intakes must be screened with a 1.0 mm or smaller slot size screen when the seawater desalination facility is withdrawing seawater.
- An owner or operator may use an alternative method of preventing entrainment, provided it results in intake and mortality of eggs, larvae, and juvenile organisms that is less than or equivalent to a 1.0 mm slot size screen. The owner or operator must demonstrate the effectiveness of the alternative method to the Regional Water Board.
- To minimize impingement, through-screen velocity at the surface water intake may not exceed 0.5 feet per second.

If a surface water intake is approved by the Regional Water Board, the owner or operator of a facility must submit a report to the Regional Water Board estimating the marine life mortality resulting from

the construction and operation of the facility after implementing the required site, design, and technology measures. For operational mortality related to intakes, the report must include a detailed entrainment study. This study must span at least 12 consecutive months, with sampling designed to account for variations in oceanographic or hydrologic conditions, as well as larval abundance and diversity, to provide reasonably accurate abundance estimates. Samples must be collected using a mesh size no larger than 335 microns, and individuals must be identified to the lowest practicable taxonomical level. An Empirical Transport Model (ETM)/Area of Production Forgone (APF) analysis should represent the entrained species collected using the 33-micron net. Owners or operators with subsurface intakes are not required to conduct an ETM/APF analysis for their intakes and are not required to mitigate intake-related operational mortality.

6.2 Regulations Affecting Treatment and Distribution of Finished Water

6.2.1 State Water Resources Control Board

Created by the State Legislature in 1967, the five-member State Water Board protects water quality in California by setting statewide policy, coordinating and supporting its four Divisions, and reviewing petitions that contest Board actions. The Division of Water Quality consists of nine Regional Water Boards, which implements the federal Clean Water Act in California. The State Water Resources Control Board oversees implementation of the Safe Drinking Water Act through the Division of Drinking Water and the allocation of water rights through the Division of Water Rights. The Division of Financial Assistance provides loans and grants for clean water and drinking water projects. This section discusses the potential regulatory impacts from the Division of Water Rights, Division of Water Quality, and the Division of Drinking Water.

6.2.1.1 Division of Water Rights

The State Water Board is responsible for reviewing and authorizing water rights in California, which are necessary for consumptive uses from enclosed water bodies within the state. The State Water Board issues permits for water rights specifying amounts, conditions, and construction timetables for diversion and storage. Water rights are generally not required for proposed seawater desalination facilities using water from the open ocean but may be a factor for facilities that plan to use water from enclosed or semi-enclosed areas, such as bays, estuaries, or saline groundwater.

6.2.1.2 Division of Water Quality (“Regional Board”)

The State and Regional Water Boards are jointly responsible for implementing California’s water quality requirements, including issuing permits under the Clean Water Act. The Regional Water Boards also oversee compliance with Clean Water Act Section 316(b), which mandates that “the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.” Under these provisions, extensive monitoring may be required to demonstrate that feedwater intakes from facilities do not cause unacceptable ecological impacts.

Each of the state’s nine Regional Water Boards is responsible for water quality permitting within its region. **Table 6.1** outlines which Regional Water Board has jurisdiction over each of the three potential

sites. For coastal seawater desalination facilities, the most common permit required is the Section 401 Water Quality Certification permit. This permit is necessary when proposing to place fill in a water body, and it is issued by the state in conjunction with a Section 404 permit from the U.S. Army Corps of Engineers. "Fill" includes intake or outfall pipelines, beach wells, transmission lines, or other similar structures. Seawater desalination facilities that involve new intakes or require modification of existing outfalls are likely to need a 401 water quality certification. Therefore, construction of new subsurface slant well intakes at all three sites would require a 401 water quality certification during construction, and outfall modifications would require a 401 water quality certification at all three sites.

Table 6.1 Regional Water Quality Control Board Jurisdiction

Seawater Desalination Plant Location	Regional Water Quality Control Board
Doheny State Beach Expansion	San Diego
El Segundo	Los Angeles
Port Hueneme	Los Angeles

All three sites would obtain NPDES coverage for brine discharge under the applicable Regional Water Board, with intake-related permitting proceeding under the subsurface intake pathway. All three sites would discharge the seawater reverse osmosis concentrate (brine) to existing outfalls for discharges that would be regulated under the Ocean Plan, which is also enforced by the Regional Water Boards and discussed in **Section 6.3.**

6.2.1.3 Division of Drinking Water

The Division of Drinking Water's (DDW) twenty-six Field Operations Branches are responsible for the regulation of public water systems to provide safe water to all Californians. The field offices conduct inspections, issue permits, determine compliance with the Safe Drinking Water Act and state regulations, and conduct enforcement activities. **Table 6.2** shows which DDW Field Office has jurisdiction over each of the three potential sites. Traditionally, the Central District (District 16) has had jurisdiction over Metropolitan as a whole, however, and it is expected that the Central District would be the lead field office in permitting a Metropolitan seawater desalination facility as a new source of supply.

Table 6.2 Division of Drinking Water District Office

Treatment Plant Location	DDW District Office
Doheny State Beach Expansion	District 08 – Santa Ana (located in Orange County)
El Segundo	District 15 – Metropolitan (located in Glendale)
Port Hueneme	District 06 – Santa Barbara (located in Carpinteria)
Existing Metropolitan Water District WTPs	District 16 – Central (located in Glendale)

DDW's Program Management Branch develops regulations, approves innovative treatment technologies, accredits environmental laboratories, maintains water quality databases and websites, integrates recycled water with potable water uses, and maintains quality assurance programs. This division is located at DDW headquarters in Sacramento; however, staff are located throughout the state. The Treatment Technology Unit advises Field Operations staff when new treatment technologies are

proposed for a water treatment plant. The Water Treatment Technology Approval Process,[16] last updated in 2002, must be followed when a technology that is not listed in existing regulations as a Best Available Technology (BAT) is proposed. The process includes pilot and/or demonstration studies that are reviewed by a statewide Water Treatment Committee.

Seawater desalination plants on Santa Catalina Island are drinking water treatment plants in Southern California that have been operating under DDW permits for many years. The treatment plants' permitting and operation are briefly described here as examples for what an anticipated DDW permitting process would entail for a new seawater desalination plant.

Catalina Island, located off the coast of Los Angeles, relies on ocean water to supplement other water sources. Two seawater desalination plants use reverse osmosis. The first plant was built in 1992, and a second was added in 2016. The plants' combined capacity is 0.45 mgd, which provides about 40% of the island's drinking water, and most crucially, enables peaking capacity for tourism demand during dry summer months. Southern California Edison (SCE) provides power, water, and gas to the island and is the DDW permittee for operation of the seawater desalination plants.[17]

The DDW permit conditions for these RO plants are similar to those of other DDW permits for surface water treatment plants. Main areas of concern for DDW permitting would be ensuring membrane integrity of the RO units and ensuring a stable water quality in the distribution system through optimized corrosion control. It is also important to note that DDW permits are for operation of the completed water treatment plant and therefore are not officially issued until after construction and any start-up testing needed to assure that the plant is capable of producing safe and potable water is completed and results reviewed by DDW staff.

6.2.2 California Coastal Commission

The CCC plays a critical role in regulating the construction and operation of seawater desalination plants along the California coastline by reviewing and approving proposed projects, ensuring they comply with coastal protection laws, and mitigating potential environmental impacts on marine life and coastal ecosystems before a seawater desalination plant can be built. The CCC has the authority to issue Coastal Development Permits (CDPs), which are required for any development project within the coastal zone, including seawater desalination plants. In jurisdictions with a certified Local Coastal Program (LCP), the applicable city or county typically has primary authority to issue CDPs for development located landward of the mean high tide (MHT) line, with the CCC retaining appellate authority. The CCC retains direct permitting authority for development located seaward of the MHT line, as well as for tidelands, submerged lands, and public trust areas. Because seawater desalination projects often include both onshore and offshore components, permitting responsibility may involve both the local jurisdiction and the CCC.

The review process includes a thorough assessment of the potential environmental impacts of a proposed seawater desalination plant on marine life, water quality, and coastal habitats, considering factors like brine discharge and seawater intake. If a seawater desalination plant is approved, the CCC

[16] https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/dwdocuments/technologyapprovalprocess.pdf
[17] https://energized.edison.com/stories/new-desalination-plant-comes-to-catalina-island

can impose conditions to mitigate negative environmental impacts, such as monitoring requirements and specific design modifications.

While the CCC's authority encompasses the entire California coastline, the feasibility of specific locations is affected by the CCC's review of site-specific factors and public input. The CCC evaluates the proposed location of a seawater desalination plant, considering factors such as shoreline erosion, geological stability, and potential impacts on nearby communities, including environmental justice considerations. The CCC also holds public hearings to allow community members to provide feedback on proposed seawater desalination projects. Due to public opposition of some proposed projects, seawater desalination projects now have lengthy stakeholder engagement processes to facilitate community support.

The Coastal Act grants the CCC broad discretionary authority to "protect, conserve, restore, and enhance" the state's coastal resources, and the specific permit conditions for approved projects are issued on a case-by-case basis. As such, recent projects are summarized here to serve as case studies for the components of successful and unsuccessful projects.

6.2.2.1 Dana Point (South Orange County)

In October 2022, the CCC unanimously approved a CDP for the DODP in Dana Point (California Coastal Commission 2022). An aerial of the project site with proposed facilities is shown in **Figure 6.2**. The plant will be located between Pacific Coast Highway and Stonehill Drive, next to San Juan Creek and produce up to 5 million gallons of drinking water per day. Benefits of the project considered by the CCC include new, local, and sustainable water supply, emergency water supplies in case of natural disasters, and reduced reliance on imported water.

The plant will use slant wells to collect ocean water from beneath the seafloor. It will also use solar panels and possibly hydrogen fuel cells to offset some of its energy demand.

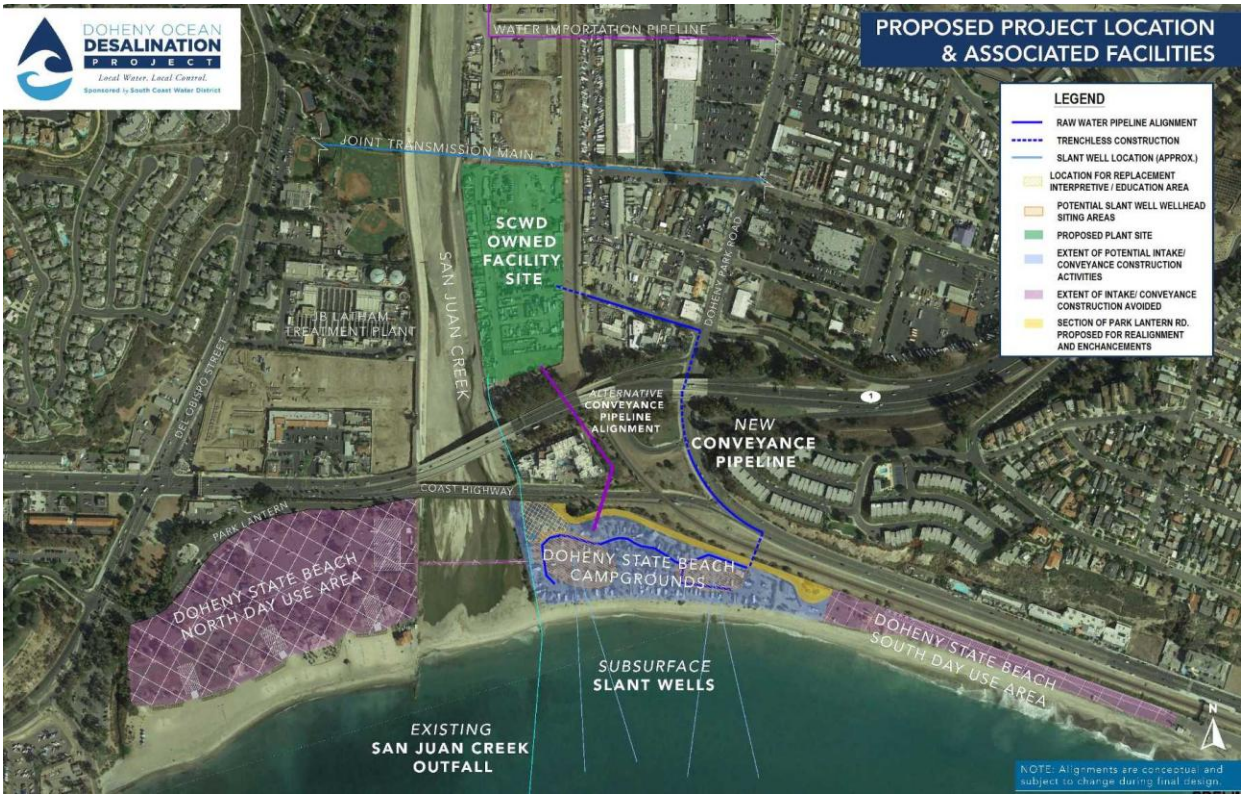


Figure 6.2 Doheny Seawater Desalination Plant (Courtesy of South Coast Water District)

The project was approved with several special conditions to confirm that it will be consistent with public access and recreation, marine and water quality protection, and relevant seismic and coastal hazards policies. However, some environmental groups and the Society of Native Nations raised concerns about the project's environmental impacts, warning that the plant discharge could harm marine mammals. Special conditions for the Doheny Desalination Facility coastal development permit are listed in **Appendix F**.

6.2.2.2 Monterey (Monterey County)

The CCC approved a CDP for a seawater desalination plant in Marina, California in an 8-2 vote in November 2022 (California Coastal Commission 2022). A rendering of the site is shown in **Figure 6.3**. The plant will be built on a former sand-mining site in Marina, about 15 minutes north of Monterey and supply Cal American Water (Cal-Am) customers in the Monterey Peninsula region and the community of Castroville. Benefits of the project considered by the CCC include providing a reliable water source for the region, protecting the Carmel River ecosystem and improving coastal access.

Figure 6.3 Monterey Seawater Desalination Plant

The project is to be constructed in phases and includes five to seven new slant wells near the Monterey Bay shoreline in the city of Marina. The initial phase of the project would produce 4.8 mgd of treated water. The full-scale project would produce 6.4 mgd of treated water only if Cal-Am can demonstrate a need for the additional water supply and demonstrate that the first phase has been operating in a manner that is protective of local groundwater supplies and nearby wetlands. Cal-Am's proposed GHG Emissions Reduction Plan aims to achieve net zero emissions for each year's operations by using renewable energy to the extent possible and to procure and retire Renewable Energy Credits, Carbon Offsets, and other similar instruments that are meant to offset emissions and that are acceptable to any of the several state-approved carbon registries (i.e., any entity approved by the California Air Resources Board to act as an "off-set project registry" under the state's Cap-and-Trade Program). In addition, the project's design includes other measures to address energy usage such as: designing the piping system to limit pressure losses and reduce pumping and energy requirements, for example, by using larger diameter pipes with smooth surfaces, limiting pipe length, and reducing the number of fittings and valves; and by including variable frequency drives on electrical and treatment equipment to reduce the operating speeds to match the pump discharge repressure requirements and reduce energy usage (CDM Smith, 2014).

Concerns raised by the CCC include:

- Environmental impacts: The plant's discharge could pollute waters frequented by marine life. It could also have substantial impacts on sensitive habitat areas for threatened and endangered species.
- Equity: The plant would benefit wealthier adjacent communities, while Marina would bear the industrial burden. One-third of the Marina community is low-income, and many speak little English.

The CCC approved the plant with several conditions to limit harm to the environment and local communities. Special conditions to the Monterey Desalination Facility coastal development permit are listed in **Appendix F**.

6.2.2.3 Carlsbad (San Diego County)

In November 2007, the CCC unanimously approved the CDP for Poseidon's proposal to construct and operate a seawater desalination facility in Carlsbad (California Coastal Commission 2007). An overview of the seawater desalination plant facility is shown in **Figure 6.4**. The facility is located at the decommissioned Encina Power Plant and is owned and operated by Poseidon Resources (Channelside) LLC. The facility withdraws raw water from Agua Hedionda, a coastal estuary, through a modified intake pipeline and the facility produces approximately 50 mgd of potable water. The Encina Power Plant was in operation when Carlsbad started operation; when Encina closed, Poseidon had to modify the intake. The plant's intake was retrofitted with wedgewire screens to reduce the entrainment and impingement of marine life and to conform with the California Ocean Plan. The plant's outfall system discharges brine via the Encina Water Pollution Control Facility's wastewater outfall. The brine is therefore diluted with treated wastewater prior to being released into the ocean to minimize environmental impact.

Figure 6.4 Carlsbad Seawater Desalination Plant (Courtesy of Dudek)

The facility was originally proposed to co-locate with the Encina Power Plant to utilize some of the several hundred million gallons of water the plant pumped daily from Agua Hedionda. However, that power plant has since been shut down and a new power plant constructed on the same site no longer uses seawater for cooling. Consequently, the CDP was approved based on the seawater desalination facility functioning as a standalone operation. The project was approved with several special conditions to confirm that it will be consistent with public access and recreation, marine and water quality

protection, and relevant seismic and coastal hazards policies. Special conditions in the Carlsbad Desalination Facility CDP are listed in **Appendix F**.

6.2.2.4 Huntington Beach (Orange County)

In a decision that came after nearly 25 years of debate, the CCC unanimously rejected Poseidon Water's proposed 50-mgd production desalination plant in Huntington Beach in May 2022 on the grounds that the potential harms and project risks far outweighed any benefit. Objections to the project included:

- Cost: The water would be expensive to produce, would only benefit private equity firms and investors, and would produce the most expensive type of potable water.
- Demand: There was no local demand for the water.
- Environmental impact: The project would harm marine life by drawing in large amounts of ocean water through a screened intake, and the project proponent was not able to demonstrate to the CCC's staff that adequate mitigation measures would be implemented.
- Location: The plant would be located along an earthquake fault zone and had risks from seismic and tsunami impacts; the project area was at risk of flooding as sea levels rise; and construction could disturb an adjacent remediation site.

6.2.2.5 Case Study Takeaways

From these case studies, recommendations for a new seawater desalination project undergoing Coastal CCC permitting include the following:

- **Comprehensive Environmental Assessment:** Provide a thorough evaluation of potential environmental impacts, particularly on marine life and coastal ecosystems. This should include studies on brine discharge effects and seawater intake methods. Marine life impact avoidance and mitigation strategies should be identified early in project development, including intake technology selection, entrainment and impingement reduction measures, brine discharge diffuser design, and adaptive management approaches.
- **Community Engagement:** Establish a robust stakeholder engagement process to address community concerns and gather public input. Public hearings should be an integral part of the project planning to build support and transparency.
- **Site-Specific Considerations:** Evaluate the feasibility of the project location by considering factors like shoreline erosion, geological stability, and risks from natural disasters (e.g., earthquakes, flooding). Address potential impacts on nearby communities, especially those with environmental justice concerns.
- **Sustainable Design Features:** Incorporate sustainable technologies, such as solar power and energy-efficient systems, to minimize the plant's energy demands and environmental footprint.
- **Equitable Benefits Distribution:** Confirm that the benefits of the seawater desalination project are equitably distributed among communities, particularly addressing the needs of low-income or marginalized populations.

- **Long-Term Monitoring and Adaptation:** Implement ongoing monitoring requirements to assess environmental impacts and be prepared to adapt operations or mitigation strategies as necessary to address unforeseen issues. Monitoring programs should be structured to verify the effectiveness of marine life mitigation measures and support adaptive management if performance objectives are not met.
- **Transparent Cost Analysis:** Conduct a transparent cost analysis to justify the economic viability of the project and confirm it does not disproportionately burden local residents with high water costs.

6.3 Regulations Affecting Outfall

6.3.1 Ocean Plan Brine Discharge Determination Components

The first four sections below provide a breakdown of the four principal seawater desalination project analysis components of Ocean Plan Chapter III.M (site, design, technology, mitigation) as they pertain to brine discharge. Each of these four components are required to be evaluated by a Regional Water Board in the Water Code section 13142.5(b) determination process. In this process the Regional Water Board, rather than the applicant, determines what is "feasible."

The definition of "feasible" in the Ocean Plan is "capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social and technological factors" (Ocean Plan 2019, Appendix I). This definition of "feasible" is the same as that in the CEQA.

6.3.1.1 Site

The siting analysis conducted under Task 1.1 (CDM Smith 2024) identified potential locations and system configurations for seawater desalination, guided by the Ocean Plan and the Streamlining Report to Expedite Permitting. The three highest ranked sites all included use of existing wastewater outfalls for brine disposal. As part of the Task 1.1 ranking process, many of the brine discharge related siting items required to be analyzed under Ocean Plan Chapter III.M.2.(b) were preliminarily addressed.

A directly pertinent Ocean Plan siting criterion (III.M.2.(b)(6)) for the regulatory analysis for the three recommended sites is whether there is existing discharge infrastructure and available wastewater effluent to dilute (blend with) the facility's brine discharge to reduce salinity impacts. The Task 1.1 siting analysis identified the amount of treated effluent and/or reverse osmosis concentrate (ROC) available for blending with the desalination brine at the existing wastewater outfalls.

If an existing outfall needs to be modified to accommodate the brine discharge, the feasibility of avoiding sensitive habitats and species when constructing discharge infrastructure must be analyzed. A related requirement would be analyzing the direct and indirect impacts of facility construction and operation on marine life, individually and in combination with potential anthropogenic effects from reasonably foreseeable activities in the area affected by the facility.

6.3.1.2 Design

Under Ocean Plan Chapter III.M.2.(c) the Regional Water Board will require the applicant to look at various outfall designs to confirm that mortality of all forms of marine life is minimized to the greatest extent possible. Like the siting analysis, many of the Ocean Plan brine discharge design criteria have been addressed as part of Task 1.1 given that the top three ranked sites use existing wastewater outfalls.

Items that may require additional analysis or verification for each site's brine discharge design are:

- Discharge configuration (e.g., diffusers) that minimizes impacts to sensitive habitats and species.
- Outfall design such that the Brine Mixing Zone (BMZ) does not adversely affect sensitive habitat.
- Outfall design such that the discharges do not result in dense, negatively buoyant plumes that result in adverse effects due to elevated salinity or hypoxic conditions occurring outside the BMZ (no greater than 100 meters from the point of discharge).
- Modeling and/or field studies to demonstrate compliance with brine plume dilution and dispersion requirements and calculation of the shear-related mortality.
- Outfall design that minimizes suspension of benthic sediments.

6.3.1.3 Technology

Under Ocean Plan Chapter III.M.2.d.(2) there are two primary discharge technologies cited plus an alternative discharge category. The top three ranked sites identified under Task 1.1 use existing wastewater outfalls that would blend brine with available effluent and/or ROC. These three sites are in conformance with the top two preferred Ocean Plan technologies as listed below:

- The preferred technology is to comingle (blend) brine with other wastewater effluent (e.g., municipal treated effluent, ROC, power plant thermal effluent).
- Multiport diffusers are the second-best method for disposing of brine, designed to maximize dilution, minimize the size of the BMZ, minimize the suspension of benthic sediments, and minimize mortality of all forms of marine life.
- Alternative discharge methods that provide a comparable level of protection to marine life
- Flow augmentation (drawing additional seawater through the intake for brine dilution purposes) is prohibited unless the additional flow is drawn through a subsurface intake.

A critical technology requirement for brine outfall discharges is that there be sufficient wastewater available for blending, adequate diffuser design or a combination of both to confirm compliance with the Ocean Plan Chapter III.M.3.b. receiving water limitation for salinity. The Ocean Plan states:

> "Discharges shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured no further than 100 meters (328 feet) horizontally from each discharge point. There is no vertical limit to this zone."

An effluent limitation to comply with this receiving water limitation is required to be included in brine discharge NPDES permits, calculated based on the following formula:

$$Ce = Co + Dm*(2.0\ ppt)$$

Where:

Ce = effluent concentration limitation in ppt
Co = salinity concentration at the completion of initial dilution (i.e., Co = 2.0 ppt + Cs)
Cs = natural background salinity in ppt (mean monthly)
Dm = minimum probable initial dilution as parts seawater per part brine discharge

Initial dilution is determined using a numeric model (e.g., Visual Plumes) and which cannot assume any ambient currents (which aid in mixing) per Ocean Plan Chapter III.C.4.d. Model inputs also need to address future wastewater availability for blending, for example if it is projected that diversions for increased recycled water demands may occur.

The effluent concentration limitation for salinity in the DODP was determined using the formula outlined in Chapter III.M.3.b.(2) of the Ocean Plan and noted above. The natural background salinity, Cs, was calculated based on 20 years of historical data collected near the proposed discharge location. Using the lowest natural background salinity of 30.4 ppt to provide a conservative approach, the salinity effluent concentration limitation was calculated as follows:

$$Ce = (2.0\ ppt + 30.4\ ppt) + 100*(2.0\ ppt) = 232.4\ ppt$$

This confirms that the salinity increase from discharge will not exceed the Ocean Plan's daily maximum limit. The project's supporting studies confirmed that the expected salinity from the brine discharge would be well below this limitation under various RO recovery rates, indicating that the effluent concentration will meet the required salinity standard to comply with the receiving water limitation. (California Regional Water Quality Control Board, 2022)

6.3.1.4 Mitigation

Seawater desalination facilities must identify and mitigate any discharge-related marine life mortality that occurs because of exposure to hypersaline and anoxic conditions and shearing stress from turbulent mixing. Ocean Plan Chapter III.M.2.e. requires mitigation for all construction- and operation-related impacts caused by the seawater desalination facility. Mitigation 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*."

Key elements of Chapter III.M.2.e. require the following:

- Marine Life Mortality Report. The report provides an estimate of construction- and operation-related mortality. The full estimate is a composite of intake (entrainment and impingement) and discharge (BMZ and shear-related mortality) impacts. The final mortality calculated in the report becomes the required mitigation.
- The applicant can select between two mitigation options:
  - Option 1 - Complete a mitigation project. This is generally regulator's preferred option. However, there can be few mitigation projects available in some areas to create the

required mitigation credits. Implementation may require having mitigation projects in place and meeting performance standards before seawater desalination plants will be allowed to be commissioned. Calculation of mitigation ratios (in-kind versus out-of-kind) can be complex.

- Option 2 - Fee-based mitigation program. This is potentially a simpler option for mitigating impacts. However, the State has not yet identified the proper entity that could receive and administer the collected fees.

For example, the mitigation measure associated with the DODP involves a project addressing the increased turbulence/shearing mortality caused by the addition of brine to wastewater. This incremental impact is calculated by comparing baseline wastewater flows with commingled wastewater and brine flows. To compensate for marine life mortality impacts from the project's construction and operation, the draft Marine Life Mitigation Plan outlines a restoration of 7.45 acres in the South Los Cerritos Wetlands, led by the Los Cerritos Wetlands Authority. This includes 5.25 acres of tidal salt marsh habitat and 2.2 acres of subtidal habitat (California Regional Water Quality Control Board San Diego Region 2022).

6.3.1.5 Monitoring and Reporting Programs

Ocean Plan Chapter III.M.4 requires submittal of a Monitoring and Reporting Plan (MRP) to the Regional Water Board for approval. Minimum requirements are monitoring for benthic community health, aquatic life toxicity, hypoxia, and compliance with the receiving water limitation for salinity. These are assumed to be site-specific project requirements that would be incorporated into the existing MRPs of the NPDES permits associated with the three recommended sites with wastewater outfalls as identified in Task 1.1.

6.3.1.6 Conditional Water Code Section 13142.5(b) Determination

Per Ocean Plan Chapter III.M.2.a(5) a Regional Water Board may expressly condition a Water Code section 13142.5(b) determination. Proposed changes in the design or operation of a seawater desalination project that could increase the intake or mortality of all forms of marine life beyond that in an approved Determination could trigger the requirement for a new Determination.

A potential example of a brine-related triggering change would be a reduction in the volume of wastewater available for dilution of brine. Increased indoor water conservation and/or increased demand for recycled water could reduce the wastewater flow available for brine blending.

6.3.1.7 Doheny Desalination Facility NPDES Permit Requirements

Brine discharge requirements for the 5-mgd production Doheny Desalination Facility are contained in the NPDES permit issued by the San Diego Regional Water Board to the SOCWA Order No. R9-2022-0005 (California Regional Water Quality Control Board San Diego Region, 2022). The Doheny facility includes 10 mgd of subsurface intake wells and a brine discharge of 5 mgd, blended with available SOCWA effluent. Attachment H to the SOCWA permit includes the Water Code section 13124.5(b) determination made by the Regional Water Board.

Attachment H and other portions of the SOCWA permit, available at https://www.socwa.com/wp-content/uploads/2022/08/SJCOO_r9_2022_0005.pdf, provide examples of requirements that could be imposed on the three seawater desalination projects under consideration.

6.4 Other Regulatory Considerations

6.4.1 Greenhouse Gas Emissions

California's GHG reduction objectives are mandated in the Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32), and its successor, Senate Bill (SB) 32. In 2018, Governor Jerry Brown's Executive Order B-55-18 committed California to achieve carbon neutrality by 2045.

AB 32 mandated the state to reduce its GHG emissions to 1990 levels by 2020. SB 32 strengthened this goal, aiming for a 40% reduction below 1990 levels by 2030. To meet these targets, the California Air Resources Board (CARB) and the state Office of Planning and Research advise local planning agencies to set reduction goals that align with these statewide objectives (CARB 2022; California Governor's Office of Land Use and Climate Innovation 2017). Under CEQA, significance thresholds for GHG emissions are established by the applicable lead agency; however, some agencies have applied a screening threshold of approximately 10,000 metric tons per year of carbon dioxide equivalent (CO_2e) for stationary source projects to determine whether a project may result in a cumulatively considerable contribution to GHG emissions. Final threshold determination would occur during project-specific environmental review.

A new seawater desalination facility would need to be constructed and operated in alignment with Metropolitan's 2022 Climate Action Plan (CAP), which has a target goal of reducing GHG emissions by 40 percent below 1990 levels and reach carbon neutrality by 2045 (Metropolitan 2022). The facility's emissions and electricity usage would be included in the metrics for monitoring progress toward the CAP goals for emission reductions. The Metropolitan CAP modeled and included the planned construction and operational GHG emissions from the proposed Regional Recycled Water Program (RRWP), renamed to Pure Water Southern California (PWSC) in 2022, in the forecast.

The CARB regulates and monitors the state GHG emissions and is required to develop and update a scoping plan (CARB undated) that lays out the strategy for meeting the established goals. The scoping plan sets targets at the state level rather than imposing mandates on local agencies. However, language from the 2022 scoping plan states that local governments should focus on emission sources and actions within their control and set targets that support the overall state goals (CARB 2022). The scoping plan impacts construction and operation of a new seawater desalination facility in the following ways:

- **Energy Efficiency Requirements:** Seawater desalination facilities must implement high-efficiency technologies, such as ERDs and variable-speed pumps, to minimize energy consumption during operations. Additionally, plant designs and piping layouts must be optimized to reduce pressure losses and pumping requirements.
- **Renewable Energy Integration:** Seawater desalination facilities are encouraged to power operations using renewable energy sources, such as solar or wind, to reduce dependence on carbon-intensive electricity. Partnership with utility providers may be required to procure renewable energy or develop on-site energy generation solutions.

- **GHG Emissions Monitoring and Reporting:** Seawater desalination facilities must quantify and report GHG emissions associated with both construction and operational phases as part of the permitting and environmental review process. This includes emissions from fuel consumption during construction and long-term operational electricity usage.
- **Mitigation and Carbon Offset Measures:** Seawater desalination projects may need to incorporate GHG mitigation measures, such as carbon offset programs or investment in energy efficiency improvements. Measures to reduce construction emissions could involve cleaner construction equipment, the use of low-carbon materials, and optimized construction schedules.

6.4.2 CEQA

Under CEQA, a seawater desalination plant would likely require a full EIR, due to the potential for significant impacts on marine life, water quality, coastal ecosystems, and energy consumption associated with its construction and operation. In addition to the energy usage, public input, marine life impacts, and coastal impacts that would be evaluated as part of the other regulatory mechanisms discussed in this memorandum, the CEQA process would include analyses of noise and visual impacts. All impacts that are considered significant would require feasible mitigation measures.

6.4.3 Federal Requirements

Under the NEPA, the federal counterpart to CEQA, additional environmental review would be required at the Port Hueneme site because of its location on a military base, and the likelihood of multiple federal approvals. The federal lead agency under NEPA would be determined based on the specific federal nexus for the project, including land use authorization, funding, or required federal permits. While the U.S. Navy may have a role due to land ownership and operational control at the naval base, it would not automatically serve as the NEPA lead agency unless it is the primary federal decision maker for the proposed action. Other federal agencies with permitting or approval authority could also serve as lead or cooperating agencies, depending on the project structure. The ongoing Extraction Barrier and Brackish Water (EBB) Project at Point Mugu, for example, received a Mitigated Negative Declaration under CEQA but is undergoing a full Environmental Assessment under NEPA.

In addition, the Port Hueneme's location on a U.S. Naval base would necessitate cooperative agreements and Memorandum of Understanding for a real estate agreement to allow installation of the wells and treatment plant. For the ongoing EBB Project, it has taken several years to develop the real estate action needed to allow contracting to proceed for drilling monitoring wells.

6.4.4 Mitigation Challenges

Under Ocean Plan Chapter III.M, even projects that adopt preferred technologies such as subsurface intakes, brine blending through existing wastewater outfalls, and well-designed diffusers still face substantial mitigation obligations related to construction and operation. For example, at Doheny, despite using subsurface slant wells and brine commingling, regulators required significant habitat restoration to offset shear-related and brine-zone impacts, including multi-acre tidal marsh and subtidal restoration, as well as long-term monitoring. These mitigation requirements can be technically complex, require identification of suitable restoration sites, and involve multi-agency coordination extending well beyond plant construction. Similarly, the Carlsbad Desalination Plant was required to implement

extensive marine life mitigation, including long-term wetland restoration and ongoing monitoring commitments, which added substantial cost and schedule considerations to the project. Site-specific factors drive the scale and cost of mitigation. Port Hueneme may require broader marine life mortality accounting and additional federal coordination under NEPA and Navy real estate agreements, which would increase mitigation scope. El Segundo, the current subsurface slant well intake assumption avoids intake entrainment and impingement mitigation requirements that would have applied to an open intake, shifting the focus to discharge-related and construction-related mitigation. Overall, technology choices can reduce environmental impacts but do not eliminate the need for costly, multi-year mitigation and monitoring commitments.

6.4.5 State Lands Commission

In addition to the permits described above, any seawater desalination project that involves use of sovereign lands, including offshore intake or outfall pipelines, subsurface intake wells extending beneath tidelands, or marine discharge infrastructure, would require authorization from the California State Lands Commission. While this authorization is issued in the form of a lease rather than a permit, it represents a critical approval that must be secured prior to construction and operation. The California State Lands Commission has jurisdiction over public trust lands, including submerged lands and tidelands, and evaluates proposed projects for consistency with the Public Trust Doctrine. The lease approval process includes environmental review, coordination with other responsible agencies, and California State Lands Commission action at a public hearing. As such, obtaining a State Lands Commission lease would be an essential component of the regulatory pathway for any project involving offshore or coastal infrastructure.

6.5 Site-Specific Permitting Considerations

This section compares how Ocean Plan intake provisions, CDP considerations, and brine-discharge permitting may differentially affect the three ranked sites. Predicted permitting and delivery timelines for each site are provided in **Section 7**. Actual permitting pathways, timelines, and requirements would depend on future project-specific applications, agency consultations, environmental documentation, and evolving regulatory conditions.

Permitting remains one of the highest-risk elements for seawater desalination projects in California. Although estimated timelines are presented in **Section 7** for comparative planning purposes, actual durations could extend beyond those assumed due to agency findings, public opposition, administrative appeals, litigation under CEQA or the Coastal Act, or evolving regulatory interpretations. Decisions by the CCC, RWQCBs, federal agencies under NEPA, and other permitting authorities are discretionary and may impose additional study requirements, mitigation measures, or design modifications that affect schedule and cost. As demonstrated by prior projects in California, permitting timelines can be materially influenced by stakeholder engagement outcomes and legal challenges.

6.5.1 Doheny Seawater Desalination Plant

Doheny uses subsurface slant wells, so Ocean Plan intake regulations are likely to have less significant impact than for a surface intake. Similar to the CCC's CDP for the Doheny Desalination Plant, the expansion must account for proximity to a state beach and potential effects on public access and recreation, and—like the other sites—address tsunami/flooding vulnerability and CEQA sensitivities for

archaeological and/or tribal cultural resources during excavation. For brine discharge, the project would commingle concentrate with wastewater via an existing outfall, with brine representing approximately 40% of the total discharge; brine discharge requirements for the existing 5-mgd Doheny facility are already included in the SOCWA NPDES permit, so the Metropolitan expansion would likely need fewer new and/or less complex refinements of prior studies than new discharges at Port Hueneme or El Segundo. The SOCWA NPDES permit recognizes a minimum probable initial dilution of 162:1 (currently permitted at 100:1), indicating additional dilution credit is likely available if needed; based on these factors, the regulatory burden for brine discharge appears lowest at Doheny.

6.5.2 Port Hueneme Seawater Desalination Plant

Port Hueneme would utilize subsurface slant wells, so Ocean Plan intake regulations are likely to have a less significant impact compared to an open intake, since subsurface intakes reduce entrainment and impingement by drawing water from beneath the seafloor. All three sites are near the coast and therefore vulnerable to tsunamis and flooding, and excavation may raise CEQA concerns regarding archaeological and/or tribal cultural resources. For brine discharge, the Ocean Plan's preferred technology is to commingle brine with wastewater using existing outfall infrastructure; Oxnard has an existing wastewater outfall with treated effluent and/or reuse ROC for commingling, and brine would represent approximately 30% of the total discharge. Compared to Doheny, which is an expansion of an already permitted approach, permitting a new brine discharge at Port Hueneme would likely require new raw water modeling, diffuser design analysis, and marine life impact studies to demonstrate compliance with Ocean Plan requirements.

6.5.3 El Segundo Seawater Desalination Plant

The El Segundo site is considered with subsurface slant wells, which the Ocean Plan highly favors for minimizing intake and mortality of marine life and which generally impose a less significant intake-related regulatory burden than a surface intake. Given the urban surroundings, this site may face challenges concerning nearby disadvantaged communities and should confirm that project benefits are equitably distributed and that the industrial burden does not disproportionately impact these populations. Like the other coastal sites, El Segundo is vulnerable to tsunamis and flooding, and excavation activities may raise CEQA concerns regarding archaeological and/or tribal cultural resources. For brine management, the Ocean Plan's preferred approach of commingling with existing wastewater using existing outfall infrastructure would apply here, with brine representing approximately 25% of the total discharge.

7.0 Cost Evaluation and Scheduling

This section presents planning-level capital cost and schedule estimates developed to support comparative screening of alternatives. Estimates are conceptual and subject to significant refinement as project definition advances. Using the preliminary siting and technical studies completed under this effort, CDM Smith prepared a cost evaluation and scheduling assessment to support a more detailed comparison of the candidate seawater desalination sites. This section presents planning-level capital cost estimates for the top three ranked sites, including major components such as seawater intakes, desalination treatment facilities, concentrate disposal, land acquisition where applicable, conveyance, and system integration. In addition, a high-level set of parametric cost factors applicable to all sites evaluated in the siting analysis is summarized. A corresponding planning-level project schedule was also developed, accounting for site-specific characteristics such as intake type, treatment plant configuration, conveyance infrastructure, pumping stations, and overall system integration requirements.

7.1 Basis of Estimate

An OPCC has been developed for each of the top-ranked sites, considering site requirements, production capacities, intake and outfall types, and system integration design. The OPCC represents a planning-level estimate of anticipated capital construction costs based on the current conceptual understanding of each alternative. The OPCC provides an AACE Class 5 accuracy range based on the maturity level of each site's engineering definitions. According to the current definitions, the Class 5 OPCC corresponds to a level accuracy range of -50% to +100%. A Class 5 estimate is early in the project definition and is used for purposes such as initial concept screening. A Class 5 estimate is typically prepared using parametric models, treatment capacity factors, analogous information and/or judgment. As a Class 5 estimate developed for concept screening, the OPCC should not be used for budgeting, funding authorization, or procurement purposes. To develop the OPCC, several assumptions have been made—some general and applicable to all sites, and others specific to each site. These assumptions are based on CDM Smith's experience with similar projects and the unique characteristics of each site.

The following sections outline the general and specific assumptions considered for each location.

7.1.1 General

The general assumptions applicable to all sites include:

- Treatment Plant
  - Capacity based on the information provided in **Section 4**.
  - Efficiency (recovery): 50% considering the production flow divided by the inlet (raw seawater) flow.
- Slant Wells
  - Capacity: 1,500 - 2,000 gallons per minute per individual well. Total number of wells based on the information provided in **Section 4**.

- Cost: Based on budgetary quotations. However, due to significant volatility in this type of work, CDM Smith cannot precisely determine where costs will stabilize. Therefore, a cost range is provided in the OPCCs. The cost per slant well is estimated to range between $3,800,000 and $10,000,000, where the low and high end represents low and high steel cost, as well as favorable and unfavorable geotechnical conditions, respectively. Recent information indicates that the cost per well is approximately $7.7 million ($6.6 million for excavation and $1.1 million for well casing and screen materials). Nevertheless, for the purposes of this study, a unit cost range encompassing this value has been used to provide a conservative estimate appropriate for the concept screening level of this analysis.

- System Integration: conveyance system characteristics based on the information provided in **Section 5**.

To estimate the cost of each site component, high-level (conceptual) definitions were developed based on site characteristics, capacities, and specific factors (e.g., site location and elevation, site preparation, intake type and location, treatment process, etc.). These definitions enabled the determination of pump capacities (number, total head, flow rate), pipe lengths and sizes, crossings, required earthworks, main instrumentation, and other details contributing to the cost estimate.

The cost of each alternative's components (i.e., intake, outfall, treatment plant, conveyance, and pump stations) was estimated using in-house parametric cost factors derived from similar projects. Costs associated with GHG mitigation measures have been excluded from the cost estimates and would require further project-specific analysis. Land acquisition costs have been excluded from the cost estimate assumptions except where site control requirements were specifically evaluated, such as at El Segundo. For Doheny, land cost was excluded because the land needed for the expansion has already been purchased as part of Phase 1 of the DODP. For Port Hueneme, this planning-level estimate assumes that the required facilities would be constructed on property made available by the current owner; if additional property rights or permanent easements are ultimately needed, land acquisition costs would be incorporated following negotiations and formal appraisal.

Distribution conveyance costs have also been excluded from the cost estimate assumptions. Where open-cut trenching is considered for the potential pipe between pump stations and Metropolitan pipelines, a minimum 5-foot pipe cover has been included. Micro tunneling is considered for crossings. Micro tunneling cost is estimated per linear foot using in-house parametric cost factors based on the pipe diameter and potential alignments provided in **Section 5**.

Environmental mitigation costs for coastal desalination plants in California vary significantly depending on intake design, site sensitivity, and applicable regulatory requirements. These costs can also increase substantially over the lifecycle of a project as regulatory standards evolve. For example, the Carlsbad Desalination Plant required significant additional capital investment to comply with the California Ocean Plan Amendments (OPA).

In addition to capital costs, ongoing environmental mitigation and compliance activities represent a material operational expense. These include routine sampling, monitoring, regulatory reporting, and adaptive management. For coastal desalination facilities in California, discharge monitoring and reporting costs are typically on the order of ~$500,000 to $1,000,000 per year, depending on permit

requirements, monitoring frequency, and analytical scope. These recurring costs are necessary to demonstrate compliance with water quality objectives and marine protection standards under the Ocean Plan and associated permits.

The cost of police officer support for managing or directing traffic flow during road work has been excluded. Instead, internal flaggers and traffic control measures have been considered.

Demolition and restoration for all conveyance piping operations have been considered.

All backfill is to be engineered, with 80% import of 3/8" rock.

