Prepared for

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SEABED INFILTRATION GALLERY CONSTRUCTION AND LIFE-CYCLE COSTS FOR A PROPOSED 20 MGD OCEAN WATER DESALINATION FACILITY EL SEGUNDO, CALIFORNIA

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS

CEQA	California Environmental Quality Act
Desal PMP	Ocean Water Desalination Program Master Plan
EIR	Environmental Impact Report
ISTAP	Independent Scientific Technical Advisory Panel
MGD	million gallons per day
MF	micro-filtration
N/A	Not Applicable
NRG Facility	NRG Generating Station site in El Segundo
RO	Reverse Osmosis
SIG	Seabed infiltration galleries
SSI	Subsurface Seawater Intake
UF	ultra-filtration
West Basin	West Basin Municipal Water District

1. BACKGROUND AND INTRODUCTION

West Basin Municipal Water District (West Basin) is a water wholesaler that provides imported drinking water and recycled water to nearly one million people, industrial, and commercial users in the coastal Los Angeles area. West Basin's Water Reliability 2020 Program aims to reduce dependence on imported water from 66% to 33% by 2020. To reduce dependency on imported water, and increase drought resiliency, West Basin is striving to increase recycled water production, expand conservation efforts, and develop new sources of potable water that are locally available and hydrologically-independent, such as ocean water desalination (desal) (Malcolm Pirnie - Arcadis, 2013).

For well over a decade, West Basin has conducted a step-wise investigation of desalination, which began with pilot testing from 2002 to 2009 at the NRG Generating Station site in El Segundo (NRG Facility) followed by a demonstration facility in Redondo Beach that was operated from 2010 to 2014. The goal of the demonstration facility was to research and test numerous methods and processes for all stages of operation of a desalination facility (intake, treatment, discharge) that could be used for full scale designs.

To identify the next steps for full scale development of ocean water desalination, West Basin completed an Ocean Water Desalination Program Master Plan (Desal PMP) (Malcolm Pirnie - Arcadis, 2013). This document identified an Environmental Impact Report (EIR) as the next step. The California State Water Resources Control Board amended the Ocean Plan in 2015 to provide specific requirements for development of ocean water desalination facilities along the coast of California. The Ocean Plan has identified SSIs as the preferred ocean water intake option as SSIs involve collecting water from beneath the seafloor and from the coastal margin through a hydrologically conductive sediment layer which eliminate marine life loss through entrainment.

As such, West Basin conducted an evaluation of the feasibility of subsurface seawater intakes (SSIs) in compliance with the amended Ocean Plan (2015) as part of the EIR. The key findings of the feasibility study are presented in Appendix 2A in the EIR document. It is noted that the EIR reviewed an ocean water desalination facility with a production capacity of 20 million gallons per day (MGD)[1] at the NRG Facility location in El Segundo (see Figure 1.1) as the local project at a project level. The document also reviewed a

[1] 20 MGD is considered the minimum capacity for the project per analysis of the need for desalinated water based on West Basin's 2010 Urban Water Management Plan (UWMP) (RMC, 2011) and the Desal PMP.

potential expansion of the facility from 20 MGD to 60 MGD as a regional project at a programmatic level.

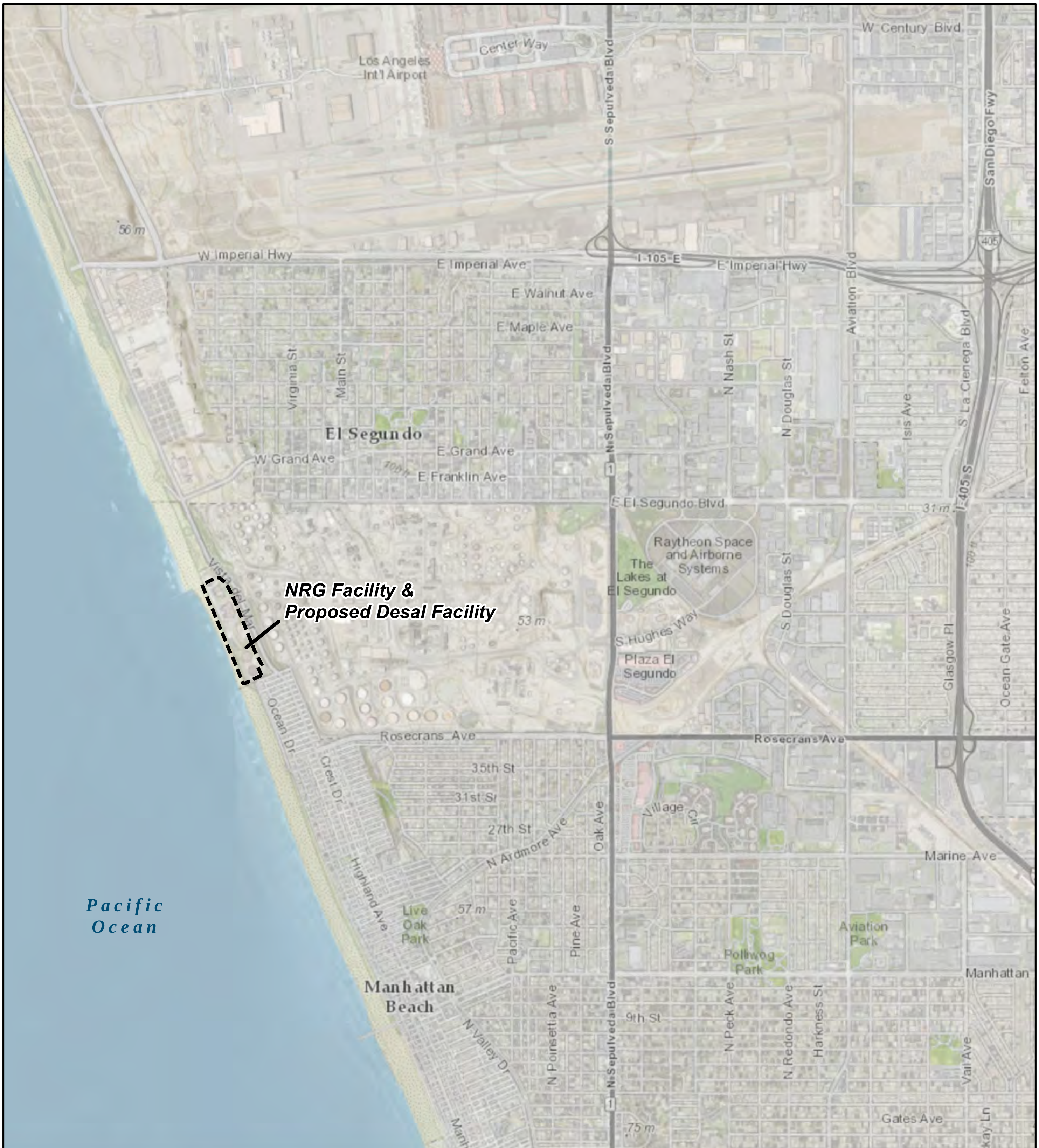
To demonstrate the feasibility of SSI, only the local project with a production capacity of 20 MGD, which would require an ocean water intake (feed water) rate of approximately 40 MGD, were evaluated in the SSI feasibility study. The study considered site-specific geotechnical data, hydrogeology, benthic topography, oceanographic conditions, presence of sensitive habitats, presence of sensitive species, impact on freshwater aquifers, existing infrastructure, design constraints (e.g., construction complexity), precedence (and associated technical risk), the Basin Plan, environmental and social factors, and economic viability (Geosyntec, 2016).

The following seven different SSI technologies (see Geosyntec, 2016 – Appendix B for detailed descriptions), were evaluated;

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

The analysis determined that none of the seven SSI technologies are feasible for the design intake rate of 40 MGD (Geosyntec, 2016, Section 7.6). In particular, the construction of a SIG in the high-energy and relatively unprotected conditions 6,500 feet offshore from the NRG Facility is unprecedented, which exacerbates the performance risk and uncertainty of outcome. In addition, another factor in determining that the seabed infiltration gallery (SIG) intakes were not feasible was lack of economic viability due to high construction costs. The finding was largely based upon drawing parallels and comparisons with similar analyses performed for the Poseidon desal plant in Huntington Beach (ISTAP, 2015).

The purpose of the current study is to refine and expand the cost analyses by conducting site-specific and scale-specific cost analyses for a SIG intake at the NRG Facility location in El Segundo for a 20 MGD production capacity (40 MGD intake capacity). Analyses include consideration of construction costs, operation and maintenance costs, and life-cycle analyses. In addition, the study considers the costs and viability of implementation of a hybrid intake system where a fraction of the 40 MGD intake water is drawn through a SIG with the remainder drawn through open intakes equipped with wedge wire screens (WWS, or screened open intakes). The joint goals are therefore to refine the cost estimate for a full SIG intake, and to determine whether a partial SIG option combined with WWS may be economically viable.



Legend

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Site Location Map

Subsurface Seawater Intake Study
West Basin Municipal Water District

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LA0324	December 2017	Figure 1.1

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1.1 Report Organization

This remainder of the report is organized as follows:

- Section 2, *Approach*, describes the overall approach taken, including the different SIG capacities considered and the co-utilization of screened open intake.
- Section 3, *Seabed Infiltration Gallery Construction, Size and Configuration,* describes the SIG intake technology considered in this report, including construction alternatives, SIG sizes and configuration.
- Section 4, *Cost Estimates,* presents the cost estimates of the alternative intake designs.

2. APPROACH

The study considers a range of combinations of screened open intake and SIG intake rates to meet the desired 40 MGD intake capacity (corresponding to 20 MGD production capacity). Specifically, six different SIG intake rates are considered: 2.5, 5, 10, 20, 30, and 40 MGD. For all SIG capacities, it is assumed that the screened open intake is constructed for a full 40 MGD intake capacity in order to provide full redundancy in the case of SIG maintenance activities or SIG failure (e.g. resulting from erosion of the seafloor and exposure of the SIG infrastructure, or from fouling of the sediment layer above the SIG and failure of rehabilitation attempts).

The study develops estimates for capital construction costs and annual operations and maintenance costs, and then evaluates these costs over the life cycle of the intakes used by the project. The study does not account for environmental impacts and mitigations.

As discussed below, costs for the screened open intake are based on the previous Desal PMP study (Malcolm Pirnie - Arcadis, 2013) as well as West Basin's 2017 updated cost estimates for the conceptual design (CH2M, 2017), while incremental costs for the SIG options are developed based on conceptual designs and site-specific setting. The cost estimates presented in the study is calculated based on a Class V estimate as categorized by the American Association of Civil Engineers (AACE), with an expected accuracy of between -30% on the lower bound and +50% on the upper bound.

2.1 Screened Open Intake Costs

The 2013 Desal PMP study and the 2017 updated cost estimates are used as the basis for the cost of the screened open intake. Capital costs for the WWS component are not adjusted, since it is assumed that the full 40 MGD WWS intake capacity will be constructed regardless of the assumed SIG capacity. This approach provides complete redundancy in the event of SIG maintenance or extensive downtime. In addition, the 40 MGD intake capacity, corresponding to 20 MGD of product water, is considered as the local project in the EIR to offset 20 acre-feet per year (AFY) of imported water supply. As discussed in the PMP, smaller capacities are considered as not being economically viable for this project, thus, such an alternative are not reviewed in the EIR. As updated in the 2017 cost estimates, the capital costs of the screened open intake a small percentage of the cost of the overall desalination plant project, therefore the cost of redundancy with the screened open intake is low for the benefit of ensuring 40 MGD intake rate in the event of SIG maintenance or extensive downtime.

The operations and maintenance (O&M) costs for the WWS were based on 2017 cost estimates and assume a screen replacement frequency of 20 years.

2.2 SIG Costs

Conceptual designs and construction techniques are developed for each of the SIG sizes (Section 3) to calculate SIG construction capital cost estimates and O&M cost estimates (Section 4). These SIG costs are added to the costs developed for the screened open intake to obtain total intake costs for each of the six SIG capacities.

The capital cost estimates (Section 4.1) for the SIG include the offshore components (i.e., the SIG structure and construction) as well as a separate onshore pumping station (i.e., in addition to the pumping station used for the screened open intake).

The O&M cost estimates (Section 4.2) for the SIG include costs required to maintain the SIG structure (i.e., core sampling of engineered fill, cleaning and replacement of upper layer of engineered fill, and pipe cleaning), as well as maintenance of the additional pump station. The O&M cost estimates for the SIG does not include costs for replacing the SIG and assume the SIG will be operational for the life time of the project (25 years). This is a conservative assumption because of the lack of precedence of SIG operation for 25 years.

2.3 Life-Cycle Cost Analysis

Life-cycle cost analysis is performed (Section 4.3) for each of the six different SIG capacities as well as a scenario without SIG. Based on information provided by West Basin Municipal Water District the analyses assumed a 5% discount rate and 25-year life cycle.

3. SEABED INFILTRATION GALLERY CONSTRUCTION, SIZE AND CONFIGURATION

3.1 Overview of SIG

Seabed infiltration galleries (SIG) consist of a network of perforated pipes over which a series of sand and gravel layers are placed that increase in grain size with depth. Seawater percolates through the sand into the perforated pipes, which feed pumped conveyance pipes that bring the seawater onshore to the desal plant. Construction would rely on typical underwater construction techniques (Section 3.2) and involve installing sheet piles and dredging sediment to about 10 to 20 feet below the existing seafloor elevation, laying a perforated pipe network and conveyance pipes, and backfilling with layers of engineered sand and gravel fill.

Large surface areas may be required to obtain desired SIG capacity, and coupled with complex construction occurring in potentially challenging off-shore conditions, this generally makes SIG construction expensive.

The optimal location for SIGs is at or beyond the “closure depth” where long term seafloor elevation is relatively stable and there is no significant net sediment transport between the nearshore and offshore (< 0.5 feet change in seabed elevation), so the risk of the SIG becoming buried (due to deposition of fine-grained sediment) or exposed (due to erosion of the engineered fill) is minimal. Analysis by Dr. Scott Jenkins (Geosyntec, 2016 – Appendix K) indicated that the closure depth at El Segundo is approximately 50 feet (15 m) and is located 6,500 feet offshore. Based on such criteria, the approximate location feasible for installation of the SIG is shown in Figure 3.1.

The optimal SIG location at Huntington Beach was determined to be approximately 3,400 feet offshore, at approximately 42 feet of water depth (ISTAP, 2015). The El Segundo Beach and Huntington Beach settings are generally similar in terms of wave exposure, bathymetry and high energy ocean environment (Geosyntec, 2016 – Appendix K). Therefore, as detailed below, El Segundo is subject to the same constraints (e.g., unprecedented construction in high energy environment, potential deposition of silts and clays, performance uncertainty, high technical and economic risk) as well as additional constraints and challenges (i.e., located further offshore at greater depth) as compared to Huntington Beach for construction of a SIG.

Additional details of SIGs (and other SSI technologies) were presented in the SSI feasibility study, including general discussions (Geosyntec, 2016 – Appendix B) and discussions and analyses specific to the NRG Facility site at El Segundo (Geosyntec, 2016, Section 7). Specific challenges and constraints for a SIG at the NRG Facility that were identified include (Geosyntec, 2016, Section 7.6):

- Construction of a SIG in the high-energy, unprotected conditions offshore from the NRG Facility is unprecedented:
  - By comparison, an existing SIG at Fukuoka on the north-west side of the island of Kyushu Japan is in a fetch-limited protected environment and is not exposed to the long-period open ocean swell waves that are present in the Santa Monica Bay.
  - Similarly, a small-scale test SIG at Long Beach is located inside the breakwater system of the Long Beach/Los Angeles where it is completely sheltered from wave exposure.
- Potential deposition of silts and clays on the Santa Monica Bay seafloor can occur with El Nino storms and decrease the performance yield and require difficult, expensive, and potentially environmentally damaging maintenance.
- The uncertainty of performance of the SIG given that construction and operation is unprecedented in the challenging ocean conditions at El Segundo.
- High technical and economic risk.