Instrumentation and Control (I&C) and Electrical allowances of 5% and 15%, respectively, have been considered based on the level of estimate.

General Conditions, including project management and supervision, site security, temporary facilities and utilities, mobilization and demobilization, have been estimated as 12% of the direct cost, including allowances.

Indirect costs, including permits, sales tax (permanent and non-permanent), builder's risk, bonds, and liabilities, have been considered as 7.0% to 8.0% of the direct cost, including allowances and general conditions, depending on site particularities.

Contractor's Overhead and Profit (OH&P) has been considered as 12% of the sum of total direct cost, allowances, general conditions, and indirect costs based on OH&P of similar projects and CDM Smith experience.

Escalation to the midpoint of construction has been considered based on an inflation of 5% per year. For these OPCCs, it has been assumed that the midpoint of construction would be in mid-2029. The OPCCs do not include escalation beyond the assumed midpoint of construction, financing costs, owner's costs, or long-term operations and maintenance expenses, all of which would require further evaluation during subsequent project development phases.

The estimates exclude the impact of future tariffs and the feasibility of solar panels at all sites.

7.1.2 Operations and Maintenance

O&M costs were developed at a planning level using representative unit cost assumptions for major fixed and variable cost components associated with seawater desalination facilities. Variable O&M costs include energy, chemicals, membrane replacement, and waste disposal. Fixed O&M costs include labor, permit compliance, indirect costs, and maintenance. These categories were selected to capture the primary recurring costs that would be expected based on the treatment plant capacity.

The basis for these O&M assumptions was the cost information presented in Desalination Engineering: Planning and Design (Voutchkov 2013), which provides industry reference values for seawater desalination facilities. The published values were escalated to 2025 dollars for use in this analysis. As a result, the O&M cost estimates are intended to provide a consistent comparative basis among alternatives and are appropriate for screening-level evaluation, but they do not reflect site-specific

operating strategies, utility rates, labor agreements, or permit requirements that would need to be refined during future project development.

7.1.3 Specific Assumptions by Site

7.1.3.1 Doheny Seawater Desalination Plant

The potential expanded Doheny seawater desalination plant has a production capacity of up to 10 mgd, considers subsurface slant wells to obtain the required seawater and uses an existing SJCOO to discharge the reverse osmosis concentrate. It's worth noting that the slant wells' capacity required to produce 10 mgd of treated water must be confirmed through offshore drilling, which may indicate the presence of viable offshore targets from the campground area. If the slant wells' capacity is found to be less than 20 mgd, the treatment plant would need to be downsized accordingly, based on the confirmed maximum capacity of the slant wells. For the purposes of this study, the system has been costed assuming 10 mgd of treated water capacity.

The potential intake system consists of six slant wells grouped into four wellhead pods. MTBM was considered for constructing the well pipes which connect the wellhead pods on the beachside, including a total of 1,500 linear feet of 24-inch pipe. Additional wells may be required to produce 20 mgd as previously mentioned. If additional wells are required, the wells cost must be adjusted accordingly. Use of subsurface slant wells may reduce suspended solids and organic loading relative to open ocean intakes, potentially resulting in pretreatment process simplification or operational savings; however, subsurface sources may also present elevated iron and manganese concentrations that could require additional treatment provisions, chemical conditioning, or more frequent media management, which may increase capital and operational costs.

A 42-inch HDPE pipe conveys seawater from the wellhead pods to the treatment plant. A total of 1,100 feet is anticipated to be constructed using an MTBM, while 1,300 feet is to be installed via open-cut excavation.

The outfall includes the construction and installation of 300 feet of 24-inch HDPE pipe to connect the treatment plant outlet to the SJCOO. The construction method involves open-cut excavation and dredging.

The treatment plant is designed with a standard treatment process based on the expected seawater quality from slant wells. The process includes single-stage pressure filtration followed by cartridge filters, a two-pass reverse osmosis system, and post-stabilization treatment and storage. This expansion would be located on the same site as Phase 1; therefore, no land acquisition is considered.

This site considers two system integration alternatives:

- **Tie-in Option 1:** Two pump stations co-located at the desalination facility, which would tie-in to the existing JTM and the existing WIP as depicted in **Figure 7.1**. The potential alignments from the seawater desalination facility to the two tie-in points include a total of approximately 3,400 LF of new pipe and one trenchless crossing (associated with railroad crossing). Each pump station is equipped with five pumps (four duty, + one standby) with a capacity of 2.5 mgd per pump.

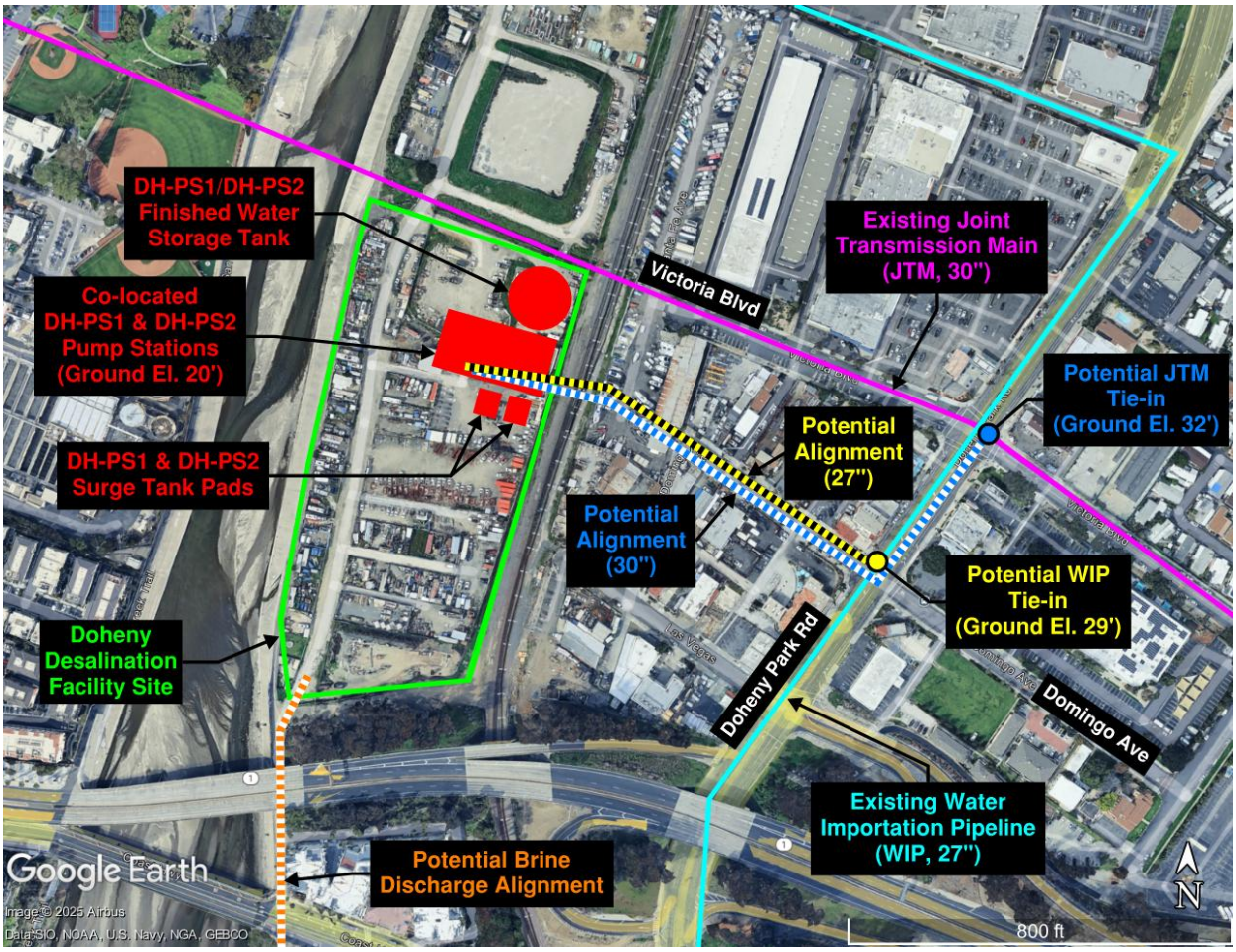


Figure 7.1 Tie-In Option 1 Potential Alignments for Doheny Seawater Desalination Facility

- **Tie-in Option 2:** This option would allow the new supply to be conveyed to both the JTM and the South County Pipeline. Three new pump stations would be required, including two pump stations co-located at the seawater desalination facility and one new pump station near the Tri-Cities pressure regulating stations (PRS), as depicted in **Figure 7.2**. The potential alignments from the desalination facility to the two tie-in points include a total of approximately 3,400 LF of new pipe and one trenchless crossing (associated with railroad crossing). Additionally, the potential alignment from the WIP to the booster pump station and back to the South County Pipeline includes a total of 2,500 LF of new pipe and no trenchless crossings. Each pump station is equipped with five pumps (four duty, one standby) with a capacity of 2.5 mgd per pump.

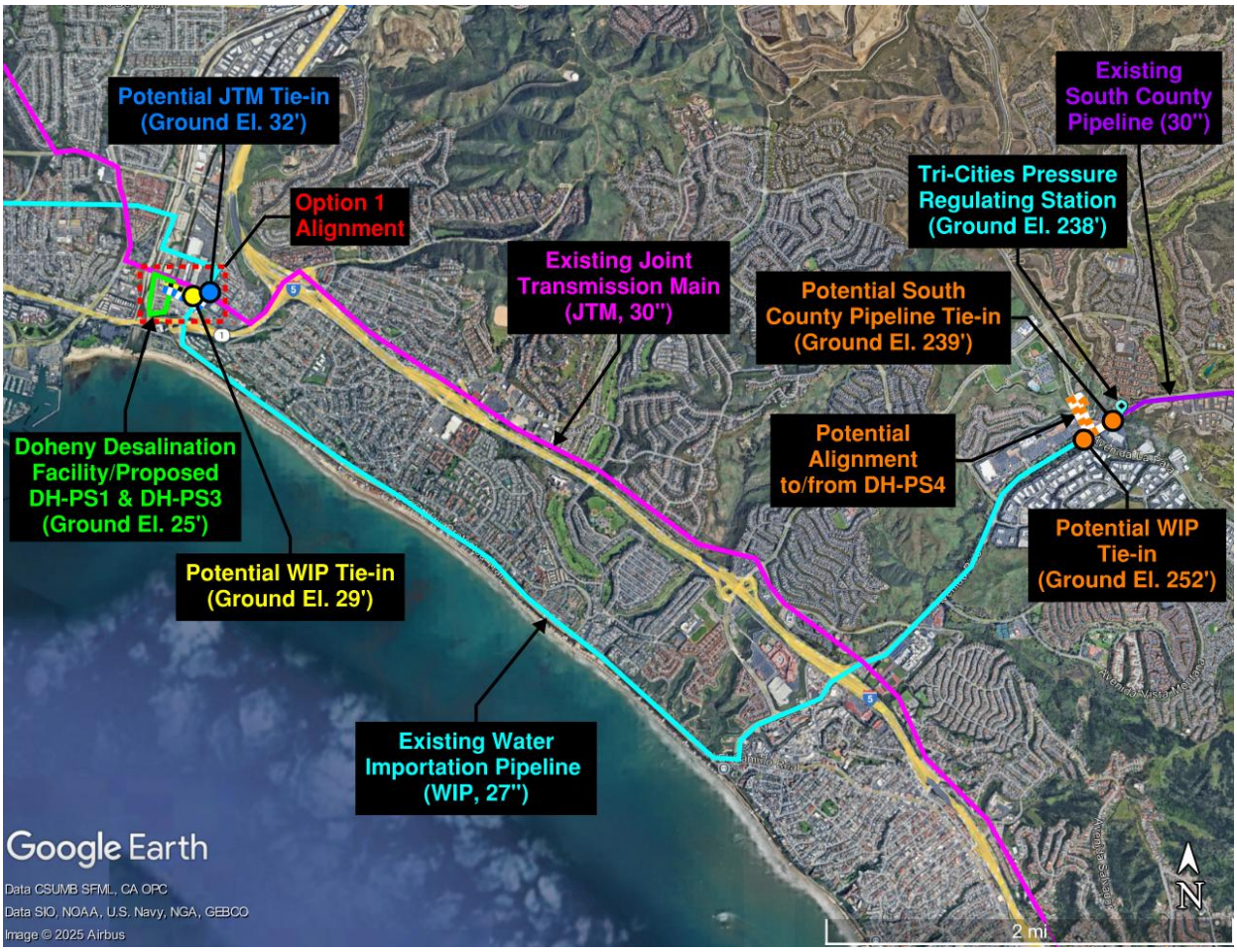


Figure 7.2 Tie-in Option 2 Potential Alignments for Doheny Seawater Desalination Facility

An OPCC has been prepared for both options based on the definitions provided in **Section 5**. These OPPCs have the following exclusions:

- Dewatering has not been included, as the available information does not suggest it would be required for the construction activities.
- Contaminated soils/environmental remediation has not been considered, as the available information does not indicate any record or need for such measures in the area.

A contingency of 25 percent has been included to reflect the level of design uncertainty and potential unforeseen construction activities associated with this screening level evaluation.

7.1.3.2 Port Hueneme Seawater Desalination Plant

The potential Port Hueneme seawater desalination plant has a production capacity of 20 mgd and considers subsurface slant wells to obtain the required seawater and uses an existing Oxnard WWTP Outfall to discharge the reverse osmosis concentrate.

The intake system consists of twenty slant wells grouped into five wellhead pods. A Micro Tunnel Boring Machine (MTBM) was considered for constructing the well pipes which connects the wellhead pods on the beachside, including a total of 9,600 linear feet of 24-inch pipe.

A 42-inch high-density polyethylene (HDPE) pipe conveys seawater from wellhead pods 1 to 4 to the treatment plant, while a 24-inch HDPE pipe is used to convey water from wellhead pod 5 to the plant. A total of 12,300 feet is anticipated to be constructed using an MTBM.

The outfall includes the partial demolition of existing pavement to facilitate the construction and installation of 200 feet of 42-inch HDPE pipe, connecting the treatment plant outlet to the Oxnard wastewater outfall. The construction method involves open-cut excavation.

The treatment plant is designed with a standard treatment process based on the expected seawater quality from slant wells, similar to Site 3 except for the capacity. The process includes single-stage pressure filtration followed by cartridge filters, a two-pass reverse osmosis system, and post-stabilization treatment and storage.

The conveyance system has been costed based on the definitions provided in **Section 5**. **Figure 7.3** provides the potential alignment based on **Section 5** definitions. The potential alignment from the desalination facility to the LBWFP clearwells includes approximately 153,100 LF of new 40-inch pipe, 7,800 LF of existing 66-inch pipe, and ten trenchless crossings (associated with the crossing of railroads, highways, and major intersections along the potential alignment). The costs associated with the site work for pump station PH-PS1 are allocated to the treatment plant site cost.

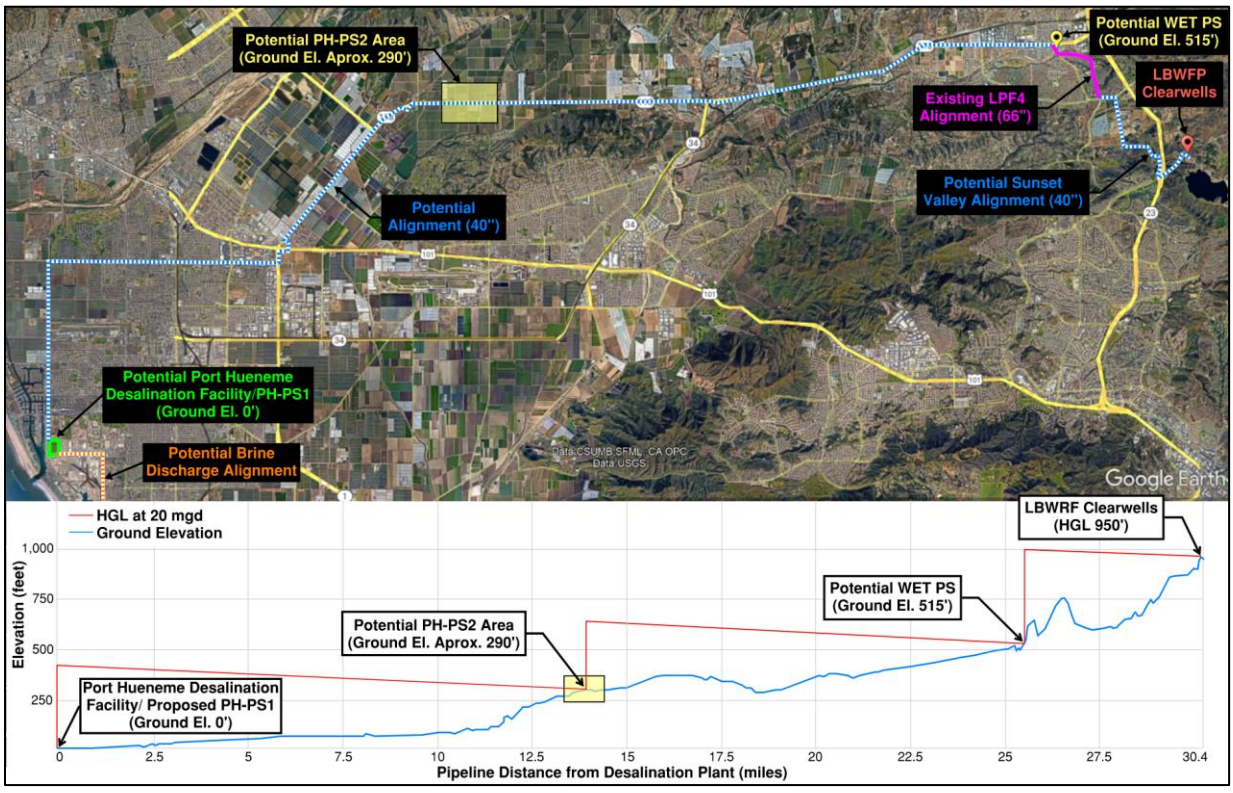


Figure 7.3 Port Hueneme Seawater Desalination Facility Potential Alignment

This OPCC reflects a planning level, AACE Class 5 screening estimate prepared for comparative evaluation purposes. Consistent with the current level of design development, the following items were not included in the OPCC:

- Dewatering has not been included. The estimate assumes conventional open cut construction methods without specific allowances for groundwater control. Site specific geotechnical investigations have not yet been performed for this alternative. Should this alternative advance, dewatering requirements would be evaluated based on detailed geotechnical studies and incorporated into future estimate updates.
- Contaminated soils/environmental remediation have not been included. No site specific environmental investigations were performed as part of this planning level study. If subsequent environmental assessments identify contaminated soils or groundwater requiring special handling or remediation, those costs would be incorporated into future estimate updates.
- Land appraisal and acquisition have not been included. This planning level estimate assumes that required facilities would be constructed on property made available by the current owner. If additional property rights or permanent easements are required, land acquisition costs would be incorporated following negotiations and formal appraisal. This is discussed further in **Section 8**.
- A contingency of 25 percent has been included to reflect the level of design uncertainty and potential unforeseen construction activities associated with this screening level evaluation.

7.1.3.3 El Segundo Seawater Desalination Plant

Initial planning assumed that the El Segundo Power Plant site would be decommissioned and available for redevelopment. However, NRG Energy indicated this will not be feasible to consider at this time.

WBMWD previously evaluated various locations for a desalination plant at the Scattergood Generating Station and the Chevron Refinery. Four of the locations were identified as potential suitable alternative locations for the potential El Segundo seawater desalination facility. These potential locations and their approximate lot sizes are shown in **Figure 7.4**.

Figure 7.4 Potential Locations for El Segundo Seawater Desalination Facility

For the purposes of this study, the Chevron Refinery Site B in **Figure 7.4** was used to cost this alternative based on the system integration analysis provided in **Section 5**.

The original evaluated site for the El Segundo seawater desalination facility assumed the existing cooling water intake for the El Segundo Power Plant would be available to convert to a raw water open ocean intake; however, that site is no longer available. As a result, the Chevron Refinery Site B does not have access to existing infrastructure and must rely on the construction of new subsurface slant wells to supply the seawater desalination facility. The closest existing desirable outfall to this site is the Hyperion Wastewater Outfall. The treatment plant would have a 10 mgd production capacity.

The OPCC considers the excavation and fill required to prepare the site but does not consider the demolition of the existing facilities located in the treatment plant site as they would depend on the final selected site. It is worth noting that demolition activities may be needed.

The intake system consists of nine slant wells grouped into three wellhead pods. A MTBM was considered for constructing the well pipe that connects the wellhead pods on the beachside, including a total of 4,000 linear feet of 30-inch pipe.

A 30-inch HDPE pipe conveys seawater from wellhead pods to the treatment plant. For the purposes of the cost estimate, a total of 2,500 feet is anticipated to be constructed using an MTBM, while 3,100 feet is to be installed via open-cut excavation. The outfall includes the construction and installation of 8,700 feet of 24-inch HDPE pipe to connect the treatment plant outlet to the Hyperion Wastewater Outfall. A total of 5,600 feet is anticipated to be constructed using an MTBM, while 3,100 feet is to be installed via open-cut excavation.

The treatment process includes single-stage pressure filtration followed by cartridge filters, a two-pass reverse osmosis system, and post-stabilization treatment and storage.

The land acquisition cost is based on the cost factor range of $44.25/sqft to $81.99/sqft provided in the February 2025 cost study for the El Segundo site conducted by Riggs & Riggs, Inc., and scaled by acreage to reflect the potential Chevron site. The conveyance system has been costed based on the definitions provided in **Section 5** and depicted in **Figure 7.5**. The potential alignment from the seawater desalination facility to the tie-in point includes approximately 10,600 LF of new 24-inch pipe and five trenchless crossings (associated with the crossing of railroads, highways, and major intersections along the potential alignment). The costs associated with the site works for pump station ES-PS1 are allocated to the treatment plant site cost.

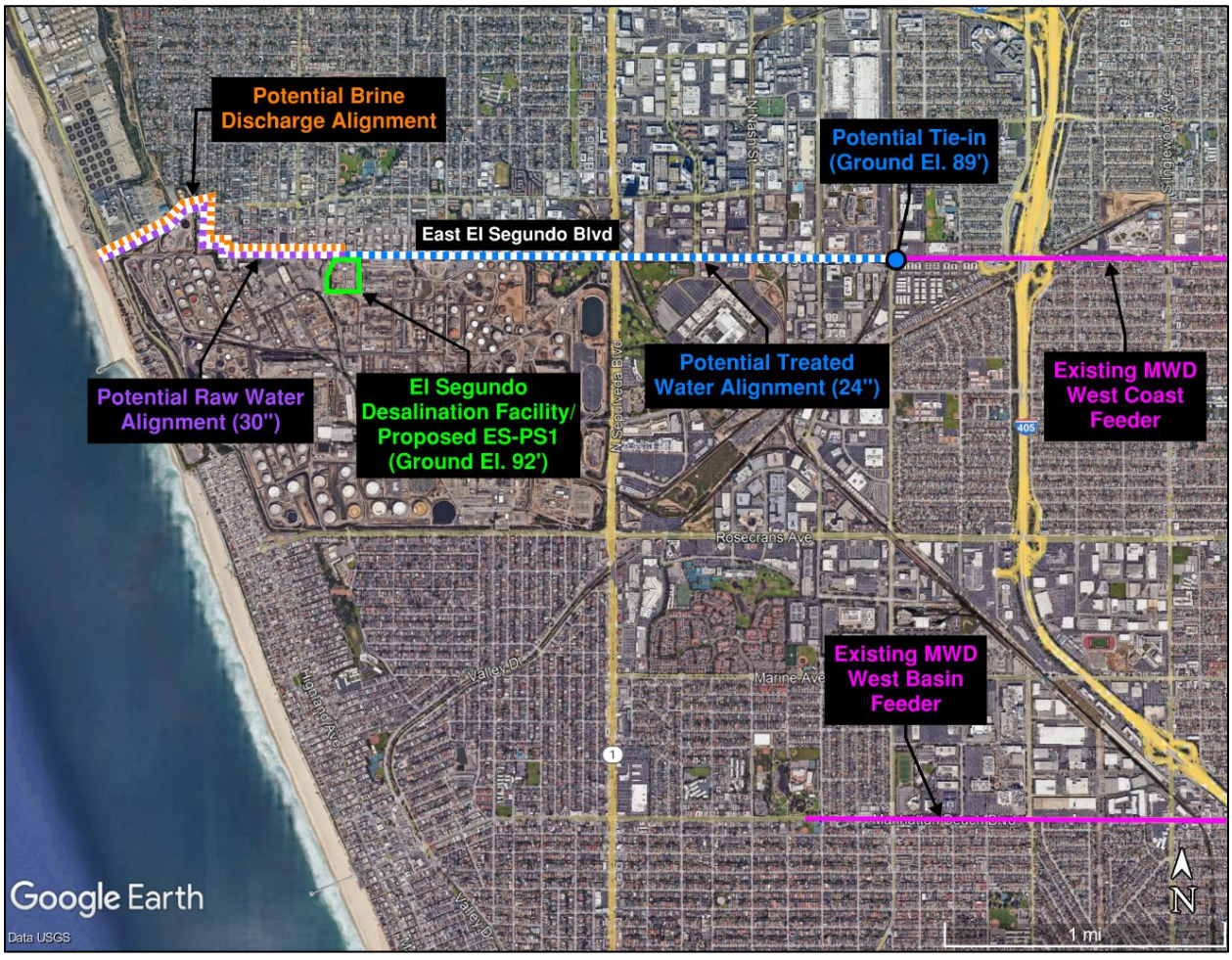


Figure 7.5 El Segundo Seawater Desalination Facility Potential Alignment

This OPCC has the following exclusions:

- Dewatering has not been included, as the available information does not suggest it would be required for the construction activities.

A contingency of 25 percent has been included to reflect the level of design uncertainty and potential unforeseen construction activities associated with this screening level evaluation.

7.2 Parametric Cost Factors

A set of parametric cost factors has been calculated using the OPCCs developed for the three potential seawater desalination sites. These factors can be used to perform a high-level cost estimate for other sites based on basic engineering definitions, such as capacities, intake type, number of slant wells, and pipe length and size. The cost factors are described in the following subsections and account only for the direct cost of each item. Indirect costs must be added separately, based on the specific conditions of each project. Additionally, it is important to consider the limitations of each factor, as outlined in the following sections.

7.2.1 Intake – Slant Wells

The cost of the intake will depend on the type of intake selected. The following cost factor has been determined for slant wells. The cost factor is defined per slant well, as it serves as a comparable and scalable base unit.

As stated in the basis of estimate, due to significant volatility in this type of work, CDM Smith cannot precisely determine where costs will stabilize. Therefore, two cost factors have been calculated as shown in **Table 7.1**, accounting for both low-end and high-end costs.

Table 7.1 Cost Factor for Slant Wells

Cost Factor	Low-End Value	High-End Value
Slant Wells, USD/Well	$5,453,000	$11,653,000

7.2.2 Treatment Plant

The cost of the treatment process is influenced by the type of treatment and its capacity. Additionally, there are associated economies of scale related to plant size; larger equipment or facilities tend to be more cost-efficient per unit produced. For this reason, a cost factor curve has been developed using the OPCCs and in-house data (**Figure 7.6**). This curve correlates the cost of the treatment plant with its capacity (C) in mgd, considering an applicable capacity range between 0 and 30 mgd.

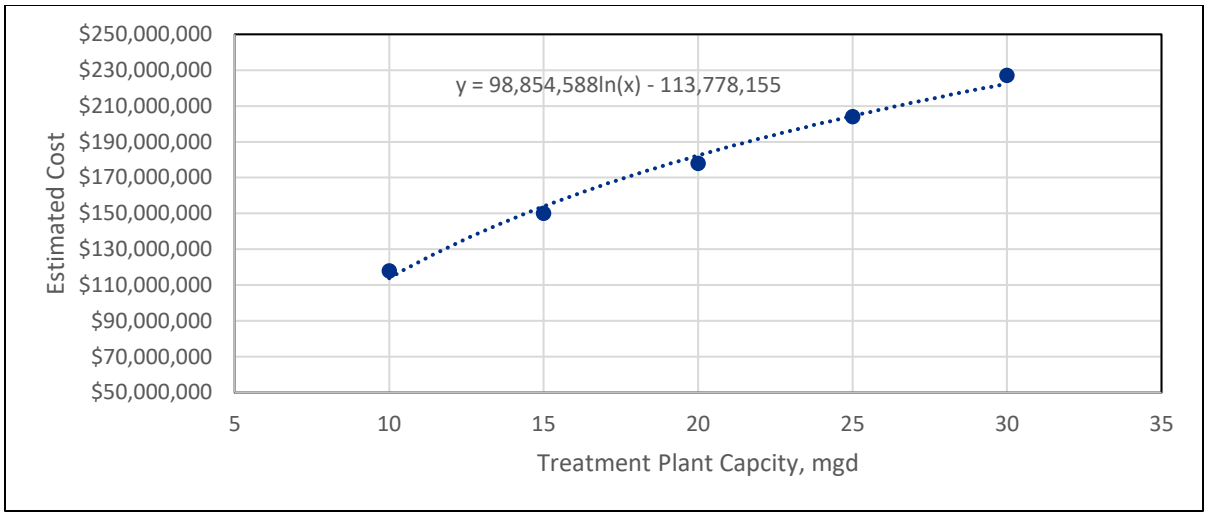


Figure 7.6 Treatment Process Cost Factor Curve

Other factors, such as the recovery rate, also impact treatment costs. The cost factor curve provided does not account for cost efficiencies associated with lower or higher recovery rates.

The cost factor is only applicable to onshore desalination.

7.2.3 Brine Concentrate Disposal

The cost of concentrate disposal is influenced by the outfall flow rate and pipe length. To establish a cost factor applicable to other sites, the cost factor is defined per unit length (linear feet) and pipe diameter (inches) and shown in **Table 7.2**. The construction method and other site-specific factors also impact outfall costs. Therefore, based on the OPCCs, the provided cost factor is only applicable to open-trench construction.

Table 7.2 Cost Factor for Brine Pipeline

Cost Factor	Value
Outfall Pipe, USD/ft/in	$34

These factors apply only to HDPE pipes and can be applicable to onshore pipes. Other site-specific factors or special construction requirements are not covered by these cost factors and must be accounted for separately.

7.2.4 Conveyance

7.2.4.1 Pump Stations

The cost of a pump station is influenced by its capacity and pump size. Based on the OPCCs, the cost factor is defined per capacity (mgd) and total head (TH, ft) of each pump station and shown in **Table 7.3**.

Table 7.3 Cost Factor for Pump Stations

Cost Factor	Value
Pump Station, USD/mgd/TH	$1,060

7.2.4.2 Pipeline

The cost of pipelines associated with conveyance pump stations is influenced by their diameter, unit length, and construction method. Based on this, the cost factor is defined per unit length (linear feet) and pipe diameter (inches) and is further differentiated by construction method, including open-trench and trenchless (micro tunneling - MTBM) construction as shown in **Table 7.4**.

Table 7.4 Cost Factor for Raw Water and Treated Water Pipelines

Cost Factor	Open-Trench	Trenchless (MTBM)
Conveyance Pipeline, USD/ft/in	$34	$110

These factors apply only to HDPE pipes and can be applicable to onshore pipes. Other site-specific factors or special construction requirements are not covered by these cost factors and must be accounted for separately.

7.3 OPCCs for Recommended Sites

This section summarizes the OPCC for each of the three potential seawater desalination sites based on the assumptions outlined in **Section 7.1**. The OPCCs in this section correspond to an ACCE Class 5 estimate, with a level accuracy range of -50 to +100 percent. Refer to **Section 7.1** for additional details of this Class definition. These OPCCs reflect facility-level capital costs based on defined intake, treatment, outfall, and limited system integration assumptions. They do not include broader regional conveyance, distribution to specific demand centers, or land purchase costs.

The OPCCs of the Doheny and El Segundo seawater desalination facilities have been developed based on the Port Hueneme cost estimate provided in **Appendix G** and scaled up based on cost factors and each site's characteristics.

7.3.1 Doheny Seawater Desalination Plant

The potential Doheny seawater desalination plant includes two system integration (tie-in) options described in **Section 7.1**. Consequently, two separate OPCCs have been developed for the conveyance system, as shown in **Table 7.5**. Additionally, due to uncertainties associated with slant well construction costs, a cost range has been considered.

Table 7.5 Opinion of Probable Cost for Potential Doheny Seawater Desalination Plant

Item	Tie-in Option 1 Cost	Tie-in Option 2 Cost
Slant Wells and Wellhead Pods	$32,718,000 - $69,918,000	$32,718,000 - $69,918,000
Well Pipe Beachside Conveyance	$3,960,000	$3,960,000
Well Pipe Header to Treatment Plant Conveyance	$8,633,000	$8,633,000
Subtotal – Intake	$45,311,000- $82,511,000	$45,311,000- $82,511,000
Treatment Plant to Outfall Conveyance	$839,000	$839,000
Subtotal - Outfall	$839,000	$839,000
Treatment Plant	$113,843,000	$113,843,000
Subtotal - Treatment Plant	$113,843,000	$113,843,000
Pump Stations Finished Water	$14,296,000	$21,761,000
Open Trench Conveyance	$3,966,000	$6,870,000
Trenchless Conveyance	$1,949,000	$2,974,000
Subtotal - Conveyance	$20,211,000	$31,605,000
Subtotal - Direct Cost	$214,816,000 - $270,616,000	$226,210,000 - $282,010,000
Allowances	$35,926,000 - $43,342,000	$38,197,000 - $45,613,000
General Conditions	$25,936,000 - $31,289,000	$27,575,000 - $32,929,000
Indirect Costs	$16,988,000 - $20,495,000	$18,062,000 - $21,569,000
Contractor Total OH&P	$31,086,000 - $37,504,000	$33,052,000 - $39,469,000
Subtotal - With Contractor OH&P	$290,140,000 - $350,034,000	$308,484,000 - $368,378,000
Contingency	$72,535,000 - $87,508,000	$77,121,000 - $92,094,000
Escalation to Mid-Point Construction	$85,591,000 - $103,260,000	$91,003,000 - $108,672,000
TOTAL	**$448,266,000 - $540,802,000**	**$476,608,000 - $569,144,000**

7.3.2 Port Hueneme Seawater Desalination Plant

The potential Port Hueneme seawater desalination plant utilizes slant wells for the intake; therefore, due to uncertainties associated with slant well construction costs, a cost range has been considered. (**Table 7.6**).

Table 7.6 Opinion of Probable Cost for Potential Port Hueneme Seawater Desalination Plant

Item	Cost
Slant Wells and Wellhead pods	$109,090,000 - $233,090,000
Well Pipe Beachside Conveyance	$24,096,000
Well Pipe Header to Treatment Plant Conveyance	$61,524,000
Subtotal - Intake	$194,710,000 - $318,710,000
Treatment Plant to Outfall Conveyance	$31,837,000
Subtotal - Outfall	$31,837,000
Treatment Plant	$178,000,000
Subtotal - Treatment Plant	$178,000,000
Pump Stations Finished Water	$38,962,000
Open Trench Conveyance	$85,695,000
Trenchless Conveyance	$10,628,000
Subtotal - Conveyance	$135,285,000
Subtotal - Direct Cost	$539,832,000 - $663,833,000
Allowances	$107,178,000 - $131,796,000
General Conditions	$77,641,000 - $95,476,000
Indirect Costs	$55,369,000 - $68,088,000
Contractor Total OH&P	$93,603,000 - $115,103,000
Subtotal - With Contractor OH&P	$873,623,000 - $1,074,296,000
Contingency	$218,406,000 - $268,574,000
Escalation to mid-point construction	$257,719,000 - $316,917,000
TOTAL	**$1,349,748,000 - $1,659,787,000**

7.3.3 El Segundo Seawater Desalination Plant

The potential El Segundo sweater desalination plant considers slant well intakes as well as using the property of the Chevron Refinery. The OPCC (**Table 7.7**) includes the land acquisition, slant wells and outfall connection, and works to integrate the treatment plant with the existing system. As the potential El Segundo seawater desalination facility utilizes slant wells for the intake a cost range has been considered for this item. This range also considered the low- and high-end cost factors for the acquisition of the Chevron Refinery land.

Table 7.7 Opinion of Probable Cost for Potential El Segundo Seawater Desalination Plant

Item	Low-End Cost Slant Wells and Land Acquisition	High-End Cost Slant Wells and Land Acquisition
Land Acquisition	$15,285,000	$28,322,000
Subtotal - Site Preparation	$15,285,000	$28,322,000
Slant Wells and Wellhead pods	$49,077,000	$104,877,000
Well Pipe Beachside Conveyance	$13,200,000	
Well Pipe Header to Treatment Plant Conveyance	$11,412,000	
Subtotal - Intake	$73,689,000	$129,489,000
Treatment Plant to Outfall Conveyance	$17,314,000	
Subtotal - Outfall	$17,314,000	
Treatment Plant	$113,843,000	
Subtotal - Treatment Plant	$113,843,000	
Pump Stations Finished Water	$7,346,000	
Open Trench Conveyance	$1,000,000	
Trenchless Conveyance	$990,000	
Subtotal - Conveyance	$9,336,000	
Subtotal - Direct Cost	$229,467,000	$298,304,000
Allowances	$44,728,000	$58,145,000
General Conditions	$32,903,000	$42,774,000
Indirect Costs	$24,254,000	$31,530,000
Contractor Total OH&P	$39,762,000	$51,690,000
Subtotal - With Contractor OH&P	$371,114,000	$482,443,000
Contingency	$92,778,000	$120,610,000
Escalation to mid-point construction	$109,478,000	$142,320,000
TOTAL	**$573,370,000**	**$745,373,000**

7.4 Total Costs for Recommended Sites

Combined capital and O&M cost estimates are presented in **Table 7.8** and include the low end and high end of the estimated total cost. O&M costs include variable costs such as energy, chemicals, membrane replacement, waste disposal as well as fixed costs such as labor, permit compliance, indirect costs, and maintenance. Capital costs were annualized over 30 years, using a 5 percent interest rate. Annualized

capital costs were added to annual O&M costs to arrive at the total annualized cost. For further details of the summaries presented in **Table 7.8**, see **Appendix H**.

Major cost drivers for the potential Doheny seawater desalination plant include utilization of an existing site and outfall, short conveyance, and the site having an expandable layout. Major cost drivers for the potential Port Hueneme seawater desalination plant include long conveyance (approximately 153,000 LF), three pump stations, and a large slant well field. Major cost drivers for the potential El Segundo seawater desalination plant include construction in a densely urban area and land acquisition.

Table 7.8 Comparative Total and Unit Capital Cost Summary for Recommended Sites[1]

Site	Capacity (mgd)	Estimated Capital Cost (Low-High)	Unit Capital Cost ($M/mgd)	Unit Capital Cost ($K/AFY)	Annualized Capital Cost ($M/yr)	Estimated O&M Cost ($M/yr)	Total Annualized Cost ($/AF)
Doheny[2]	10	$448-569M	$45-57	$40-51	$29-37	$19	$4,300-5,000
Port Hueneme	20	$1.35-1.66B	$68-83	$60-74	$88-108	$39	$5,700-6,600
El Segundo	10	$573-745M	$57-75	$51-67	$37-48	$19	$5,100-6,100

[1]Costs shown exclude conveyance and distribution infrastructure beyond identified system integration tie-in points. Land acquisition is included only where explicitly stated (e.g., El Segundo).

[2]Doheny capacity is for expansion over the existing planned 5 mgd capacity.

7.5 Basis of Schedule

Using the preliminary siting and technical studies completed under this effort, CDM Smith developed planning-level project schedules to support a more detailed evaluation of the top-ranked seawater desalination projects. This section summarizes the basis of the schedules prepared for the three highest-ranked projects, which encompass major project phases including planning, permitting, design, and construction for the seawater intake and outfall facilities, desalination treatment plant, and associated conveyance systems. Schedule durations are conceptual and do not reflect commitments or negotiated timelines with regulatory agencies.

7.5.1 General

7.5.1.1 Scope of Work

The scope of work for each project, including production capacity, intake and outfall type, location, and specific site characteristics, is provided in **Section 4**. Pumping station and conveyance system definitions are detailed in **Section 5**.

7.5.1.2 Execution Strategy

One factor that influences schedule is the project delivery approach. Project delivery approaches are presented in **Section 8**. The delivery approach(es) will be selected in the future if Metropolitan chooses to advance any of these potential projects. It was assumed for the purposes of this report that the projects will be executed using a traditional Design-Bid-Build approach.

The estimated schedule provides a breakdown and timeline of each project's main activities from planning through construction. It includes the following main activities:

- Permitting
- Design
- Land Procurement (if applicable)
- Pre-Procurement (if applicable)
- Bid/Award process
- Construction, Commissioning, and Startup

Permitting

Permitting includes activities associated with CEQA, WRCB, the Regional Board, the CCC, and DDW, as outlined in **Section 6**.

The permitting activities duration has been adjusted based on the unique elements of each project. Additional details are provided in **Section 7.5.2**.

Even though piloting is not a specific DDW requirement, piloting is common for optimizing design criteria and evaluating alternatives. While piloting is sometimes conducted concurrent with the preliminary design, completing the piloting early would allow for the lessons learned to be incorporated into the regulatory review process and final design. An early piloting schedule has been included in the three alternatives in the event that it is utilized. Piloting should be planned to last for a minimum of two years, allowing time for design, procurement, start-up and at least one year of operation.

Design

This activity encompasses the conceptual through 100% design phases, including all applicable disciplines required to develop these types of projects before advertisement. The specific design duration is provided in **Section 7.5.2**.

Land Procurement

Depending on the alternative, land procurement may be necessary. The estimated schedule considers the timing for land procurement based on each site's specific needs per **Section 7.5.2** definitions.

Pre-Procurement

Pre- procurement activities focus on long lead items for both the desalination treatment plant and the conveyance system, including:

- Intake pumps (slant well pods)
- Major pumps (transfer pumps, RO high pressure pumps, treated water pumps, conveyance system pumps)
- Energy recovery devices
- Major electrical equipment

- SCADA system
- One year of pre-procurement activities has been assumed for all three projects, running in parallel with the final phase of design.

Bid/Award Process

After completing 100% design, a bidding process of six months before the construction period has been considered for the three projects.

Construction, Commissioning, and Startup

Construction duration of all three projects has been assumed according to the corresponding scope of work. The specific construction duration for each of them is provided in **Section 7.5.2**.

A commissioning and startup period has been considered after the completion of construction. Commissioning activities can be performed by systems and subsystems before the end of construction to expedite the schedule, if a more aggressive approach is needed. For the purposes of this TM, a more conservative approach has been assumed, considering that commissioning should start once construction is complete.

7.5.1.3 Litigation, Mitigation, and Unforeseen Activities

Even with the most careful planning and conservative implementation approach, most projects would still face challenges and setbacks throughout the project development. This is particularly true for seawater desalination projects, many of which have faced multiple lawsuits and permit appeals across various permitting agencies. The Carlsbad desalination facility is reported to have faced eight lawsuits and five permit appeals, all of which had been resolved in the project's favor by 2011. The Monterey Peninsula Water Supply Project has faced 11 lawsuits throughout its history. One of the lawsuits, led by neighboring water agencies, addresses groundwater extraction limit and groundwater basin harm claims, related to the project's slant wells. This case proceeded to trial in November 2025, with proceedings extending into early 2026; as of the latest publicly available records, a final judgment has not yet been issued. The outcome of this litigation could influence project implementation and highlights the potential for extended legal processes even after key environmental and regulatory approvals have been obtained.

A seawater desalination project in California would need to incorporate a comprehensive suite of mitigation measures to address potential and perceived impacts. These measures typically focus on marine ecosystem protection and GHG emissions, with mitigation measures having a potential effect on the overall project schedule. On the marine side, regulatory agencies have required proponents to mitigate for impingement and entrainment impacts from screened ocean intakes. This may involve habitat preservation, restoration, or enhancement projects, such as coastal wetland or lagoon restoration, eelgrass bed reestablishment, artificial reef or kelp bed enhancement, or contributions to marine hatchery programs. These measures may demand early feasibility studies, life-cycle cost–benefit evaluations, and alignment with local, state, and federal agency requirements, all of which can extend permitting timelines. In addition, "out-of-kind" mitigation may be necessary where direct habitat replacement is not feasible, requiring further consultation and agreement among agencies, which can add time to the approval process.

Similarly, GHG and energy mitigation requirements under California's CEQA process and local Climate Action Plans require development of a detailed "Energy Minimization and GHG Reduction Plan". This involves quantifying the facility's carbon footprint, identifying energy efficiency measures, and often committing to renewable energy purchases or partnerships (e.g. solar, wind, or carbon sequestration projects). As demonstrated in the Carlsbad seawater desalination facility, navigating agency requirements and achieving a "carbon neutral" or "carbon zero" status involves both technical design and stakeholder engagement. These steps frequently require additional environmental review cycles, coordination with power providers, and, in some cases, construction of off-site mitigation projects, all of which add complexity and can extend project schedules by a year or more depending on the scale of the mitigation commitments.

A mitigation bar has been incorporated into each schedule concurrent with the construction phase. Mitigation activities may, in certain cases, extend beyond the completion of construction, depending on project-specific commitments. Unforeseen activities and potential litigation cannot be explicitly incorporated into the schedule, as their durations are inherently variable and dependent on their specific nature and complexity, ranging from months to years. Accordingly, it is recommended that Metropolitan consider appropriate contingencies to account for potential delays.

7.5.2 Specific Assumptions by Site

7.5.2.1 Doheny Seawater Desalination Plant

Intake, Outfall, and Seawater Desalination Plant

The potential Doheny seawater desalination plant has a production capacity of up to 10 mgd, considers subsurface slant wells to obtain the required seawater and uses the existing SJCOO to discharge the reverse osmosis concentrate.

The treatment plant is designed with a standard treatment process based on the expected seawater quality from slant wells. The treatment process includes single-stage pressure filtration followed by cartridge filters, a two-pass reverse osmosis system, and post-stabilization treatment and storage. This expansion would be located on the same site as Phase 1; minimal additional land acquisition is required to locate additional slant wells.

It's worth noting that the slant wells' capacity required to produce 10 mgd of treated water must be confirmed through offshore drilling, which may indicate the presence of viable offshore targets from the campground area. If the slant wells' capacity is found to be less than 20 mgd, the treatment plant would need to be downsized accordingly, based on the confirmed maximum capacity of the slant wells. For the purposes of this study, 10 mgd of treated water capacity is assumed.

Conveyance System

Section 5 analyzed two system integration alternatives:

- Tie-in Option 1: Two pump stations co-located at the desalination facility, which would tie-in to the existing JTM and the existing WIP.

- Tie-in Option 2: This option would allow the new supply to be conveyed to both the JTM and the South County Pipeline. Three new pump stations would be required including two pump stations co-located at the desalination facility and one new pump station near the Tri-Cities PRS.

For the purposes of this study and considering the level of detail of the estimated schedule, a similar duration has been considered for both integration alternatives.

Permitting

Under CEQA, a seawater desalination plant would require a full EIR. Since Phase 1 of the DODP has already completed an EIR, a duration of one year has been assumed for the project expansion, as many baseline studies have already been conducted.

A three-year duration has been assumed for each of the rest of the permits, including:

- SWRCB – Ocean Plan Consistency Determination
- Regional Board – Section 401 & NPDES Permit
- CCC – CDP Permit

DDW Permit studies would start during the planning phase through design, and final permit would be granted after construction completion.

Design

A two-year design phase has been assumed for this site based on the existing infrastructure, production capacity, characteristics and system integration requirements.

Land Procurement

The potential Doheny seawater desalination plant does not require land procurements, as it will be located at the site of the Phase 1 project.

Construction, Commissioning, and Startup

A three-year construction period has been considered for this project based on its characteristics and the conveyance system requirements. Pump station construction would be executed in parallel.

Based on the project complexity, and expected numbers and capacities of equipment, a four-month commissioning and startup period has been considered at the end of construction.

7.5.2.2 Port Hueneme Seawater Desalination Plant

Intake, Outfall, and Seawater Desalination Plant

The potential Port Hueneme seawater desalination plant has a production capacity of 20 mgd and considers subsurface slant wells to obtain the required seawater and uses an existing Oxnard WWTP Outfall to discharge the reverse osmosis concentrate.

The intake system consists of twenty slant wells grouped into five wellhead pods.

The treatment plant is designed with a standard treatment process based on the expected seawater quality from slant wells, similar to Doheny except for the capacity. The process includes single-stage

pressure filtration followed by cartridge filters, a two-pass reverse osmosis system, and post-stabilization treatment and storage.

The outfall includes the partial demolition of existing pavement to facilitate the construction and installation of 200 feet of 42-inch HDPE pipe, connecting the treatment plant outlet to the Oxnard wastewater outfall.

Conveyance System

The conveyance system components are depicted in **Section 5**.

The potential alignment from the desalination facility to the LBWFP clearwells includes approximately 153,100 LF of new 40-inch pipe, 7,800 LF of existing 66-inch pipe, ten trenchless crossings (associated with the crossing of railroads, highways, and major intersections along the potential alignment), and three pump stations.

Permitting

Under CEQA, the potential Port Hueneme seawater desalination plant would require a full Environmental Impact Report (EIR). Since no previous studies have been performed for this site and based on its production capacity and site size, a duration of three years has been assumed.

A three-year duration has been also assumed for each of the rest of the permits, including:

- SWRCB – Ocean Plan Consistency Determination
- Regional Board – Section 401 & NPDES Permit
- CCC – CDP Permit

DDW Permit studies would start during the planning phase through design, and final permit would be granted after construction completion.

Design

A four-year design phase has been assumed for this site based on its capacity, characteristics and system integration requirements.

Land Procurement

The potential site for the seawater desalination facility is within the Port Hueneme Naval Base and in the Oxnard Plain. The estimated schedule considers six months for the agreement with the Naval Base.

Construction, Commissioning, and Startup

A four-year construction period has been considered for this project based on its characteristics and the conveyance system requirements. Pump station construction would be executed in parallel.

Considering that the potential Port Hueneme seawater desalination plant has a 20 mgd capacity, more equipment and a more complex overall system, a six-month commissioning and startup period has been considered after construction completion.

7.5.2.3 El Segundo Seawater Desalination Plant

Intake, Outfall, and Seawater Desalination Plant

The potential El Segundo seawater desalination plant would rely on the construction of new subsurface slant wells to supply the seawater desalination facility. The closest existing desirable outfall to this site is the Hyperion Wastewater Outfall. The treatment plant would have a 10 mgd production capacity

The treatment process includes single-stage pressure filtration followed by cartridge filters, a two-pass reverse osmosis system, and post-stabilization treatment and storage.

Conveyance System

The conveyance system components are depicted in **Section 5**. The potential alignment from the desalination facility to the tie-in point includes approximately 10,600 LF of new 24-inch pipe and five trenchless crossings (associated with the crossing of railroads, highways, and major intersections along the potential alignment), and one pump station located at the plant site.

Permitting

Under CEQA, this project would require a full EIR. Since no previous studies have been performed for this project, a duration of two years has been assumed.

A three-year duration has been assumed for each of the rest of the permits, including:

- SWRCB – Ocean Plan Consistency Determination
- Regional Board – Section 401 & NPDES Permit
- CCC – CDP Permit

DDW Permit studies would start during the planning phase through design, and final permit would be granted after construction completion.

Design

A three-year design phase has been assumed for this site based on its capacity, characteristics and system integration requirements.

Land Procurement

Initial planning assumed that the El Segundo Power Plant site would be decommissioned and available for redevelopment. However, NRG Energy indicated this will not be feasible to consider at this time. Four of the locations were identified as potential suitable alternative locations for the potential El Segundo seawater desalination facility.

For the purposes of this study, a one-year land procurement period has been considered to acquire the corresponding land. This activity would start after the CDP Permit is issued and would run in parallel to design.

Construction, Commissioning, and Startup

A three-year construction period has been considered for this project based on its characteristics and the conveyance system requirements. This duration includes the brine concentrate conveyance pipe to

the Hyperion Wastewater outfall that would need to be built in parallel to the seawater desalination treatment plant.

A four-month commissioning and startup period has been considered at the end of construction.

7.6 Estimated Schedules for Recommended Sites

This section summarizes the schedules for each of the top three ranked projects based on the assumptions outlined in **Section 7.4.2**.

7.6.1 Doheny Seawater Desalination Plant

The estimated schedule for this project is provided in **Figure 7.7**. Based on the specific requirements of this project, the total estimated duration from the planning phase to construction completion is 9.5 years.

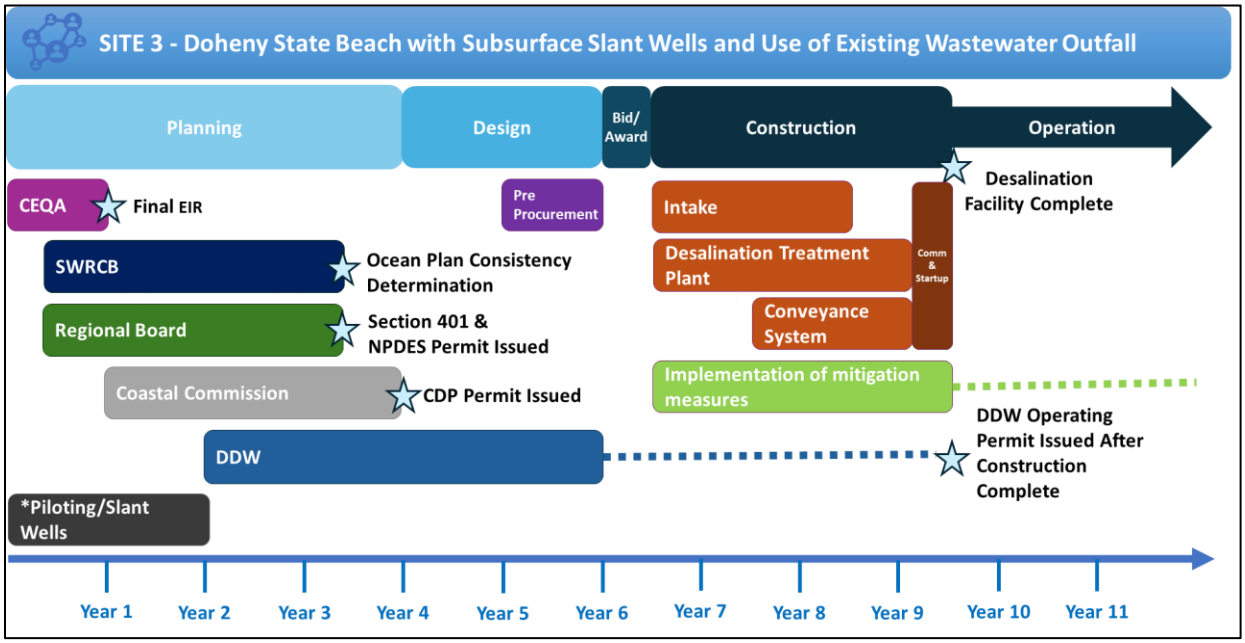


Figure 7.7 Potential Doheny Seawater Desalination Plant Estimated Schedule

7.6.2 Port Hueneme Seawater Desalination Plant

This project provides the largest treatment plant (based on production capacity) among the three potential projects. In addition, this project involves three pump stations and 153,100 linear feet of new pipeline for system integration. Based on these and other assumptions outlined in **Section 7.5.2**, the total estimated duration for this alternative is estimated to be 12.5 years and is shown in **Figure 7.8** below.

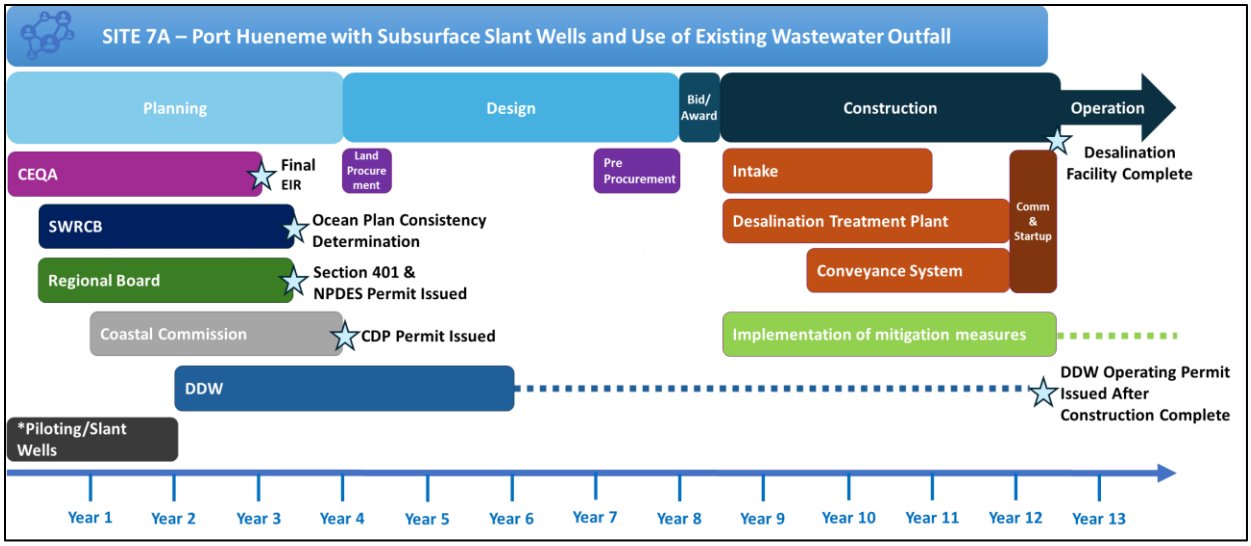


Figure 7.8 Potential Port Hueneme Seawater Desalination Plant Estimated Schedule

7.6.3 El Segundo Seawater Desalination Plant

Figure 7.9 presents the estimated schedule for the potential El Segundo seawater desalination plant. Considering the unique characteristics of this alternative (new site, no base line studies, and production capacity), the overall timeline from planning to construction completion is projected to be 10.5 years.

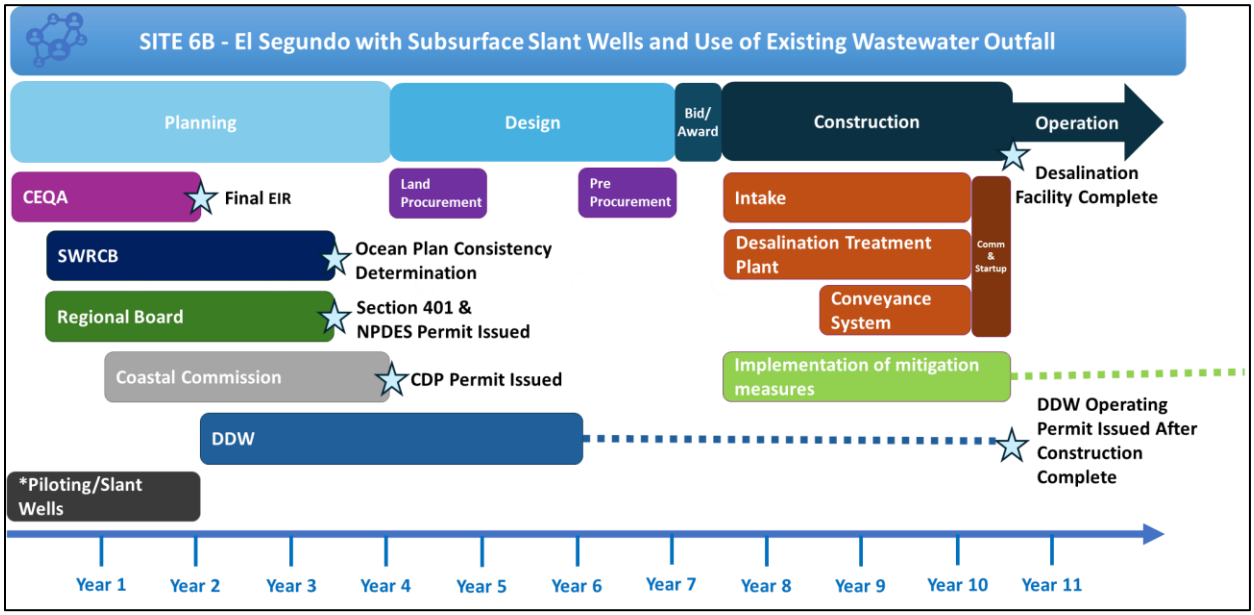


Figure 7.9 Potential El Segundo Seawater Desalination Plant Estimated Schedule

8.0 Funding and Partnership Opportunities

This section describes potential partnering and financing approaches for three seawater desalination sites. Alternative project delivery methods are discussed because the availability, structure, and effectiveness of partnering and financing arrangements are closely linked to the selected delivery model. The partnership, financing, and delivery concepts discussed in this section are exploratory and were developed to inform potential future implementation pathways. No partnership agreements, funding commitments, or delivery selection are implied by this study.

Metropolitan's potential involvement in developing these desalination sites should be informed by three overarching considerations: the strategic role of desalination within Metropolitan's water supply portfolio, financial and balance sheet objectives, and the desired allocation of risk and control across project delivery, ownership, and operations.

8.1 Considerations for Project Delivery and Partnerships

8.1.1 Key Considerations on Partnerships/Financing Models

The three overarching considerations identified above directly influence suitability of alternative partnership structures and financing approaches:

- **Strategic Role of Desalination:** Metropolitan must define the role that seawater desalination would play within its overall water supply portfolio, including how desalinated supplies would support reliability, drought resilience, and long-term system flexibility.
- **Financial and Balance Sheet Considerations:** Metropolitan must consider whether and to what extent it seeks to limit the addition of debt service obligations associated with desalination investments, and how alternative delivery and financing structures could affect its balance sheet.
- **Risk Allocation and Level of Control:** Metropolitan must determine the desired level of control over facility design, construction, and operations, and the extent to which project risks would be retained by Metropolitan or transferred to third-party partners.

8.1.2 Key Risk Factors Associated with Seawater Desalination Plants

Regarding Question 3 above, seawater desalination projects present risks that are pertinent to partnership decisions. Key project risk factors are highlighted in **Table 8.1**.

Table 8.1 Project Risk Factors

Type of Project Risk Factor	Description
Performance Requirements/Demand	Risk that actual performance requirements and/or demand will differ from plans, including (1) planned demand risk, where actual water demand is lower or higher than projected in long-term planning, and (2) wet-year demand risk, where unusually wet years reduce the need for desalinated water, potentially leading to underutilization of the facility.
Planning/Permitting Approvals	Risk that environmental study outcomes and community consultation may affect project viability, including permit denial or significant environmental and community opposition and litigation.
Design	Risk that project design is faulty, leading to unexpected construction costs or operational problems in meeting performance requirements.
Construction	Risk that construction will exceed budgeted cost, contain faults and be completed late.
Operation	Risk that required performance will not be achieved because of operational problems (e.g., membrane fouling, forced shutdown due to algal blooms, power outages, staff turnover).
Financial	Risk caused by changes in interest rates, inflation, financing, taxes, financial ability, security on loans, and rising cost or lack of available energy.
Commercial	Risk that changes to the corporate environment, e.g. structure of successful bidding company or consortium, taxation, insurance, viability and other rates and charges may affect project viability.
Government Policies	Risk that state or federal government may change policies that affect project viability.
Climate Risk and Location Hazards	Risk that energy use and emissions issues arise. Examples include sea level rise, extreme weather events, and seismic/geologic hazards.
Political	Risk related to public perception or criticism; i.e., ultimate responsibility for performance of the system.

Building a seawater desalination plant in California requires numerous permits and approvals from various regulatory agencies, which requires considerable time and effort. Obtaining permits for the Claude “Bud” Lewis Carlsbad Desalination Plant took 13 years. Typical permits and approvals needed include:

- **EIR:** The EIR assesses the potential environmental impacts of the project and suggests measures to mitigate those impacts. It includes public review and input.
- **CEQA Compliance:** Projects in California must comply with CEQA, which requires informing decision-makers and the public about potential environmental impacts.
- **CCC Approval:** If the project is located in a coastal area, CCC approval is necessary. This includes considerations for energy efficiency and greenhouse gas mitigation.
- **State Water Quality Control Board Permits:** These permits are required to confirm that the project complies with water quality standards and regulations.
- **State Lands Commission Approval:** If the project involves the use of state-owned lands, approval from the State Lands Commission is required.
- **Local Government Permits:** Various local government permits may be needed, including building permits, zoning approvals, and other local regulatory requirements.

- **Greenhouse Gas Mitigation Plan:** This plan outlines measures to offset greenhouse gas emissions associated with the project.
- **Impingement/Entrainment Mitigation Plan:** This plan addresses the impacts on marine life caused by seawater intakes.

8.1.3 Basic Options for Use of the Product Water

The partnership opportunities are also affected by how the water is going to be delivered. There are two basic options for use of the desalinated product water that affect the nature of possible partnerships: 1) Direct sale of the water to local agency or agencies and 2) Developing a water exchange. Both are discussed below.

8.1.3.1 Direct Sales

Direct sale of the water to a local agency is institutionally simplest. This local use of the product water offsets the imported water purchases that the local agency(ies) currently make. The cost of the desalinated water can be melded into the cost of all of Metropolitan's supplies and sold at Metropolitan's treated water rate.

Also, like most water infrastructure, seawater desalination plants are most economical when they run at full capacity. To be efficient, the local agency must have enough year-round imported water demand to buy the full desalination supply capacity, and to reduce their imported water purchases commensurately. Otherwise, excess product water must either be stored, or the plant capacity must be throttled back, which is costly and operationally complex.

Alternatively, the local agency(ies) could be asked to leave their local supplies, such as groundwater, unused or unpumped during low imported water demand periods to accommodate the desalinated water. Local agencies would likely be reluctant to reduce use of local supplies without some form of compensation, which affects the economics of the desalinated supply.

8.1.3.2 Exchanges

A water exchange would entail structuring agreements to allow purchasers and investors in the seawater desalination plant to indirectly access the product water by exchanging the reduction in local imported water demand caused by introducing the desalinated water supply with another of Metropolitan's imported supplies (such as Colorado River water or State Project Water) that the purchaser can access. For example, desalinated water could be delivered/metered to member agency's system and Metropolitan would forgo an equivalent amount of Colorado River water. This water would, through legal agreements, be dedicated to the purchaser (for example, Southern Nevada Water Authority [SNWA]) and pumped/metered from their connection to the Colorado River.

Making water available to parties on the Colorado River would require the development of exchange agreements that potentially involve international parties.

8.1.4 Partnerships

Seawater desalination partnerships have at least three dimensions:

- Required partnering with local agencies to deliver the water (whether directly or by exchange).

- Potential partnering with the private sector for project delivery (including financing).
- Partnering with other utilities to exchange water (e.g., in Arizona or Nevada).

Each of these will be considered later under discussion about each of the three potential sites. The three questions will be revisited in **Section 8.3**.

8.2 Seawater Desalination Plant Project Delivery Approaches

Before a discussion of the potential partnership/financing opportunities can occur, it is important to understand how the delivery models manage risk and affect the partnerships/financing discussion. The next section is a brief overview of project delivery alternatives. A formal process to select the appropriate approach is needed as the trade-offs across these approaches are significant and must align with the owner's philosophy and risk tolerance.

Such an evaluation is often conducted by an Owner's Agent (OA). An OA acts in the interest of the Owner on all phases of a construction project beginning with conceptualization of the project through commencement of operations at the newly built or acquired facility. The OA's duties, which are specifically outlined in an agreement with the Owner, allow the OA to act as a liaison between the Owner and the architects, engineers, general contractors, and construction managers. The role of the OA is to work with project management teams, internal or external, on a daily basis to assess progress and identify any issues as well as answer routine Owner questions, scrutinize overall project performance, evaluate change order requests, and provide insight and analysis that enable the Owner to make more informed decisions during all phases of the project. The OA's interests are aligned with the Owner's interests, and the OA can, if authorized to do so, act as the experienced eyes and ears of the Owner who will likely not have the time available themselves to sufficiently monitor the project as closely as needed. The Owner and the OA accept the relationship of trust, good faith and fair dealing, and fully cooperate with each other and any other consultants working on the project.[18]

A range of project delivery approaches are available and are characterized primarily by the role of the owner and who owns the different risks (as summarized above). In this report, Public-Private Partnership (PPP or P3) is used as an umbrella term for long-term contractual arrangements in which a private partner may design, finance, build, and/or operate a public facility, with risk allocation defined by the contract. The willingness to assume risk varies across owners, designers, and contractors and varies over time and market conditions, project experience, and availability of affordable insurance. Grants and loans would be available under any delivery approach as long as Metropolitan (or some public agency) retained some or all ownership.

Much has been written on this topic; a good summary of current thinking on Alternative Project Delivery may be found at the National Academy of Construction website[19]. The December 2010 Study on Alternative Project Delivery Methods (managed by the author) evaluated various options for the Dana Point Desalination Plant. They are described further below. That project is currently being delivered through a Progressive Design-Build-Operate and Maintenance (DBOM) approach.

[18] http://aghllaw.com/wp-content/uploads/2017/05/Role-of-a-Owners-Agent.pdf
[19] https://www.naocon.org/wp-content/uploads/Alternative-Project-Delivery-Methods.pdf

Metropolitan is currently only able to utilize Design Build and Progressive Design Build per the administrative code: §8148. Alternative Project Delivery In lieu of the public works procurement process described in Section 8142, the District may utilize the following three alternative project delivery methods for a public works project: design-build, progressive design-build, or construction manager/general contractor. All other project delivery methods would require a change in the Administrative Code. It is likely that labor unions would have a significant viewpoint on the selection of other alternative project delivery methods.

8.2.1 Alternative Project Delivery

The Alternative Project Delivery options include:

- Engineering, Procurement, Construction, and Management (EPCM)
- Design-Bid-Build (DBB)
- Construction Manager (CM)
- Construction Manager at Risk (CMAR)
- Design-Build (DB)
- Design-Build-Operate (DBO)
- Build Own Operate (BOO)
- Build Own Operate Transfer (BOOT)
- Alliance

The following sections contain a brief description of these models.

8.2.1.1 Engineering, Procurement, Construction, and Management

In the EPCM method, the owner (Metropolitan) contracts with a single organization (company) to provide all engineering, procurement, construction, and management. For a fee, this entity manages design, multiple subcontracts, owner-furnished equipment, and commissioning, through a professional services contract as shown in **Figure 8.1**.

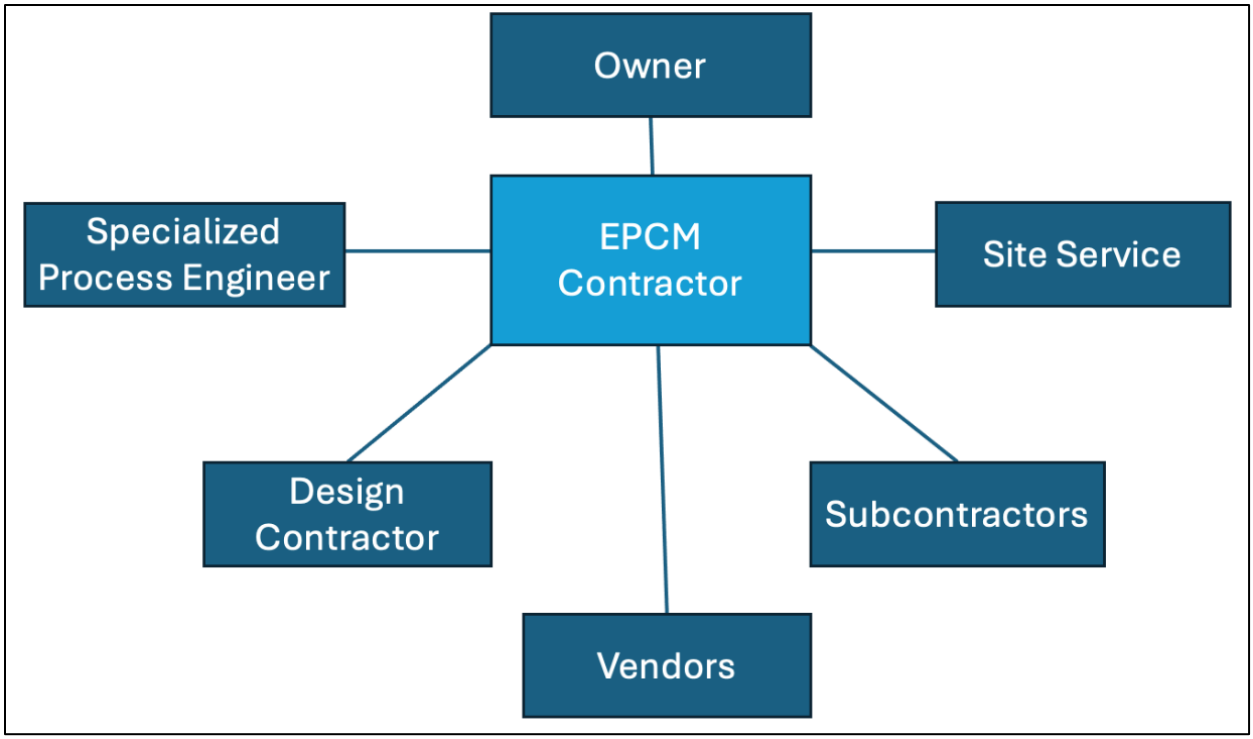


Figure 8.1 Engineering, Procurement, Construction, and Management

Individual contracts between the owner and the company are let, which allocate risk. The EPCM company has only a management role. **Table 8.2** presents the advantages and disadvantages of EPCM.

Table 8.2 Advantages and Disadvantages of Engineering, Procurement, Construction, and Management

Advantages	Disadvantages	Contract Form
EPCM is suitable for large projects where the owner has inadequate staff resources to manage the project.	The owner typically bears the risks associated with cost.	Cost reimbursable (may include certain negotiated fixed overheads).
EPCM is good for fast-track projects.	Legal costs can be higher to negotiate multiple contracts.	
▪ EPCM allows extensive owner interaction throughout the project delivery process. ▪ This could include modifying project specs as there are multiple contracts and not a single, over-arching contract.	▪ Substantial owner involvement is needed to confirm specific requirements are understood by the EPCM contractor. ▪ Increased owner effort is required because of the heavy involvement in day-to- day operations.	
Lower overall cost, no mark-up due to contract risk; owner retains competitive pricing advantage.	Schedule risk lies with the owner.	
Owner staff sense of ownership strengthened.	Potential for gap in scope coverage between the contractor and vendors/suppliers.	
More control over process.	High level of interface risk between EPCM members.	
More transparency on project costs.		

Advantages	Disadvantages	Contract Form
Owner's financing flexibility.		
Well-suited for less defined projects with anticipated changes to scope of the contract/supply chain.		
Less litigation—teams can identify issues early and remedy situation before larger problems arise.		
Provides a turn-key solution.		

This method is very popular for mining projects where the owner has clear requirements for production and quality of equipment. It is gaining popularity in the petrochemical, power, and desalination areas.

Two examples of EPCM delivered seawater desalination plants include:

- Sorek Desalination Plant, Israel: One of the largest seawater reverse osmosis plants was delivered using an EPCM approach (it is also an example of a BOOT discussed below). The project involved extensive engineering and procurement phases to provide efficient operation.
- Carlsbad Desalination Plant, California: This facility used EPCM delivery to manage the complex integration of various systems and technologies, ensuring compliance with environmental regulations and operational efficiency.

8.2.1.2 Design-Bid-Build

The DBB project delivery method is traditionally used by Metropolitan and is depicted in **Figure 8.2**.

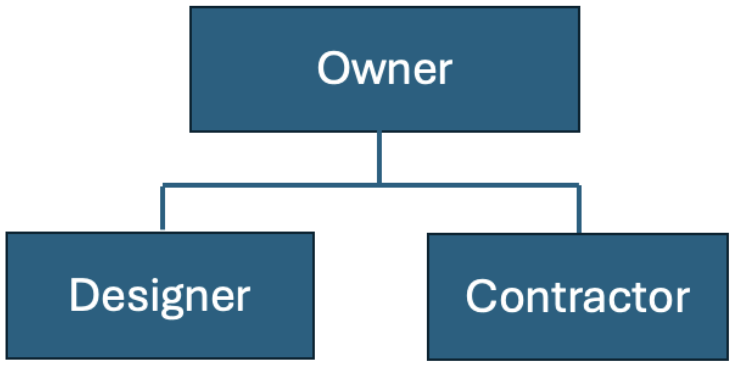


Figure 8.2 Schematic of Design-Bid-Build Participants

The process entails a designer preparing preliminary and detailed drawings, a bid being let, and a contract let for construction.

It involves the owner appointing a project manager to sequentially manage performance requirements, investigations (including providing significant input), and pursuing planning approvals followed by separate stages for design and construction through lowest cost-competitive bidding. The owner requirements can be incorporated on design issues and operational requirements. Once acceptance testing occurs, the owner takes over operations.

DBB relies on the skill and experience of the design engineer(s) together with owner oversight to deliver the seawater desalination facilities rather the competitive pressure employed by other methods.

The design risk lies with the design consultant. Construction risk lies with the contractor. The project manager holds the contract administration risk. The owner assumes the operations, financial, demand, and planning risks.

There is standard documentation for supply of professional services, and low contractual risk because of the large amount of work done this way. The technical documentation needs to be of a high standard to minimize contractual disputes. **Table 8.3** depicts advantages and disadvantages of DBB.

Table 8.3 Advantages and Disadvantages of Design-Bid-Build

Advantages	Disadvantages	Contract Form
DBB is commonly used in the U.S., and most water utilities are generally comfortable with it.	Usually takes longer to deliver the project as tasks are sequential.	Cost reimbursable(design); (may be lump sum or fixed price design for all or portion of design in select instances; fixed price/lump sum (construction); unit rate or adjustment factors may also apply
The owner maintains significant control and can specify the desired features and control design.	▪ The designer, constructor, and operator are not integrated, and some risk of "finger-pointing" exists. ▪ If problems arise, disputes on responsibility can be difficult to resolve. ▪ Owner responsible for design errors and omissions	
The owner can react to site conditions through a schedule of rates contract.	There is limited post-design innovation/cost savings.	
Competitive construction prices for the design can be obtained.	Limited or no early contractor involvement.	
Maximizes risk transfer to contractor.	The owner must staff operations.	
Less costly to administer.	Contracts can be adversarial in nature risking litigation.	

Where the project involves little scope innovation, DBB is often the best approach. DBB is also suited for projects involving expansion of existing works where conforming to the overall design of the facility is needed. A variation on this approach is called "multiple primes" where, instead of one contractor selected for construction, multiple contracts are let.

8.2.1.3 Construction Manager

Both CM and CMAR are variations to the DBB approach. With CM or CMAR, the build portion of the project may involve multiple contractors with the owner supplementing their oversight capabilities with a dedicated construction manager. **Figure 8.3** depicts CM participants.

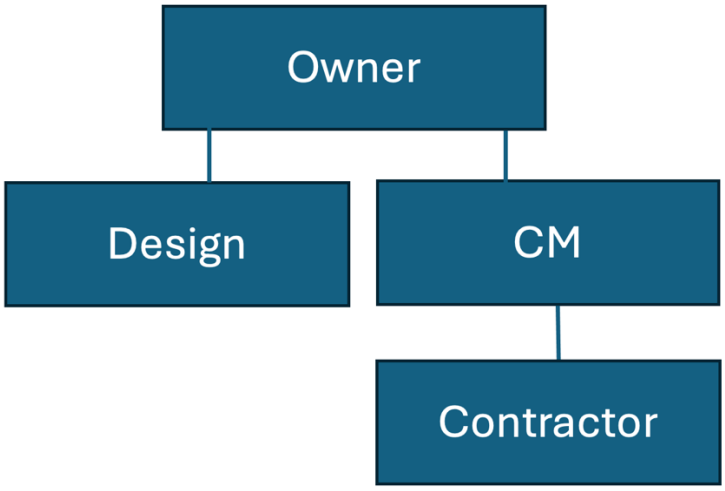


Figure 8.3 Construction Manager Participants

The CM would have a range of responsibilities that are often determined by the owner's capabilities and capacity. In CM, the owner retains the responsibility, authority, and risks of construction. **Table 8.4** depicts the advantages and disadvantages of CM.

Table 8.4 Advantages and Disadvantages of Construction Manager

Advantages	Disadvantages	Contract Form
Supplements owner's CM capabilities and resources.	Full project risk retained by owner until all construction packages bought out.	Cost reimbursable
Provides owner with maximum flexibility and control throughout project.	CM is not responsible for the faults of the contractors.	
	Firm project cost not established until later in the project timeline.	

8.2.1.4 Construction Manager at Risk

The CMAR process streamlines project delivery by emphasizing collaboration, detailed planning, and proactive management. **Figure 8.4** depicts Construction Manager at Risk participants.

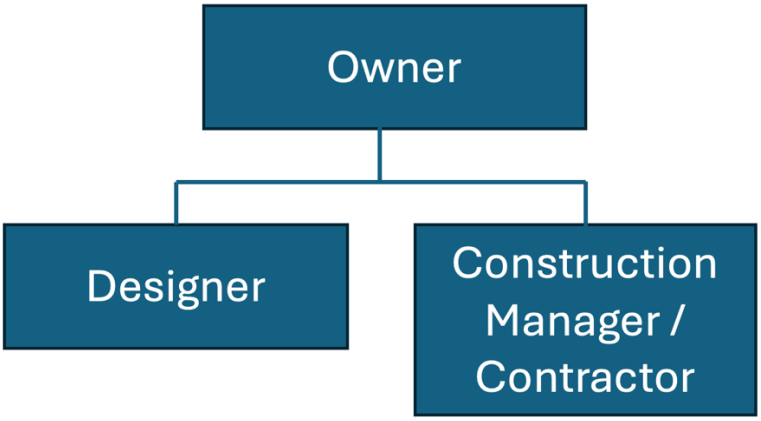


Figure 8.4 Construction Manager at Risk Participants

the use of a CMAR transfers owner responsibilities, authorities, and risks to the Construction Manager At Risk, either in whole or in part.

CMAR involves four key stages: selecting the construction manager, setting a guaranteed maximum price (GMP), planning during pre-construction, and managing the construction phase. Each step is essential for ensuring a successful, cost-effective outcome. **Table 8.5** depicts advantages and disadvantages of CMAR.

Table 8.5 Advantages and Disadvantages of Construction Manager at Risk

Advantages	Disadvantages	Contract Form
Similar to DBB.	Similar to DBB during construction.	Cost reimbursable (to upset limit or with gain/pain provisions).
Greater visibility to subcontractor pricing.	Owner involvement in contractor selection may create performance challenges for the CMAR.	
Construction input during design phase.		
Shifts construction risk to the CMAR entity.		

8.2.1.5 Design-Build

In a DB project, a company takes the responsibility for the design and construction of the facilities. A schematic of the participants is depicted in **Figure 8.5**.

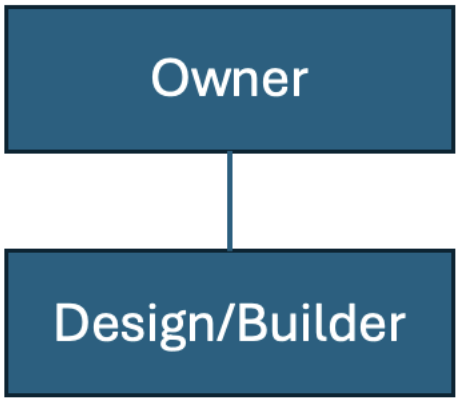


Figure 8.5 Schematic of the Design-Build Participants

This approach entails four basic steps:

- **Planning and Team Selection:** the design-build process begins with selecting a team that would handle both the design and construction phases.
- **Preliminary Design and Budget:** the design-build team works closely with the owner to understand their vision, budget and timelines.
- **Collaborative Design Development:** This step confirms the design is feasible and avoids surprises later.
- **Streamlined Construction:** the same team overseeing the design now leads the build, eliminating the need for a handoff.

The design is based on meeting explicit facility performance requirements. The company may subcontract some of the required tasks, for example, some technical design elements. The facilities are transferred to the owner upon completion for subsequent operation. Standard documentation for DB contracts are well understood in the market.

There are numerous examples of DB for water and sewer facilities. This method can deliver the asset in a shorter time than DBB. Costs can be reduced because the design is driven by the company with a focus on winning a competitive bid. All bidders must complete a portion of the design to finalize their financial bids, creating an opportunity to assess different design approaches. The degree of specification detail in the contract would reflect the potential for innovation and cost savings.

The private sector accepts the design risk and the construction risk in this method. There is some extension of time risk to the owner. There is much greater risk to the owner if changes are initiated by the owner. The owner assumes the operation, financial, demand, and planning process risks.

The owner needs to be able to unambiguously specify the project performance requirements and be able to assess the relative merits of different processes and systems. **Table 8.6** depicts advantages and disadvantages of DB.

Table 8.6 Advantages and Disadvantages of Design-Build

Advantages	Disadvantages	Contract Form
▪ A single company has a clear responsibility to deliver a facility which meets performance requirements and is responsible for design and construction. ▪ This minimizes conflicts when resolving faults. ▪ Owner is not responsible for designer errors and omissions.	Complete and up-front knowledge of performance requirements is needed	Many variations, fixed price, GMP, cost reimbursable, and others
The method is often adopted to shorten the delivery time	▪ It is not suitable when owner objectives may change during project delivery. ▪ A variation of this method is Progressive Design-Build, which provides more flexibility for owner involvement	
If site conditions are predictable and scope is well defined, control of the design by the contractor should lead to a low capital cost facility	▪ Proposers may focus on the capital cost (as they are not responsible for operations) leading to high operating costs. ▪ Requiring multiple year performance demonstration requirements can address this limitation.	
Design and construction contractors may have process knowledge and/or patented equipment not available to design consultants.	Significant expertise is required to define performance requirements in contractual documents.	
Greater potential for off-site fabrication.	Litigation is a risk as the form of contract is adversarial in nature.	
Increased opportunities for optimization and innovation.	Quick decision making required.	
	Greater sophistication needed to administer the contract.	

DB is well suited to projects with simple investigation and planning approval needs, where the time frame to completion is required to be shortened. It is also suited to complex projects such as treatment works or major pumping stations where there are several options which could satisfactorily meet performance requirements. It is also more suited to facilities where most of the total life cycle costs are in the initial capital cost. If DB is to be used for seawater desalination plants with high operating costs, then a proving period needs to be incorporated in the contract.

Examples of DB in seawater desalination plants include the 25 mgd Tampa Bay Desalination Plant in Florida. The Design-Build Team included AECOM and other contractors. The RO plant was completed in 2008. The 1,000 mgd multi-effect distillation and RO Ras Al Khair Desalination Plant in Saudi Arabia was built in 2014 by a DB team a consortium including Acciona and others.

8.2.1.6 Design-Build-Operate

In a DBO, a company or consortium contracts to design, build, and operate a facility. The company transfers the ownership to the owner upon completion. A schematic of the participants is depicted in **Figure 8.6**.