3.2 SIG Construction Alternatives

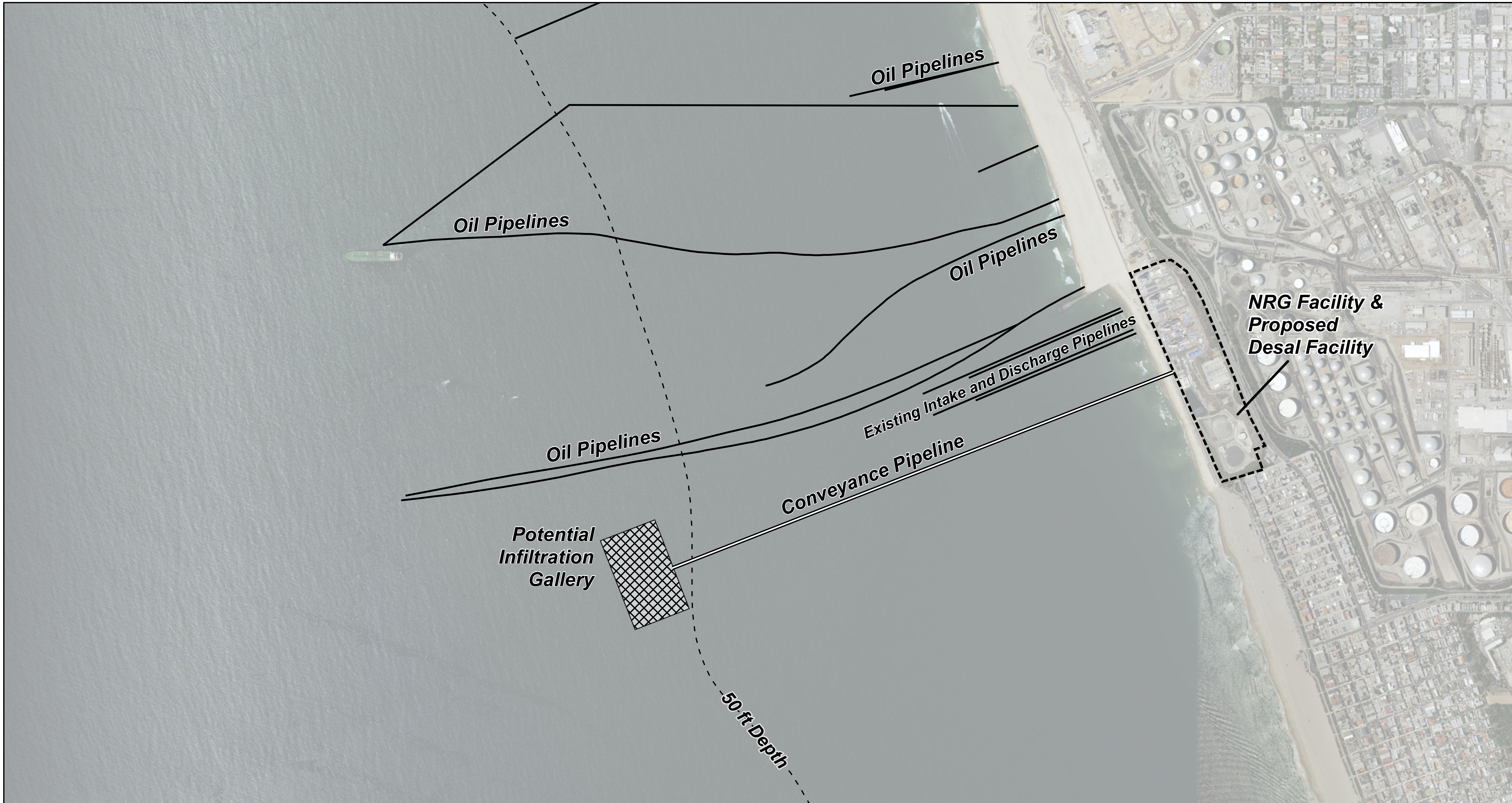
3.2.1 Float-In and Trestle Approaches

The 50 feet depth, coupled with the high-energy ocean environment and long-period ocean swells prevent the efficient use of conventional marine floating equipment, similar to Huntington Beach (ISTAP, 2015). The two viable construction approaches identified for this site are:

- SIG-Trestle: Performing all work from a trestle elevated above the waves, and
- SIG-Float-In: Prefabricating all major SIG components off-site and using floating equipment to transport and install modular units.

The primary objective of the alternate Float-In approach is to shift fabrication and assembly of large modular units to a protected harbor area where work can be conducted without concern for ocean swell conditions, and to transfer these modular units to the installation site by a flat-deck barge for final installation using bottom founded equipment. Figure 3.2 through Figure 3.5 present the construction stages 1 through 6 using the float-in method (ISTAP, 2015).

All of the construction equipment and methods proposed for the trestle construction approach have been fully developed and proven on previous marine projects on the Pacific coast of North America and around the world for the construction of ocean intakes and outfalls. The float-in method also utilizes fully developed and proven marine construction methods except for the driving of sheet-piles utilizing a remote controlled underwater pile installation system as shown in Stages 3A and 3B shown in Figure 3.3. However, a pile driving system could be designed and constructed with currently available technology.



Note:
Gallery Footprint for 40 MGD Intake Rate
MGD = Million Gallons per Day

Seafloor Infiltration Gallery

Subsurface Seawater Intake Study
West Basin Municipal Water District

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Figure 3.1

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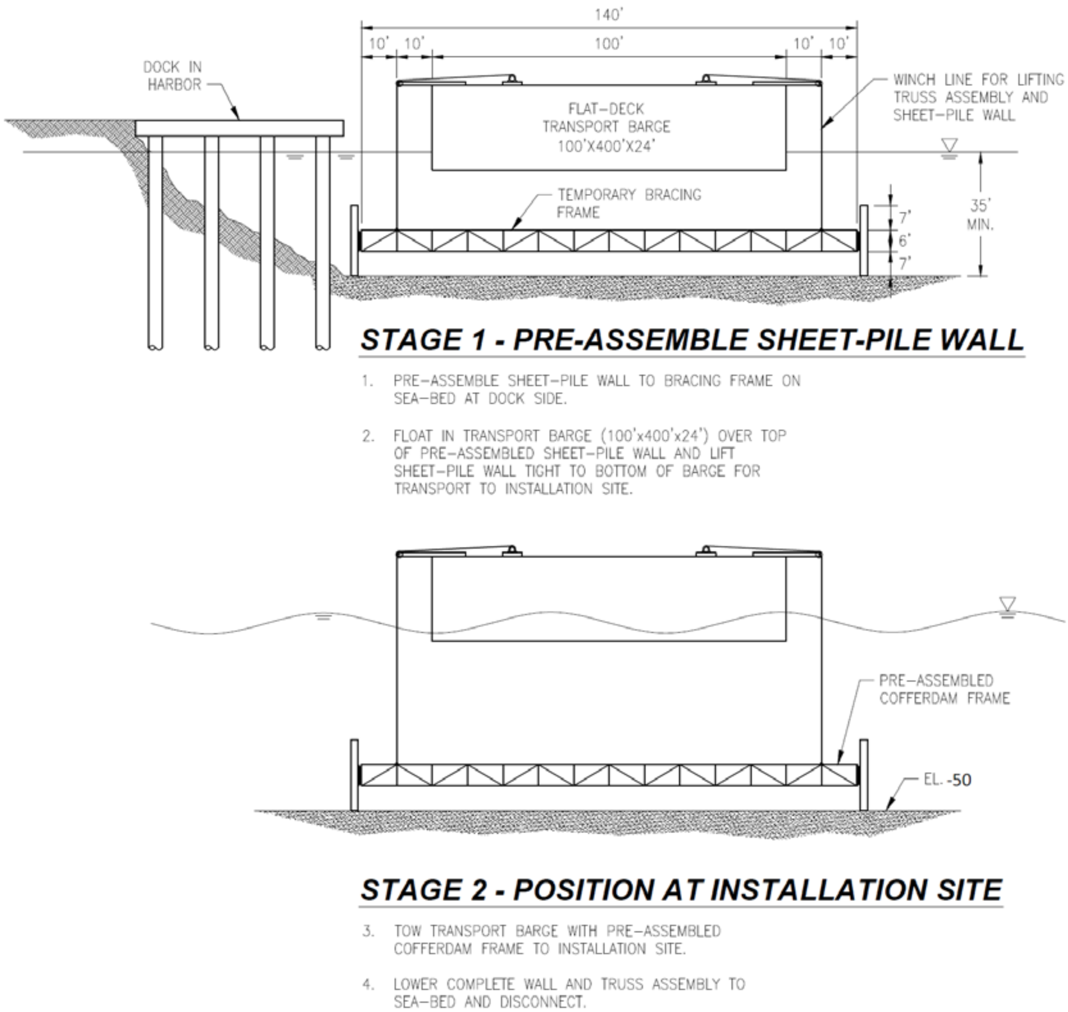


Figure 3.2: Float-In Construction Stages 1 and 2 (modified from ISTAP, 2015)

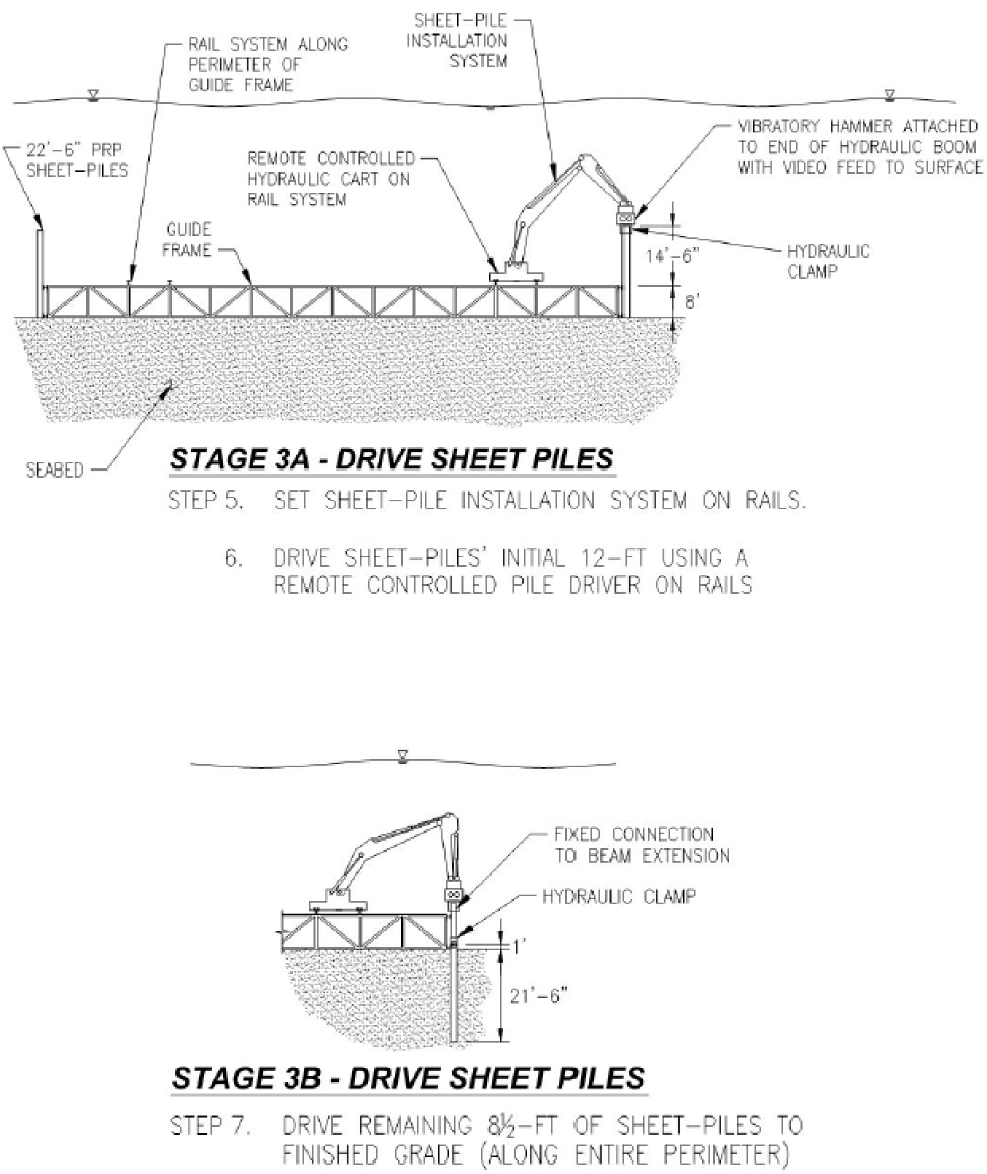


Figure 3.3: Float-In Construction Stages 3A and 3B (modified from ISTAP, 2015)

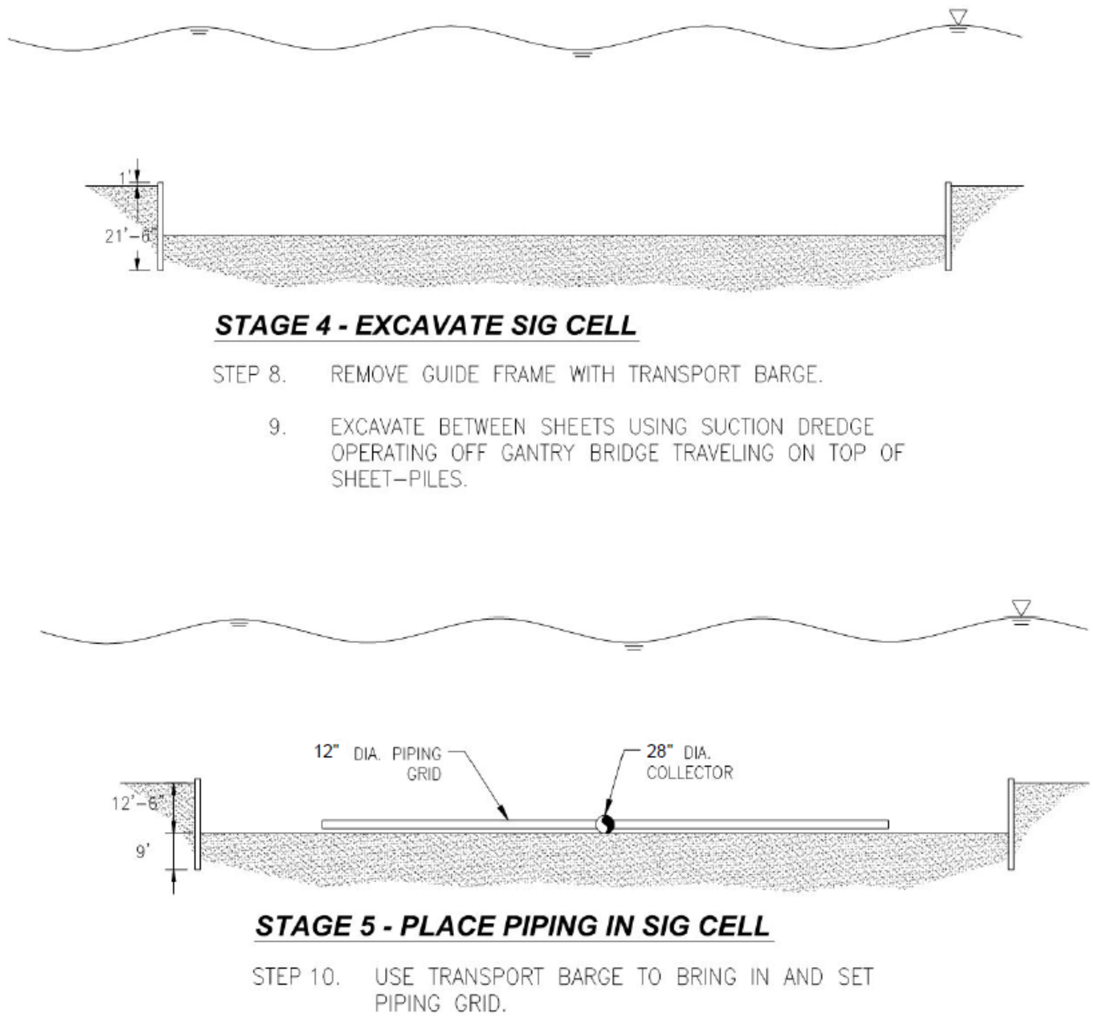


Figure 3.4: Float-In Construction Stages 4 and 5 (modified from ISTAP, 2015)