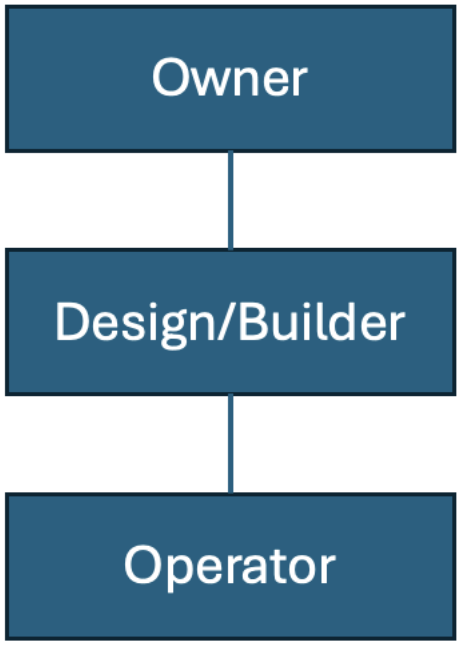


Figure 8.6 Schematic of the Design-Build-Operate Participants

The owner enters into a long-term lease agreement with the company to operate the facility, typically 10 to 25 years. The company is reimbursed for operations on a fixed cost-plus variable payment structure, consisting of a stable base fee with additional payments based on performance or usage metrics during construction and operation. The construction is funded by the company, but upon completion, and subject to meeting performance requirements, is reimbursed by the owner.

High owner involvement is required to define performance requirements for the construction and operation phases. The company only gets paid upon meeting performance requirements. Accordingly, clear acceptance testing procedures need to be developed. The owner is required to administer ongoing operational performance (availability, volume, and service).

The risks associated with design, construction, and operation (and often maintenance) are allocated to the private sector. **Table 8.7** depicts advantages and disadvantages of DBO.

Table 8.7 Advantages and Disadvantages of Design-Build-Operate

Advantages	Disadvantages	Contract Form
▪ Company is responsible for design, construction, and operations. ▪ Single point of responsibility for performance of the facility, which should lower costs.	▪ The owner must define project requirements and risks before bidding. ▪ Significant bidding costs are involved.	Lump sum (D/B) and either lump sum or performance-based compensation (output, availability) during O&M phase.
The owner retains ownership and has some control to cope with unexpected changes in performance requirements.	Ongoing an extensive administration is required.	
DBO companies have process knowledge and patented equipment not available to design consultants.	Changes cannot be made after awarding the contract without significant effort.	
	Litigation is a risk as the form of contract is adversarial in nature.	
	Owner has limited involvement in decision making until the project is transferred in operations.	

The DBO method suits projects with high capital values (like seawater desalination plants) or where operational costs are a significant portion of total life cycle costs. If owners do not wish to transfer ownership but wish to introduce a competitive model into their existing system, DBO is suitable. Also, if operations or geographic location do not play to a core strength, the DBO model can manage that risk. Finally, DBOs are suited to owners looking to lock in minimum cost solutions over a long time frame.

Examples of water projects delivered by DBO include:

- Sri Lanka's award to SUEZ of a contract to design, build, and operate a RO desalination plant in Jaffna, the capital city of the Northern Province of the country.
- Doheny Desalination Plant is being delivered by a progressive design, build, operate, and maintain approach and features a joint venture of Acciona, Filanc, and Hazen and Sawyer. Progressive design-build (PDB) builds on the principles of traditional design-build but offers greater flexibility during the early stages of a project. In PDB, the owner selects a design-builder based on qualifications rather than cost and collaborates closely during the design phase before finalizing the price and construction details. Key features of PDB include:
  - Two-Phase Process: The project is developed in two stages: pre-construction (collaborative planning and design) and construction.
  - Owner Involvement: Owners actively participate in the design decisions, ensuring alignment with project goals.
  - Flexibility: The approach allows adjustments to scope, budget, and schedule as the design progresses.

PDB is ideal for projects with evolving or uncertain requirements (the beach wells are an example of this uncertainty). PDB is also suited for projects where owner input is critical to success.

The Doheny Desalination Plant project also includes contract operations and maintenance components.

- **Lake Pleasant Water Treatment** Plant – Phoenix, Arizona. When the Lake Pleasant Water Treatment Plant opened in 2007, it was the largest water DBO project in North America. The $228 million plant, delivered on schedule and within budget, has a capacity of 80 mgd.
- **Fillmore Water Recycling Plant – Fillmore, California.** American Water designed, built, and now operates this wastewater treatment plant that recycled 100 percent of the water it treats. The facility was built to replace an existing, outdated facility that no longer met modern environmental standards.
- **Tolt Water Treatment Plant (Tolt) – Seattle, Washington.** In 1997, Tolt was one of the first major water DBO projects in the United States. It was created through DBO. Qualified companies each submitted one bid covering the design, construction, and operation of the facility for a minimum of 15 years and extending up to 25 years. The City owns the facility and City engineers oversee the operation. The DBO approach was used to better align the design engineers, the contractor/builders, and the operations, saving the City tens of millions of dollars in capital investment.

8.2.1.7 Build Own Operate

The BOO approach involves selecting a company to design, build, and operate the facility in perpetuity. A schematic of the participants is depicted in **Figure 8.7**.

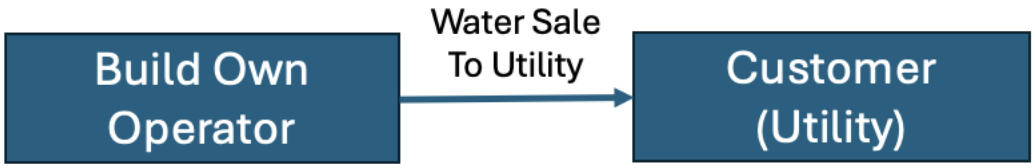


Figure 8.7 Schematic of the Design-Build-Operate Participants

The company finances construction and operation in return for revenue, which is normally paid through a fixed availability charge and a volume charge. The assets are owned by the company/private sector, and all major project risks are transferred to the company.

High owner involvement is required to establish performance criteria and guarantee requirements for design, construction, operation, and finance. A proving period is normally incorporated to confirm the project is operating according to a performance specification. Once compliance has been achieved, the payments flow to the company.

Large projects usually require separate agreements between the company who would design, build, and operate the facility and the financing entities. The legal fees associated with this alternative delivery approach are high because the project documentation is non-standardized. depicts advantages and disadvantages of BOO.

The BOO delivery method is suitable for greenfield projects (undeveloped land) with a high capital value. The method suits projects where operating costs comprise a significant portion of total life cycle costs.

The method suits owners who wish to transfer the maximum amount of risk to the private sector, such as: Projects which have a limited life, where there is no value in acquiring the asset at the end of the period, or where the owner's strategies may make the asset redundant at a particular time in the future. The method is suited to owners where ownership and operation are not seen as core business. The method is suited to owners where ownership and operation are not seen as core businesses, and owners looking to achieve minimum cost solutions and to lock these in over a long time frame.

Table 8.8 depicts advantages and disadvantages of BOO.

Table 8.8 Advantages and Disadvantages of Build Own Operate

Advantages	Disadvantages	Contract Form
Owner completely transfers responsibility of the project to a private party and pays for services, outputs, or benefits it receives, if any.	▪ Owner has limited influence on the details of engineering or construction. ▪ Owner's ability to adjust facility focus diminished or non-existent.	Sale contract
The bidding process encourages competition in design, construction, operation and finance, promoting an efficient, low-cost solution.	Owner may be precluded from developing a competing facility.	
Most of the project risk is transferred to the private sector.	▪ Requires intensive owner involvement to define project requirements and risks. Involves significant bidding costs and complex negotiations. ▪ Owner has little control to deal with unexpected changes in performance requirements.	
Eliminates the tension between maintenance and replacement.	This method is not flexible as the asset is owned by the company.	
There is a clear focus of delivering service outcomes.	This method requires a strong regulatory structure.	
Owner can pay for product, avoiding capital outlays.	Agency must purchase a minimum amount of water even if water demands drop.	

An example of the BOO delivery approach is the Hamma Seawater Desalination Plant completed in 2008 by Veolia. Veolia provided joint venture funding to build and operate this project and today holds a long-term contract to operate and maintain the plant, ensuring continuous access to water for the people of Algiers.

In a BOO, Metropolitan would enter into a Water Purchase Agreement (WPA), agreeing to purchase a quantity of water that meets an agreed-to water quality specification at a price (with escalators). The WPA between Poseidon and the San Diego County Water Authority (CWA) for the Carlsbad Desalination Plant is a 30-year, take-if-delivered contact with a term beginning at financial close. The WPA commits the CWA to purchase a minimum 48,000 AF/year of product water and provides the option to demand a maximum 56,000 AF/year. WPAs are helpful in locking in the quantity, quality, and price considerations. The downside is that they often require purchase of a fixed amount of production and, if the contracting agencies' water demands drop (as in the case of CWA), the potential to strand the investment is real; CWA must buy the water whether it needs it or not.

8.2.1.8 Build Own Operate Transfer

In the BOOT method, a company (or consortium of companies operating under partnering agreement(s)) is chosen to build, own, and operate the facilities with the eventual transfer back to the owner. The consortium is generally reimbursed so that it recovers its costs and gains a return on its investment. Significant and early owner involvement is required to define all project requirements as well as close performance monitoring over the life of the project to administer payment to the consortium.

The risks associated with design, construction, operation, and finance are allocated primarily to the private sector. The degree of allocation is dependent on individual contract arrangements. Since the legal arrangements must cover all aspects of the project there are substantial document requirements.

Table 8.9 depicts advantages and disadvantages of BOOT.

Table 8.9 Advantages and Disadvantages of Build Own Operate Transfer

Advantages	Disadvantages	Contract Form
▪ Obtains competitive design, construction, operation, and finance engagement. ▪ It should achieve a minimum cost solution provided reasonable design freedom is allowed, and uncertainties are minimal.	▪ Requires intensive owner involvement to define project requirements and risks prior to bidding. ▪ Significant bidding costs and complex negotiations are required prior to contract execution.	Concession type contract
Most of the project risk is allocated to the private sector.	The owner has less control than under DBO to deal with unexpected changes in performance requirements since the site and the asset are under the control of the consortium.	
Owner does not carry cost of project on their balance sheet.	This method is not flexible, e.g. to changing regulatory requirements or changing demand.	
Ownership transferred after a defined period of time.		

BOOT is suited to owners looking to achieve minimum cost solutions and to lock these in over a long time frame or where the facilities are not seen as core business (e.g. the facilities are easily separable from the rest of the owner's business/operations). It is also suitable for complex, high capital cost facilities or where project operating costs are a significant portion of total life cycle costs. Projects with some complexity and scope for innovation are suited to this method.

An example of BOOT is the Sorek Desalination Plant in Israel, which will be operated by a private consortium for 25 years. The plant produces ~624,000 cubic meters of water per day. Ownership will transfer to the Israeli government after the operational period.

8.2.1.9 Alliance Contracting or Integrated Project Delivery

In Alliance Contracting or Integrated Project Delivery method, several companies, agencies, and/or the owner work together as partners in an alliance to design, build, and operate the facilities on an agreed fee basis. A schematic of the participants is depicted in **Figure 8.8**.

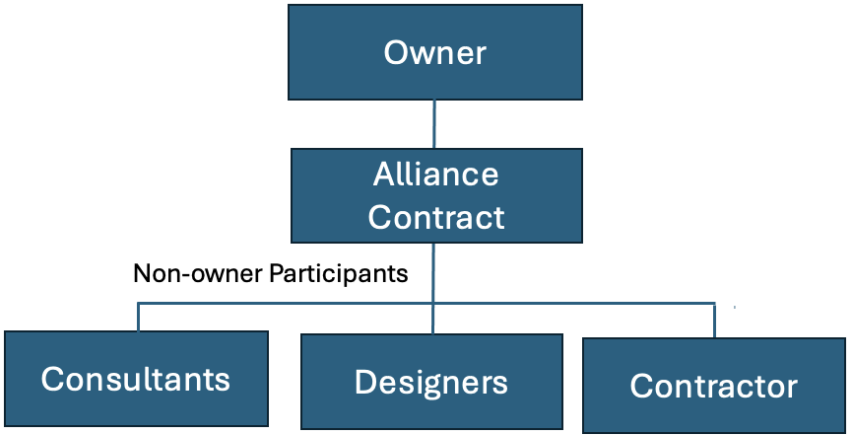


Figure 8.8 Schematic of the Alliance Contract or Integrated Project Delivery Participants

The participants apportion tasks and the overall profits or losses that accrue. This was employed for the Northside Storage Tunnel in Sydney, Australia, and the Gold Coast Desalination Plant in Queensland, Australia. The method is ideally suited to projects where risk cannot be quantified before bidding. The owner must be prepared to participate in the alliance as an equal, but not dominant, partner as all decisions must be unanimous. This can be difficult for owners used to a traditional capital project delivery method.

In this method, risks are shared between the participants, but ultimately, risk lies with the owner. **Table 8.10** depicts advantages and disadvantages of Alliance Contracting/Integrated Project Delivery.

Table 8.10 Advantages and Disadvantages of Alliance Contracting (Integrated Project Delivery)

Advantages	Disadvantages	Contract Form
Team based approach.	Extensive planning required.	Cost plus incentives
Alignment of goals.	Potential for forced integration of project team members.	
Multi-party agreement such that all stakeholders work as one.	Long procurement.	
Collective management.	▪ No buy in by team members. ▪ Trust building takes time.	
Contractually required collaboration.	▪ It requires a high level of expertise of team members from all parties. ▪ Lack of education can hinder progress.	
▪ Shared risk. ▪ Allows risks to be managed in an equitable manner and generally reduces potential for conflict.	Lack of legal precedent.	
It can deliver a project quickly.	Still new to the industry.	
▪ Useful where projects have important objectives other than cost (e.g. schedule, environment, safety, etc.). ▪ This method can directly incorporate these considerations into the reimbursement of the	Not an apples-to-apples supplier base.	

Advantages	Disadvantages	Contract Form
partners, allowing the team focus to be more balanced than in the DBB method.		
Optimizes use of technology (BIM, EPM, LEAN) in project development.	Difficult to apply to public sector contracting.	
▪ All costs are open book and, therefore, transparent which builds trust. ▪ Encourages participants to focus on solving problems collaboratively. ▪ Changes to scope are priced in a transparent manner, eliminating opportunities for windfall profits.	Value for money can be difficult to prove objectively.	
Can include an operating period.	Complex agreements.	

Alliance Contracting is suited to projects where past project delivery methods are poor (for example, tunnels, ocean works) due to the inability to fairly allocate and quantify risk at the time of bidding. Also, projects where objectives other than cost, such as schedule, operations, safety, environment, community outreach, or maintenance objectives are important. Alliance Contracting can be helpful where high level of interaction is needed with existing facilities or where close collaboration is required to determine optimum solutions. This approach minimizes litigation risk.

Examples where Alliance Contracting was used include:

- **Sydney Desalination Plant, Australia:** This facility used an alliance contracting model to foster collaboration among the government, contractors, and consultants, leading to improved project delivery and cost management.
- **Málaga Desalination Plant, Spain:** The project adopted an alliance approach to integrate various stakeholders, which helped streamline processes and reduce construction time.

8.2.2 Public Private Partnership

As mentioned previously, the term public-private partnership (PPP or P3) is frequently used and may refer to a wide range of contracting and financing structures. There is no consensus about how to define a PPP. The term can cover hundreds of different types of long-term contracts with a wide range of risk allocations, funding arrangements, and transparency requirements. Despite there being no formal consensus regarding a definition, the term has been defined by the Organisation for Economic Co-operation and Development (OECD) as "*long term contractual arrangements between the government and a private partner whereby the latter delivers and funds public services using a capital asset, sharing the associated risks*."[20]

[20] OECD (2012), Recommendation of the Council on Principles for Public Governance of Public-Private Partnerships, https://www.oecd.org/governance/budgeting/PPP-Recommendation.pdf

PPP-type arrangements may feature in several of the project delivery approaches. While each of the project delivery approaches above refers to a singular company, it is common for these companies to be joint ventures of two or more firms.

Examples of P3s in the seawater desalination area include:

- Sydney Desalination Plant, Australia, operated under a P3 model. The plant was constructed in 2010 to provide water security during droughts. The private partner, Veolia, manages operations and maintenance.
- Carlsbad Desalination Plant, California, USA. The largest desalination plant in the Western Hemisphere was developed through a P3 between the San Diego County Water Authority and Poseidon Water. The plant provides about 10% of San Diego's water supply.
- Ashkelon Desalination Plant, Israel, was one of the first large-scale desalination plants using a P3 approach. It is operated by a consortium including IDE Technologies and the Israeli government. The plant supplies approximately 20 percent of Israel's drinking water.
- Sorek Desalination Plant, Israel. The plant was developed through a P3. It is operated by a private consortium, including IDE Technologies and is one of the largest and most advanced seawater desalination plants globally.
- Desalination Plant in Abu Dhabi, UAE was developed as a P3 between the government and private investors. The plant provides potable water through reverse osmosis technology.

P3 models can effectively address water scarcity through innovative desalination solutions.

Selection of the appropriate approach is usually conducted through a rigorous collaborative evaluation between the project proponent and their advisory consultant as the risk trade-offs are significant and long-lived and require detailed discussion/buy-in.

The selection of the appropriate alternative delivery approach should consider whether:

- The history of existing methods of project delivery is poor or not well established (e.g., slant beach wells, ocean works): is it due to the inability to fairly allocate and quantify risk at the time of bid?
- How much and how significant the required outcomes are developed during the project delivery (e.g., projects where community consultation strongly influences project details)?
- How urgent is delivery of the project?
- Objectives other than cost rank highly (e.g., operational considerations, safety, environment, community outreach).
- Highly complex interaction with existing assets.
- Requires a high level of close collaboration among parties to determine the optimum solution.

Coastal Southern California seawater desalination plants reflect many of these decisions and risk factors.

In addition, Metropolitan should consider:

- **Capital Cost and Complexity of Project:** As the project value increases, larger contractors become more interested in bidding, offering innovations in the design, construction, and operation of facilities. They are also prepared to invest more in developing their ideas if the ultimate reward is large.
- **Government Policy:** Some government policies may preclude certain delivery methods. This is particularly true of private ownership of assets. In some jurisdictions, owners may not be able to share risks which they are not directly responsible for.
- **Finance**: Where the owner has a high level of debt and wishes to avoid additional debt, BOOT and BOO are feasible options.
- **Regulatory Approvals:** Where detailed designs are needed to obtain regulatory approval, DBB and EPCM are suited options.
- **Timing:** For projects where very tight delivery times are required, the best suited options include DB, DBO, and EPCM delivery methods.
- **Design:** Where the best skills to undertake the design are with contractor/operators then DB, DBO, BOOT, BOO, and Alliance (Integrated Project Delivery) models are preferred.
- **Type of Site (Brownfield or Greenfield):** Where there are existing assets and industrial operators which need to be considered (brownfield) then the DBB and EPCM allow a high level of client/owner interaction.
- **Operations:** Where the owner has a high level of operations skill and this is seen as core business then DBB, EPCM, DB, and Alliance models are best suited. Where operations is not a core skill, or current operators are at lower than industry benchmark levels, then DBO, BOOT, and BOO are favored.

In general, where project risks are well understood then the DBB and EPCM methods are preferred. If demand/load projections are likely to change dramatically, then it is best to avoid methods with long-term operational terms.

If risks are poorly understood (e.g. geotechnical, wave climate, ocean currents) or scope is poorly defined, then an Integrated Project Delivery or the Alliance approach that has been used in Australia provides a clear process for managing unforeseen risks by sharing responsibility for unknown risks.

8.2.3 Partnering Considerations/Potential Roles

Owner - The simplest partner arrangements involve the least number of parties. To that end, Metropolitan owning, operating, and distributing the water is simple.

Purchaser - Metropolitan could also buy a guaranteed quantity and quality of desalinated seawater supply at an agreed-to price and term from a seawater desalination plant. Wholesaling that water to one member agency under the current policies governing Metropolitan water deliveries would minimize the complexity and transactional costs. The member agency (and their sub-agencies) bear responsibility for the supply past the Metropolitan service connection, which is identical to current supply policies.

Facilitating the Local Supply Exchange Framework (LSEF) – In August of 2025, Metropolitan's Board approved the LSEF to allow local water agencies across the region to sell and purchase locally produced supplies among one another. Metropolitan's role is as a facilitator of an exchange of local supplies (e.g. desalinated seawater) between its member agencies.

- Wheeling water – Metropolitan could provide access to its physical distribution system to move water supplies between parties, charging the appropriate wheeling charges.
- Financier – Metropolitan could agree to provide financing for all or part of a project.
- Technical adviser – Metropolitan could be a technical advisor. This role could apply to different parts of project delivery from design oversight to construction management.

8.3 Monitoring and Reporting Requirements for Private Sector Operators

Should Metropolitan involve private sector operations there are a variety of contractual monitoring and reporting considerations that should be documented. Below are summarized considerations for the current water purchase agreement for the Carlsbad Desalination Plant.

8.3.1 Product Water Quality Compliance (Core Daily Requirement)

8.3.1.1 Required Standard

The Project Company must continuously produce product water that complies with:

- All Applicable Law drinking water standards.
- All permit requirements.
- Additional contract-specific quality standards beyond minimum regulatory limits .

8.3.1.2 Daily Checklist

- Verify finished water meets all state and federal potable water standards
- Verify contract-specific water quality targets are met
- Confirm chlorine residual is maintained
- Confirm chloramine / ammonia ratio is within required operating limits
- Confirm no unacceptable water enters the distribution system

8.3.1.3 Immediate Action

If water is:

- Off-Specification Product Water → corrective response required.
- Unacceptable Water → immediate reporting + operational remedy required.
- Potential public health issue → boil water notice obligations may apply

8.3.2 Sampling and Laboratory Monitoring

8.3.2.1 Required Sampling Locations

Contract requires compliance determination at designated sampling points for finished product water quality.

Monitoring Checklist:

- Sample at contract-defined compliance locations
- Follow approved sampling frequency
- Use certified laboratory methods
- Maintain chain-of-custody records
- Retain all analytical records for audit

8.3.2.2 Laboratory Requirements

Sampling, testing, and laboratory work must comply with:

- Applicable Law
- Governmental approvals
- Certified methods and licensing requirements

8.3.3 Treatment Process Monitoring

8.3.3.1 Continuous Process Monitoring Required

Operator must continuously monitor treatment performance including:

- Raw seawater intake conditions
- Pretreatment performance
- Reverse osmosis performance
- Chemical dosing systems
- Post-treatment stabilization
- Disinfection systems
- Chlorination / chloramination control

8.3.3.2 Operational Goal

Maintain treatment process so final water quality remains compliant despite source variability.

8.3.4 Raw Seawater Quality Monitoring

8.3.4.1 Required Monitoring

Contract specifically recognizes raw seawater variability as performance risk.

Monitor for:

- Turbidity
- Salinity
- Temperature
- Organics
- Algae / red tide conditions
- Contamination events
- Other raw seawater quality changes affecting treatment

Special Trigger Conditions:

- Red tide bloom documentation
- Contamination event reporting
- Relief claims documentation if raw water conditions impair production

8.3.5 Performance Monitoring (Plant Output / Reliability)

8.3.5.1 Daily Performance Tracking

- Delivered volume vs demand schedule
- Flow rate compliance
- Pressure compliance
- Operating mode performance
- Pump availability
- Shutdown hours logged

8.3.5.2 Performance Guarantee Monitoring

Track compliance with:

- Annual supply commitment
- Monthly supply commitment
- Flow limitations
- Delivery obligations

8.3.6 Off-Spec Water Response Protocol

8.3.6.1 If Off-Specification Water Occurs

- Immediately identify affected volume
- Notify Water Authority

- Document cause
- Implement corrective treatment action
- Prevent recurrence

8.3.6.2 If Unacceptable Water Occurs

- Stop delivery if necessary
- Notify immediately
- Follow emergency corrective procedures
- Support regulatory communication if required

8.3.7 Monthly Operations Report (Formal Contract Deliverable)

Must include:

- Treatment performance summary
- Water quality incidents
- Regulatory test results
- Monitoring data
- Equipment outages
- Shutdowns
- Failures to meet performance guarantees
- Environmental / health test results
- Notices from regulators
- Utility outages
- Maintenance impacts on treatment performance

8.3.8 Annual Operations and Maintenance Report

Required annually within 45 days after contract year end and must include:

- Summary of monthly reports
- Review of operational practices
- Review of maintenance practices
- Regulatory fines or penalties
- Capital modifications
- Equipment replacements
- Operational performance review

8.3.9 Regulatory Reporting / Permit Compliance

Ongoing requirements:

- Submit all permit-required reports to agencies
- Provide copies to Water Authority
- Report non-compliance immediately
- Track enforcement notices

Includes:

- Drinking water permits
- Environmental monitoring
- Health/safety compliance reports

8.3.10 Recordkeeping Requirements

Must maintain for audit (for minimum of 10 years):

- Water quality test records
- Lab reports
- Calibration records
- Process monitoring logs
- Incident logs
- Regulatory correspondence

8.4 Potential Partnerships and Exchanges

8.4.1 Doheny Seawater Desalination Plant

The potential expansion of the Doheny seawater desalination plant would provide an additional 10 mgd of production capacity (there is sufficient demand in South Orange County to absorb this amount).

There are two options for tie-in locations to pump product water from the desalination facility into existing transmission systems:

- Tie-in to the existing JTM and the existing WIP. The JTM was constructed in 1961 to convey potable water from a Metropolitan connection in Irvine, California to cities in southern Orange County, ending in northern San Diego County at the San Onofre State Park San Onofre Bluffs Campground.
- The WIP was constructed in 1991 to convey potable water from a connection at the South County Pipeline to the City of San Clemente along Avenida Pico and to South Coast Water District, ending in Stonehill Avenue near San Juan Creek in Dana Point. These facilities are part of the Joint Regional Water Supply System (JRWSS) and include two reservoirs and

approximately 38 miles of water transmission main with turnouts at approximately 40 locations to deliver water to six member agencies and three customers in northern San Diego County. The JRWSS is contract operated by SCWD on behalf of Irvine Ranch Water District, El Toro Water District, Santa Margarita Water District, Moulton Niguel Water District, and the City of San Clemente. Customers include Southern California Edison (San Onofre Nuclear Generating Station), United States Marine Corps Camp Pendleton, and California State Parks. The JRWSS facilities in the vicinity of the Desalination Plant are owned by South Coast Water District and the City of San Clemente.

- Convey the new supply to the JTM, the WIP, and the South County Pipeline (which is accessed through the WIP pipeline). The South County Pipeline is owned by the Santa Margarita Water District (SMWD).

The current partners on the initial 5 mgd phase include Eastern Municipal Water District, Laguna Beach County Water District (LBCWD), and potentially the city of San Clemente (CSC) and the Santa Margarita Water District (SMWD) .

A study has also been completed that assessed the opportunity to introduce effluent from the adjacent SOCWA JB Latham Wastewater Treatment as an augmented supply for the Doheny Project in the future, potentially increasing overall production from the Doheny Project.

8.4.1.1 Potential Partners

Water delivery out of the potential Doheny seawater desalination plant is the most institutionally complicated of the three sites. The distribution of 10 mgd of new desalinated supply out of the Doheny Desalination Plant would reach several Metropolitan sub-agencies in South Orange County.

Metropolitan has no pipeline or other facilities in the area; the potential expansion, under Metropolitan's control, would subsist as an "island" in the South Orange County local delivery system (although the East Orange County Feeder #2 is the direct supply to the JTM through CM-10, along with the AMP being a direct supply to the SCP. Supplies from Doheny could be served up the JTM and the WIP or to the SCP to serve local agencies). As such, it may make sense to outsource development of that 10 mgd expansion plant (much as the existing 5 mgd facility is being delivered) and buy the water from the owner of the plant (consistent with production and quality specifications). Delivery, accounting, and physical conveyance of the supply would be structured consistent with the existing Metropolitan-MWDOC-retailer wholesale and governance framework, with water delivered into the South Orange County transmission system without requiring MWDOC to act as a resale purchaser. South Coast Water District could take responsibility for transmission and distribution to its service area, with MWDOC serving a coordinating and contractual role consistent with its function as Metropolitan's member agency.

Under this approach, the partnering arrangement would consist of:

- **DBO Delivery Model:** A Carlsbad Desalination Plant style DBO (including maintenance) agreement with a private plant owner/operator, with the option for Metropolitan to assume ownership after a defined term (e.g. 30 yrs). Depending on Metropolitan's financing objectives,

private funding could be incorporated. The potential for eventual asset transfer would support Metropolitan involvement in key design, operational, and maintenance decisions.

- **Water Supply Agreement:** A long-term Water Purchase Agreement between Metropolitan and the plant owner, defining production capacity, water quality requirements, availability, and performance standards.
- **Wholesale Coordination and Delivery Framework:** An agreement among Metropolitan, MWDOC, and SCWD that establishes delivery, accounting, and governance provisions for the desalinated supply, structured consistent with the existing Metropolitan-MWDOC-retailer wholesale framework.
- **Transmission and Distribution Operations:** An operating agreement between MWDOC and SCWD under which SCWD would be responsible for transmission and distribution of the desalinated supply within its service area.

8.4.2 Port Hueneme Seawater Desalination Plant

Product water from the potential 20 mgd Port Hueneme seawater desalination facility is intended to support the water supply reliability of the State Water Project Dependent areas and is located in Ventura County within Calleguas's service area. **Section 5** demonstrated that there was sufficient wintertime demand to use all the product water. The potential seawater desalination facility would be located on the Port Hueneme Naval Base.

8.4.2.1 Potential Partners

Given there is sufficient local demand for the 20 mgd of supply, exchange partners would not necessarily be needed, unless Metropolitan were interested in off-setting some of the capital and O&M expense by bringing on a partner(s). Using the water locally would involve an agreement with Calleguas. This would be relatively straightforward institutionally as far as Metropolitan is concerned (i.e. one agreement with one Member Agency). The Metropolitan desalinated water connection could be operationally treated like any other member agency service connection. Calleguas's member agencies receiving this supply may weigh in regarding specific issues of importance at the local level (e.g. water quality/blending and integration considerations).

An agreement with the U.S. Government (Navy) for siting of the facility would be required. The Navy may wish to enter into an agreement for base-load supply or pay a fee for some level of stand-by emergency supplies (i.e. dedicating some portion of capacity during a government emergency).

8.4.2.2 Exchanges

Should Metropolitan wish to avoid the cost of investing in all or some portion of the Port Hueneme seawater desalination plant contracts with other investors or water purchasers could be entered. A State Water Project exchange could involve a Metropolitan member agency interconnection with other agencies where Metropolitan would wheel State Water Project allocations or deliver desalinated water flows. Such an investor/partnership arrangement would require multiple agreements including:

- An agreement with Calleguas to confirm that the desalinated water is used locally and offsets what would, otherwise, be a Metropolitan delivery.

- An agreement with each investor/purchaser specifying the nature of the investment (e.g. capital and operations and maintenance (O&M) cost contributions, ownership terms, liability issues, construction terms, non-performance, etc.).
- An exchange agreement with each investor/purchaser that specifies, among other things, the operations and water accounting methodologies that will confirm the water is stored in the SWP system and available to the investor/purchaser. This would also include provisions for how spills in the SWP Storage system would be handled.

8.4.3 El Segundo Seawater Desalination Plant

Product water from the potential 10 mgd El Segundo seawater desalination facility would integrate with the Metropolitan system by delivering treated desalinated water into the West Coast Feeder, providing water supply to Metropolitan's Common Pool. **Section 5** suggestsed that there was sufficient capacity for both the West Coast Feeder and Common Pool to readily accommodate an additional flow of 10 mgd. The location would incorporate a slant well intake approach with multiple siting options.

8.4.3.1 Potential Partners

Similar to the Port Hueneme seawater desalination plant, there is sufficient local demand for the 10 mgd of supply. Exchange partners would not necessarily be needed (unless Metropolitan were interested in offsetting some of the capital and O&M expense by bringing on a partner(s).

Siting of the facility on property owned by others would require necessary leases and property easements to accommodate the plant and planned slant wells and access to an outfall. As with any industrial site, historical use of the industrial property may present some soil contamination issues that need to be mitigated.

High quality cooling water is in high demand for oil refineries as it can extend the blowdown frequency for cooling water applications and save costs. A direct delivery to a refinery could be market priced to recover full capital and O&M costs plus, reducing impacts on Metropolitan's water rates. In addition to a potential site for a desalination facility, the Chevron refinery is a potential water user/partner.

8.5 Funding and Financing Opportunities

Grant funding for seawater desalination projects is very limited. Some federal programs are frozen and under review as are some State programs.

Potential opportunities Metropolitan should consider/track include:

1. Federal Office of Science (SC), FY 2025 Continuation of Solicitation for the Office of Science Financial Assistance Program

This program might be useful if there are unique scientific elements to the development of desalination.

Link: https://www.grandets.gov/search-results-detail/356590

Description: The SC mission is to deliver scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic and national security of the United States.

SC is the Nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for our Nation's energy future.

SC accomplishes its mission and advances national goals by supporting:

- The frontiers of science—exploring nature's mysteries from the study of fundamental subatomic particles, atoms, and molecules that are the building blocks of the materials of our universe and everything in it to the DNA, proteins, and cells that are the building blocks of life. Each of the programs in SC supports research probing the most fundamental disciplinary questions.
- The 21st Century tools of science—providing the Nation's researchers with 28 state-of-the-art national scientific user facilities - the most advanced tools of modern science - propelling the U.S. to the forefront of science, technology development and deployment through innovation.
- Science for energy and the environment—paving the knowledge foundation to spur discoveries and innovations for advancing the Department's mission in energy and environment. SC supports a wide range of funding modalities from single principal investigators to large team-based activities to engage in fundamental research on energy production, conversion, storage, transmission, and use, and on our understanding of the earth systems.

2. U.S. Bureau of Reclamation WaterSmart Program

Through the WaterSMART Program, the Bureau of Reclamation provides financial assistance to support water management improvements, planning and design activities, water reclamation and reuse projects (including desalination), establishment and development of collaborative watershed groups, watershed management projects, habitat restoration and improved fish passage, a comprehensive approach to drought planning, implementation actions to proactively address water shortages, and other similar projects that contribute to sustainability in the Western United States. Desalination Construction Projects (U.S. Bureau of Reclamation, WIIN Act). Eligible applicants include State/local governments, Tribes, irrigation/water districts, and similar entities in western U.S. states. Federal Award: Up to $30 million; federal cost-share up to 25% of project costs.

There are several funding categories under WaterSMART including:

- Water and Energy Efficiency Grants: The primary category of funding under WaterSMART Grants, focusing on projects that result in quantifiable and sustained water savings.
- Drought Response Program: Provides funding for collaborative drought planning efforts, decision support tools, and the construction of infrastructure projects to mitigate impacts of drought.
- Title XVI Program and Desalination Construction: Provides funding for the planning, design, or construction of water recycling and desalination projects to develop alternative water supplies and stretch limited water supplies in the Western United States.

The following notice of funding opportunities related to desalination are currently paused and are under review until further notice:

- FY25 Applied Science Grants funding opportunity

- FY25 Large-Scale Water Recycling Projects funding opportunity
- Link: https://www.usbr.gov/watersmart/weeg/

3. California Water Desalination Grant Program under Proposition 4

Proposition 4 provides vital funding to support locally driven water infrastructure and climate adaptation projects, including efforts to improve groundwater management and dam safety, protect riverine systems, and enhance flood preparedness across California.

This program provides grants for planning, design, and construction of desalination projects. Typical grant size is $45,000 to $10,000,000. Funding comes from Proposition 50 and Proposition 1, with over $123 million awarded to various projects since its inception. However, the Continuous Application Process is currently suspended, meaning no new applications are being accepted at this time. Link: https://water.ca.gov/Work-With-Us/Grants-And-Loans/Desalination-Grant-Program.

According to their website, California DWR:

> "will soon have new grant funding available to help advance California's climate resilience goals, made possible by Proposition 4 - the Safe Drinking Water, Wildfire Prevention, Drought Preparedness, and Clean Air Bond Act of 2024. Approved by voters in November 2024, this $10 billion general obligation bond will fund projects that address climate change and strengthen California's long-term resilience."

4. Bipartisan Infrastructure Law Funding

This law allocates $250 million specifically for desalination projects over five years. Projects must be located in the Western U.S. or U.S. territories and require a feasibility study for funding consideration.

5. The Department of Energy (DOE)

Occasionally funds desalination research through its Water Security Grand Challenge, focusing on innovative technologies. Link: https://www.energy.gov/science/office-science-funding-opportunities

6. State Water Resources Control Board (SWRCB)

The Drinking Water State Revolving Fund (DWSRF) program assists public water systems in financing the cost of drinking water infrastructure projects needed to achieve or maintain compliance with Safe Drinking Water Act (SDWA) requirements. Eligible project types include treatment systems, distribution systems, interconnections, consolidations, pipeline extensions, water sources, water meters, and water storage. The interest rate is half of the most recent General Obligation Bond rate, and the most common construction financing term is 30 years. Link: https://www.waterboards.ca.gov

7. Water Infrastructure and Innovation Act (WIFIA)

Link: https://www.epa.gov/wifia/about-wifia-program. The Water Infrastructure Finance and Innovation Act of 2014 (WIFIA) established the WIFIA program, an EPA-operated bank that provides supplemental, flexible, low-cost credit assistance to public and private borrowers for all types of wastewater, drinking water, and stormwater projects. The WIFIA program offers long-term loans that

can be combined with State Revolving Fund assistance, municipal bonds, and federal and state grants to help communities deliver more critical water infrastructure projects for a lower cost with less impact on rate payers. The WIFIA program has funding available on an ongoing basis. This allows prospective borrowers to request financing on their schedule. Prospective borrowers can apply for and receive WIFIA loans at nearly any stage of project completion and can even receive financing for planning and design-only loans.

8. California Infrastructure and Economic Development Bank (IBank)

Link: https://ibank.ca.gov. The California Infrastructure and Economic Development Bank (IBank) was created in 1994 to finance public infrastructure and private development that promote a healthy climate for jobs, contribute to a strong economy and improve the quality of life in California communities. IBank has broad authority to issue tax-exempt and taxable revenue bonds, provide financing to public agencies, provide credit enhancements, acquire or lease facilities, and leverage State and Federal funds. In recent years interest rates for 22 to 30-year loans have ranged from 4.1% to 4.8%. Eligible projects include water supply. Eligible costs for financing include:

- All or any part of the cost of construction, renovation, and acquisition of all lands, structures, real or personal property.
- Rights, rights of way, franchises, licenses, easements, and interests acquired or used for a project.
- The cost of demolishing or removing any buildings or structures on land so acquired, including the cost of acquiring any lands to which the buildings or structures may be moved.
- The cost of machinery and equipment.
- Other expenses necessary or incidental to determining the feasibility of any project or incidental to the construction, acquisition, or financing of any project.
- The cost of architectural, engineering, financial and legal services, plans, specifications, estimates, and administrative expenses.
- Interest prior to, during, and for a period after, completion of construction, renovation, or acquisition, as determined by IBank.
- Reserves for principal and interest and for extensions, enlargements, additions, replacement, renovations, and improvements.

Eligibility and Application:

- Eligible applicants include local governments, public agencies, and non-profit organizations.
- Applications usually require detailed project proposals, financial information, and environmental compliance documentation.

8.6 Potential Delivery Approach

8.6.1 Doheny Seawater Desalination Plant

The potential Doheny seawater desalination plant expansion is the most complicated of the three potential projects in many respects. A potential delivery approach is based on the following assumptions that would require Metropolitan validation:

- The potential 10 mgd seawater desalination facility is relatively small compared to Metropolitan's other treatment facilities.
- The potential seawater desalination facility would be an expansion of the current plant under contract for development and would need to be tightly integrated with operations of that facility and distribution system.
- Development of large-scale coastal desalination in southern California is not likely in the short to mid-term.
- The potential seawater desalination plant would operate as an island in Metropolitan's existing system and present some integration complexity.
- Metropolitan does not need financing partners.
- Metropolitan, while deeply capable, does not currently have design, construction, and operating expertise for coastal desalination. Numerous private sector companies possess this expertise making for a competitive private sector market (the current Phase 1 Doheny plant was developed by the private sector).
- Seawater desalination will become increasingly important to southern California's water supply future and, accordingly, Metropolitan should gain experience for future application.
- Beach wells should provide an operationally stable supply of source water; there are some treatments process risks at that location associated with low dissolved oxygen seawater in the beach wells.

In light of these assumptions, pursuing a similar Design, Build, Operate project delivery approach (which includes maintenance responsibility) as the current planned 5 mgd seawater desalination plant with a potential transfer option in the long-term seems reasonable. Contracting with a local retail water purveyor to administer, operate, and maintain the distribution system should be considered.

8.6.2 Port Hueneme Seawater Desalination Plant

A potential delivery approach is based on the following assumptions that would require Metropolitan validation:

- The potential 20 mgd seawater desalination facility is relatively small compared to Metropolitan's other treatment facilities.
- Seawater desalination will become increasingly important to southern California's water supply future and, accordingly, Metropolitan should gain experience for future application.

- Development of numerous large-scale coastal desalination facilities in southern California is not likely in the short to mid-term.
- The potential seawater desalination plant is relatively distant from Metropolitan's existing treatment facilities with limited integration opportunities.
- Metropolitan does not need financing partners.
- Metropolitan, while deeply capable, does not currently have design, construction, and operating expertise for coastal desalination. Numerous private sector companies possess this expertise making for a competitive private sector market.
- Beach wells should provide an operationally stable supply of source water. Experience from the Doheny site will inform the beach well development at the potential Port Hueneme site.

In light of these assumptions, pursuing a design, build, operate (and maintain) project delivery approach with the potential to ultimately transfer the asset to Metropolitan after some period seems reasonable. Metropolitan would need to be engaged in the agreements regarding purchasers of the water and the Navy. The project delivery risk would be largely shifted to the successful bidding company.

8.6.3 El Segundo Seawater Desalination Plant

A potential delivery approach is based on the following assumptions that would require Metropolitan validation:

- The potential 10 mgd seawater desalination facility is relatively small compared to Metropolitan's other treatment facilities.
- Development of numerous large-scale coastal desalination facilities in southern California is not likely in the short to mid-term.
- Seawater desalination will become increasingly important to southern California's water supply future and, accordingly, Metropolitan should gain experience for future application.
- The potential seawater desalination plant is relatively close to Metropolitan's existing distribution facilities and Common Pool with limited integration complexity.
- Metropolitan does not need financing partners.
- Metropolitan, while deeply capable, does not currently have design, construction, and operating expertise for coastal desalination. Numerous private sector companies possess this expertise making for a competitive private sector market.
- Beach wells should provide an operationally stable supply of source water. Experience from the Doheny site will inform the beach well development at the potential El Segundo site.

In light of these assumptions, pursuing a Design, Build, Operate project delivery approach (which includes maintenance responsibility) with a near to mid-term transfer option after successful start-up and operations seems reasonable. This approach could provide direct operational and maintenance experience that Metropolitan could apply at other future plants. Metropolitan could consider implementing this plant first to leverage that operations and maintenance experience in future design/construction packages for the other plants.

9.0 Conclusions

9.1 Literature Review

The literature review confirms that seawater desalination is a technically feasible but highly complex water supply option that is strongly influenced by siting constraints, regulatory requirements, energy demand, and environmental considerations. Past studies and implemented projects demonstrate that intake and outfall design are among the most critical determinants of regulatory feasibility, with subsurface intakes generally required where site conditions allow. The review also highlights that energy consumption remains a key driver of both cost and greenhouse gas emissions, although advances in membrane technology and energy recovery systems continue to improve efficiency and operational performance.

Lessons learned from prior California and global desalination efforts underscore the importance of early stakeholder engagement, clear demonstration of water supply need, and proactive consideration of environmental justice and permitting risks. Collectively, the findings from the literature review provided a foundational framework for this study, informing the screening and evaluation of candidate sites, development of planning-level cost and schedule estimates, and assessment of regulatory pathways. These insights support Metropolitan's evaluation of seawater desalination as a potential component of a diversified, climate-resilient water supply portfolio under CAMP4W.