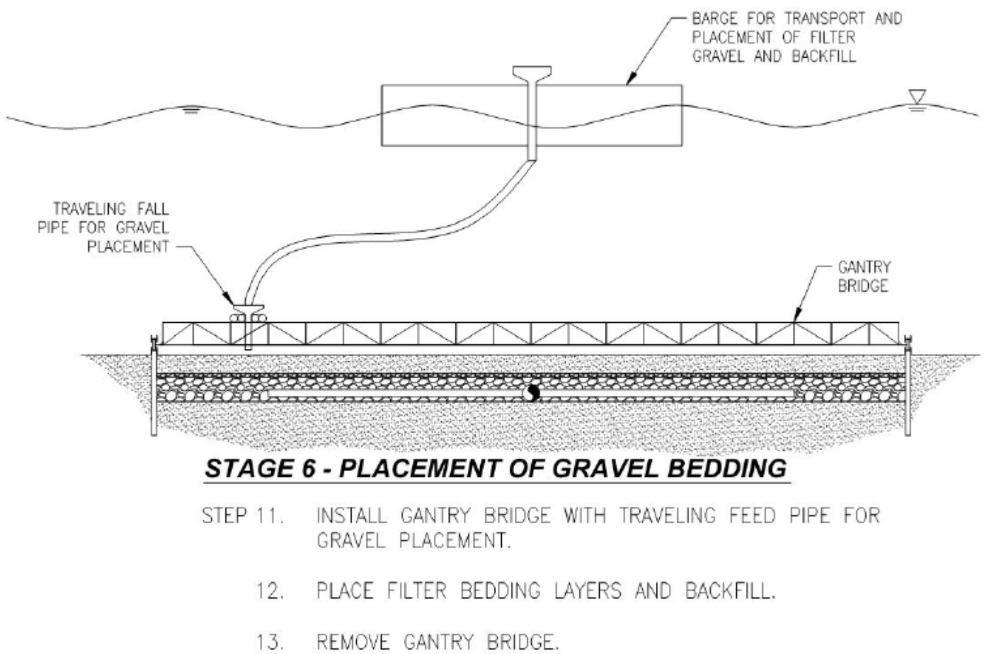


Figure 3.5: Float-In Construction Stage 6 (modified from ISTAP, 2015)

3.2.2 Construction Approach for El Segundo

The SIG-Trestle approach was found to be of similar cost as the SIG-Float-In approach for Huntington Beach (ISTAP, 2015). But, construction at El Segundo would require longer temporary access trestles (6,500 feet versus 3,400 feet for Huntington Beach). However, the smaller intake rates considered for El Segundo (2.5 to 40 MGD versus 100 MGD for Huntington Beach) would require fewer boat trips to the SIG construction site. Finally, 45 feet below sea level limit is considered practical for offshore construction on the seafloor using the trestle approach (Bittner, 2015) and the depth to the seafloor at the potential SIG location at El Segundo is approximately 50 feet. Therefore, the SIG Float-In approach is considered the most economically viable of the two possible construction approaches for the SIG at El Segundo.

3.3 SIG Size and Configuration

Seabed filtration is a modular process, and the number of cells in a SIG can be designed to meet the requirements of different intake rates. For this analysis, six intake rates are considered for the SIG; 2.5, 5, 10, 20, 30 and 40 MGD. The 40 MGD intake rate corresponds to the full-scale intake for a production capacity of 20 MGD, which is considered the minimum capacity for the project (Section 1). West Basin is also considering lower SIG intake rates in this analysis in order to assess the economic feasibility of a wide range of SIG configurations. The SIG configurations for the six intake rates are based on the assumption of no redundancy for the SIG intake, i.e., the number of cells considered would provide the capacity for the selected intake rate without additional capacity from the SIG. The Huntington Beach SIG project assumed a design redundancy of 20%, i.e., the SIG is designed with a capacity corresponding to 120% of the planned intake. The screened open intake is assumed to provide the necessary redundancy for operation of the desalination plant at El Segundo (see Section 2.1). If the SIG capacity decreased, for example due to clogging, the screened open intake would be utilized to augment the flow to the planned 40 MGD intake rate. This assumption results in a lower cost for construction and operation of the SIG compared to the case with redundancy.

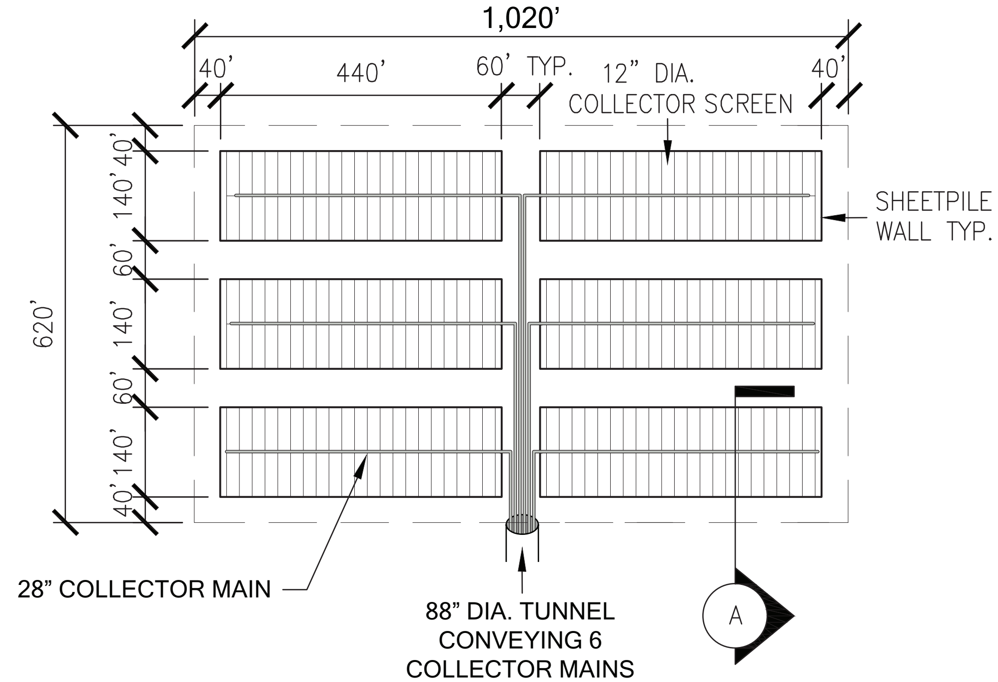
The proposed cell layout is based on the proposed potential construction methods identified by Robert Bittner and the SIG infiltration rates developed by Tom Missimer for Huntington Beach (ISTAP, 2015) and other SIG projects. The conceptual cell layouts for the full-scale SIG (40 MGD) and for the six intake rates are illustrated in Figure 3.6 and Figure 3.7, respectively. These layouts were reviewed by Robert Bittner for El Segundo. The number of cells vary between one (2.5 and 5 MGD) and six (40 MGD), and the total area ranges from 1.5 to 14.5 acres, corresponding to the area to be dredged to install the SIG cells. The typical cross-section of the SIG is illustrated in Figure 3.6.

The proposed SIG piping layouts are illustrated in Figure 3.7 for the six intake rates. Each SIG cell consists of multiple 12” collector screens, which are connected to a 28” collector main. The collector mains are gathered into a single buried conveyance pipe tunnel running to an onshore pumping station. The conveyance pipe tunnel is buried 10 feet below the seafloor to prevent exposure and damage with sediment erosion, corresponding to a trench 13.3- to 18.5-feet-deep depending on the pipe size for the different SIG configurations. In order to enable installation of the conveyance pipe through the surf-zone a trestle would be constructed for the first 1,000 feet from shore for all SIG layouts.

Table 3.1: List of Construction Assumptions

SIG Intake Rate (MGD)	**2.5**	**5**	**10**	**20**	**30**	**40**	**Reference**
SIG Sitting							
Water Depth (ft)	50						Geosyntec, 2016
Distance to shore (ft)	6,500						Geosyntec, 2016
SIG Cells							
Design Loading Rate (gpm/ft^2)	0.075						ISTAP, 2015
Design Redundancy	0%						WWS provides redundancy
Cell Size (ft*ft)	220*140	440*140					ISTAP, 2015
Number of Cells	1	1	2	3	5	6	
Cell Depth (ft)	12.5						ISTAP, 2015 and Figure 3.6
SIG Cell Construction							
FRP Sheet Pile Dimension (ft*ft)	2*23						
Number of FRP Sheet Piles	360	580	1,160	1,740	2,900	3,480	
Dredging Volume (CY)	14,259	28,519	57,037	85,556	142,593	171,111	
Engineering Fill (short tons)	19,228	38,456	76,911	115,367	192,278	230,734	
Total SIG Footprint (acres)	1.5	2.6	5.2	7.5	12.2	14.5	Figure 3.7
SIG Piping							
Cell Collector Pipe	12” Perforated HDPE						
Number of Collector per Cell	11	22					
Total Number of Collector	11	22	44	66	110	132	
Total Length of Collector Pipes (ft)	1,540	3,080	6,160	9,240	15,400	18,480	
Cell Conveyance Pipe	28” HDPE						
Total Length of Conveyance Pipes (ft)	6,850	7,070	14,140	21,410	36,150	43,620	
Tunnel Conveyance Pipe	N/A	N/A	63"	63"	88"	88"	
Total Length of Tunnel Conveyance (ft)	N/A	N/A	6,500				
Trestle to Install the Conveyance Pipe (ft)	1,000						

ft = feet
gpm/ft^2 = gallons per minute per square foot
CY = cubic yard
" = inches
HDPE = High-density polyethylene
FRP = Fiber-reinforced plastic
N/A = Not applicable



PIPING PLAN (40 MGD)

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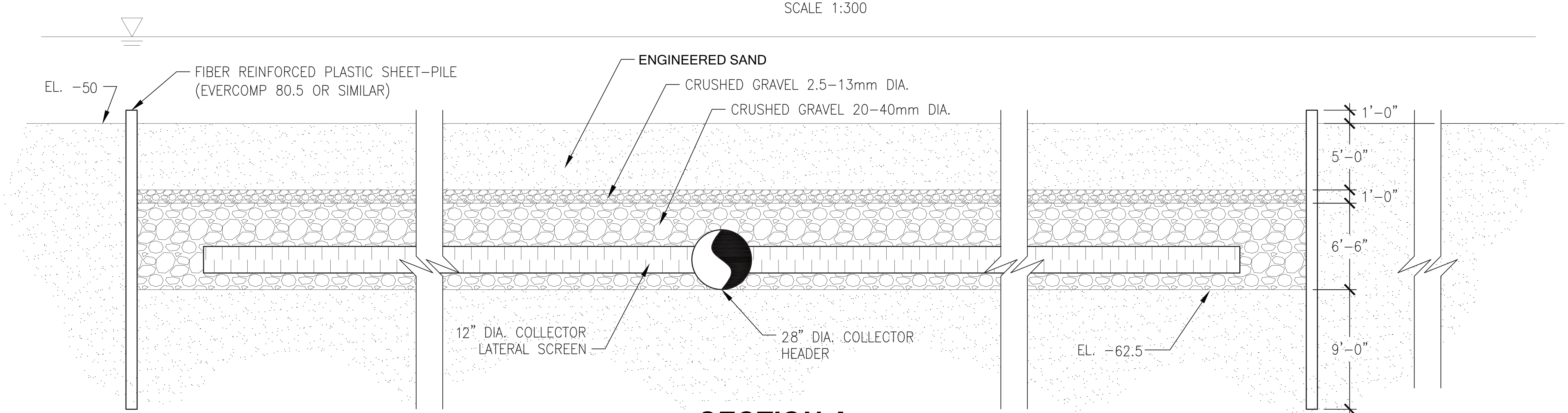

SECTION A

SCALE 1:100

Legend

Modified from Bob Bittner's design (ISTAP, 2015)

SIG Layout and Cross Section for 40 MGD Intake Rate

Subsurface Seawater Intake Study
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Figure 3.6

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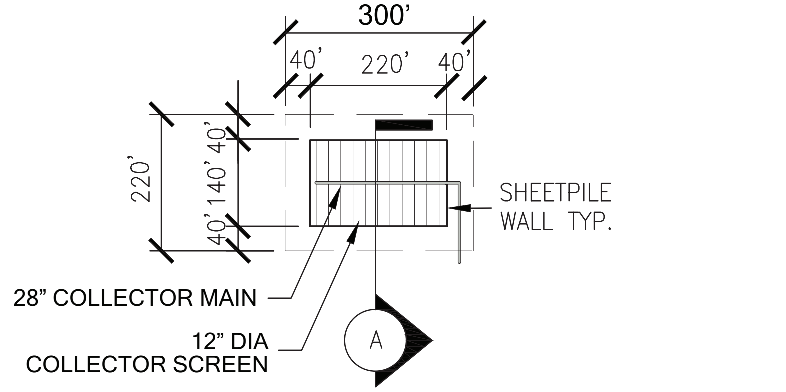
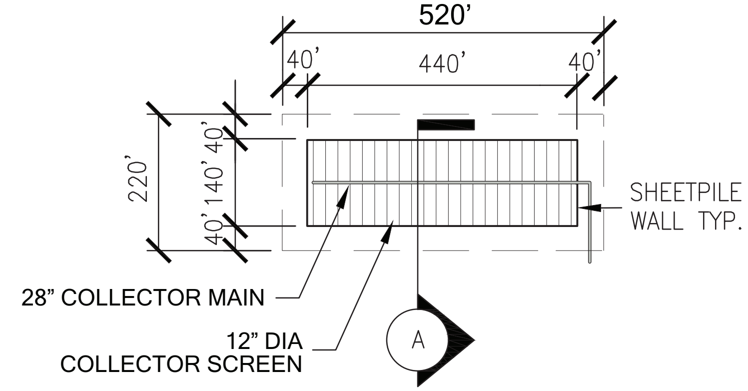


PIPING PLAN (2.5 MGD)
SCALE 1:300



PIPING PLAN (5 MGD)
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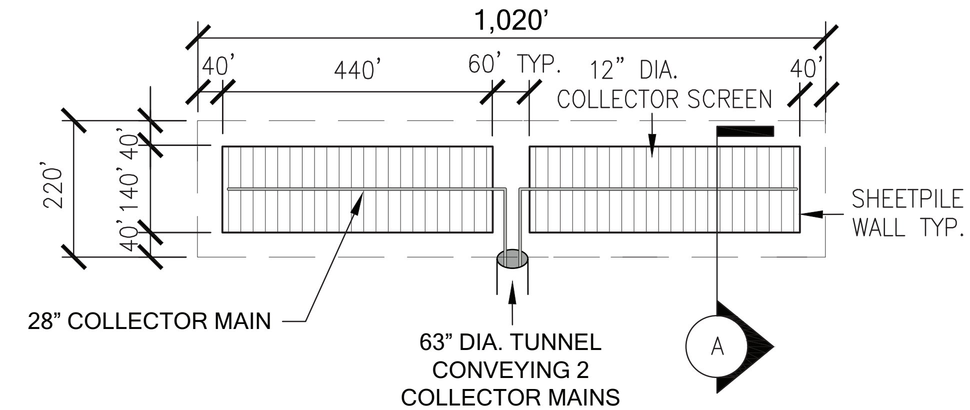