9.2 Emerging Technologies

The review of emerging desalination technologies indicates that while conventional SWRO remains the most mature and reliable approach for near-term project implementation, a range of developing technologies has the potential to improve efficiency, reduce environmental impacts, and expand future siting opportunities. Advancements in membrane performance, energy recovery devices, and process optimization continue to reduce energy intensity and operating costs, while innovations in subsurface and offshore intake concepts and concentrate management may address some of the environmental and permitting challenges associated with traditional facilities.

TRL assessments show that many emerging concepts remain in pilot or demonstration phases and are not yet suitable for immediate large-scale deployment. However, several technologies exhibit strong potential for future application as regulatory requirements evolve, and performance data mature. Continued monitoring, targeted piloting, and coordination with research initiatives will be important to evaluate the applicability of these technologies to Metropolitan's service area. Collectively, the emerging technologies assessment provides strategic insight into how future advancements could enhance the feasibility and sustainability of seawater desalination as part of Metropolitan's long-term water supply portfolio.

9.3 Siting Evaluation

The siting evaluation demonstrated that the feasibility of seawater desalination within Metropolitan's service area is highly site dependent, with performance driven by a combination of water supply benefit, regulatory complexity, environmental and social justice considerations, cost-effectiveness, technology

readiness, system integration, and vulnerability to sea level rise. Application of the MCDA framework enabled a consistent and transparent comparison of candidate sites and supported identification of the most viable locations for further evaluation.

Based on this assessment, Doheny State Beach, El Segundo, and Port Hueneme emerged as the top-ranked sites due to their relative advantages in system integration potential, availability of existing infrastructure, and overall balance of technical and regulatory considerations. The siting evaluation results informed subsequent analyses of cost, schedule, regulatory pathways, and partnerships, and provide Metropolitan with a defensible basis for prioritizing future planning efforts. Collectively, the findings support a phased and adaptive approach to advancing seawater desalination projects, focused on sites with the greatest potential to contribute to long-term water supply reliability under CAMP4W.

9.4 System Integration and Water Quality

System integration analyses indicate that all three potential seawater desalination plants could be feasibly connected to Metropolitan's existing distribution network or that of its member agencies, though the level of effort and complexity varies by site. The potential Doheny seawater desalination plant offers the simplest integration, with short conveyance routes and direct tie-in options to existing Orange County infrastructure via the JTM, WIP, or South County Pipeline. The potential El Segundo seawater desalination plant also provides favorable integration potential, as its proximity to the West Coast Feeder enables efficient delivery to Metropolitan's Common Pool with minimal new conveyance infrastructure. In contrast, the potential Port Hueneme seawater desalination plant requires a significantly longer conveyance system (approximately 153,000 linear feet of new 40-inch pipeline and three pump stations) to deliver water to Calleguas's Lake Bard Water Filtration Plant, resulting in greater capital cost and hydraulic complexity.

From a water quality perspective, desalinated seawater produced at each site would require post-treatment re-mineralization and conditioning to achieve compatibility with Metropolitan's treated water quality goals and distribution system materials. While blending can be used to enhance product water stability and reduce chemical dosing, available blend water may vary and desalination facilities should be capable of producing stabilized product water independent of blending. Analyses indicate that, with appropriate chemical conditioning and blending strategies, finished water from all three sites can meet Metropolitan's water quality objectives. Site-specific differences in source water quality and integration locations influence re-mineralization requirements, blending ratios, and operational flexibility, with Doheny and El Segundo offering more favorable conditions for blending with existing treated supplies.

Overall, Doheny presents the most straightforward and cost-effective integration opportunity, El Segundo provides a centrally located option with strong system connectivity and manageable water quality integration, and Port Hueneme, while feasible from a hydraulic and water quality perspective, requires the most extensive new conveyance infrastructure and operational coordination to integrate into the Metropolitan system. However, Port Hueneme addresses supply reliability challenges with Metropolitan's State Water Project dependent area.

9.5 Regulatory Complexity

All three potential seawater desalination sites would require extensive permitting under California's regulatory framework, including compliance with the California Ocean Plan, CEQA, SWRCB and Regional Water Quality Control Board permitting, CDP approval, State Lands Commission authorization, and DDW review. Among the three sites, the potential Doheny seawater desalination plant presents the lowest regulatory complexity because it would expand an existing permitted facility with prior CEQA and baseline environmental studies already completed. The potential Port Hueneme seawater desalination plant is expected to face the most extensive permitting effort due to its location on federal property (Port Hueneme Naval Base), requiring coordination with the U.S. Navy and multiple overlapping federal and state approvals. The potential El Segundo seawater desalination plant would fall in between, as it involves a new site with established industrial use but would still require a full CEQA Environmental Impact Report and coastal permitting for new slant wells and outfall connections.

Overall, Doheny offers the most streamlined path to implementation, while El Segundo and Port Hueneme are subject to greater permitting and interagency coordination requirements, potentially extending schedule durations and increasing preconstruction costs.

9.6 Cost Summary and Schedule

The comparative cost analysis indicates that total capital costs for the three potential seawater desalination plants range from approximately $448 million to $1.66 billion, reflecting differences in capacity, conveyance length, and site-specific development factors. The potential Doheny seawater desalination plant is the least costly, estimated at $448–$569 million (about $45–$57 million per mgd or $40-51 per AFY), benefiting from existing infrastructure and minimal conveyance needs. The potential Port Hueneme seawater desalination plant is the most expensive at $1.35–$1.66 billion ($68–$83 million per mgd or $60-74 thousand per AFY), primarily driven by its larger capacity, multiple pump stations, and long conveyance pipeline requirements. The potential El Segundo seawater desalination plant falls in the mid-range at $573–$745 million ($57–$75 million per mgd or $51-67 thousand per AFY), influenced by land acquisition and urban site constraints.

These estimates represent AACE Class 5 screening-level OPCCs with an expected accuracy range of -50 to +100 percent. It is important to note that these capital cost estimates exclude conveyance and distribution infrastructure beyond the defined system integration tie-in points. Site-specific land acquisition is included only where explicitly identified (e.g., El Segundo). As a result, total program capital costs to deliver water to specific demand areas may be materially higher than the values presented. For further details of the summaries presented in **Table 9.1,** see **Appendix H**.

The total annualized cost provides a more complete planning-level comparison of the recommended sites by combining annualized capital costs with estimated annual O&M costs and normalizing the total cost by annual water production. As shown in **Table 9.1**, Doheny has the lowest total annualized cost at approximately $4,300-$5,000 per AF, reflecting its smaller expansion scope and opportunity to leverage existing and planned DODP infrastructure. El Segundo is estimated at approximately $5,100-$6,100 per AF, while Port Hueneme is estimated at approximately $5,700-$6,600 per AF. Although Port Hueneme has a higher total annualized unit cost, it also provides the largest supply yield of the recommended

sites and offers significant regional reliability benefits for Ventura County. For further details of the summaries presented in **Table 9.1,** see **Appendix H**.

Table 9.1 summarizes the estimated capital costs based on the AACE Class 5 OPCCs presented in **Section 7**, corresponding normalized unit capital costs, estimated annual O&M costs, and the estimated total annualized cost for each potential site. For further details of the summaries presented in **Table 9.1**, see **Appendix H**.

Table 9.1 Comparative Total and Unit Capital Cost Summary for Recommended Sites[1]

Site	Capacity (mgd)	Estimated Capital Cost (Low-High)	Unit Capital Cost ($M/mgd)	Unit Capital Cost ($K/AFY)	Annualized Capital Cost ($M/yr)	Estimated O&M Cost ($M/yr)	Total Annualized Cost ($/AF)
Doheny[2]	10	$448-569M	$45-57	$40-51	$29-37	$19	$4,300-5,000
Port Hueneme	20	$1.35-1.66B	$68-83	$60-74	$88-108	$39	$5,700-6,600
El Segundo	10	$573-745M	$57-75	$51-67	$37-48	$19	$5,100-6,100

[1]Costs shown exclude conveyance and distribution infrastructure beyond identified system integration tie-in points. Land acquisition is included only where explicitly stated (e.g., El Segundo).

[2]Doheny capacity is for expansion over the existing planned 5 mgd capacity.

Estimated implementation schedules for the three potential seawater desalination plants range from 9.5 to 12.5 years and generally follow the same relative pattern as capital costs and infrastructure complexity. Doheny is anticipated to have the shortest overall schedule due to simpler conveyance, favorable system integration, and reduced constructability challenges. El Segundo presents a moderate schedule profile, with urban permitting, site constraints, and coordination with existing infrastructure influencing design and construction durations. Port Hueneme is expected to require the longest implementation schedule, driven by extensive conveyance construction, multiple pump stations, and increased permitting and construction complexity. Overall, while Port Hueneme provides the greatest potential production capacity, Doheny represents the lowest-cost and most implementation-ready alternative, and El Segundo offers a balanced, centrally located mid-range option with strong system integration potential.

9.7 Funding Opportunity and Potential Partnerships

Funding opportunities for seawater desalination projects are limited but could be leveraged through a combination of federal, state, and local programs that support water supply resilience, infrastructure modernization, and climate adaptation. Key potential sources include the U.S. Bureau of Reclamation WaterSMART Program, EPA Water Infrastructure Finance and Innovation Act loans, the State Water Resources Control Board Drinking Water State Revolving Fund, and upcoming California Department of Water Resources desalination grants under Proposition 4. Additional opportunities may also be available through public-private partnerships or collaborations with regional or interstate agencies that share long-term water reliability objectives.

Of the three potential sites, the Doheny seawater desalination plant appears best positioned to pursue near-term funding due to its project readiness and existing environmental documentation. The potential

El Segundo and Port Hueneme projects could become strong candidates in future funding cycles as further studies progress. Overall, desalination project financing would likely require a combination of grants, low-interest loans, and partnership contributions to manage costs and support implementation.

Successful implementation of seawater desalination projects within the Metropolitan service area would depend on forming strategic partnerships with local agencies, utilities, and potential private stakeholders. Each of the three evaluated sites presents distinct partnership opportunities based on ownership, location, and integration potential. The Doheny seawater desalination plant offers the most clearly identifiable near-term partners and an existing delivery framework (SCWD, MWDOC, and JRWSS), although expansion remains institutionally complex due to islanded integration and multi-party coordination requirements. These existing relationships provide a clear framework for a potential water purchase agreement or joint operations approach. The potential El Segundo seawater desalination plant could be developed in partnership with nearby member agencies and industrial users such as Chevron, which may provide both siting and cost-sharing opportunities. The potential Port Hueneme seawater desalination plant would likely involve coordination with Calleguas and the U.S. Navy, given its locations on the Port Hueneme Naval Base and potential regional reliability benefits.

Overall, Doheny offers the most identifiable set of potential partners and existing contractual touchpoints, El Segundo provides opportunities for regional and industrial collaboration, and Port Hueneme presents the potential for federal and regional partnerships that could enhance reliability and cost-sharing for future desalination development.

9.8 Recommendations for Next Steps

Regarding the Doheny seawater desalination facility, Metropolitan could continue coordinating with South Coast Water District to monitor project development and gather insights applicable to future regional seawater desalination efforts. Because the facility is being advanced under a DBO project delivery approach with a private entity responsible for delivery and operations, it would be valuable for Metropolitan to evaluate policy alignment and comfort level with this type of long-term project delivery and operating structure. Early outreach to potential regional partners could also help clarify possible roles in water purchase, wheeling, or cost-sharing arrangements. In the near term, Metropolitan could focus on monitoring regulatory approvals, construction progress, and operational performance data from the initial phase, as well as documenting lessons learned related to permitting, public engagement, and DBO implementation. Ongoing observation of regulatory progress, construction milestones, and operational data will provide useful information to inform future planning and policy considerations. Longer-term decision triggers to monitor include demonstrated long-term beach well performance, confirmed operating cost trends, evolution of Ocean Plan requirements, and broader regional supply-demand conditions that may warrant expansion. In addition, while evaluation of co-development with an integrated DPR project was beyond the scope of this study, future coordination could consider whether integrating DPR and desalination facilities may offer operational flexibility, shared infrastructure opportunities, or enhanced regional supply reliability benefits.

For the potential Port Hueneme seawater desalination plant, additional research could focus on refining the technical feasibility of subsurface slant wells through a targeted hydrogeologic investigation. Understanding the site’s subsurface conditions is key to assessing long-term performance and

regulatory viability, particularly in determining whether the local aquifer system can support the estimated 40 mgd extraction capacity needed for full-scale production. Near-term actions could include collection of additional geotechnical and hydrogeologic data, pilot testing of slant well performance, and coordination with permitting agencies regarding subsurface intake acceptability. In parallel, Metropolitan could continue evaluating alternative intake concepts such as the offshore or submerged buoy technology, which may offer a viable approach in areas where subsurface intakes face hydraulic limitations. Collaborative studies with Calleguas and the United States Navy could further help identify data gaps, shared infrastructure opportunities, and long-term regional integration pathways. Long-term triggers to monitor include maturation and cost reduction of alternative intake technologies, changes in federal or state permitting policies affecting ocean intakes and discharges, and regional reliability conditions that would justify advancing a 20 mgd facility.

Finally, for the potential El Segundo seawater desalination facility, Metropolitan could continue monitoring progress on the PWLA program, with particular attention to how the use of the Hyperion WWTP effluent may evolve. If these programs proceed as planned, nearly all of Hyperion's wastewater could be captured for advanced treatment and reuse, leaving little or no effluent in the ocean outfall for blending with brine from a potential seawater desalination facility. This scenario could create permitting challenges related to discharge concentration and compliance with Ocean Plan requirements. Additionally, development of one or both large-scale potable reuse projects in the region could reduce the incremental supply need currently envisioned for seawater desalination in this area, potentially affecting project timing, scale, or overall viability. Near-term actions could include continued coordination with regional agencies regarding effluent availability projections, discharge modeling assumptions, and Ocean Plan compliance pathways. Continued coordination with regional stakeholders would help evaluate these evolving conditions and identify opportunities for future partnership exploration. Long-term triggers to monitor include the scale and timing of potable reuse buildout, changes in discharge regulations or blending requirements, and future technology advancements in high-recovery desalination or concentrate management that could mitigate discharge constraints.

This research study provides a strategic framework to guide future decision-making under CAMP4W. Advancement of any seawater desalination project would require separate Board authorization, environmental review, stakeholder engagement, and detailed engineering studies.

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Appendix A Key Information from Literature Review

Table A.1 Summary of Key Information from Literature Review

Agency/ Sponsor	Document Title	Type of Study	Publication Date	Key Findings
MWD	MWD Desalination Integration Study	Planning Study	1994	12 sites for a potential seawater desalination project were evaluated and alternatives were developed for integrating product water into the local/ regional distribution system. Each site was evaluated across a range of facility production capacities (20, 40, 60, 80 and 100 mgd). Findings included: - Large capacity plants are most cost-effective when tied into either MWDs or local agency systems. In general, local agency system integration is more cost effective for lower capacity plants (20 and 40 mgd).
SDCWA	A Pilot Study Using Seawater Reverse Osmosis Membranes in Combination with Various Pretreatments to Meet the Challenges of Pacific Seawater Desalination	Pilot Study	2006	A 3-year pilot study (2003 to 2006) was conducted at Encina Power Station which looked at RO performance relative to three (3) different pre-treatment approaches, which demonstrated:- There are advantages of utilizing cooling water from the power station for feed to the future desalination facility - Both granular media and membrane filtration pretreatment proved effective during normal water quality conditions; however, membrane filtration was more difficult to operate due to fouling RO fouling accelerated during deterioration in the raw water quality irrespective of the pretreatment technology.
SDCWA	Supplement to the Precise Development Plan and Desalination Plant Project Final Environmental Impact Report	Environmental Impact Report (EIR) Supplement	2006	Transition from co-located operations with Encina Power Station to permanent stand-alone operations, was considered, including changes to the intake/discharge and proposed capacity changes, covering: - A proposal to increase production by 5 mgd through advances in RO (reverse osmosis) technology and only minimal improvements to the plant. New information added related to environmental analysis, which considered air quality, biological resources, greenhouse gas emissions, hydrology and water quality, energy (including stand-alone supply), and growth inducement.
WBMWD	Microfiltration/Reverse Osmosis Ocean Water Desalination Pilot Plant Project	Pilot Study	2008	The 5-year study looked at MF(microfiltration)/UF(ultrafiltration) pretreatment, along with RO, using power plant influent/effluent cooling water as the feed water source. Both MF and UF membranes provided high quality feedwater for the RO with only occasional losses in permeability due to red tide events which occurred during the study.
Multi-Party[1]	Investigation of Binational Desalination for the Benefit of Arizona, United States and Sonora, Mexico	Preliminary Planning Study	2009	The project costs for a large (107 or 1,070 mgd) binational seawater desalination facility to be located in Puerto Peñasco (Mexico) were evaluated: - Product water would be conveyed to Imperial Dam (United States). Class 5 OPCC (+50% to -30%) for 20-year term prepared.

Agency/ Sponsor	Document Title	Type of Study	Publication Date	Key Findings
SDCWA	Camp Pendleton Seawater Desalination Project Feasibility Study	Feasibility Study	2009	Two sites near the Santa Margarita River were investigated for a seawater desalination facility: - Sites had been vetted and selected in consultation with Camp Pendleton personnel. - Project envisioned the plant being constructed in phases (50 mgd Initial, 150 mgd Ultimate) as supply and demand conditions warranted. - Various intake designs were considered and final selection was deferred based on future hydrogeologic studies. - A dedicated outfall with diffuser ports would be used to convey brine and occasional discharges from Camp Pendleton's SRTTP wastewater treatment facility. - Estimated 20-30 acres required for 150 mgd facility. - Anew high voltage service connection and self-generation were considered viable with respective trade-offs. - A conveyance path for the product water was recommended to minimize cost, environmental impacts and areas frequented by the public. - Both proposed sites present certain regulatory challenges associated with impacts to aesthetics, the local marine environment, and threatened/endangered species habitat. Class 4 OPCC were prepared for both site alternatives.
SDCWA	Rosarito Beach Binational Desalination Plant Feasibility Evaluation and Preliminary Design Phase 1	Feasibility Study	2010	The study concluded there were no fatal flaw issues in the siting of a proposed 50 mgd seawater desalination facility adjacent to the existing power generation facility (CFE) at Rosarito Beach, to serve customers in both Mexico and California: - Identified a feasible pipeline alignment route for bringing treated water to San Diego. - Confirmed that sufficient electrical power is available from CFE. - Noted that a 6-8 month seawater pilot plant study was performed in 2004 and operating data from that investigation is available. Noted that there are complex cross-border. environmental permitting issues, and little precedent, for a bi-national project of this nature.
Affordable Desalination Collaboration (Re-organized by chronological order)	Optimizing Seawater Reverse Osmosis for Affordable Desalination	Pilot Study	2012	The Initial demonstration study showed that using energy efficient RO technologies and pumps, Dow Filmtec membranes and energy recovery equipment, it was possible to achieve a 35 percent (%) savings in cost compared to typical expectations for seawater desalination. Following adjustments to equipment and new flow regimes to increase system recovery resulted in a total energy consumption comparable to other traditional water sources in southern California.

Agency/ Sponsor	Document Title	Type of Study	Publication Date	Key Findings
				The projected total water cost reached a minimum at 50% system recovery (45% RO recovery) at 9 gallons per square foot per day (gfd) or at 55% system recovery (50% RO recovery) at 7.5 gfd.
MWD	Assessment of Existing Seawater Desalination Integration Practices	Technical Report	2012	Utilities approaches to integrating large-scale seawater desalination plants into their existing distribution systems were evaluated. Ten (10) plants were surveyed around the world. All plants utilized RO but had varying intakes and percentage of seawater desalination as part of their overall water portfolio. Recommendations included: - To minimize DBP formation and chloramine residual decay, a water quality goal for bromide should be established for the RO permeate, as opposed to plant effluent after post-treatment and primary disinfection. - A cost-benefit analysis on the appropriate treatment level for boron. Engagement of a knowledgeable Owner's Agent and development of a carefully planned water quality performance spec were deemed essential for controlling project cost, maximizing efficiency, and facilitating successful implementation.
LBWD	Two-Pass Nanofiltration Seawater Desalination Prototype Testing and Evaluation	Pilot Study	2013	The performance of a two-pass nanofiltration process intended to reduce the energy requirement for desalting was considered and showed: - With pH adjustment (>9.2), boron removal was successful in achieving the product water boron goal (<1 mg/L). - Compared to the single-pass RO system, the specific energy consumption for the 2-pass NF (nanofiltration) was slightly higher than a single-pass RO due to a lower overall recovery - TDS levels in the 2-pass NF permeate were around 200 mg/L, which was similar to typical LBWD distributed drinking water concentrations. The 2-pass NF process resulted in the lowest cost of product water which met the drinking water regulations and goals ($4.07–$4.24/kgal for 50 mgd)
MWDOC	Final Summary Report Doheny Ocean Desalination Project Phase 3 Investigation	Technical Report	2013	Findings of 6 years of testing associated with the slant wells for a proposed seawater desalination facility located in Dana Point, CA, are presented: - Slant wells were pursued for this project as they were deemed the most cost-effective approach for this location. Other approaches were discarded due to either high costs and/or difficulty in permitting. - Sant wells performed well over the extended testing period and produced water low in turbidity, bacteriological activity and silt density index (SDI). High levels of dissolved iron and manganese were present in the marine groundwater, which would be expected to decrease over time as the aquifer is recharged with Yes - made global change of MWD to Metropolitan seawater.
MWDOC	Pilot Plant Testing of Slant Well Seawater	Pilot Study	2013	Pilot study operated for 19 months (June 2010 to April 2012) to support further refinement of groundwater modeling and to provide information needed for full

Agency/ Sponsor	Document Title	Type of Study	Publication Date	Key Findings
	Intakes and AWT Pretreatment Technologies for Control and Removal of Iron and Manganese			scale system design, including any necessary RO pretreatment for iron and manganese removal as well as any treatment for control of biological activity. - RO performance both with and without pretreatment were considered. - Stable RO performance was observed with no pretreatment (only 5-micron cartridge filtration), indicating the slant well water had a low fouling potential. Additionally, the anoxic condition maintained the iron and manganese in their soluble state. - Aeration, along with media filtration, was sufficient to oxidize and remove iron, however, manganese remained in the dissolved state, passing through the media filters without oxidation. Granular Media Filtration (GMF) with catalytic media and oxidant (sodium hypochlorite) dosing provided the highest quality filtrate for application to the RO membranes. This configuration had the lowest iron and manganese levels, low SDI values, and showed acceptable RO permeability decline during testing.
WBMWD	Ocean Water Desalination Program Master Plan	Master Plan	2013	Critical aspects associated with West Basin's future desalination program were addressed. Two locations were assessed in detail: NRG El Segundo Generating Station and Applied Energy Services (AES) Redondo Beach Generating Station. - Both sites warranted further consideration. - Open ocean intake and outfall with diffusers which utilize existing intake and discharge tunnels associated with the power plants was determined to be the most cost-effective solution for this size facility - Local service connections determined to be the most effective solution for product water conveyance Onsite power generation was recommended as natural gas is already available at both sites.
Poseidon Water	Technical Feasibility of Subsurface Intake Designs for the Proposed Poseidon Water Desalination Facility at Huntington Beach, California	Feasibility Study	2014	The technical feasibility of using one or more potential subsurface seawater intake (SSI) technologies to supply between 100 and 127 mgd of feed water to a 50-mgd capacity seawater desalination facility was evaluated. Seabed infiltration gallery and surf zone (beach) gallery options were deemed technically feasible, however, neither type has been used at the scale required for a 50-mgd capacity facility and both types would face constructability challenges related to subsea construction, particularly a surf zone gallery type.
CMWD	Seawater Desalination Technical Memorandum	Technical Memorandum	2016	A preliminary assessment, and estimated costs, for 10 and 80 mgd seawater desalination facility options was performed. Evaluation of specific sites for a future facility was not part of this evaluation.
WBMWD	Feasibility Assessment of Subsurface Seawater	Feasibility Study	2016	Seven (7) different subsurface seawater intake (SSI) technical approaches for a future 40 mgd facility located in El Segundo, CA were considered.

Agency/ Sponsor	Document Title	Type of Study	Publication Date	Key Findings
	Intakes Proposed Desalination Facility El Segundo, California			All 7 approaches were ruled infeasible due to either lack of precedent, fatal flaws, and/or impeded access on land for associated infrastructure
San Diego County Water Authority (SDCWA)	Feasibility Assessment of Carlsbad Desalination Plant Intake and Discharge Alternatives	Feasibility Study	2017	Evaluation of WWS for modification to existing intake system led to concluding that WWS are not the preferred intake alternative due to: - No precedence for WWS at the required scale, raising concerns regarding both performance and long-term reliability, - Uncertainty how WWS will fare in low energy seawater lagoon environment, - Results in permanent loss of benthic habitat within the lagoon, - Higher cost and longer implementation schedule compared with other alternatives.
Poseidon Water	Carlsbad Desalination Plant Wedgewire Screen Pilot Study	Pilot Study	2022	Passive vs Active Wedgewire Screens (WWS) were evaluated for a new intake system to be constructed upon closure of the Encina power station. Passive WWS required monthly manual cleaning events to control biofouling. Active WWS (automatic rotation against fixed brushes 3-4x per day) effective at controlling biofouling.
SCWD	Integrated Water Resource Plan	Master Plan	2022	The Integrated Water Resources Plan (IWRP) reviewed SCWD's water supply portfolio from both a supply and system reliability standpoint: - Planning scenarios were developed to account for risk under different uncertainties, such as climate change, local water demands and groundwater, and imported water conditions. - A list of preliminary water supply alternatives was initially identified to meet SCWD's future needs and screening criteria were applied to these preliminary alternatives to determine which ones should be carried forward for more detailed evaluation. - The highest scoring portfolio included a 5 mgd Doheny Ocean Desalination Plant (with 2.1 mgd going to SCWD and 2.9 mgd going to partners), finished tank storage, expanded landscape conversions, and expanded non-potable recycled water.
CSDIG	Seawater Desalination Siting and Streamlining Report to Expedite Permitting	Technical Report	2023	The California Seawater Desalination Interagency Group (CSDIG) outlines a process for Memorandum of Agreement (MOA) signatory agencies to coordinate and collaboratively review documents and materials submitted as part of seawater desalination project applications. Recommendations include: - a list of criteria under which new seawater desalination projects would be evaluated under a streamlined permitting track which would result in faster and more effective Agency permitting.

Agency/ Sponsor	Document Title	Type of Study	Publication Date	Key Findings
				- integrated water resource management planning to streamline the process of performing a needs analysis for seawater desalination facilities. - Project proponents seeking a streamlined path should take a proactive approach and submit the water supply and demand assessment to the agencies early in the permitting and CEQA processes. - A number of future amendments to the CCC Ocean Plan to improve clarity such as providing additional guidance on the information needed by project proponents to demonstrate a need for desalinated water.
Metropolitan Water District of Southern California (MWD)	Offshore Seawater Desalination White Paper: New Technology and Opportunities	Technical Memorandum	2024	Offshore desalination technologies and presents current companies and research institutions with active innovative desalination technologies or prototypes are summarized: - Technology readiness levels were assessed for each technology type. Ship/ Barge-based desalination was given the highest ranking (9 or commercially available) while submerged offshore desalination and floating ocean buoys for wave and non-wave powered desalination were given scores of 7 (prototype has been demonstrated in an operational environment).

[1]Multi-Party = Arizona Department of Water Resources, United States Bureau of Reclamation, and the Comision Estatal del Agua

Appendix B Key Information from Emerging Technologies

Table B.1 Summary of Key Information for Emerging Technologies

Technology Area	Technology Type	Technology Readiness Level	Key Information
Offshore Desalination	Ship/barge-based desalination	Up to 9	▪ The floating ships or barges are equipped with a RO desalination plant, storage tanks, and other necessary equipment for the treatment and distribution of water. It is a highly adaptable solution, particularly in areas lacking infrastructure or resources to support traditional desalination plants. ▪ Technology's benefits are rapid deployments, scalable operations, and a diluted brine discharge. It may address the following land-based barriers: high construction costs and desalination plant deployment in areas lacking infrastructure. ▪ This technology can be implemented by several companies. One company has already delivered a 13.2 mgd barge-based diesel-powered desalination facility, which is the basis for considering this technical approach commercially available and in operation.
	Submerged offshore desalination	5 to 7	▪ Concepts include placing RO modules on the seafloor, anchoring RO modules that reside 30 meters above the seafloor, and suspending RO modules from ships or wind turbine platforms. ▪ Treatment systems use natural hydrostatic pressure to obtain the pressure needed for RO. ▪ It may address the following land-based barriers: high energy requirements/Greenhouse gases emissions, significant environmental impacts, and challenging permitting requirements. ▪ Several companies are developing proprietary technologies. They have different levels of readiness depending on the current prototype/piloting status, as well as the status of signed Memorandums of Understanding (MOUs) and/ or active commercial contracts.
	Floating ocean buoys for wave and non-wave-powered desalination	3 to 7	▪ The technologies are divided into two groups, wave energy converter (WEC) and non-WEC. The captured energy by WEC systems powers RO membrane-based desalination. Non-WEC systems involve a floating buoy anchored to the ocean floor connected to a pipeline and power cables that run to the ocean floor to filter seawater passively through the RO membrane. ▪ Claimed benefits include modular equipment, scalable operations, rapid deployments, reduced energy demand, reduced impact on the environment and marine life, and no need for chemical pre-treatment of intake water. ▪ Some companies working on WEC applications have prototypes operating in a representative environment. In contrast non-WEC applications are still progressing through proof of concept.
	Integrated offshore wind energy desalination	5	▪ Technology approach is to couple offshore wind power and desalination by using wind turbine energy to power the desalination process. ▪ Onshore facility footprint is reduced to post treatment systems and finished water storage and pumping. ▪ Technical approach relies on fairly mature parent technologies. ▪ 2 companies are working on this technology; but neither of them has been tested in operational environments.
Alternative Desalination Technologies	Forward Osmosis	2	▪ Employs a natural pressure gradient provided by a higher salinity "draw" solution, typically ammonium carbonate. The draw solution provides a natural, higher osmotic driving force compared to hydraulic pressure, resulting in low fouling potential, low energy consumption, and simplicity.

Technology Area	Technology Type	Technology Readiness Level	Key Information
			▪ Purified water is separated from the draw solution using an additional separation process. The separated draw solutes are recovered and reused or discharged. ▪ Currently, forward osmosis (FO) is used in the food and beverage industry, but is still conceptual for use with high salinity water.
	Membrane Distillation	2	▪ Involves evaporation of water from a saline solution and transport of the water vapor via thermal gradient through a hydrophobic membrane, followed by condensation. ▪ Advantages of membrane distillation (MD) include use of low-grade heat, minimal pretreatment needs, and negligible scaling. Challenges include need for waste heat to promote economic feasibility, membrane fouling, and membrane degradation due to loss of hydrophobicity. ▪ Currently in the development and demonstration phase.
	Capacitive Deionization	7	▪ Directs saline solution between porous electrode pairs that adsorb ions by applying a low voltage electric field, producing deionized water. Upon removal, ions are desorbed from the surface of the electrodes by removing the induced electric field, and electrodes are regenerated. ▪ Advantages include low energy requirement and simple construction. Challenges include limited adsorption capacity of electrodes, slow kinetics of transport of ions across electrodes, high cost of capacitive deionization (CDI) modules, and fouling potential of the electrode surface. ▪ Currently in the development stage in United States, although full-scale facilities are reportedly operating in China and Mongolia.
	Hydraulic Injection Desalination	4	▪ An agreement was reached amongst Saudi organizations to implement hydraulic injection desalination (HID) at scale based on results from proprietary research. ▪ Little is known about the technology, but owner's claim potential to lower energy consumption below 2 kW/m^3.
	Halophytic Algae	1	▪ Uses salt-tolerant algae to accumulate salt within the algal cells. The salt-laden algae can then be removed via traditional filtration processes and used as biofuel to offset energy inputs. ▪ Currently in the early stages of research development and has been shown to remove up to 30% of salt from saline solutions.
	Freeze/Thaw Desalination	1	▪ Relies on phase changes as ice crystals reject salt from their structure, allowing it to be separated from ice as a brine. ▪ Primary benefit is less energy required compared to traditional RO. The primary challenge is washing and separation of ice crystals without melting and recontamination with salt.
	Solar Thermal Desalination	2	▪ Combines thermal desalination systems with a concentrated solar system. Commonly employs thermal collectors or concentrated thermal collectors to extract the energy required. ▪ Advantages include use of renewable solar energy and minimization of land-use requirements compared to traditional sun-powered thermal desalination.
	Supercritical Water Desalination	1	▪ Supercritical conditions occur at elevated pressures and temperatures, creating a poor solvent and allowing for separation of solid salt particles via precipitation. ▪ This technology is in the development phase and has not been tested outside of the laboratory.

Technology Area	Technology Type	Technology Readiness Level	Key Information
Brine Minimalization/ Mining	Various	6	▪ High recovery systems (HRS) are commonly used for brackish water and inland desalination facilities; however, their target has almost universally been to reduce the cost of brine disposal and maximize the use of the water source rather than to produce specific mineral products. ▪ Some mineral products can command a high price, making them attractive as mineral recovery alternatives, yet the level of purity required to obtain this higher price is often difficult to achieve. ▪ Commercial concentrate recovery facility has been built in El Paso, Texas, but has struggled to maintain reliable operation and has yet to bring salt products to market. ▪ The lowest cost brine minimization approach considered feasible for large seawater desalination plants would be the installation of evaporation ponds for a small portion of the desalination brine, thus producing manageable quantities of sea salt that can be directly tied to a market or used for onsite sodium hypochlorite generation.
Energy Recovery and Pumping	Positive Displacement Pumps	8	▪ Positive displacement (PD) pumps are commonly used in the oil & gas sector due to their pump characteristics, ability to handle viscous liquids, and high reliability. ▪ Compared with centrifugal pumps, PD pumps operate at the same efficiency regardless of the downstream pumping conditions. ▪ Compared with centrifugal pumps, PD pumps provide higher pumping efficiencies (Up to 90% vs 75 to 85%). ▪ The largest PD pumps available on the market have a capacity of around 1 mgd. This essentially limits their use to small seawater RO facilities (<5 mgd). There is not currently a market for larger capacity PD pumps.
	Pressure Exchange Type Energy Recovery	9	▪ Several types of energy recovery devices (ERDs) have been in use in the seawater RO industry for many years. Since the early 2000s, the Pressure Exchange (Isobaric) type devices have effectively replaced Pelton Wheels and Turbochargers due to the higher efficiency this technology provides (Up to 97%). ▪ There are two primary manufacturers of isobaric ERDs – Energy Recovery Inc (ERI) and Flowserve, with ERI's product offering providing the majority of installations since the mid-2000s.
	Pressure Retarded Osmosis	7	▪ Pressure retarded reverse osmosis (PRO) is a process that would harness the osmotic pressure difference between two solutions of different salinities to generate power or perform work. ▪ In a sea water reverse osmosis (SWRO) facility, PRO could recover energy from the concentrate by using a low salinity water, such as a river or wastewater discharge, using the osmotic pressure differential to generate electricity or drive a turbine. ▪ The technology has been successfully demonstrated at SWRO facilities in Japan, demonstrating that net power usage could be reduced by 0.34 kWh/m^3. ▪ Kyowakiden Industry Company is developing a commercial product for use in desalination facilities
	Depth Exposed Membrane for Water Extraction (DEMWAX)	2	▪ DEMWAX uses natural pressure and water movement at depth to provide the energy required for the RO process.

Technology Area	Technology Type	Technology Readiness Level	Key Information
			▪ The RO membranes are positioned at the bottom of a well casing located onshore. The desalination process employs the hydrostatic pressure to power the RO process. Permeate would need to be pumped back to the surface. ▪ There is limited information on the stage of the DEMWAX technology beyond a 2015 white paper available on the company (EconoPure Water Systems) website outlining the concept.
	Wave Energy	6	▪ Several companies have developed commercial size products for generating power from wave energy. ▪ Some of these products are currently undergoing long-term piloting and/or are slated to begin piloting in the near-term. ▪ Wave energy products fall under two general categories: Submerged and Semi-Submerged. ▪ To meet the demand of a large seawater desalination facility, multiple wave energy units would need to be deployed and networked together. Current piloting/demonstration has not expanded beyond single units in operation.
	Seawater pump storage with desalination	3	▪ It uses off-peak energy to pump seawater into a higher-elevation storage reservoir. During high electricity demand, the stored seawater is released back down through a turbine to generate electricity and also to feed the desalination plant. ▪ The hydrostatic pressure reduces or eliminates the additional energy requirements for the RO process; thus all the required energy is supplied by the turbines. ▪ Restricted to locations that meet specific siting criteria (e.g. sufficient coastal elevation rise and available land for reservoir siting).
	Off-Site Renewable Energy	9	▪ Several seawater desalination projects have offset future energy use through the inclusion of off-site large-scale wind energy farms, namely in Australia. ▪ By utilizing off-site locations, it is possible to economically develop large-scale wind/solar projects, utilize preferable locations for the preferred form of renewable energy generation, and streamline permitting. ▪ Introduces technical/ permit/ organizational complexity by creating a parallel project.
Subsurface Seawater Intakes	Vertical, Slant, Horizontal, and Radial Collector Wells	7 to 9	▪ Vertical “beach” wells have a long track record in the industry, primarily for supplying small-scale facilities. The largest seawater desalination facility utilizing beach wells is the Sur plant in Oman which has a capacity of 80,000 m3/d (approximately 21 mgd), which has been in operation since 2007. ▪ Slant wells have been tested in California and are proposed for use on the forthcoming Doheny ocean desalination project as well as the Monterey Peninsula Water Supply project. Both projects will have an initial capacity of approximately 5 mgd. ▪ Horizontal wells for seawater extraction were introduced to the market in the late 1990s, however, subsequent experience in Spain demonstrated a high susceptibility to plugging over time. ▪ Radial (Ranney) wells have a long track record in groundwater applications, being well suited to the favorable hydrogeological conditions present near many rivers. They are much less common for seawater extraction which is characterized by much finer grained materials surrounding these marine coastal locations.

Technology Area	Technology Type	Technology Readiness Level	Key Information
Outfalls	Seabed/ Beach/ Deep Infiltration Gallery	9	▪ Infiltration galleries are based on locating a networked intake system beneath an engineered seabed and utilizing the material above the intake as a type of slow sand filter. ▪ A desalination plant in Fukuoka, Japan has successfully operated a 27-mgd seabed infiltration gallery for almost 20 years and a demonstration project was operated in Long Beach, CA for 3 years. ▪ Deep infiltration galleries (or Water Tunnels) utilize a large horizontally drilled pipe (i.e. tunnel) which connects a series of vertical or radial collector wells to an onshore pump station. One such application of this approach has been used for several years to supply a portion of the raw water used by the Alicante II desalination facility in Spain. ▪ Technical hurdles to this technology include relatively limited performance/ reliability data available, complex construction methods, environmental impacts during construction, and potential susceptibility to severe ocean currents/waves as well as earthquakes.
	Venturi Diffusers	8	▪ Alternative mixing device to standard diffuser type (“duckbill”) valve. ▪ Journal article co-written by researchers and product designer cites better near field mixing of brine with seawater using venturi mixers. ▪ Venturi mixers have been installed at two seawater desalination plants: Maspalomas II (Canary Islands) and Gozo (Malta).
	Bio-Enhancing Concrete	8	▪ Developed to improve marine ecosystems and provide mitigation for offshore construction. ▪ Reportedly has an 80% reduced carbon footprint and 7 times the carbon sequestration capacity of conventional concrete ▪ 3-year pilot project at the Port of San Diego began in 2021 on Harbor Island. Also, in use at Port of Vigo, Spain.
	Carbon Sequestration	7 to 9	▪ Ocean alkalinity enhancement (OAE) has been proposed as a method of reducing GHG from the atmosphere, using the ocean’s natural processes as a carbon sink, and enhancing these through the discharge of high alkalinity desalination brine that results from the discharge of brine back to the ocean. ▪ One study estimated that most marine locations can achieve an uptake-efficiency of 0.6 to 0.8 moles of carbon dioxide (CO_2) sequestration per mole of alkalinity added to the ocean from desalination brine. ▪ Assuming an average seawater alkalinity of ~130 mg/L as $CaCO_3$, the brine discharge could be expected to reduce atmospheric CO_2 by approximately 230 pounds for every million gallons discharged. ▪ Technology developed by Captura is focused on removing carbon directly from seawater for subsequent use or permanent storage. Their system could be coupled with a seawater desalination plant or installed as a stand-alone process.
	Process Monitoring & Energy Efficiency	9	▪ Several companies are involved in this space which aims to simultaneously improve energy efficiency, reduce chemical consumption and maximize membrane life through improved process control and optimized chemical cleaning achieved through both machine learning and advanced analytics. ▪ Several mature products are available in the market to suit both targeted and broad applications.

Technology Area	Technology Type	Technology Readiness Level	Key Information
			▪ Software is being developed broadly across the industry by software developers, engineering firms, and equipment/technology suppliers.
Artificial Intelligence	Predictive Maintenance	9	▪ Software aims to improve predictive maintenance practices by utilizing machine learning to monitor equipment data and provide timely maintenance intervention notification. ▪ Several software offerings are available on the market. ▪ Both software developers and equipment/technology providers are working in this space.

Appendix C Cost Summary from Siting Study

Site #	Name	Intake	Outfall	Product Water (MGD)	Product Water (AFY)	Slant Well Cost ($)	Open Ocean Intake Cost ($)	Well Pipe to Treatment Cost ($)	Treatment Plant Cost ($)	Product Water Conveyance to Shore ($)	Discharge Pipe Cost ($)	New Ocean Outfall Cost ($)	O&M Cost ($/yr)	Total Capital Cost ($)	Annualized Capital Cost ($/yr)	Total Annualized Cost ($/yr)	Cost/MG ($)	Cost/AF ($)
1A	Oceanside Vicinity (Oceanside)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10	11,201	$ 95,404,500	--	$17,630,000	$178,123,089		$26,136,000	--	$29,144,190	$317,293,589	$20,640,403	$49,784,593	$13,640	$4,445
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10	11,201	$ 95,404,500	--	$17,741,000	$178,123,089	--	$38,016,000	--	$29,144,190	$329,284,589	$21,420,435	$50,564,625	$13,853	$4,514
2A	Camp Pendleton MCTSSA	New Ocean Intake	Existing San Onofre Power Plant Outfall	50	56,005	--	$ 1,691,712,000	--	$655,972,935	--	$205,920,000	--	$163,665,209	$2,553,604,935	$166,115,666	$329,780,875	$18,070	$5,888
2B	Camp Pendleton MCTSSA	New Ocean Intake	New Ocean Outfall	50	56,005	--	$ 1,691,712,000	--	$655,972,935	--	--	$563,904,000	$163,665,209	$2,911,588,935	$189,403,039	$353,068,248	$19,346	$6,304
3	Doheny State Beach Expansion	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	10	11,201	$ 95,404,500	--	$17,297,000	$178,123,089	--	--	--	$29,144,190	$290,824,589	$18,918,557	$48,062,747	$13,168	$4,291
4	Huntington Beach	Slant Wells (20)	Existing AES Huntington Beach Generating Station Power Plant Outfall	20	22,402	$212,010,000	--	$21,099,000	$312,287,437	--	--	--	$58,288,380	$545,396,437	$35,478,821	$93,767,201	$12,845	$4,186
5	Long Beach	New Ocean Intake	New Ocean Outfall	20	22,402	--	$ 676,684,800	--	$312,287,437	--	--	$225,561,600	$65,466,084	$1,214,533,837	$79,007,169	$144,473,253	$19,791	$6,449
6A	El Segundo	Slant Wells (20)	Existing Hyperion WWTP Outfall	20	22,402	$212,010,000	--	$14,256,000	$312,287,437	--	--	--	$58,288,380	$538,553,437	$35,033,674	$93,322,054	$12,784	$4,166
6B	El Segundo	Converted Power Intake	Existing Hyperion WWTP Outfall	20	22,402	--	$ 51,119,509	--	$312,287,437	--	--	--	$65,466,084	$363,406,947	$23,640,143	$89,106,227	$12,206	$3,978
7A	Port Hueneme	Slant Wells (20)	Existing Oxnard WWTP Outfall	20	22,402	$212,010,000	--	$45,619,000	$312,287,437	--	$48,787,000	--	$58,288,380	$618,703,437	$40,247,546	$98,535,926	$13,498	$4,399
7B	Port Hueneme	New Ocean Intake	Existing Oxnard WWTP Outfall	25	28,003	--	$ 845,856,000	--	$374,155,061	--	$55,757,000	--	$81,832,605	$1,275,768,061	$82,990,543	$164,823,148	$18,063	$5,886
8	Port Hueneme (Offshore Desal)	N/A	N/A	20	22,402	--	--	--	$562,117,387	$451,123,200	--	--	$44,557,470	$1,013,240,587	$65,912,754	$110,470,224	$15,133	$4,931

						Slant Wells					New Open Ocean Intake							Converted PP Intake						
Site #	Name	Intake	Raw Water Flow (MGD)	Assumed Recovery (%)	Plant Capacity (MGD)	# Wells	Cost per Well (2017 US$)[1]	Escalation Rate (%)	Total Escalation to 2024 (%)	Cost per Well (2024 US$)	raw water flow per foot (2018 $)[2]	Distance (mi)	Distance (ft)	Opean Ocean Intake Cost (2018 $)[2]	Escalation Rate (%)	Total Escalation to 2024 (%)	Estimated Cost (2024 $)	Capital Charge (2006 $)[3]	Escalation Rate (%)	Total Escalation to 2024 (%)	Total Cost (2024 $)	Engineering/ Permitting (20%)	Contingency (30%)	Total Cost per Well ($)	Total Cost ($)
1A	Oceanside Vicinity (Oceanside)	Slant Wells (9)	20	50%	10	9	$3,700,000	13%	91%	$7,067,000	--	--	--	--	--	--	--	--	--	--	--	$1,413,400	$2,120,100	$10,600,500	$95,404,500
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells (9)	20	50%	10	9	$3,700,000	13%	91%	$7,067,000	--	--	--	--	--	--	--	--	--	--	--	$1,413,400	$2,120,100	$10,600,500	$95,404,500
2A	Camp Pendleton MCTSSA	New Ocean Intake	100	50%	50	--	--	--	--	--	$400	1.5	7920	$633,600,000	13%	78%	$1,127,808,000	--	--	--	--	$225,561,600	$338,342,400	--	$1,691,712,000
2B	Camp Pendleton MCTSSA	New Ocean Intake	100	50%	50	--	--	--	--	--	$400	1.5	7920	$633,600,000	13%	78%	$1,127,808,000	--	--	--	--	$225,561,600	$338,342,400	--	$1,691,712,000
3	Doheny State Beach Expansion	Slant Wells (9)	20	50%	10	9	$3,700,000	13%	91%	$7,067,000	--	--	--	--	--	--	--	--	--	--	--	$1,413,400	$2,120,100	$10,600,500	$95,404,500
4	Huntington Beach	Slant Wells (20)	40	50%	20	20	$3,700,000	13%	91%	$7,067,000	--	--	--	--	--	--	--	--	--	--	--	$1,413,400	$2,120,100	$10,600,500	$212,010,000
5	Long Beach	New Ocean Intake	20	50%	10	--	--	--	--	--	$400	3	15840	$253,440,000	13%	78%	$451,123,200	--	--	--	--	$90,224,640	$135,336,960	--	$676,684,800
6A	El Segundo	Slant Wells (20)	40	50%	20	20	$3,700,000	13%	91%	$7,067,000	--	--	--	--	--	--	--	--	--	--	--	$1,413,400	$2,120,100	$10,600,500	$212,010,000
6B	El Segundo	Converted Power Intake	40	50%	20	--	--	--	--	--	--	--	--	--	--	--	--	$14,563,963	13%	234%	$34,079,673	$6,815,935	$10,223,902	--	$51,119,509
7A	Port Hueneme	Slant Wells (20)	40	50%	20	20	$3,700,000	13%	91%	$7,067,000	--	--	--	--	--	--	--	--	--	--	--	$1,413,400	$2,120,100	$10,600,500	$212,010,000
7B	Port Hueneme	New Ocean Intake	50	50%	25	--	--	--	--	--	$400	1.5	7920	$316,800,000	13%	78%	$563,904,000	--	--	--	--	$112,780,800	$169,171,200	--	$845,856,000
8	Port Hueneme (Offshore Desal)	N/A				--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Slant Well Costs (Monterey)[1]			
Cost per Well (2017 US$)	$2,774,907	$3,436,629	$4,944,976
Cost per Well (2017 US$)	$2,749,603	$3,245,905	$4,679,729

Avg Cost per Well (2017 US$) $3,700,000.00

Attachment 3 – Cost Effectiveness of Proposals

Proposal Costs

	Boart	Holt	Layne
7 Slant Wells	19,424,352	24,056,406*	34,614,832
9 Slant Wells	24,746,427	29,213,148*	42,117,562

* includes Holt's submitted costs for $5 material which was not included in their base bid

Hard bids received for the Monterey Desal slant wells lust the drillers' costs

Sources:
1. Monterey Peninsula Water Supply Project Hydrogeologic Investigation, Geoscience (2017).
2. M61, American Water Works Association (2024). From upcoming revision to the Cost Chapter of M61 (range of $180 to $370). Number increased to 400 to reflect higher range.
3. Supplement to the Precise Development Plan and Desalination Plant Project Final Environmental Impact Report City of Carlsbad, Dudek (2006). Table 3-4: capital cost for conversion of lagoon wedgewire screen with diffuser.

Site #	Name	Intake	Outfall	Plant Capacity (MGD)	Subsurface Wells (MGD)	Piping from Wells to Treatment Plant (mi)	Velocity (fps)	Pipe Area (ft^2)	Pipe Diameter (ft)	Well Pipe to Treatment Cost ($)[1]	Distance to Existing Outfall (mi)	Velocity (fps)	Pipe Area (ft^2)	Pipe Diameter (ft)	Discharge Pipe Cost ($)[1]	Distance to Offshore Plant (mi)	Velocity (fps)	Pipe Area (ft^2)	Pipe Diameter (ft)	Conveyance Pipe Cost ($)[2]
1A	Oceanside Vicinity (Oceanside)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10	20	1.6	4	7.7	3.5	$17,630,000	3.3	4	3.9	2.5	$26,136,000	--	--	--	--	--
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10	20	1.6	4	7.7	3.5	$17,741,000	4.8	4	3.9	2.5	$38,016,000	--	--	--	--	--
2A	Camp Pendleton MCTSSA	New Ocean Intake	Existing San Onofre Power Plant Outfall	50	--	--	--	--	--	--	13	4	19.3	5.0	$205,920,000	--	--	--	--	--
2B	Camp Pendleton MCTSSA	New Ocean Intake	New Ocean Outfall	50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	Doheny State Beach Expansion	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	10	20	1.6	4	7.7	3.5	$17,297,000	0	--	--	--	--	--	--	--	--	--
4	Huntington Beach	Slant Wells (20)	Existing AES Huntington Beach Generating Station Power Plant Outfall	20	40	1.5	4	15.5	4.5	$21,099,000	0	--	--	--	--	--	--	--	--	--
5	Long Beach	New Ocean Intake	New Ocean Outfall	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
6A	El Segundo	Slant Wells (20)	Existing Hyperion WWTP Outfall	20	40	1.0	4	15.5	4.5	$14,256,000	0	--	--	--	--	--	--	--	--	--
6B	El Segundo	Converted Power Intake	Existing Hyperion WWTP Outfall	20	40	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7A	Port Hueneme	Slant Wells (20)	Existing Oxnard WWTP Outfall	20	40	3.2	4	15.5	4.5	$45,619,000	4.4	4	7.7	3.5	$48,787,000	--	--	--	--	--
7B	Port Hueneme	New Ocean Intake	Existing Oxnard WWTP Outfall	25	--	--	--	--	--	--	4.4	4	9.7	4.0	$55,757,000	--	--	--	--	--
8	Port Hueneme (Offshore Desal)	N/A	N/A	20	--	--	--	--	--	--	--	--	--	--	--	4	4	7.7	3.5	$451,123,200

Sources:
1. $50 per inch-foot of piping per CCI cost estimate for a conceptual conveyance alignment.
1. M61, American Water Works Association (2024). From upcoming revision to the Cost Chapter of M61 (range of $180 to $370). Number increased to 400 to reflect higher range.

Site #	Name	Intake	Outfall	Plant Capacity (MGD)	US$/gpd (2020)[1]	US$ (2020)	Escalation Rate (%)	Total Escalation to 2024 (%)	US $ (2024)	Engineering/ Permits (20%)	Contingency (30%)	Total Cost ($)
1A	Oceanside Vicinity (Oceanside)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10	$8	$78,124,162	13%	52%	$118,748,726	$23,749,745	$35,624,618	$178,123,089
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells (9)	Existing Oceanside WWTP Outfall	10	$8	$78,124,162	13%	52%	$118,748,726	$23,749,745	$35,624,618	$178,123,089
2A	Camp Pendleton MCTSSA	New Ocean Intake	Existing San Onofre Power Plant Outfall	50	$6	$287,707,427	13%	52%	$437,315,290	$87,463,058	$131,194,587	$655,972,935
2B	Camp Pendleton MCTSSA	New Ocean Intake	New Ocean Outfall	50	$6	$287,707,427	13%	52%	$437,315,290	$87,463,058	$131,194,587	$655,972,935
3	Doheny State Beach Expansion	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	10	$8	$78,124,162	13%	52%	$118,748,726	$23,749,745	$35,624,618	$178,123,089
4	Huntington Beach	Slant Wells (20)	Existing AES Huntington Beach Generating Station Power Plant Outfall	20	$7	$136,968,174	13%	52%	$208,191,625	$41,638,325	$62,457,487	$312,287,437
5	Long Beach	New Ocean Intake	New Ocean Outfall	20	$7	$136,968,174	13%	52%	$208,191,625	$41,638,325	$62,457,487	$312,287,437
6A	El Segundo	Slant Wells (20)	Existing Scattergood PP Outfall or Hyperion WWTP Outfall	20	$7	$136,968,174	13%	52%	$208,191,625	$41,638,325	$62,457,487	$312,287,437
6B	El Segundo	Converted Power Intake	Existing Scattergood PP Outfall or Hyperion WWTP Outfall	20	$7	$136,968,174	13%	52%	$208,191,625	$41,638,325	$62,457,487	$312,287,437
7A	Port Hueneme	Slant Wells (20)	Existing Oxnard WWTP Outfall	20	$7	$136,968,174	13%	52%	$208,191,625	$41,638,325	$62,457,487	$312,287,437
7B	Port Hueneme	New Ocean Intake	Existing Oxnard WWTP Outfall	25	$7	$164,103,097	13%	52%	$249,436,707	$49,887,341	$74,831,012	$374,155,061
8	Port Hueneme (Offshore Desal)	N/A	N/A	20	$12	$246,542,714	13%	52%	$374,744,925	$74,948,985	$112,423,477	$562,117,387

Sources:
1. M61, American Water Works Association (2024). From Construction Costs curve provided in cost chapter of upcoming revision to M61. Value is in 2018 $, was escalated to 2024 $ and added contigency.

Site #	Name	Intake	Outfall	Raw Water Flow (MGD)	Assumed Recovery (%)	Plant Capacity (MGD)	$ per MGD of raw water flow per foot (2018 $)[1]	Distance (mi)	Distance (ft)	Estimated New Outfall Cost (2018 $)[1]	Escalation Rate (%)	Total Escalation to 2024 (%)	Estimated Cost (2024 $)	Engineering/ Permits (20%)	Contingency (30%)	Total Cost ($)
1A	Oceanside Vicinity (Oceanside)	Slant Wells (9)	Existing Oceanside WWTP Outfall	20	50%	10	--	--	--	--	--	--	--	--	--	--
1B	Oceanside Vicinity (Camp Pendleton SRTTP)	Slant Wells (9)	Existing Oceanside WWTP Outfall	20	50%	10	--	--	--	--	--	--	--	--	--	--
2A	Camp Pendleton MCTSSA	New Ocean Intake	Existing San Onofre Power Plant Outfall	100	50%	50	--	--	--	--	--	--	--	--	--	--
2B	Camp Pendleton MCTSSA	New Ocean Intake	New Ocean Outfall	100	50%	50	$400	1	5280	$211,200,000	13%	78%	$375,936,000	$75,187,200	$112,780,800	$563,904,000
3	Doheny State Beach Expansion	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	20	50%	10	--	--	--	--	--	--	--	--	--	--
4	Huntington Beach	Slant Wells (20)	Existing AES Huntington Beach Generating Station Power Plant Outfall	40	50%	20	--	--	--	--	--	--	--	--	--	--
5	Long Beach	New Ocean Intake	New Ocean Outfall	40	50%	20	$400	1	5280	$84,480,000	13%	78%	$150,374,400	$30,074,880	$45,112,320	$225,561,600
6A	El Segundo	Slant Wells (20)	Existing Scattergood PP Outfall or Hyperion WWTP Outfall	40	50%	20	--	--	--	--	--	--	--	--	--	--
6B	El Segundo	Converted Power Intake	Existing Scattergood PP Outfall or Hyperion WWTP Outfall	40	50%	20	--	--	--	--	--	--	--	--	--	--
7A	Port Hueneme	Slant Wells (20)	Existing Oxnard WWTP Outfall	40	50%	20	--	--	--	--	--	--	--	--	--	--
7B	Port Hueneme	New Ocean Intake	Existing Oxnard WWTP Outfall	50	50%	25	--	--	--	--	--	--	--	--	--	--
8	Port Hueneme (Offshore Desal)	N/A	N/A	--	--	--	--	--	--	--	--	--	--	--	--	--

Sources:
1. M61, American Water Works Association (2024). From upcoming revision to the Cost Chapter of M61 (range of $180 to $370). Number increased to 400 to reflect higher range.

Appendix C
Cost Summary
Operations and Maintenance Summary

	% Total	Calculated (50 mgd Open Intake)				Slant Wells			Offshore (20 mgd)		
Variable O&M Costs	**Simplified**	**Annual Cost**	**% Total**	**$/yr/mgd**	**$/kgal**	**% Reduction for Slant Wells**	**$/yr/mgd**	**$/kgal**	**% Reduction**	**$/kgal**	**Annual Cost**
- Energy	50.0%	$ 138,286,181	84%	$ 2,765,724	$ 7.58	10%	$ 2,489,151	$ 6.82	42%	$ 3.96	$ 28,895,776
- Chemicals	10.0%	$ 4,629,417	3%	$ 92,588	$ 0.25	50%	$ 46,294	$ 0.13	25%	$ 0.10	$ 694,413
- Membrane Replacement	7.5%	$ 4,296,963	3%	$ 85,939	$ 0.24	0%	$ 85,939	$ 0.24	-170%	$ 0.64	$ 4,640,720
- Waste Disposal	2.5%	$ 2,401,244	1%	$ 48,025	$ 0.13	75%	$ 12,006	$ 0.03	100%	$ -	
Fixed O&M Costs											
- Labor	7.5%	$ 2,803,474	2%	$ 56,069	$ 0.15	0%	$ 56,069	$ 0.15	-50%	$ 0.23	$ 1,682,084
- Permit Compliance	2.5%	$ 1,011,050	1%	$ 20,221	$ 0.06	0%	$ 20,221	$ 0.06	0%	$ 0.06	$ 404,420
- Indirect Costs	10.0%	$ 5,055,250	3%	$ 101,105	$ 0.28	0%	$ 101,105	$ 0.28	0%	$ 0.28	$ 2,022,100
- Maintenance	10.0%	$ 5,181,631	3%	$ 103,633	$ 0.28	0%	$ 103,633	$ 0.28	-200%	$ 0.85	$ 6,217,958
	100%	$ 163,665,209	100%	$ 3,273,304	$ 8.97			$ 7.98		$ 6.10	$ 44,557,470

$/yr/mgd	$ 3,273,304		$/yr/mgd	$ 2,914,419		$/yr/mgd	$ 2,227,873
			% Reduction vs Open Ocean	11%		% Reduction vs Slant Well	24%
$/AF	$ 2,923		$/AF	$ 2,602		$/AF	$ 1,989

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013). Costs from this book were based on Carlsbad Desalination plant.

Appendix C
Cost Summary
Energy

Specific Energy	15	kWh/kgal
Specific Energy	4.0	kWh/m3
Specific Energy	0.0032	kWh/AF
Plant Production	50	mgd
Cost of Energy	0.2975	$/kWh
Energy Cost (2013 $)	$81,440,625	$/yr
Escalation Rate	69.8%	
Energy Cost (2024 $)	$138,286,181	$/yr

8 to 9 kWh/kgal for the RO. Approximately double after accounting for raw water pumping and ancillary systems.

Cost of power highly variable. This value results in power attributing for approximately 55% of the total O&M cost, which is reasonable.

Source: https://www.sce.com/regulatory/tariff-books/historical-rates

Offshore desalination	2	kWh/m3
	2.3	kWh/m3

based on OceanWell estimate

based on WateRise estimate

Chemical Cost	0.2	$/kgal
Plant Production	50	mgd
Chemical Cost (2013 $)	$3,650,000	$/yr
Escalation Rate	26.8%	
Chemical Cost (2024 $)	$4,629,417	$/yr

Cost of chemicals is a variable expenditure and typically is in a range of $0.025/m³ to $0.075/m³ ($0.1 to $0.3/1000 gal) of product water.

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Membrane Replacement Cost	0.17	$/kgal
Plant Production	50	mgd
Membrane Replacement Cost (2013 $)	$3,102,500	$/yr
Escalation Rate	38.5%	
Membrane Replacement Cost (2024 $)	$4,296,963	$/yr

Cartridge filters for SWRO plants have a typical minimum useful life of six to eight weeks. However, in many applications where the source water is of high quality, cartridge filter replacement is less frequent (once every 6 to 12 months). Depending on the cartridge filter size, the unit cartridge filter cost is between $8 and $30 per filter. The total membrane and cartridge filter replacement costs are typically in a range of $0.020 to $0.070/m^3 ($0.08 to $0.26/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Appendix C
Cost Summary
Waste Disposal

Waste Disposal Cost	0.095	$/kgal
Plant Production	50	mgd
Waste Disposal Cost (2013 $)	$1,733,750	$/yr
Escalation Rate	38.5%	
Waste Disposal Cost (2024 $)	$2,401,244	$/yr

The main waste stream of every membrane desalination plant is the RO system concentrate. Depending on the concentrate disposal practices, the total waste stream disposal costs are typically in a range of $0.015/m³ to $0.035/m³ ($0.06 to $0.13/1000 gal).

Depending on the capacity and distance of the available landfills in the area of the desalination plant, the residual disposal costs usually vary between $16 to $80/wet ton of sludge, which would correspond to an additional cost of water production between $0.005 and $0.025/m³ ($0.02 and $0.10/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

No. FTE	30	
Labor Cost	0.105	$/kgal
Plant Production	50	mgd
Labor Cost (2013 $)	$1,916,250	$/yr
Escalation Rate	46.3%	
Labor Cost (2024 $)	$2,803,474	$/yr

Plant Capacity (m^3/day)	Plant Automation and Labor Skill Level	
	High	Low
1000	2–3	4–6
5000	4–6	8–10
10,000	7–10	12–15
20,000	9–12	16–18
40,000	12–16	18–20
100,000	14–18	20–24
200,000	18–28	30–40
300,000	35–50	60–80

TABLE 17.9 Desalination Plant Staffing Requirements

operators on duty at all times. The labor costs are fixed for a given plant and are typically in a range of $0.015/m^3$ to $0.040/m^3$ ($0.06 to $0.15/1000 gal) of treated water.

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Permit Compliance Cost	0.04	$/kgal
Plant Production	50	mgd
Permit Compliance Cost (2013 $)	$ 730,000	$/yr
Escalation Rate	38.5%	
Permit Compliance Cost (2024 $)	$1,011,050	$/yr

Product water monitoring costs are expenditures associated with sample collection, laboratory analysis, and data management and reporting, which are required to be completed in order to comply with all applicable regulatory requirements associated with the product water supply. Typically, plant performance and product water quality monitoring costs are between $\$0.005/m^3$ and $\$0.015/m^3$ ($0.02 and $0.06/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Indirect O&M Cost	0.2	$/kgal
Plant Production	50	mgd
Indirect O&M Cost (2013 $)	$ 3,650,000	$/yr
Escalation Rate	38.5%	
Indirect O&M Cost (2024 $)	$5,055,250	$/yr

O&M reserve funds. These costs also incorporate the fees for plant operation, if a private company operates the desalination plant. Typically plant indirect O&M costs vary in a wide range—$0.025 to $0.075/m³ ($0.1 to $0.3/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

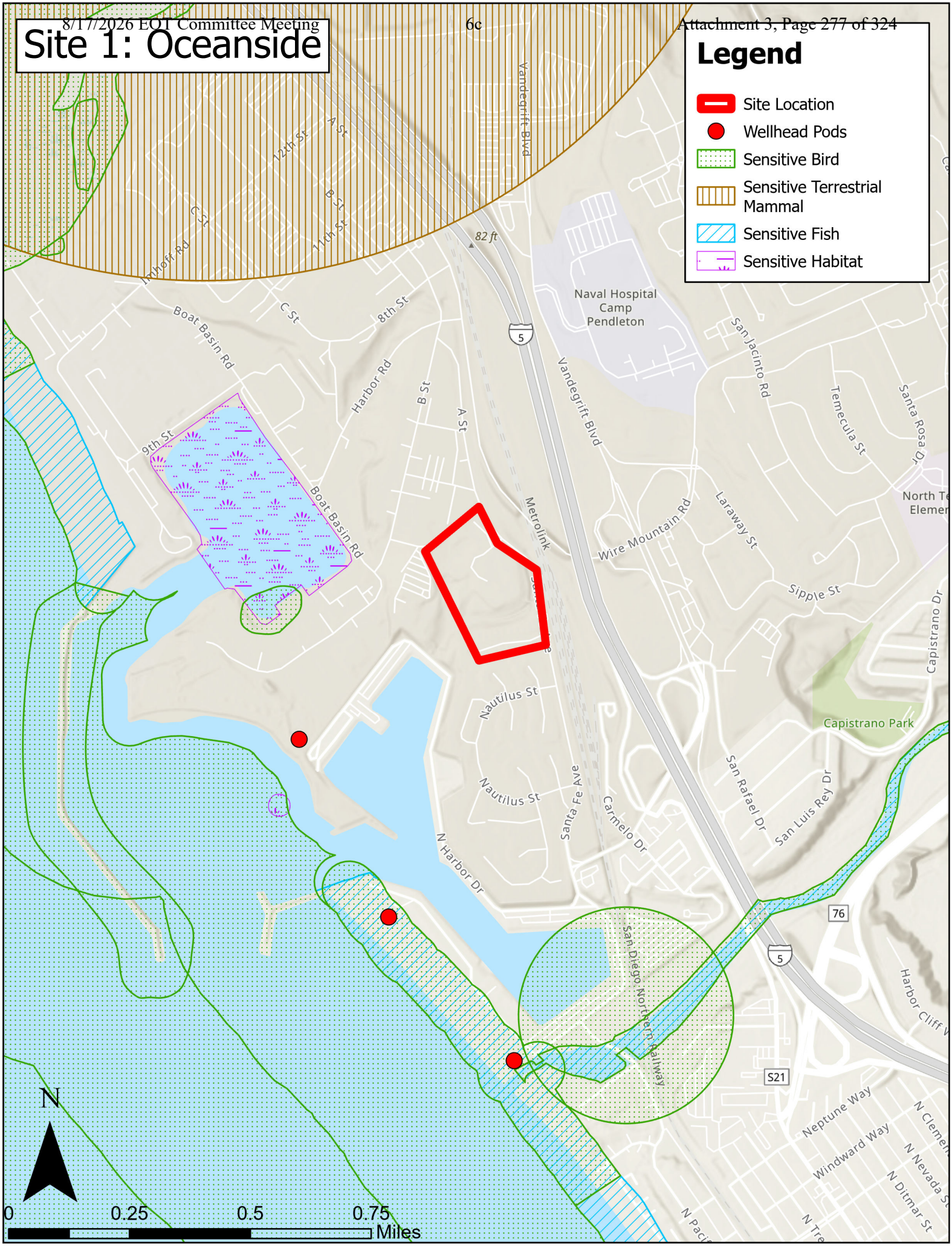
Maintenance Cost	0.205	$/kgal
Plant Production	50	mgd
Maintenance Cost (2013 $)	$3,741,250	$/yr
Escalation Rate	38.5%	
MaintenanceCost (2024 $)	$5,181,631	$/yr

Since most of the plant equipment is maintained routinely on a preset schedule independent of the actual water production, some (typically 40 to 60 percent) of the routine equipment maintenance costs are often considered fixed O&M costs. The remaining portion of the maintenance costs is accounted as a variable component and is related to the actual equipment run time. Plant total maintenance costs are typically in a range of $0.035 to $0.075/m^3 ($0.13 to $0.28/1000 gal) of desalinated water.

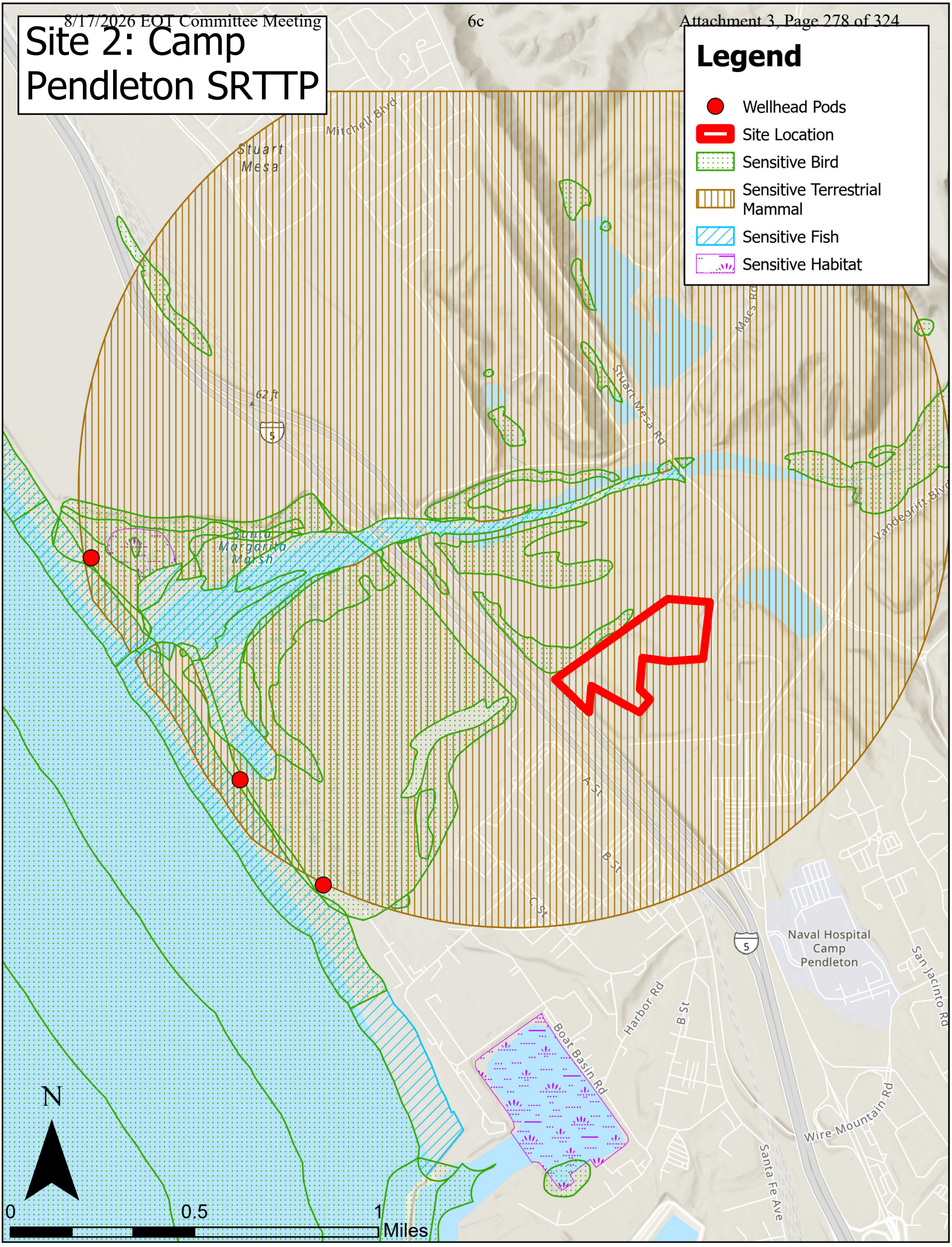
Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

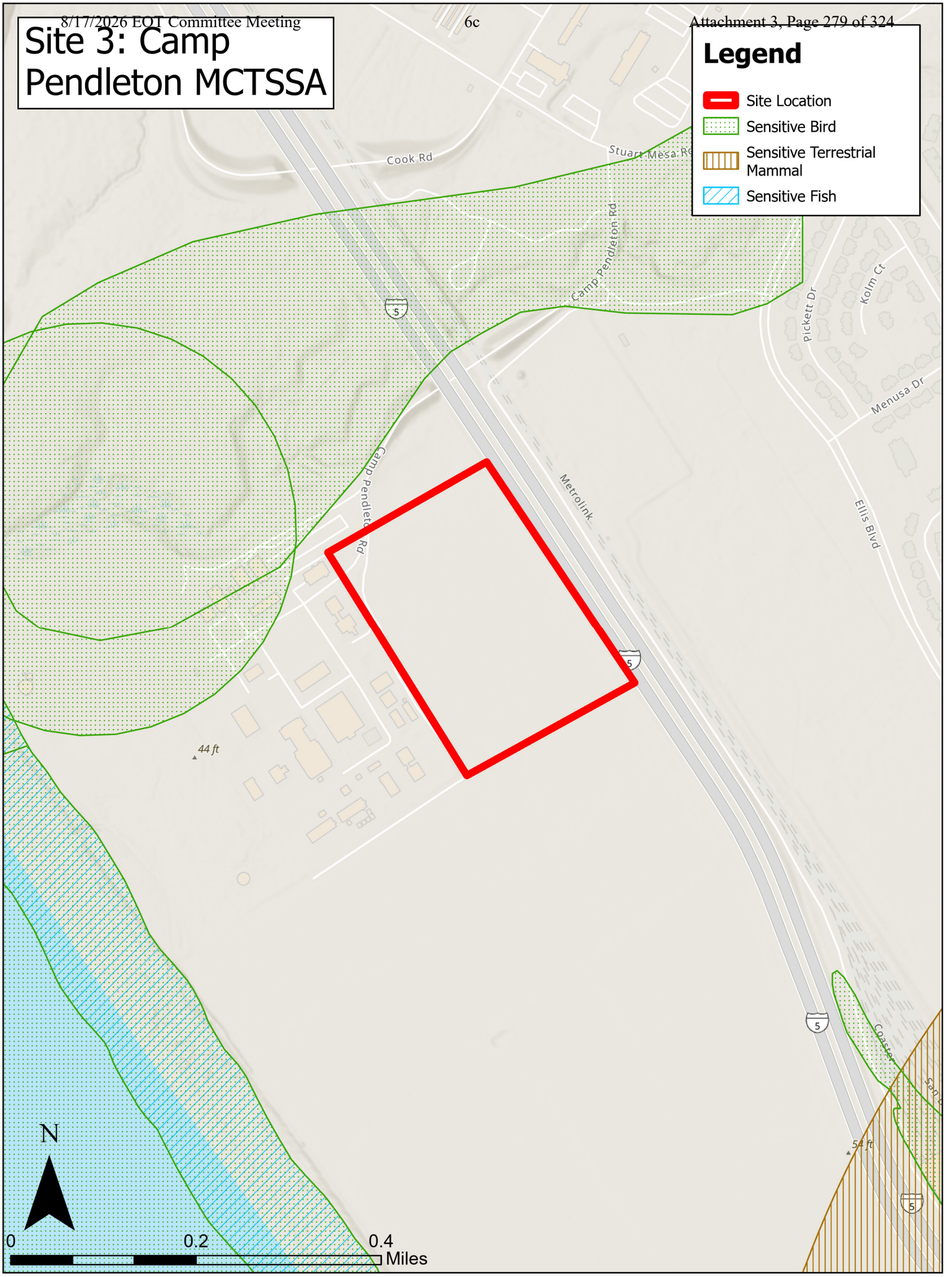
Appendix D Environmental Impact Maps

Site 1: Oceanside

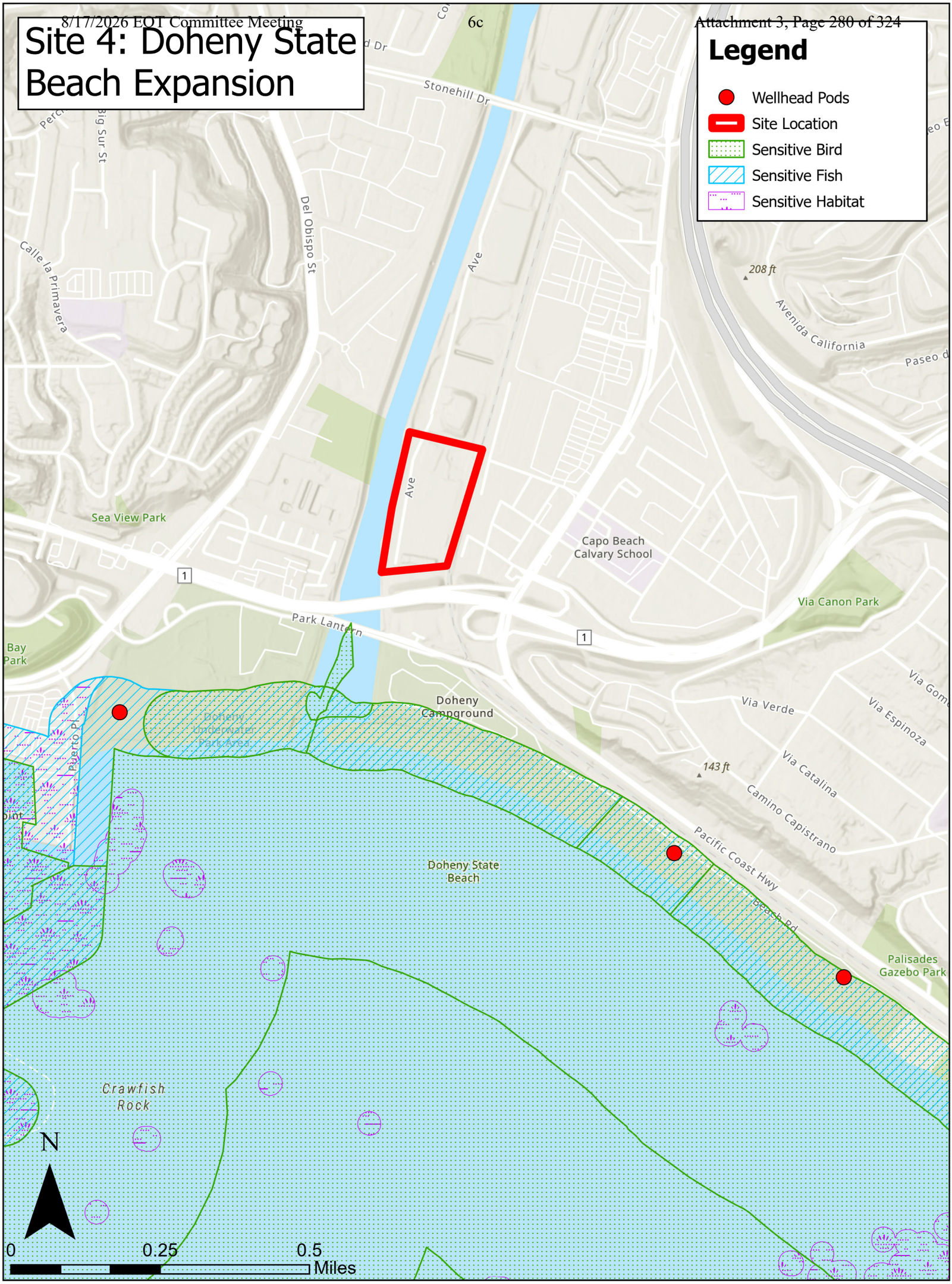


Site 2: Camp Pendleton SRTTP

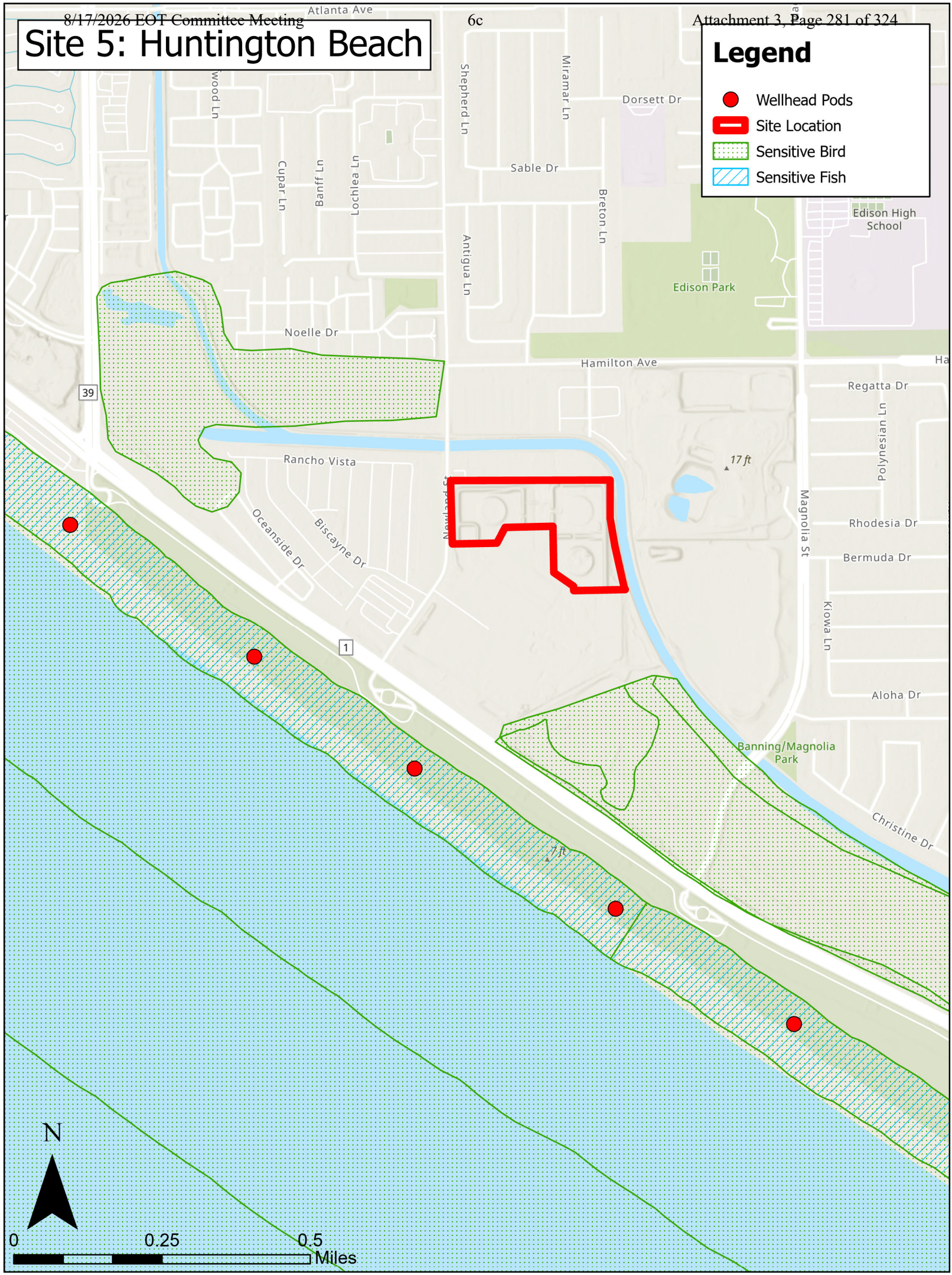



Site 3: Camp Pendleton MCTSSA
Legend
Site Location
Sensitive Bird
Sensitive Terrestrial Mammal
Sensitive Fish
Cook Rd
Stuart Mesa Rd
Camp Pendleton Rd
Pickett Dr
Kolm Ct
Menusa Dr
Metrolink
Ellis Blvd
44 ft
N
0
0.2
0.4
Miles

Site 4: Doheny State Beach Expansion



Site 5: Huntington Beach

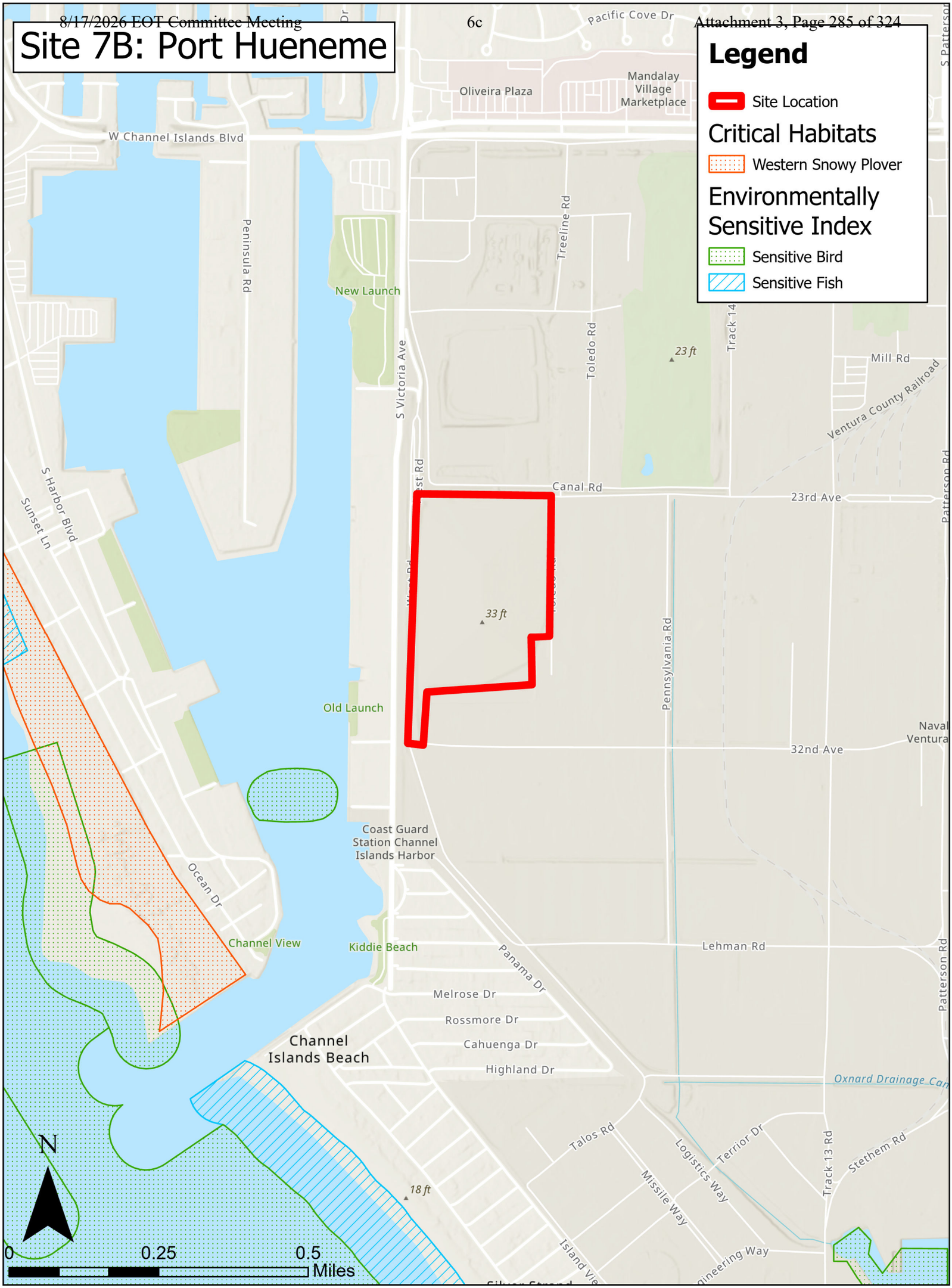


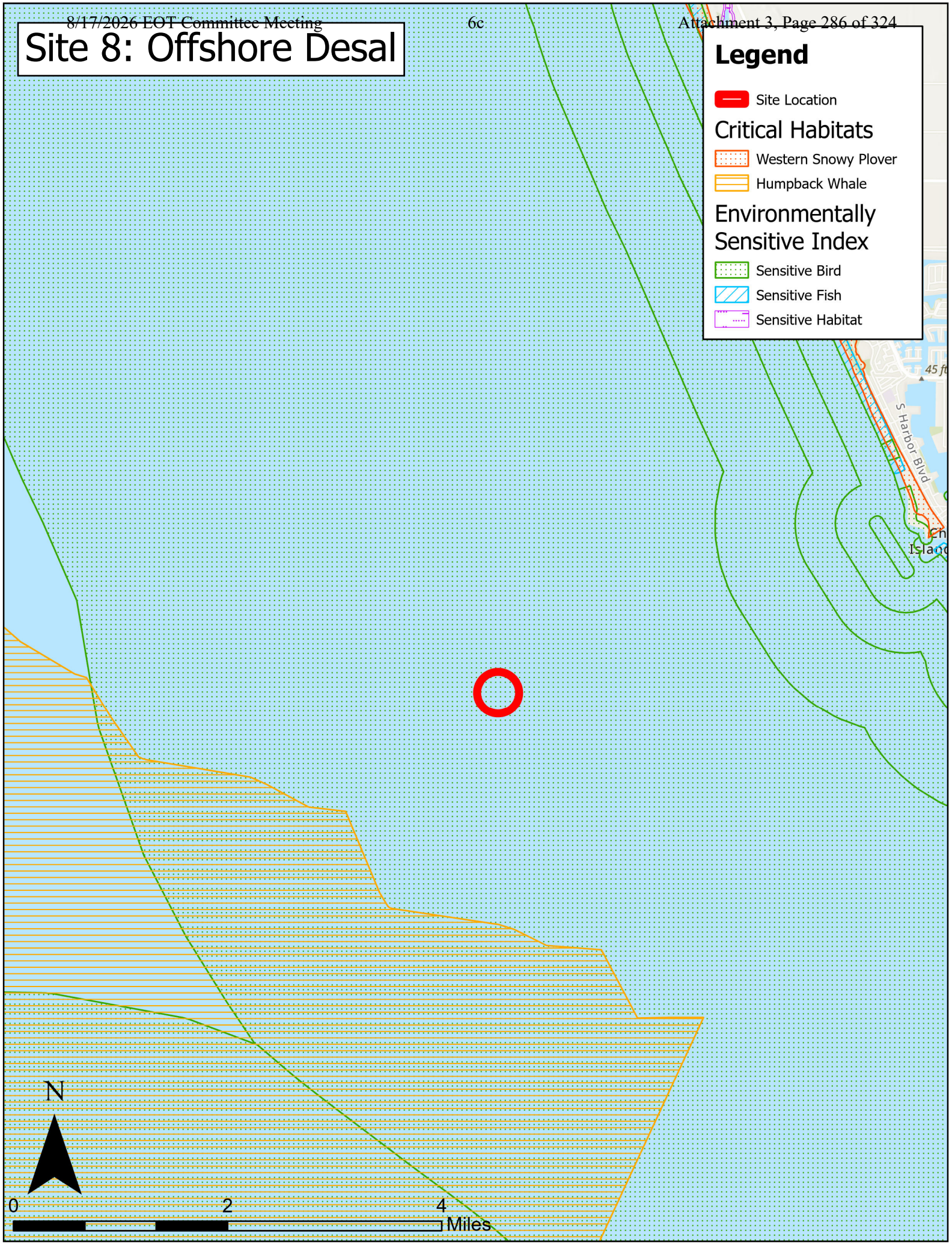
Site 6A: El Segundo

Site 6B: El Segundo
Legend
Site Location
Critical Habitats
Western Snowy Plover
Environmentally Sensitive Index
Sensitive Bird
Sensitive Fish
W Pine Ave
Loma Vista St
Whiting St
Virginia St
W Grand Ave
W Franklin A
Grand Ave
187 ft
W El Segundo Blvd
E El Segundo Blv
Vista del Mar
Chevron Oil Refinery
El Segundo Beach
Chevron Oil Refinery
184 ft
Crest Dr
Rosecrans Ave
36th Pl
36th St
Bayview Dr
33rd St
N
0
0.25
0.5
Miles

Site 7A: Port Hueneme

Site 7B: Port Hueneme




Site 8: Offshore Desal
Legend
Site Location
Critical Habitats
Western Snowy Plover
Humpback Whale
Environmentally Sensitive Index
Sensitive Bird
Sensitive Fish
Sensitive Habitat
45 ft
S Harbor Blvd
N
0
2
4
Miles

Appendix E Sea Level Rise Maps

Sea Level Rise Viewer

Oceanside, CA, USA

WATER LEVEL

VIEW BY SCENARIO | VIEW BY YEAR | ?