PIPING PLAN (10 MGD)
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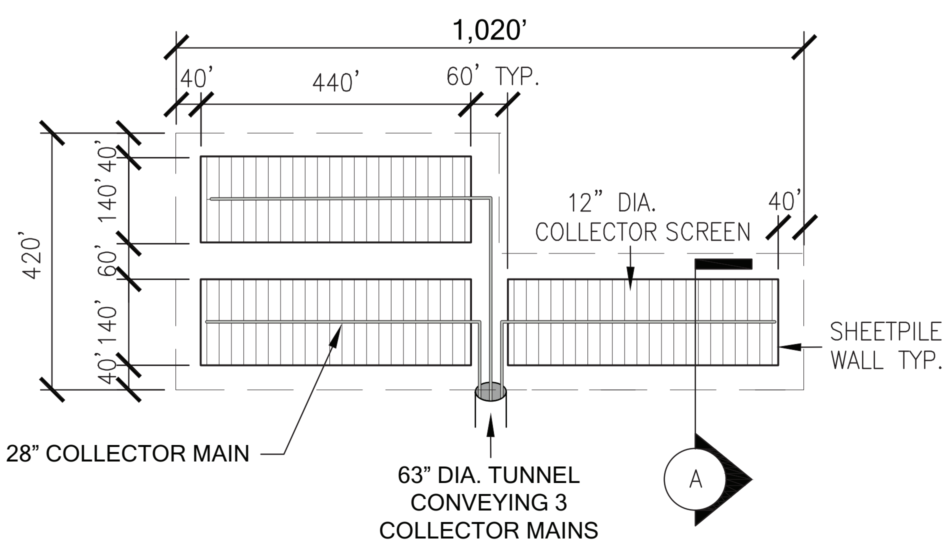

PIPING PLAN (20 MGD)
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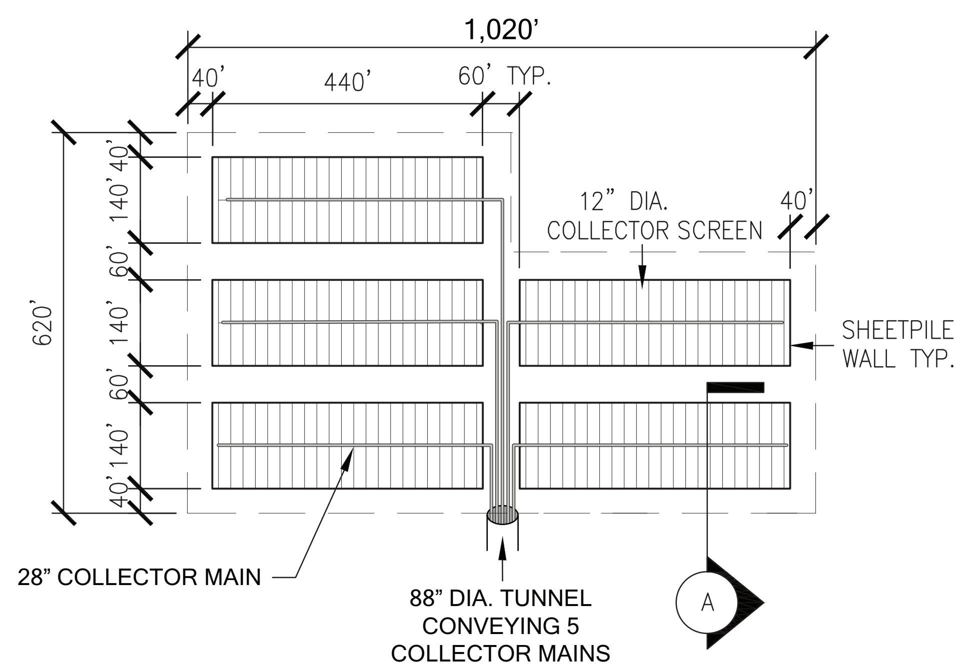
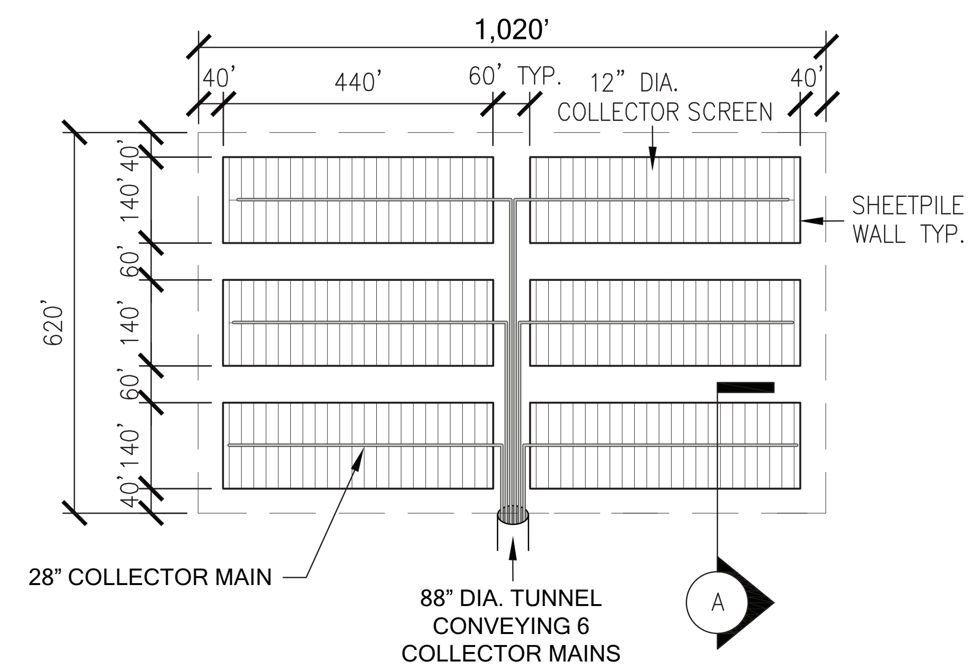


PIPING PLAN (30 MGD)
SCALE 1:300



PIPING PLAN (40 MGD)
SCALE 1:300

Legend

Modified from Bob Bittner's design (ISTAP, 2015)

SIG Layouts for Six Intake Rates

Subsurface Seawater Intake Study
West Basin Municipal Water District

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LA0324 | December 2017

Figure 3.7

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4. LIFE CYCLE COST ANALYSIS

4.1 Capital Cost Estimates

The capital costs for the project are summarized in Table 4.1. The detailed capital costs are provided in Appendix A. The capital costs for the SIGs were provided by Black & Veatch based on design assumptions (Table 3.1 and Figure 3.7) prepared by Geosyntec. The main assumptions for the SIG costs are as follows:

- Construction based on the Float-In method outlined by Robert Bittner (Section 3.2.1 and ISTAP, 2015);
- SIG size and configuration based on Table 3.1;
- 21 miles from the Staging & Assembly area (assumed to be Port of Long Beach) to the construction site;
- Construction of a 1,000 feet long trestle to install the conveyance pipe tunnel to the onshore pump station;
- Disposal of all excavated/dredged material at an offshore site, 10 miles from the construction site;
- Neither sales tax, nor gross receipts tax has been included;
- No overtime and/or shift work is included;
- Cost of permitting and engineering is not included;
- Costs associated with any geotechnical investigations prior to the design and installation of the SIG are not included; and
- Unit prices are based on historical data and 2016 RS Means cost data[2] adjusted for marine construction and for geographical area.

The capital costs for screened open intake (40 MGD capacity) are based on 2017 cost estimates (CH2M, 2017).

The construction cost estimates for the SIG are consistent with construction cost estimates for Huntington Beach using the Float-In construction approach. The construction cost for Huntington Beach for a SIG with 106 MGD intake rate was $722M, corresponding to a

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[2] https://www.rsmeans.com/

cost of \$6.81M per MGD of capacity. The construction cost for a 40 MGD SIG for the West Basin project is estimated at \$270M (SIG Capital Cost Subtotal in Table 4.1), or \$6.75M per MGD of capacity. On a dollar per unit intake volume basis, the cost estimates for the two projects are comparable.