Scenario Year

2022 Projections

10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft

2100
2080
2060
2040
2020
2000

High : 4.10ft

Intermediate High : 3.05ft

Intermediate : 1.84ft

Intermediate Low : 1.18ft

Current MHHW

UNITS

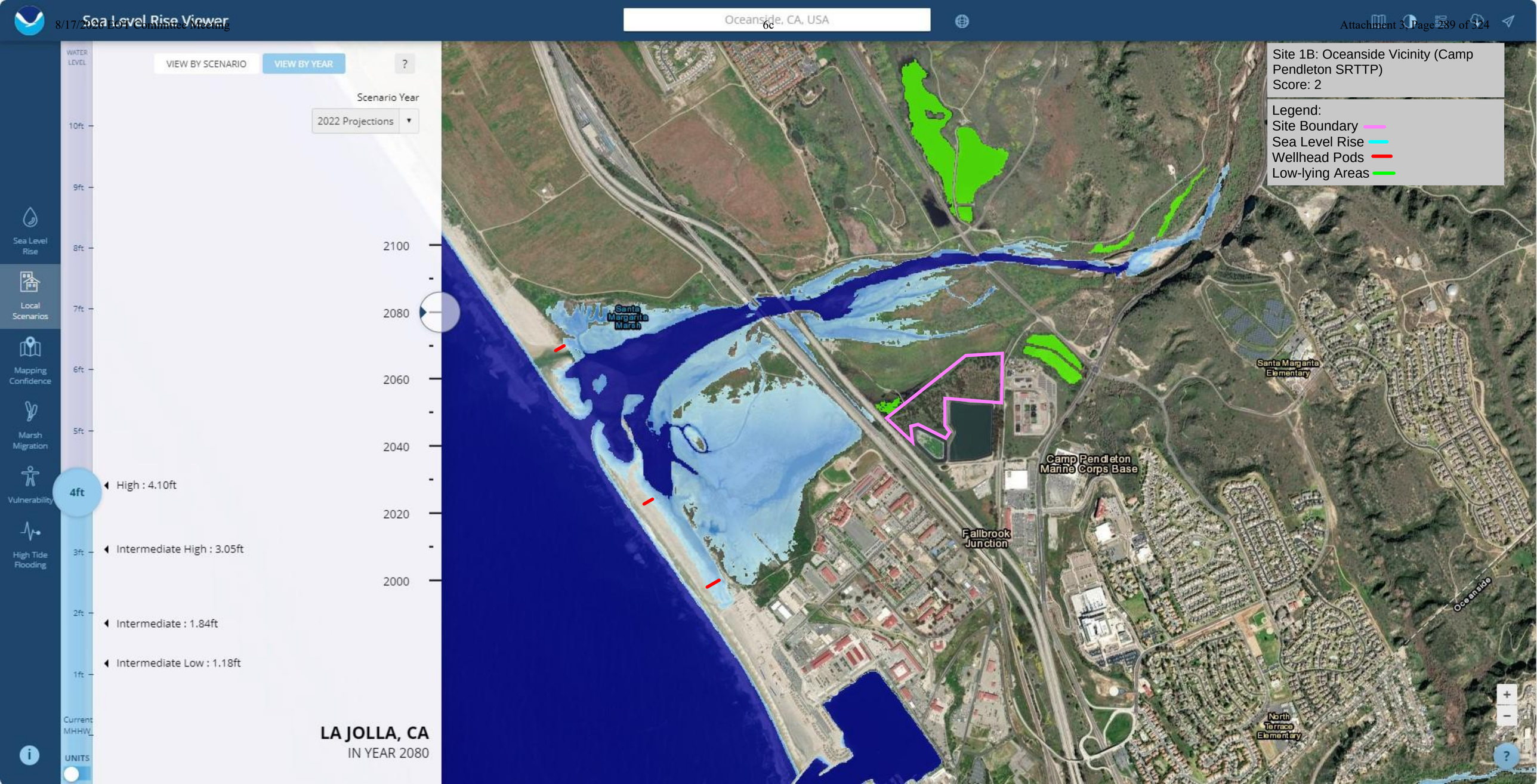
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding

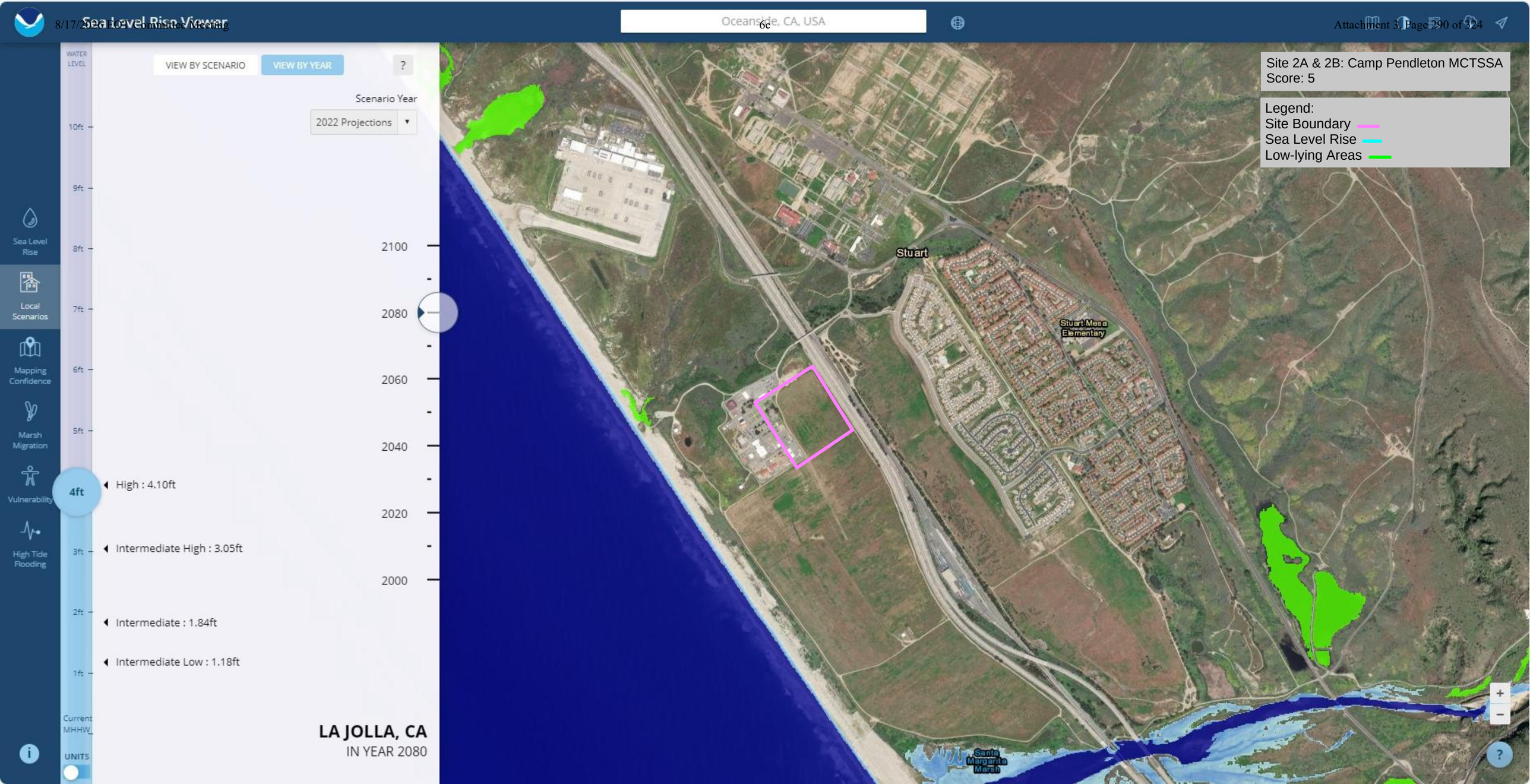
LA JOLLA, CA
IN YEAR 2080

Site 1A: Oceanside Vicinity (Oceanside)
Score: 4

Legend:
Site Boundary
Sea Level Rise
Wellhead Pods

Camp Pendleton Marine Corps Base
Fallbrook Junction
Oceanside
North Terrace Elementary
Capistrano Park
Jefferson Middle
Laurel Elementary
Mission Elementary
Oceanside Harbor
Harbor Beach
Oceanside City Beach
Ortega, Ron Recreation


Sea Level Rise Viewer
Oceanside, CA, USA
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
?
Scenario Year
2022 Projections
10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft
Current MHHW
UNITS
2100
2080
2060
2040
2020
2000
High : 4.10ft
Intermediate High : 3.05ft
Intermediate : 1.84ft
Intermediate Low : 1.18ft
LA JOLLA, CA
IN YEAR 2080
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Site 1B: Oceanside Vicinity (Camp Pendleton SRTTP)
Score: 2
Legend:
Site Boundary
Sea Level Rise
Wellhead Pods
Low-lying Areas
Santa Margarita Marsh
Santa Margarita Elementary
Camp Pendleton Marine Corps Base
Fallbrook Junction
Oceanside
North Terrace Elementary


Sea Level Rise Viewer
Oceanside, CA, USA
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
?
Scenario Year
2022 Projections
10ft
9ft
8ft
7ft
6ft
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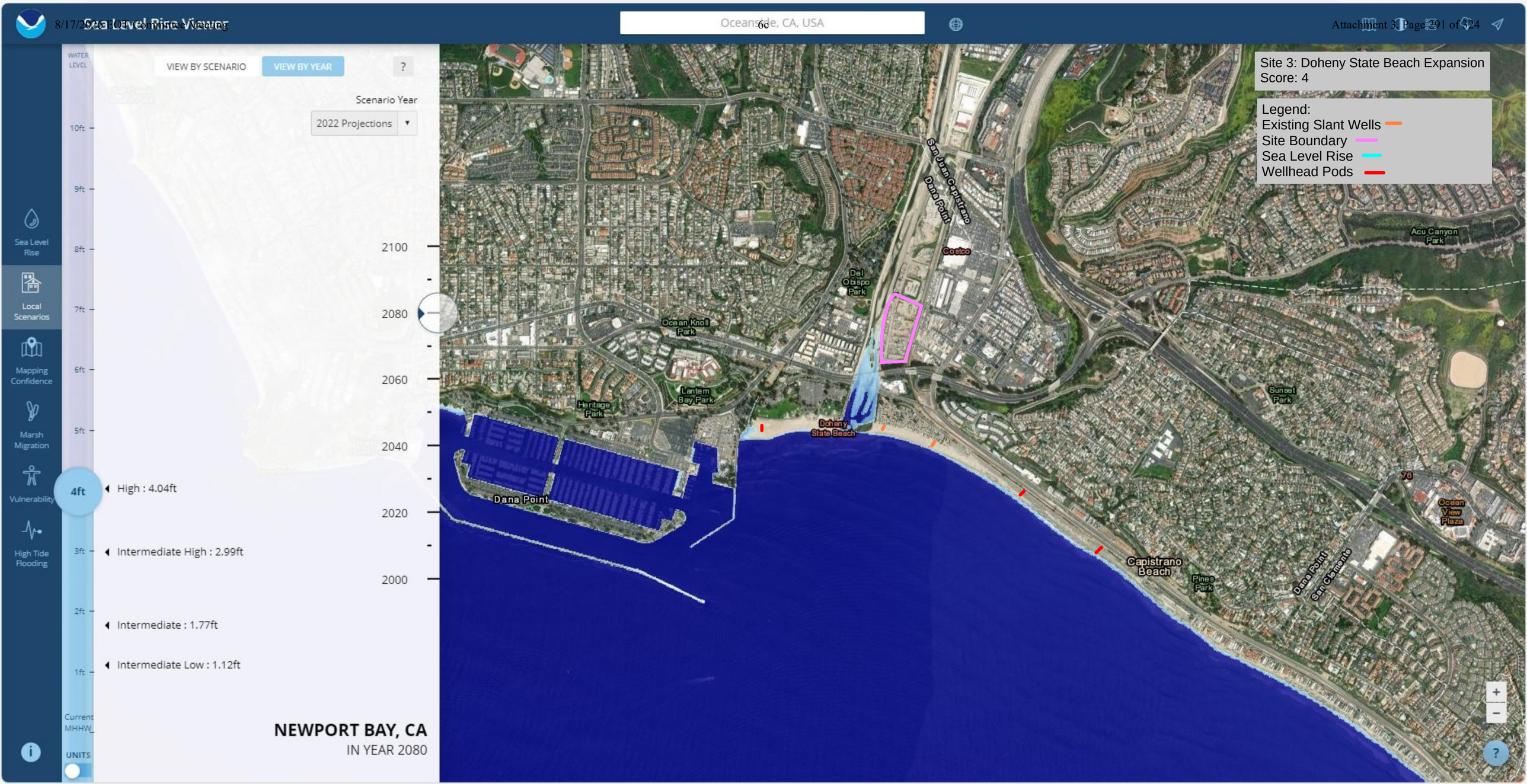
4ft
3ft
2ft
1ft
Current MHHW
UNITS
2100
2080
2060
2040
2020
2000
High : 4.10ft
Intermediate High : 3.05ft
Intermediate : 1.84ft
Intermediate Low : 1.18ft
LA JOLLA, CA
IN YEAR 2080
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Site 2A & 2B: Camp Pendleton MCTSSA
Score: 5
Legend:
Site Boundary
Sea Level Rise
Low-lying Areas
Stuart
Stuart Mesa Elementary
Santa Margarita Marsh


Sea Level Rise Viewer
Oceanside, CA, USA
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
?
Scenario Year
2022 Projections
10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft
Current MHHW
UNITS
2100
2080
2060
2040
2020
2000
High : 4.04ft
Intermediate High : 2.99ft
Intermediate : 1.77ft
Intermediate Low : 1.12ft
NEWPORT BAY, CA
IN YEAR 2080
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Site 3: Doheny State Beach Expansion
Score: 4
Legend:
Existing Slant Wells
Site Boundary
Sea Level Rise
Wellhead Pods
San Juan Capistrano
Dana Point
Costco
Del Obispo Park
Acu Canyon Park
Ocean Knoll Park
Lantern Bay Park
Heritage Park
Doheny State Beach
Sunset Park
Dana Point
Ocean View Plaza
Capistrano Beach
Pines Park
Dana Point
San Clemente

Sea Level Rise Viewer

Oceanside, CA, USA

WATER LEVEL

VIEW BY SCENARIO | VIEW BY YEAR

?

Scenario Year

2022 Projections

10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft

2100
2080
2060
2040
2020
2000

High : 4.04ft

Intermediate High : 2.99ft

Intermediate : 1.77ft

Intermediate Low : 1.12ft

Current MHHW

UNITS

Sea Level Rise

Local Scenarios

Mapping Confidence

Marsh Migration

Vulnerability

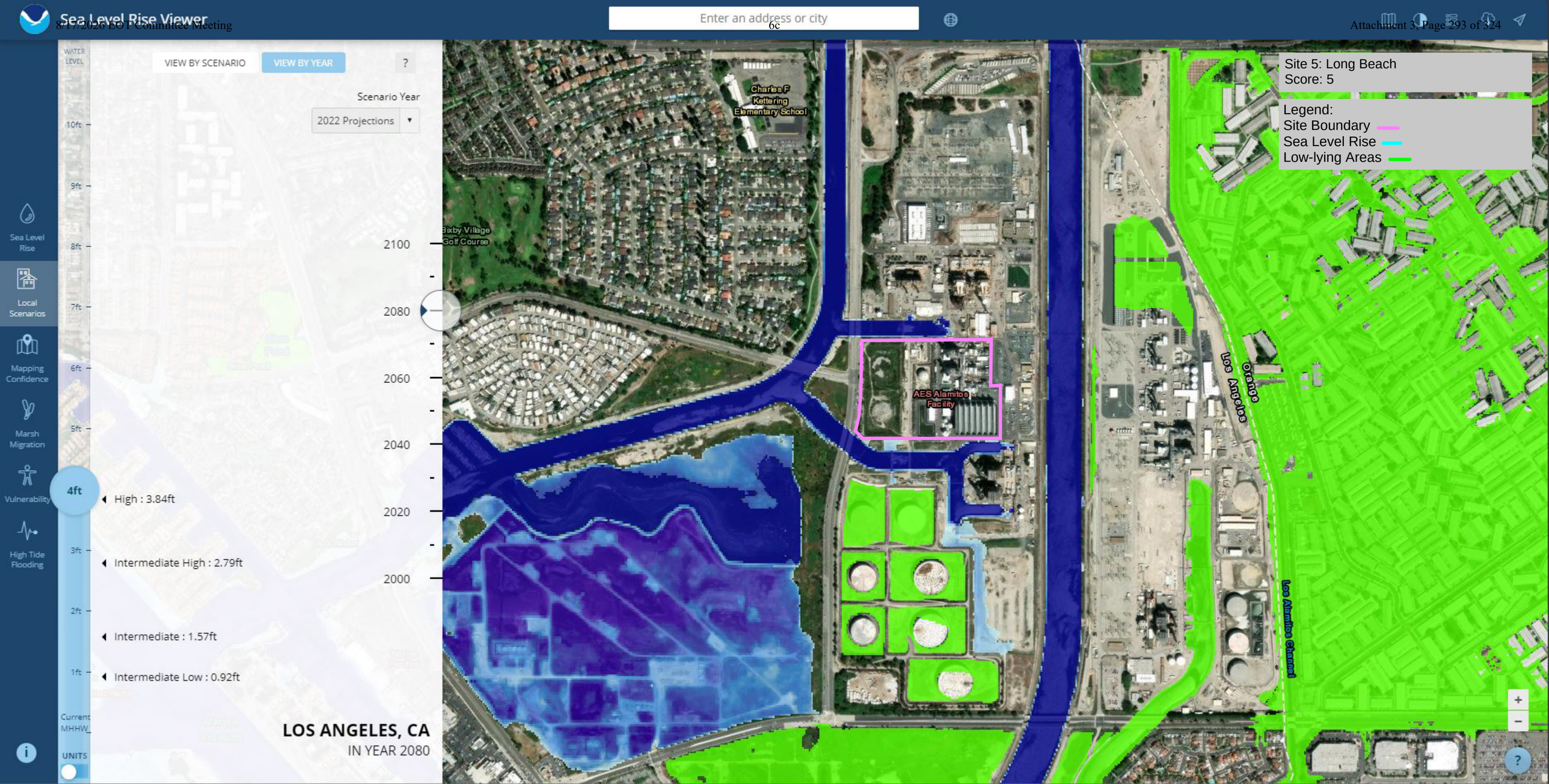
High Tide Flooding

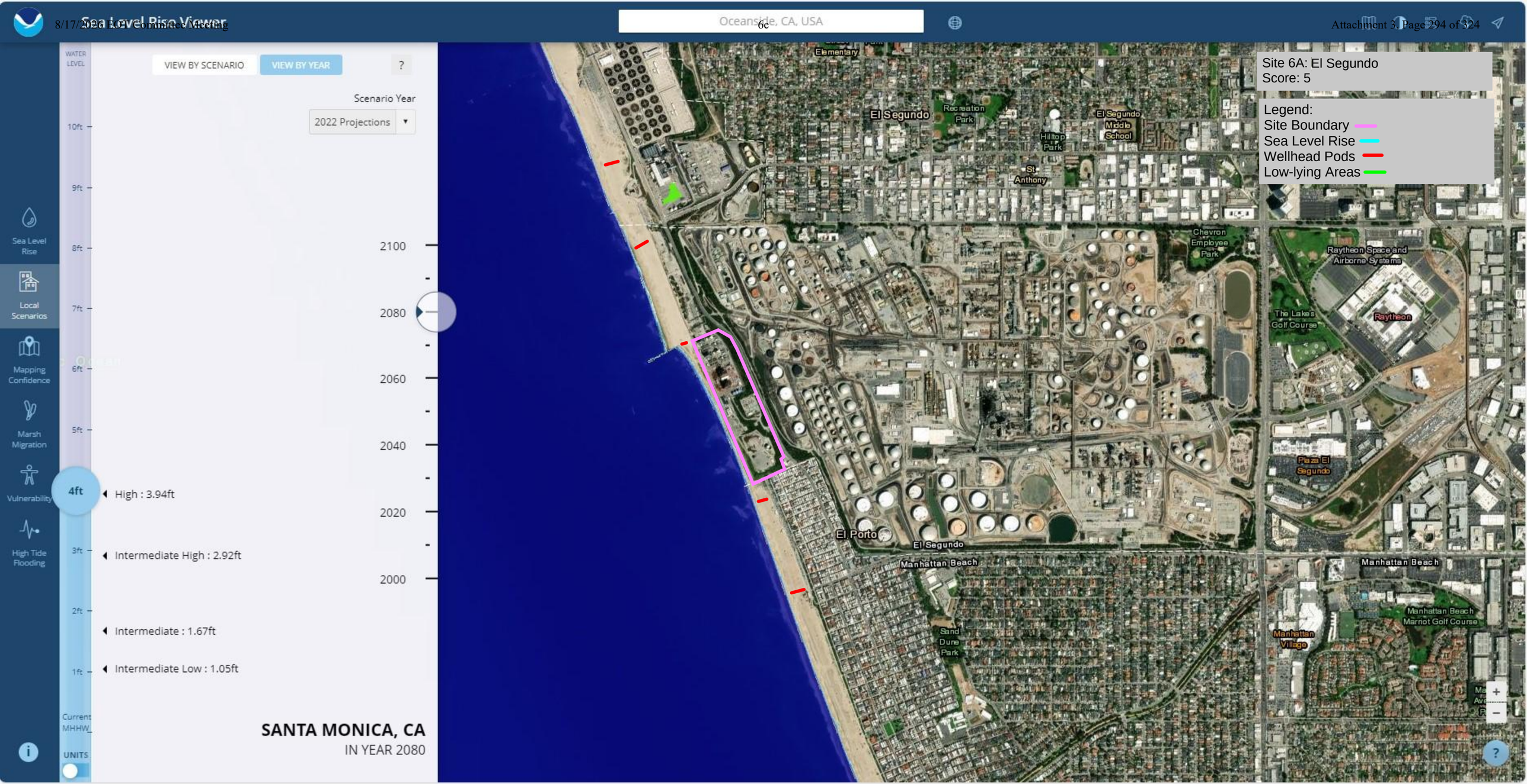
NEWPORT BAY, CA
IN YEAR 2080

Site 4: Huntington Beach
Score: 2

Legend:
Site Boundary
Sea Level Rise
Wellhead Pods
Low-lying Areas

Huntington Beach
Langenbeck Park
Mesa Verde Country Club
Orange Coast College
Fairview Park
Costa Mesa Country Club
Gisler Park
Edison Park
Talbert Regional Park
Lions Park
Santa Ana River
Huntington State Beach


Sea Level Rise Viewer
Enter an address or city
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
?
Scenario Year
2022 Projections
10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft
2100
2080
2060
2040
2020
2000
High : 3.84ft
Intermediate High : 2.79ft
Intermediate : 1.57ft
Intermediate Low : 0.92ft
Current MHHW
UNITS
LOS ANGELES, CA
IN YEAR 2080
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Charles F Kettering Elementary School
Bixby Village Golf Course
AES Alamitos Facility
Los Angeles Orange
Los Alamitos Channel
Site 5: Long Beach
Score: 5
Legend:
Site Boundary
Sea Level Rise
Low-lying Areas


Sea Level Rise Viewer
Oceanside, CA, USA
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
?
Scenario Year
2022 Projections
10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft
Current MHHW
UNITS
2100
2080
2060
2040
2020
2000
High : 3.94ft
Intermediate High : 2.92ft
Intermediate : 1.67ft
Intermediate Low : 1.05ft
SANTA MONICA, CA
IN YEAR 2080
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Site 6A: El Segundo
Score: 5
Legend:
Site Boundary
Sea Level Rise
Wellhead Pods
Low-lying Areas
El Segundo
Recreation Park
El Segundo Middle School
Hilltop Park
St. Anthony
Chevron Employee Park
Raytheon Space and Airborne Systems
Raytheon
The Lakes Golf Course
Plaza El Segundo
El Porto
El Segundo
Manhattan Beach
Sand Dune Park
Manhattan Village
Manhattan Beach Marriot Golf Course

Sea Level Rise Viewer

Oceanside, CA, USA

WATER LEVEL

VIEW BY SCENARIO | VIEW BY YEAR | ?

Scenario Year

2022 Projections

10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft

2100
2080
2060
2040
2020
2000

4ft High : 3.94ft

Intermediate High : 2.92ft

Intermediate : 1.67ft

Intermediate Low : 1.05ft

Current MHHW

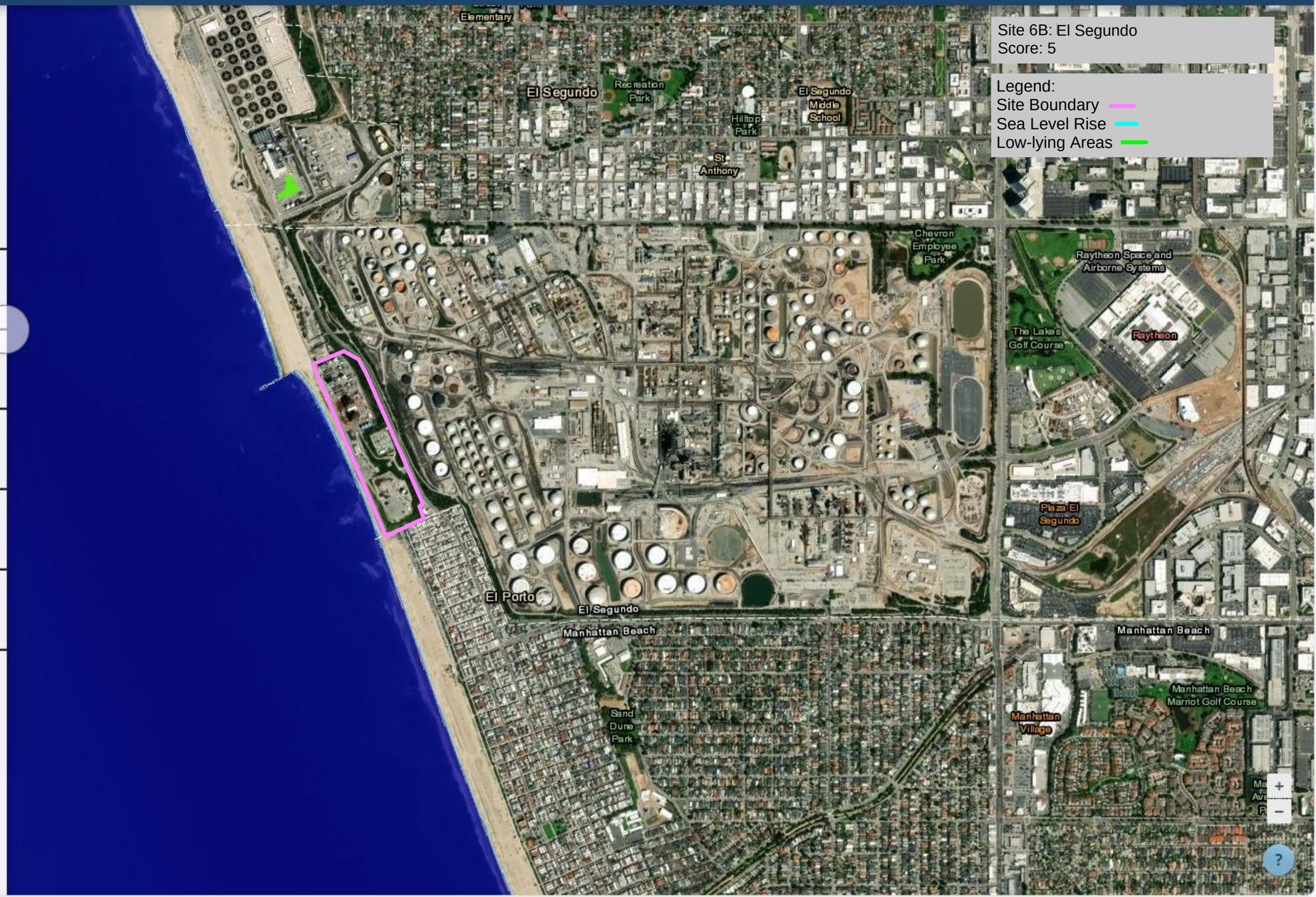
UNITS

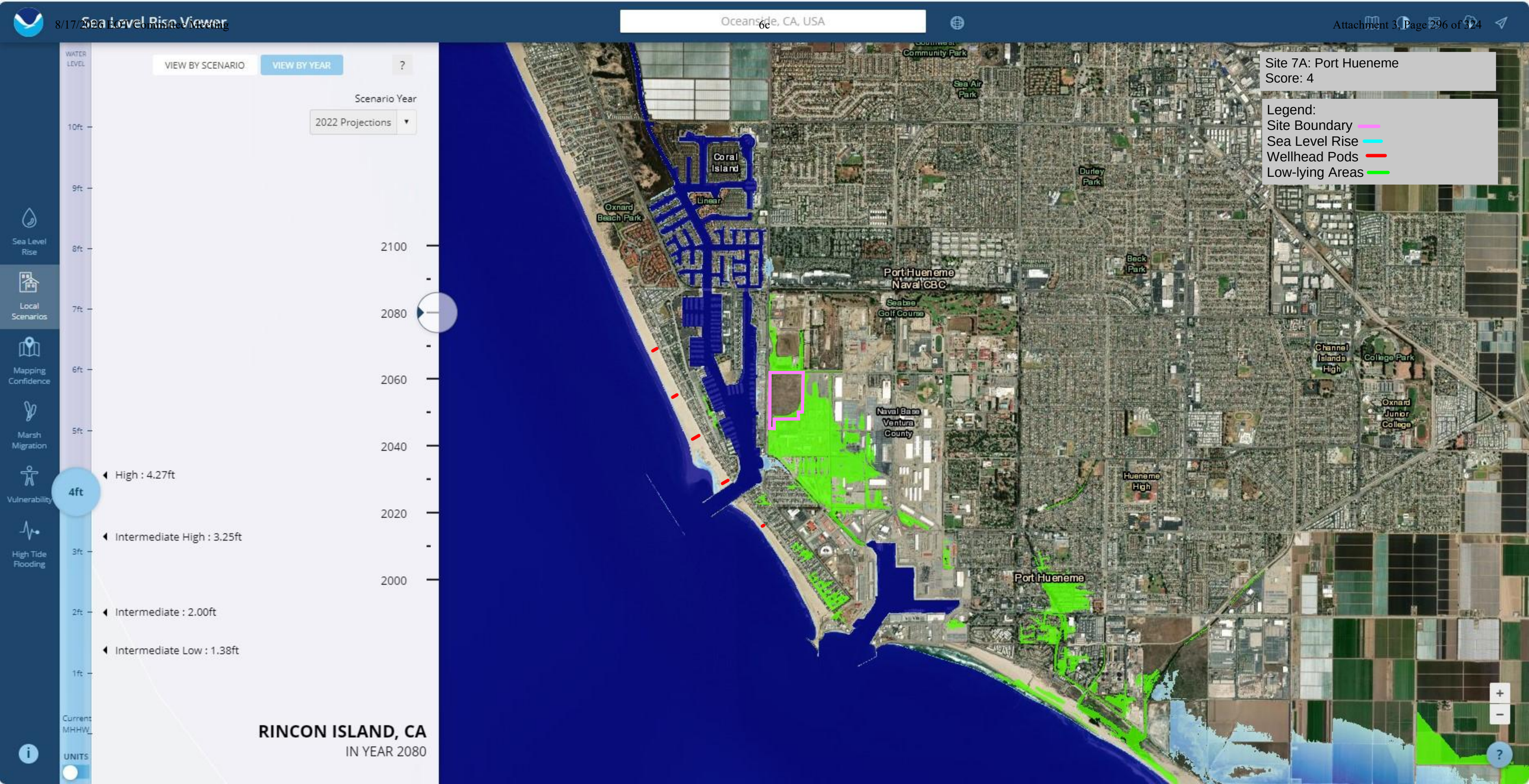
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding

SANTA MONICA, CA
IN YEAR 2080

Site 6B: El Segundo
Score: 5

Legend:
Site Boundary
Sea Level Rise
Low-lying Areas




Sea Level Rise Viewer
Oceanside, CA, USA
WATER LEVEL
VIEW BY SCENARIO
VIEW BY YEAR
?
Scenario Year
2022 Projections
10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft
Current MHHW
UNITS
2100
2080
2060
2040
2020
2000
High : 4.27ft
Intermediate High : 3.25ft
Intermediate : 2.00ft
Intermediate Low : 1.38ft
RINCON ISLAND, CA
IN YEAR 2080
Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding
Site 7A: Port Hueneme
Score: 4
Legend:
Site Boundary
Sea Level Rise
Wellhead Pods
Low-lying Areas
Coral Island
Linear
Oxnard Beach Park
Port Hueneme Naval CBC
Seabee Golf Course
Naval Base Ventura County
Port Hueneme
Hueneme High
Channel Islands High
College Park
Oxnard Junior College
Durley Park
Beck Park
Sea Air Park
Community Park

Sea Level Rise Viewer

Oceanside, CA, USA

WATER LEVEL

VIEW BY SCENARIO | VIEW BY YEAR | ?

Scenario Year

2022 Projections

10ft
9ft
8ft
7ft
6ft
5ft
4ft
3ft
2ft
1ft

2100
2080
2060
2040
2020
2000

High : 4.27ft

Intermediate High : 3.25ft

Intermediate : 2.00ft

Intermediate Low : 1.38ft

Current MHHW

UNITS

Sea Level Rise
Local Scenarios
Mapping Confidence
Marsh Migration
Vulnerability
High Tide Flooding

RINCON ISLAND, CA
IN YEAR 2080

Site 7B: Port Hueneme
Score: 4

Legend:
Site Boundary
Sea Level Rise
Low-lying Areas

Coral Island
Linear
Oxnard Beach Park
Sea Air Park
Durley Park
Beck Park
Port Hueneme Naval CBC
Seabee Golf Course
Naval Base Ventura County
Channel Islands High
College Park
Oxnard Junior College
Hueneme High
Port Hueneme

Appendix F Special Conditions to Issued Coastal Development Permits

Special conditions for the Doheny Desalination Facility coastal development permit (CDP) include:

- **Special Condition 1:** The South Coast Water District (SCWD) must provide final project plans demonstrating that the facility will be designed and constructed to withstand potential hazards such as seismic events, tsunamis, and flooding, ensuring it can serve as a reliable, local, and emergency water supply, as proposed.
- **Special Condition 2:** SCWD must submit written evidence that all necessary permits, permissions, approvals, and/or authorizations for the project have been granted by the State Lands Commission and the California Department of Parks and Recreation.
- **Special Condition 3:** SCWD must collaborate with State Parks to develop a Plan detailing how and where additional camping opportunities will be provided at other nearby coastal campgrounds, and how these options will be communicated to the public.
- **Special Condition 4:** SCWD must provide a more detailed plan and schedule for the additional public access and recreation enhancements planned for Doheny State Beach campground.
- **Special Condition 5:** SCWD must mitigate its marine life and water quality impacts by creating or restoring approximately 7.45 acres of estuarine and/or marine habitats near the project site.
- **Special Condition 6:** SCWD must develop Spill Prevention and Response Plans for both construction and operation phases of the project.
- **Special Condition 7:** SCWD must develop plans outlining Construction Best Management Practices to protect water quality.
- **Special Condition 8:** SCWD must assume responsibility for potential risks and waive any claims of damage or liability against the Coastal Commission.
- **Special Condition 9:** SCWD must submit a Geotechnical and Seismic Hazards Plan, detailing measures to ensure the project's stability during seismic events.
- **Special Condition 10:** SCWD must provide a Disaster Response Plan to ensure the facility's continued operation during expected hazards.
- **Special Condition 11:** SCWD must develop and implement monitoring measures to track coastal erosion rates near its wellfield and to respond to erosion before it threatens the project's wellfield components.
- **Special Condition 12:** No future shoreline protection devices are allowed for the project.
- **Special Condition 13:** SCWD must prepare a Flood Hazard Minimization Plan outlining measures to protect the facility from flooding.
- **Special Condition 14:** SCWD must submit an Energy Minimization and Greenhouse Gas Reduction Plan, identifying the expected annual amount of indirect greenhouse gas emissions and measures to ensure the facility operates as "net carbon neutral" annually.
- **Special Condition 15:** SCWD must conduct a study of the effects of the project's water rates in its low-income ratepayers and identify feasible measures to mitigate those adverse effects.

- **Special Condition 16:** SCWD must implement Tribal cultural resource monitoring measures during construction and adhere to reporting requirements if any Tribal cultural resources are discovered during project construction.

Special conditions for the Monterey Desalination Facility coastal development permit (CDP) include:

- **Special Condition 1:** Cal-Am must provide the final resolution of the lawsuit filed by the City of Marina regarding the groundwater extraction limits from the project's well field site.
- **Special Condition 2:** Cal-Am must submit a complete application to amend the permit if it seeks to expand authorization of the project to Phase II.
- **Special Condition 3:** Cal-Am must implement comprehensive and protective construction "best management practices" to avoid and minimize actual and potential impacts.
- **Special Condition 4:** Cal-Am must develop and implement a Spill Prevention and Response Plan to prevent spills to the extent possible and to respond appropriately if they do occur.
- **Special Condition 5:** Cal-Am must conduct its well field construction outside the period of March 1 to September 30 of any year to avoid disturbing nearby Western snowy plovers during their breeding and nesting season.
- **Special Condition 6:** Cal-Am must submit a complete CDP application before the end of the 25-year term to propose relocation, rehabilitation, or removal of the wells.
- **Special Condition 7:** The mitigation measures from the Final Environmental Impact Report/Final Environmental Impact Statement (FEIR/FEIS) must be codified and refined to ensure consistency with the Commission's practice.
- **Special Condition 8:** Cal-Am must conduct pre-construction surveys to document the condition of Environmentally Sensitive Habitat Areas (ESHA) during the preceding late spring to early summer period. This includes documenting the physical extent and acreage of all habitats within proposed impact areas, as well as metrics such as native species diversity, native species cover, invasive species cover, and vegetation community age class and/or size structure distributions, and photos to compare against conditions following conclusion of construction.
- **Special Condition 9:** All habitat mitigation for permanent impacts must occur within protected areas.
- **Special Condition 10:** Construction activities may not commence until any sensitive wildlife species have left the project area and its vicinity, and/or any sensitive plant species have been sufficiently protected or salvaged in accordance with the approved final Habitat Mitigation and Monitoring Plan.
- **Special Condition 11:** Cal-Am must construct its wells to extend as far seaward as feasible to reduce their potential groundwater impacts.
- **Special Condition 12:** Cal-Am must develop a comprehensive monitoring and reporting program to detect any potential groundwater impacts caused by the project and identify measures to implement before those impacts occur.

- **Special Condition 13:** Cal-Am must conduct extensive monitoring and reporting sufficient to detect potential effects the project may cause in those areas before they occur.
- **Special Condition 14:** Cal-Am must remove the wells and associated components if damaged and is prohibited from using shoreline protection devices in the event the well field is threatened by erosion or other hazards during the permit term.
- **Special Condition 15:** Cal-Am must acknowledge the risks involved in siting its development at this location.
- **Special Condition 16:** While awaiting approval for their low-income relief plan, Cal-Am must annually report on the two benefits offered: all ratepayers enrolled in its Customer Assistance Program would be offered free installation of low-flow fixtures that meet state efficiency requirements, and any ratepayers enrolled in the program would have a rate increase of no more than $10 per month for water provided by the project for at least five years after those deliveries begin.
- **Special Condition 17:** Cal-Am must submit a Public Access and Amenities Plan that will benefit the City's residents, which first requires Cal-Am to provide a Community Engagement Plan describing measures Cal-Am will take to engage with representatives and residents of the City to develop the Public Access and Amenities Plan.
- **Special Condition 18:** Cal-Am must have approved monitors on site for any ground-disturbing activities that may affect Tribal cultural resources.
- **Special Condition 19:** Cal-Am must submit an Energy Minimization and Greenhouse Gas Reduction Plan that specifies measures it will implement to avoid and reduce operational emissions, and to offset any remaining emissions.
- **Special Condition 20:** Cal-Am must submit drawings or other simulations of the Project's proposed above-grade features within the coastal zone showing that the selected colors are muted and would blend into the surrounding areas to ensure the project's visual impacts are minimized.

Special conditions for the Carlsbad Desalination Facility coastal development permit (CDP) include:

- **Special Condition 1:** Poseidon must reimburse the Coastal Commission for all costs and attorney fees incurred in defending any legal action challenging the permit approval or issuance.
- **Special Condition 2:** Poseidon must provide documentation proving their legal interest in all necessary properties within the coastal zone, including leases from the California State Lands Commission, the power plant owner, and local governments.
- **Special Condition 3:** Poseidon must provide documentation showing that they have executed and recorded a lease restriction against their leasehold interests, indicating that the Coastal Commission has authorized development on the property, subject to specific terms and conditions.
- **Special Condition 4:** Poseidon must submit documentation showing that the project has obtained final approvals from various agencies, including the City of Carlsbad, the Regional Water Quality Control Board, and others.

- **Special Condition 5:** Poseidon must acknowledge the risks associated with the project site, such as seismic events and erosion, and agree to assume these risks and waive any claims of damage or liability against the Coastal Commission.
- **Special Condition 6:** This permit authorizes the construction and operation of the Poseidon Carlsbad Desalination Project and associated infrastructure as described in the project description of the staff report, as clarified and modified by these conditions.
- **Special Condition 7:** Poseidon must submit final plans for the project components located in the coastal zone for review and approval.
- **Special Condition 8:** Poseidon must submit and obtain approval for a Marine Life Mitigation Plan. This plan must document the project's expected impacts on marine life, and include goals, objectives, performance criteria, and contingency measures for each mitigation site. The plan must also include "as-built" plans and annual monitoring reports for at least five years or until performance criteria are met and propose legal mechanisms to ensure permanent protection of each site.
- **Special Condition 9:** If Poseidon proposes or is required to withdraw more than an average flow of 304 mgd of seawater at any time, an amendment to the CDP must be obtained first.
- **Special Condition 10:** Poseidon must submit a Revised Energy Minimization and Greenhouse Gas Reduction Plan that addresses comments from the Coastal Commission, State Lands Commission, and California Air Resources Board.
- **Special Condition 11:** Prior to operations beginning, Poseidon must dedicate certain parcels of land to enhance public access and recreational opportunities along the coast. These dedications include:
  - A public access and parking easement of approximately 2.4 acres along the west shore of the Agua Hedionda Lagoon.
  - Approximately 10.2 acres on the west side of Carlsbad Boulevard for recreational and coastal access uses.
  - Approximately 2 acres along the north shore of Agua Hedionda Lagoon for a fish hatchery, aquatic research, and public access.
  - An access easement over approximately 0.3 acres near the south entrance of the power plant for public parking.
- **Special Condition 12:** The permit does not authorize dredging needed to maintain flows to the desalination facility's intake structure. Separate coastal development permit applications must be submitted for proposed dredging operations.
- **Special Condition 13:** Poseidon must submit a Screening Plan for review and approval. This plan must ensure that exterior mechanical equipment and facilities are screened from public view and that the design and material used are architecturally compatible with the building.
- **Special Condition 14:** Poseidon must submit a Lighting Plan for review and approval. The plan must ensure that lighting serves only operational, security and safety purposes, is shielded from

surrounding areas, and minimizes adverse effects on the ocean, lagoon, and adjacent properties.

- **Special Condition 15:** Poseidon must submit a Construction Plan for review and approval. This plan should detail the locations of all construction areas, staging areas, and access corridors within the coastal zone. It must also identify any potential disruptions to public shoreline access and include measures to avoid, minimize, or mitigate these disruptions. Additionally, the plan should specify the types and locations of erosion control and water quality best management practices to be implemented during construction to protect coastal water quality.
- **Special Condition 16:** Poseidon must submit a Storm Water Pollution Prevention Plan (SWPPP) for review and approval. The SWPPP must include Best Management Practices (BMPs) such as placing gravel bags and silt fences along the edge of all work areas to contain particulates, ensuring all concrete washing and spoils dumping occur in designated locations, covering construction stockpiles to prevent blow-off or runoff during weather events, and developing a pollution control education plan to be implemented throughout all phases of development and construction.
- **Special Condition 17:** Poseidon must submit a Water Quality Technical Report for review and approval. This report, prepared by a licensed Civil Engineer, must comply with the City of Carlsbad Standard Urban Stormwater Mitigation Plan for the post-construction desalination facility. The report must include BMPs to reduce the volume, velocity, and pollutant load of stormwater leaving the site.

Appendix G Opinion of Probable Construction Cost of the Three Top-Ranked Sites

Metropolitan Water District, CA
Southern California Seawater Desalination Research Study
Opinion of Probable Construction Cost, March 2025, Site 7A, Port Hueneme

Estimator	Jesus Quimpo
Labor rate table	CA25 Los Angeles
Equipment rate table	2025H1 $6Equip BOF
ENR CCI	FEB 2025: 13,766.3
AACEi Class	5
Estimate Type	OPCC
Design Level	Planning Level Alternates
Notes	This is an Opinion of Probable Construction Cost only, as defined by the documents provided at the level of design indicated above. CDM Smith has no control over the cost of labor, materials, equipment, or services furnished, over schedules, over contractor's methods of determining prices, competitive bidding (at least 3 each - both prime bidders and major subcontractors), market conditions or negotiating terms. CDM Smith does not guarantee that this opinion will not vary from actual cost, or contractor's bids. There are not any costs provided for: Change Orders, Design Engineering, Construction Oversight, Client Costs, Finance or Funding Costs, Legal Fees, Land Acquisition or temporary/permanent Easements, Operations, or any other costs associated with this project that are not specifically part of the bidding contractor's proposed scope. This OPCC shall remain valid for 30 days. Beyond this date, CDM Constructors should be notified of design changes. The estimate will also be reviewed to reflect current market conditions. Assumptions: No rock excavation is required. Only nominal dewatering is needed. No consideration for contaminated soils or hazardous materials is included (i.e. asbestos, lead, etc). Includes finished water distribution from desal plant to MWD facilities. Includes raw water slant wells and intakes to desalination plant.
Report format	Sorted by 'Bid Item/Area/16CSI Sctn/Element' 'Element' summary Allocate addons

Site 7A, Port Hueneme

Spreadsheet Level	Takeoff Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
Site 7A Port Hueneme with Subsurface Slant Wells								
020 Wellhead Pods								
03-00-00 Concrete								
020.031111.67.005 Concrete Saddle Supports for Well Vault Piping	1.00 ls	134,478	30,263	367	743	87	165,938.27 /ls	165,938
03-00-00 Concrete		134,478	30,263	367	743	87		165,938
03-41-00 Precast Structural Concrete								
020.034100.67.005 Vault for Well Piping Connections	20.00 ea	175,702	2,357,316	181,641			135,732.97 /ea	2,714,659
03-41-00 Precast Structural Concrete		175,702	2,357,316	181,641				2,714,659
05-50-00 Metal Fabrications								
020.055000.67.005 Metals in Vault	20.00 ea	96,884	568,574	2,294			33,387.63 /ea	667,753
05-50-00 Metal Fabrications		96,884	568,574	2,294				667,753
31-23-00 Excavation and Fill								
020.312300.67.005 EX/BF Vault for Well Piping Connections	20.00 ea	602,710	912,106	656,345	224,518		119,783.98 /ea	2,395,680
31-23-00 Excavation and Fill		602,710	912,106	656,345	224,518			2,395,680
33-11-00 Wells								
020.331100.67.005 Slanting Wells	20.00 ea				200,000,000		10,000,000.00 /ea	200,000,000
33-11-00 Wells					200,000,000			200,000,000
40-05-00 Process Piping								
020.400500.67.005 Piping and Sleeves at Well Vault	20.00 ls	1,067,661	1,321,018	31,961	152		121,039.63 /ls	2,420,793
40-05-00 Process Piping		1,067,661	1,321,018	31,961	152			2,420,793
40-05-51 Valves								
020.400551.67.005 Valves at Well Vault	5.00 ls	83,687	575,103	18,059		3,120	135,993.87 /ls	679,969
40-05-51 Valves		83,687	575,103	18,059		3,120		679,969
40-70-00 Instrumentation for Process Systems								
020.407000.67.005 Magnetic Flowmeter	20.00 ea	30,815	325,000	1,965		3,250	18,051.48 /ea	361,030
40-70-00 Instrumentation for Process Systems		30,815	325,000	1,965		3,250		361,030
43-25-00 Submersible/Immersible Liquid Pumps								
020.432500.67.005 Submersible Pump at Slanting Well	20.00 ea	94,306	23,423,843	136,462		29,250	1,184,193.06 /ea	23,683,861
43-25-00 Submersible/Immersible Liquid Pumps		94,306	23,423,843	136,462		29,250		23,683,861
020 Wellhead Pods	5.00 ea	2,286,244	29,513,224	1,029,094	200,225,414	35,707	46,617,936.56 /ea	233,089,683
025 Well Pipe Beachside Conveyance								
33-05-07.36 Microtunnelling								
025.330507.67.020 Site 7A - 24" Wellhead Pipe Pod 2 thru 4 - MTBM	9,600.00 lf				24,096,000		2,510.00 /lf	24,096,000
33-05-07.36 Microtunnelling					24,096,000			24,096,000
025 Well Pipe Beachside Conveyance	9,600.00 lf				24,096,000		2,510.00 /lf	24,096,000
030 Well Pipe Header to Treatment Plant Conveyance								
33-05-07.36 Microtunnelling								
030.330507.67.020 Site 7A - 24" Pipe from Pod 5 to Treatment Plant - MTBM	3,900.00 lf				9,864,000		2,529.23 /lf	9,864,000
030.330507.67.025 Site 7A - 42" Pipe from Pods 1-4 to Treatment Plant - MTBM	8,400.00 lf				51,660,000		6,150.00 /lf	51,660,000
33-05-07.36 Microtunnelling					61,524,000			61,524,000
030 Well Pipe Header to Treatment Plant Conveyance	12,300.00 lf				61,524,000		5,001.95 /lf	61,524,000
035 Treatment Plant to Outfall Conveyance								
02-41-00 Demolition								
035.024113.67.005 AC Pavement Demo - 42" Concentrate WTP to Outfall	138,000.00 sf	1,039,136	20,392	909,387		9	14.27 /sf	1,968,924
02-41-00 Demolition		1,039,136	20,392	909,387		9		1,968,924
32-12-16 Asphalt Paving								
035.321216.67.005 AC Pavement - 42" Concentrate WTP to Outfall	20,623.00 sy	166,904	1,354,698	114,333	295,778		93.67 /sy	1,931,713
32-12-16 Asphalt Paving		166,904	1,354,698	114,333	295,778			1,931,713
33-00-00 Utilities								
035.330505.67.005 EX/BF Open Cut Trenching - 42" Concentrate WTP to Outfall	33,500.00 cy	2,536,997	4,999,852	1,626,746	525,931	20,592	289.85 /cy	9,710,119
33-00-00 Utilities		2,536,997	4,999,852	1,626,746	525,931	20,592		9,710,119
33-05-07.36 Microtunnelling								
035.330507.67.020 Site 7A - Concentrate 42" WTP to Oxnard WWTP Outfall - MTBM	200.00 lf				3,611,800		18,059.00 /lf	3,611,800
33-05-07.36 Microtunnelling					3,611,800			3,611,800
40-05-33 Polyethylene Pipe								
035.400533.67.005 42" Concentrate Pipe- WTP to Oxnard WWTP Outfall	23,000.00 lf	2,443,610	11,140,470	719,711	307,971	3,120	635.43 /lf	14,614,881
40-05-33 Polyethylene Pipe		2,443,610	11,140,470	719,711	307,971	3,120		14,614,881
035 Treatment Plant to Outfall Conveyance	23,200.00 lf	6,186,647	17,515,411	3,370,178	4,741,480	23,721	1,372.30 /lf	31,837,437
040 Treatment Plant, Influent								
46-07-00 Packaged Water & Wastewater Treatment								
040.460700.67.005 Desalination Plant - Permeate	20.00 MGD				178,000,000		8,900,000.00 /MGD	178,000,000

Site 7A, Port Hueneme

Spreadsheet Level	Takeoff Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
46-07-00 Packaged Water & Wastewater Treatment					178,000,000			178,000,000
040 Treatment Plant, Influent	40.00 mgd				178,000,000		4,450,000.00 /mgd	178,000,000
050 Pump Station - Finished Water								
03-31-04 Slab-on-Grade Place/Fin								
050.033104.59.005 SOG Form, Place & Finish - PH-PS1	104.00 cy	77,673	69,437	4,450	2,312	690	1,486.17 /cy	154,561
050.033104.59.010 SOG Form, Place & Finish - PH-PS2	104.00 cy	77,673	69,437	4,450	2,312	690	1,486.17 /cy	154,561
050.033104.59.015 SOG Form, Place & Finish - PH-PS3	104.00 cy	77,673	69,437	4,450	2,312	690	1,486.17 /cy	154,561
050.033104.59.020 SOG Form, Place & Finish - PH-PS4	104.00 cy	77,673	69,437	4,450	2,312	690	1,486.17 /cy	154,561
03-31-04 Slab-on-Grade Place/Fin		310,690	277,749	17,801	9,247	2,759		618,246
03-31-05 Equip Pad/Base/Curb Pl/Fn								
050.033105.59.005 Equipment Pad Concrete for Pumps - PH-PS1	4.00 cy	15,406	4,010	110	414	29	4,992.21 /cy	19,969
050.033105.59.010 Equipment Pad Concrete for Pumps - PH-PS2	4.00 cy	15,406	4,010	110	414	29	4,992.21 /cy	19,969
050.033105.59.015 Equipment Pad Concrete for Pumps - PH-PS3	4.00 cy	15,406	4,010	110	414	29	4,992.21 /cy	19,969
050.033105.59.020 Equipment Pad Concrete for Pumps - PH-PS4	4.00 cy	15,406	4,010	110	414	29	4,992.21 /cy	19,969
03-31-05 Equip Pad/Base/Curb Pl/Fn		61,622	16,041	438	1,658	116		79,875
22-30-00 Plumbing Equipment								
050.223000.59.005 Hydropneumatic Surge Tank 10'dia. x 106' - PH-PS1	1.00 ea	110,027	431,255	20,748	2,717	433	565,180.18 /ea	565,180
050.223000.59.010 Hydropneumatic Surge Tank 10'dia. x 106' - PH-PS2	1.00 ea	110,027	431,255	20,748	2,717	433	565,180.14 /ea	565,180
050.223000.59.015 Hydropneumatic Surge Tank 10'dia. x 106' - PH-PS3	1.00 ea	110,027	431,255	20,748	2,717	433	565,180.16 /ea	565,180
050.223000.59.020 Hydropneumatic Surge Tank 10'dia. x 106' - PH-PS4	1.00 ea	110,027	431,255	20,748	2,717	433	565,180.16 /ea	565,180
22-30-00 Plumbing Equipment		440,109	1,725,021	82,991	10,867	1,733		2,260,721
31-11-00 Clearing and Grubbing								
050.311100.93.005 Clear & Grubb as PH-PS2	0.23 ac	4,577		2,363			30,170.87 /ac	6,939
050.311100.93.010 Clear & Grubb as PH-PS3	2.06 ac	40,990		21,162			30,170.84 /ac	62,152
050.311100.93.015 Clear & Grubb as PH-PS4	0.70 ac	13,929		7,191			30,170.86 /ac	21,120
31-11-00 Clearing and Grubbing		59,496		30,715				90,211
31-22-00 Grading								
050.312200.93.005 Rough Grade PH-PS2	143.00 cy	8,359		9,930			127.90 /cy	18,289
050.312200.93.010 Rough Grade PH-PS3	1,372.00 cy	40,518		45,791			62.91 /cy	86,309
050.312200.93.015 Rough Grade PH-PS4	263.00 cy	12,421		14,177			101.13 /cy	26,598
31-22-00 Grading		61,298		69,899				131,197
32-13-13 Concrete Paving								
050.321300.93.005 Concrete Driveway at PH-PS2	1.00 ea	5,335	2,697	3,411	15,111		26,553.32 /ea	26,553
050.321300.93.010 Concrete Driveway at PH-PS3	2.00 ea	10,671	5,394	6,821	30,221		26,553.33 /ea	53,107
050.321300.93.015 Concrete Driveway at PH-PS4	1.00 ea	5,335	2,697	3,410	15,111		26,553.34 /ea	26,553
32-13-13 Concrete Paving		21,342	10,787	13,642	60,442			106,213
32-15-40 Crushed Stone Surfacing								
050.321540.93.005 Aggregate Surface Access Road at PH-PS2	120.00 sy	445	974	178	173		14.75 /sy	1,770
050.321540.93.010 Aggregate Surface Access Road at PH-PS3	1,907.00 sy	7,078	15,469	2,830	2,746		14.75 /sy	28,123
050.321540.93.015 Aggregate Surface Access Road at PH-PS4	760.00 sy	2,821	6,166	1,128	1,094		14.75 /sy	11,210
32-15-40 Crushed Stone Surfacing		10,345	22,608	4,137	4,013			41,103
32-31-00 Fences and Gates								
050.323113.93.005 Perimeter Fence at PH-PS2	435.00 lf				29,421		67.63 /lf	29,421
050.323113.93.010 Perimeter Fence at PH-PS3	1,280.00 lf				84,476		66.00 /lf	84,476
050.323113.93.015 Perimeter Fence at PH-PS4	685.00 lf				45,051		65.77 /lf	45,051
32-31-00 Fences and Gates					158,948			158,948
33-16-31 Prestressed Concrete Aboveground Water Storage Tank								
050.331631.59.005 Domed Prestressed Concrete Storage Tank - PH-PS1	1.00 ea	3,841	1,454	2,055	1,750,258		1,757,608.12 /ea	1,757,608
050.331631.59.010 Domed Prestressed Concrete Break Tank - PH-PS3	1.00 ea	3,841	1,454	2,055	1,750,258		1,757,608.13 /ea	1,757,608
050.331631.59.015 Domed Prestressed Concrete Break Tank - PH-PS4	1.00 ea	3,841	1,454	2,055	1,750,258		1,757,608.12 /ea	1,757,608
33-16-31 Prestressed Concrete Aboveground Water Storage Tank		11,524	4,361	6,166	5,250,774			5,272,824
40-05-19 Ductile Iron Pipe								
050.400519.93.005 Interconnection Pipe at PH-PS1	497.00 lf	749,284	1,859,370	27,257	768		5,305.19 /lf	2,636,680
050.400519.93.010 Interconnection Pipe at PH-PS2	386.00 lf	651,389	1,533,999	20,497	563		5,716.18 /lf	2,206,447
050.400519.93.015 Interconnection Pipe at PH-PS3	497.00 lf	749,284	1,859,370	27,257	768		5,305.19 /lf	2,636,680
050.400519.93.020 Interconnection Pipe at PH-PS4	497.00 lf	749,284	1,859,370	27,257	768		5,305.19 /lf	2,636,680
40-05-19 Ductile Iron Pipe		2,899,242	7,112,109	102,269	2,868			10,116,488
40-05-51 Valves								
050.400551.93.005 Valves at PH-PS1	33.00 ea	96,690	702,682	49,212		208,832	32,042.91 /ea	1,057,416
050.400551.93.010 Valves at PH-PS2	29.00 ea	88,838	661,599	47,615		182,728	33,819.98 /ea	980,780
050.400551.93.015 Valves at PH-PS3	35.00 ea	103,159	784,888	52,747		208,871	32,847.56 /ea	1,149,665

Site 7A, Port Hueneme

Spreadsheet Level	Takeoff Quantity	Labor Amount	Material Amount	Equip Amount	Sub Amount	Other Amount	Total Cost/Unit	Total Amount
050.400551.93.020 Valves at PH-PS4	35.00 ea	103,159	784,888	52,747		208,871	32,847.56 /ea	1,149,665
40-05-51 Valves		391,846	2,934,056	202,321		809,302		4,337,525
43-23-00 Dry Location Liquid Pumps								
050.432300.67.030 PS 1 at PH. New Pipe to Springville-387'TDH@453HP	5.00 ea	179,870	2,934,362	39,221		3,250	631,340.74 /ea	3,156,704
050.432300.67.035 PS 2 at Springeville to Reg 6A-475'TDH@555HP	5.00 ea	179,870	2,934,362	39,221		3,250	631,340.73 /ea	3,156,704
050.432300.67.040 PS 3 at Reg 6A to Reg 7 (39")-636'TDH@743HP	5.00 ea	231,650	4,405,402	77,514		3,250	943,563.39 /ea	4,717,817
050.432300.67.045 PS 4 at Reg 7 to Conejo (950')-578'TDH@676HP	5.00 ea	231,650	4,405,402	77,514		3,250	943,563.38 /ea	4,717,817
43-23-00 Dry Location Liquid Pumps		823,042	14,679,529	233,471		13,000		15,749,041
050 Pump Station - Finished Water	5.00 ea	5,090,555	26,782,261	763,849	5,498,816	826,910	7,792,478.26 /ea	38,962,391
060 Open Trench Conveyance - Finished Water								
01-59-00 Security/Traffic & Pollution Control								
060.015900.93.005 Traffic Control	154.00 wk				3,234,000		21,000.00 /wk	3,234,000
01-59-00 Security/Traffic & Pollution Control					3,234,000			3,234,000
02-41-00 Demolition								
060.024113.93.005 Asphalt and Base Demo	43,578.00 sy	1,951,880	33,462	1,624,380		1,586,281	119.23 /sy	5,196,003
02-41-00 Demolition		1,951,880	33,462	1,624,380		1,586,281		5,196,003
03-48-00 Precast Concrete Specialties								
060.034800.93.005 Pressure Sustaining Valve Vaults	3.00 ea	58,368	280,090	48,737	392		129,195.67 /ea	387,587
03-48-00 Precast Concrete Specialties		58,368	280,090	48,737	392			387,587
32-12-16 Asphalt Paving								
060.321216.93.005 Asphalt Restoration	164,279.00 sy	466,173	1,784,860	439,295	407,534		18.86 /sy	3,097,862
32-12-16 Asphalt Paving		466,173	1,784,860	439,295	407,534			3,097,862
32-17-23 Pavement Markings								
060.321723.93.005 Pavement Markings	1.00 ls				698,512		698,512.39 /ls	698,512
32-17-23 Pavement Markings					698,512			698,512
40-05-24 Steel Pipe								
060.400524.93.005 Epoxy Lined Steel Pipe & Trenching	73,925.00 lf	19,312,831	44,515,966	7,277,759	1,581,512	393,094	988.59 /lf	73,081,162
40-05-24 Steel Pipe		19,312,831	44,515,966	7,277,759	1,581,512	393,094		73,081,162
060 Open Trench Conveyance - Finished Water	73,925.00 lf	21,789,251	46,614,379	9,390,171	5,921,949	1,979,375	1,159.22 /lf	85,695,126
070 Trenchless Conveyance - Finished Water								
33-05-07.36 Microtunnelling								
070.330507.59.005 Microtunneling Trenchless Crossing for 40"dia. - PH-PS1	2,700.00 lf	1,101,403	2,356,142	271,669	6,897,732	1,524	3,936.47 /lf	10,628,470
33-05-07.36 Microtunnelling		1,101,403	2,356,142	271,669	6,897,732	1,524		10,628,470
070 Trenchless Conveyance - Finished Water	9.00 ea	1,101,403	2,356,142	271,669	6,897,732	1,524	1,180,941.10 /ea	10,628,470
Site 7A Port Hueneme with Subsurface Slant Wells	**20.00 MGD**	**36,454,101**	**122,781,416**	**14,824,961**	**486,905,392**	**2,867,237**	**33,191,655.32 /MGD**	**663,833,106**

Site 7A, Port Hueneme

Estimate Totals

Description	Amount	Totals	Hours	Rate
Labor	36,454,101		244,679 hrs	
Material	122,781,416			
Subcontract	486,905,392			
Equipment	14,824,961		150,184 hrs	
Other	2,867,237			
	663,833,107			
Subtotal Direct Cost		**663,833,107**		
I&C Allowance	32,949,090			5.000 %
Electrical Allowance	98,847,269			15.000 %
Subtotal Allowances	**131,796,359**	**795,629,466**		
General Conditions				
GC General Conditions	95,475,536			12.000 %
Subtotal General Conditions	**95,475,536**	**891,105,002**		
Indirect Costs				
Permits(% total cost)	8,298,936			0.500 %
Sales Tax (Permanent Mat'l)	8,736,370			9.250 %
Sales Tax (Non-Permanent)	1,258,868			9.250 %
Builder's Risk Ins (% total cost)	8,298,936			0.500 %
Gen Liab Ins (% total cost)	16,597,872			1.000 %
GC Bonds (% total cost)	24,896,808			1.500 %
Subtotal Prior to OH&P	**68,087,790**	**959,192,792**		
Contractor Total OH&P	115,103,135			12.000 %
Subtotal with OH&P	**115,103,135**	**1,074,295,927**		
Construction Contingency	268,573,982			25.000 %
Total Cost in Today's Dollars	**268,573,982**	**1,342,869,909**		
Escalation to Mid Point Constr	316,917,298			23.600 %
Based on 5% per Year				
Midpt 2029				
	316,917,298	**1,659,787,207**		
Total		***1,659,787,207***		

"This Opinion of Probable Construction Cost is produced in accordance with CDM Smith's Firmwide Quality policies and best practices as described in CDM Smith's Estimating Manual Dated 01/03/12 Section 10 titled Quality Control. I hereby acknowledge that the Cost Estimating policies and procedures were followed in preparation of the Opinion of Probable Cost".

Estimator initials - JQ,LL,NC 2/26/2025

SITE 3 - DOHENY STATE BEACH EXPANSION (up to 10 MGD)

Item	Site 3			
	Tie-in Option 1 Low Slant Wells	Tie-in Option 1 High Slant Wells	Tie-in Option 2 Low Slant Wells	Tie-in Option 2 High Slant Wells
Slant Wells and Wellhead pods	$32,718,000	$69,918,000	$32,718,000	$69,918,000
Well Pipe Beachside Conveyance	$3,960,000	$3,960,000	$3,960,000	$3,960,000
Well Pipe Header to Treatment Plant Conveyance	$8,633,000	$8,633,000	$8,633,000	$8,633,000
Subtotal - Intake	**$45,311,000**	**$82,511,000**	**$45,311,000**	**$82,511,000**
Treatment Plant to Outfall Conveyance	$839,000	$839,000	$839,000	$839,000
Subtotal - Outfall	**$839,000**	**$839,000**	**$839,000**	**$839,000**
Treatment Plant	$113,843,000	$113,843,000	$113,843,000	$113,843,000
Subtotal - Treatment Plant	**$113,843,000**	**$113,843,000**	**$113,843,000**	**$113,843,000**
Pump Stations Finished Water	$14,296,000	$14,296,000	$21,761,000	$21,761,000
Open Trench Conveyance	$3,966,000	$3,966,000	$6,870,000	$6,870,000
Trenchless Conveyance	$1,949,000	$1,949,000	$2,974,000	$2,974,000
Subtotal - Conveyance	**$20,211,000**	**$20,211,000**	**$31,605,000**	**$31,605,000**
Subtotal - Direct Cost	**$180,204,000**	**$217,404,000**	**$191,598,000**	**$228,798,000**
Allowances	$35,926,000	$43,342,000	$38,197,000	$45,613,000
General Conditions	$25,936,000	$31,289,000	$27,575,000	$32,929,000
Indirect Costs	$16,988,000	$20,495,000	$18,062,000	$21,569,000
Contractor Total OH&P	$31,086,000	$37,504,000	$33,052,000	$39,469,000
Subtotal - With Contractor OH&P	**$290,140,000**	**$350,034,000**	**$308,484,000**	**$368,378,000**
Contingency	$72,535,000	$87,508,000	$77,121,000	$92,094,000
Escalation to mid point construction	$85,591,000	$103,260,000	$91,003,000	$108,672,000
TOTAL	**$448,266,000**	**$540,802,000**	**$476,608,000**	**$569,144,000**

SITE 3 - COST ESTIMATE CALCULATIONS

1.0 Slant Wells

No. wells	6	
	Low end	**High end**
Slant wells cost, USD/well	$5,453,000	$11,653,000
Total Cost	**$32,718,000**	**$69,918,000**

2.0 Beachside Conveyance

Length, ft	Size, in	Cost Factor, USD/ft/in	**Total Cost**
1500	24	$110.00	**$3,960,000**

3.0 Treatment Plant

Capacity, MGD	Cost Curve	**Total Cost**
10	98854588ln(x) - 113778155	**$113,842,946**

SITE 6B - EL SEGUNDO (10 MGD)

Item	Site 6B	
	Low-end cost Slant wells and Land Acquisition	High-end cost Slant wells and Land Acquisition
Land acquisition	$15,285,000	$28,322,000
Subtotal - Site Preparation & Acquisition	**$15,285,000**	**$28,322,000**
Converted Power Intake	$49,077,000	$104,877,000
Converted Power Intake Header Conveyance	$13,200,000	$13,200,000
Converted Power Intake Header to Treatment Plant Conv	$11,412,000	$11,412,000
Subtotal - Intake	**$73,689,000**	**$129,489,000**
Treatment Plant to Outfall Conveyance	$17,314,000	$17,314,000
Subtotal - Outfall	**$17,314,000**	**$17,314,000**
Treatment Plant	$113,843,000	$113,843,000
Subtotal - Treatment Plant	**$113,843,000**	**$113,843,000**
Pump Stations Finished Water	$7,346,000	$7,346,000
Open Trench Conveyance	$1,000,000	$1,000,000
Trenchless Conveyance	$990,000	$990,000
Subtotal - Conveyance	**$9,336,000**	**$9,336,000**
Subtotal - Direct Cost	**$229,467,000**	**$298,304,000**
Allowances	$44,728,000	$58,145,000
General Conditions	$32,903,000	$42,774,000
Indirect Costs	$24,254,000	$31,530,000
Contractor Total OH&P	$39,762,000	$51,690,000
Subtotal - With Contractor OH&P	**$371,114,000**	**$482,443,000**
Contingency	$92,778,000	$120,610,000
Escalation to mid point construction	$109,478,000	$142,320,000
TOTAL	**$573,370,000**	**$745,373,000**

SITE 6B - COST ESTIMATE CALCULATIONS

1.0 Land Acquisition

	Low end Cost	High end Cost
Cost factor, USD/sqft	$44.25	$81.99
Site Area, sqft	345,431	345,431
Total Cost	**$15,285,313**	**$28,321,871**

2.0 Slant Wells

No. wells	9	
	Low end	**High end**
Slant wells cost, USD/well	$5,453,000	$11,653,000
Total Cost	**$49,077,000**	**$104,877,000**

3.0 Beachside Conveyance - Treanchless

Length, ft	Size, in	Cost Factor, USD/ft/in	**Total Cost**
4000	30	$110.00	**$13,200,000**

4.0 Pipe header to Treatment Plant

4.1 Open Trench

Length, ft	Size, in	Cost Factor, USD/ft/in	**Open trench Cost**
3100	30	$34.00	**$3,162,000**

4.2 Trenchless

Length, ft	Size, in	Cost Factor, USD/ft/in	**MTBM Cost**
2500	30	$110.00	**$8,250,000**

TOTAL COST	**$11,412,000**

5.0 Treatment Plant to Outfall Conveyance

5.1 Open Trench

Length, ft	Size, in	Cost Factor, USD/ft/in	**Open trench Cost**
3100	24	$34.00	**$2,529,600**

5.2 Trenchless

Length, ft	Size, in	Cost Factor, USD/ft/in	**MTBM Cost**
5600	24	$110.00	**$14,784,000**

	TOTAL COST	**$17,313,600**

6.0 Treatment Plant

Capacity, MGD	Cost Curve	**Total Cost**
10	98854588ln(x) - 113778155	**$113,842,946**

7.0 Pump Station

No. PS	Capacity, mgd	TDH, ft	Cost Factor, USD/TDH/MGD	**Total Cost**
1	10	693	1060	**$7,345,800**

8.0 Conveyance Pipeline

8.1 Open Trench

Length, ft	Size, in	Cost Factor, USD/ft/in	**Open trench Cost**
1225	24	$34.00	**$999,600**

8.2 Trenchless

Crossings No.	Length per Crossing, ft
5	75

Total Length, ft	Size, in	Cost Factor, USD/ft/in	**MTBM Cost**
375	24	$110.00	**$990,000**

Appendix H Total Cost Summary of the Three Top-Ranked Sites

Appendix H
Cost Summary of Top 3 Sites
Cost Breakdown

Site #	Name	Intake	Outfall	Product Water (MGD)	Product Water (AFY)	O&M Cost ($/yr)	OPCC ($)	Annualized Capital Cost ($/yr)	Total Annualized Cost ($/yr)	Cost/MG ($)	Cost/AF ($)
3	Doheny State Beach Expansion (Low End)	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	10	11,201	$19,408,815	$448,266,000	$29,160,347	$48,569,161	$13,307	$4,336
3	Doheny State Beach Expansion (High End)	Slant Wells (9)	Existing San Juan Creek WW Ocean Outfall	10	11,201	$19,408,815	$569,144,000	$37,023,634	$56,432,449	$15,461	$5,038
7A	Port Hueneme (Low End)	Slant Wells (20)	Existing Oxnard WWTP Outfall	20	22,402	$38,817,629	$1,350,000,000	$87,819,437	$126,637,067	$17,348	$5,653
7A	Port Hueneme (High End)	Slant Wells (20)	Existing Oxnard WWTP Outfall	20	22,402	$38,817,629	$1,660,000,000	$107,985,382	$146,803,012	$20,110	$6,553
6A	El Segundo (Low End)	Slant Wells (9)	Existing Hyperion WWTP Outfall	10	11,201	$19,408,815	$573,370,000	$37,298,541	$56,707,356	$15,536	$5,063
6A	El Segundo (High End)	Slant Wells (9)	Existing Hyperion WWTP Outfall	10	11,201	$19,408,815	$745,373,000	$48,487,583	$67,896,398	$18,602	$6,062

Appendix H
Cost Summary of Top 3 Sites
Operations and Maintenance Summary

	% Total	Slant Wells		
Variable O&M Costs	**Simplified**	**% Reduction for Slant Wells**	**$/yr/mgd**	**$/kgal**
- Energy	50.0%	10%	$ 1,465,931	$ 4.02
- Chemicals	10.0%	50%	$ 55,154	$ 0.15
- Membrane Replacement	7.5%	0%	$ 93,762	$ 0.26
- Waste Disposal	2.5%	75%	$ 13,099	$ 0.04
Fixed O&M Costs				
- Labor	7.5%	0%	$ 67,500	$ 0.18
- Permit Compliance	2.5%	0%	$ 22,062	$ 0.06
- Indirect Costs	10.0%	0%	$ 110,308	$ 0.30
- Maintenance	10.0%	0%	$ 113,066	$ 0.31
	100%			$ 5.32

$/yr/mgd	$ 1,940,881
$/AF	$ 1,733

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013). Costs from this book were based on Carlsbad Desalination plant.

Appendix H
Cost Summary of Top 3 Sites
Energy

Specific Energy	15	kWh/kgal
Specific Energy	4.0	kWh/m3
Specific Energy	4,886	kWh/AF
Plant Production	50	mgd
Cost of Energy	0.2975	$/kWh
Energy Cost (2013 $)	$81,440,625	$/yr
Escalation Rate	0.0%	
Energy Cost (2025 $)	$81,440,625	$/yr

8 to 9 kWh/kgal for the RO. Approximately double after accounting for raw water pumping and ancillary systems.

Cost of power highly variable. This value results in power attributing for approximately 55% of the total O&M cost, which is reasonable.

Source: https://www.sce.com/regulatory/tariff-books/historical-rates

Updated value

0.220	$/Kwh
0.23	$/Kwh

California Energy Price Data for May 2025 - Center for Jobs

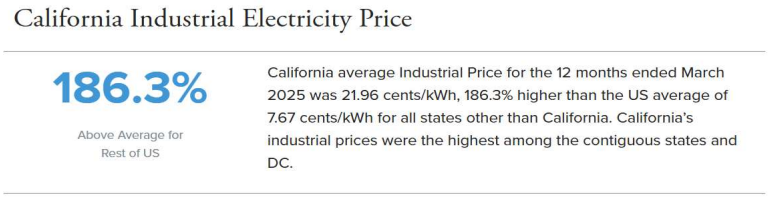
Assumed 3% annual scalation between 2025 to 2026

The original value 0.2945 remains however the escalation rate is eliminated. It is recommend MWD to provide power price for larger consumers to have more accurate power cost figure.

Offshore desalination	2	kWh/m3
	2.3	kWh/m3

based on OceanWell estimate

based on WateRise estimate



Appendix H
Cost Summary of Top 3 Sites
Chemicals

Chemical Cost	0.2	$/kgal
Plant Production	50	mgd
Chemical Cost (2013 $)	$3,650,000	$/yr
Escalation Rate	51%	
Chemical Cost (2025 $)	$5,515,401	$/yr

Cost of chemicals is a variable expenditure and typically is in a range of $0.025/m³ to $0.075/m³ ($0.1 to $0.3/1000 gal) of product water.

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Updated 2025 cost assuming 3.5% inflation rate

Appendix H
Cost Summary of Top 3 Sites
Membrane Replacement

Membrane Replacement Cost	0.17	$/kgal
Plant Production	50	mgd
Membrane Replacement Cost (2013 $)	$3,102,500	$/yr
Escalation Rate	51%	
Membrane Replacement Cost (2025 $)	$4,688,091	$/yr

Cartridge filters for SWRO plants have a typical minimum useful life of six to eight weeks. However, in many applications where the source water is of high quality, cartridge filter replacement is less frequent (once every 6 to 12 months). Depending on the cartridge filter size, the unit cartridge filter cost is between $8 and $30 per filter. The total membrane and cartridge filter replacement costs are typically in a range of $0.020 to $0.070/m^3 ($0.08 to $0.26/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Updated 2025 cost assuming 3.5% inflation rate

Appendix H
Cost Summary of Top 3 Sites
Waste Disposal

Waste Disposal Cost	0.095	$/kgal
Plant Production	50	mgd
Waste Disposal Cost (2013 $)	$1,733,750	$/yr
Escalation Rate	51%	
Waste Disposal Cost (2025 $)	$2,619,815	$/yr

The main waste stream of every membrane desalination plant is the RO system concentrate. Depending on the concentrate disposal practices, the total waste stream disposal costs are typically in a range of $0.015/m³ to $0.035/m³ ($0.06 to $0.13/1000 gal).

Depending on the capacity and distance of the available landfills in the area of the desalination plant, the residual disposal costs usually vary between $16 to $80/wet ton of sludge, which would correspond to an additional cost of water production between $0.005 and $0.025/m³ ($0.02 and $0.10/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Updated 2025 cost assuming 3.5% inflation rate

Appendix H
Cost Summary of Top 3 Sites
Labor

No. FTE	30	
Plant Production	50	mgd
Labor Cost (2025 $)	$112,500	$/yr
Escalation Rate		
Labor Cost (2025 $)	$3,375,000	$/yr

Adding 1.5 indirect labor cost

Updated 2025 cost

Plant Capacity (m^3/day)	Plant Automation and Labor Skill Level	
	High	Low
1000	2–3	4–6
5000	4–6	8–10
10,000	7–10	12–15
20,000	9–12	16–18
40,000	12–16	18–20
100,000	14–18	20–24
200,000	18–28	30–40
300,000	35–50	60–80

TABLE 17.9 Desalination Plant Staffing Requirements

operators on duty at all times. The labor costs are fixed for a given plant and are typically in a range of $0.015/m³ to $0.040/m³ ($0.06 to $0.15/1000 gal) of treated water.

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Corrected cost assuming average operator cost for MWD plus indirect factor 1.5 for labor
Metropolitan Water District of Southern California Water Treatment Plant Operator Salaries (3 Salaries submitted) | Glassdoor

Permit Compliance Cost	0.04	$/kgal
Plant Production	50	mgd
Permit Compliance Cost (2013 $)	$ 730,000	$/yr
Escalation Rate	51%	
Permit Compliance Cost (2025 $)	$1,103,080	$/yr

Product water monitoring costs are expenditures associated with sample collection, laboratory analysis, and data management and reporting, which are required to be completed in order to comply with all applicable regulatory requirements associated with the product water supply. Typically, plant performance and product water quality monitoring costs are between $\$0.005/m^3$ and $\$0.015/m^3$ ($0.02 and $0.06/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Updated 2025 cost assuming 3.5% inflation rate

Appendix H
Cost Summary of Top 3 Sites
Indirect Operation and Maintenance

Indirect O&M Cost	0.2	$/kgal
Plant Production	50	mgd
Indirect O&M Cost (2013 $)	$ 3,650,000	$/yr
Escalation Rate	51%	
Indirect O&M Cost (2025 $)	$5,515,401	$/yr

O&M reserve funds. These costs also incorporate the fees for plant operation, if a private company operates the desalination plant. Typically plant indirect O&M costs vary in a wide range—$0.025 to $0.075/m³ ($0.1 to $0.3/1000 gal).

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Updated 2025 cost assuming 3.5% inflation rate

Appendix H
Cost Summary of Top 3 Sites
Maintenance

Maintenance Cost	0.205	$/kgal
Plant Production	50	mgd
Maintenance Cost (2013 $)	$3,741,250	$/yr
Escalation Rate	51%	
MaintenanceCost (2025 $)	$5,653,286	$/yr

Since most of the plant equipment is maintained routinely on a preset schedule independent of the actual water production, some (typically 40 to 60 percent) of the routine equipment maintenance costs are often considered fixed O&M costs. The remaining portion of the maintenance costs is accounted as a variable component and is related to the actual equipment run time. Plant total maintenance costs are typically in a range of $0.035 to $0.075/m^3 ($0.13 to $0.28/1000 gal) of desalinated water.

Source: Desalination Engineering: Planning and Design, Nikolay Voutchkov (2013).

Updated 2025 cost assuming 3.5% inflation rate

PREPARED BY

CDM Smith