Table 4.1
Capital Cost Estimates for Alternative Intake Designs

SIG Intake Rate (MGD)	2.5	5	10	20	30	40	WWS Only	
SIG Construction Cost Description								**References**
Staging/Pre-Assembly of Cofferdam Frame(s)	$ 1,680,000	$ 2,560,000	$ 4,940,000	$ 7,260,000	$ 11,960,000	$ 14,280,000	N/A	CH2M, 2017
Float in Transport of Pre-Assembled Frame(s)	$ 720,000	$ 1,160,000	$ 2,320,000	$ 3,480,000	$ 5,800,000	$ 6,960,000		
Installation of Pre-Assembled Cofferdam Frame(s)	$ 2,160,000	$ 3,480,000	$ 6,960,000	$ 10,440,000	$ 17,400,000	$ 20,880,000		
Excavation of SIG Cell(s) Including Disposal of Material	$ 2,677,000	$ 3,604,000	$ 7,208,000	$ 10,812,000	$ 15,019,000	$ 17,873,000		
Installation of SIG Cell Piping Grid(s)	$ 1,155,000	$ 2,310,000	$ 4,620,000	$ 6,930,000	$ 11,550,000	$ 13,860,000		
Installation of SIG Cell(s) Bedding	$ 5,297,000	$ 5,614,000	$ 11,180,000	$ 16,698,000	$ 27,595,000	$ 32,972,000		
Installation of Collector Main Tunnel Piping to Pump Station	$ 26,727,000	$ 26,329,000	$ 46,963,000	$ 53,516,000	$ 69,942,000	$ 76,676,000		
Additional Onshore Pump	$ 229,000	$ 458,000	$ 915,000	$ 1,831,000	$ 2,746,000	$ 3,661,000		
Direct SIG Construction Subtotal	$ 40,645,000	$ 45,515,000	$ 85,106,000	$110,967,000	$162,012,000	$187,162,000		
Mobilization/Demobilization - 4.7%	$ 1,910,000	$ 2,139,000	$ 4,000,000	$ 5,215,000	$ 7,615,000	$ 8,797,000		
Bonds & Insurance - 1.5%	$ 610,000	$ 683,000	$ 1,277,000	$ 1,665,000	$ 2,430,000	$ 2,807,000		
Overhead & Profit - 15%	$ 6,097,000	$ 6,827,000	$ 12,766,000	$ 16,645,000	$ 24,302,000	$ 28,074,000		
Un-priced Allowance (Contingency) - 20%	$ 8,129,000	$ 9,103,000	$ 17,021,000	$ 22,193,000	$ 32,402,000	$ 37,432,000		
SIG Construction Subtotal	$ 57,391,000	$ 64,267,000	$120,170,000	$156,685,000	$228,761,000	$264,272,000		
SIG Capital Cost Subtotal	**$ 57,391,000**	**$ 64,267,000**	**$120,170,000**	**$156,685,000**	**$228,761,000**	**$264,272,000**	**$ -**	
WWS Capital Cost Subtotal	**$6,465,000**						**$6,465,000**	**CH2M, 2017**
Total Intake Cost	**$63,856,000**	**$70,732,000**	**$126,635,000**	**$163,150,000**	**$235,226,000**	**$270,737,000**	**$6,465,000**	
Total Intake Cost (-30%)	**$44,699,200**	**$49,512,400**	**$88,644,500**	**$114,205,000**	**$164,658,200**	**$189,515,900**	**$4,525,500**	
Total Intake Cost (+50%)	**$95,784,000**	**$106,098,000**	**$189,952,500**	**$244,725,000**	**$352,839,000**	**$406,105,500**	**$9,697,500**	

Notes:

Detailed costs and assumptions are provided in Appendix A

WWS = Wedge Wire Screen

MGD = million gallons per day

WWS Capital Cost from 2017 CH2M Estimates.

4.2 O&M Cost Estimates

The O&M costs for the project are summarized in Table 4.2 below. The detailed O&M costs are provided in Appendix A. The O&M costs for the SIGs were provided by Black & Veatch. The main assumptions for the SIG O&M costs are as follows:

- Annual core sampling to assess the sedimentation rate impinging on the SIG;
- SIG maintenance, i.e., scraping of the shallow layer, every 5 years;
- Annual cleaning of the conveyance pipelines;
- Power costs are excluded from the SIG O&M costs as they are included in the screened open intake O&M costs, assuming the same power is needed to pump a total of 40 MGD onshore; and
- Unit prices are based on historical data and 2016 RS Means cost data adjusted for marine construction and for geographical area.

The O&M costs for the screened open intake are based 2017 cost estimates for 70/30 Cu/Ni Hendrick screens replaced once during the 25-year project lifetime (CH2M, 2017).

The O&M costs for the SIG assume that the SIG maintenance every five years is successful at rehabilitating the SIG intake capacity, and do not take into account the risk of the inability to rehabilitate and need to abandon the SIG.

Table 4.2
O&M Cost Estimates for Alternative Intake Designs

SIG Intake Rate (MGD)	2.5	5	10	20	30	40	WWS Only	
SIG O&M Cost Description								**Assumptions/References**
(1) SIG Core Sampling	$ 18,000	$ 18,000	$ 36,000	$ 54,000	$ 90,000	$ 108,000	N/A	Power cost for pumping intake water is not included in the SIG O&M cost - it is included in the WWS O&M costs, assuming the same power is needed to pump total of 40 MGD
(2) SIG Maintenance	$ 50,000	$ 65,000	$ 100,000	$ 135,000	$ 205,000	$ 240,000		
(3) Conveyance Pipe Maintenance	$ 25,000	$ 25,000	$ 49,000	$ 74,000	$ 123,000	$ 148,000		
(4) Pump Station Maintenance	$ 11,000	$ 23,000	$ 46,000	$ 92,000	$ 137,000	$ 183,000		
(5) Power Costs	$ -	$ -	$ -	$ -	$ -	$ -		
Annual O&M SIG Cost	**$ 104,000**	**$ 131,000**	**$ 231,000**	**$ 355,000**	**$ 555,000**	**$ 679,000**	**$ -**	
Annual O&M WWS	**$ 707,000**	**$ 707,000**	**$ 707,000**	**$ 707,000**	**$ 707,000**	**$ 707,000**	**$ 707,000**	**Desal PMP Cost Estimate for Power Costs and CH2M 2017 for WWS replacement (20-year frequency)**
Total O&M Cost	**$811,000**	**$838,000**	**$938,000**	**$1,062,000**	**$1,262,000**	**$1,386,000**	**$707,000**	
Total O&M Cost (-30%)	**$567,700**	**$586,600**	**$656,600**	**$743,400**	**$883,400**	**$970,200**	**$494,900**	
Total O&M Cost (+50%)	**$1,216,500**	**$1,257,000**	**$1,407,000**	**$1,593,000**	**$1,893,000**	**$2,079,000**	**$1,060,500**	

Notes:

Detailed costs and assumptions are provided in Appendix A

WWS = Wedge Wire Screen

MGD = million gallons per day

O&M = Operation and Maintenance

Desal PMP = Ocean Water Desalination Program Master Plan

4.3 Results

The life cycle costs for the intakes are summarized in Table 4.3 below. Based on information provided by West Basin Municipal Water District, the analyses assumed a 5% discount rate and a 25-year life cycle.

The 40 MGD SIG was estimated to have total present worth costs ranging from $192M to $411M, or $4.8M to $11.0M per MGD of capacity, respectively; while the costs of the WWS only option ranged from $12M to $25M, or $0.3M to $0.6M per MGD of capacity, respectively. This represents a 16-fold increase in the overall estimated total costs if full-size SIG meeting 100% intake requirement was to be used.

Lowering SIG intake rates could decrease the overall intake costs but it would diminish the economies of scale. For example, the estimated costs for a SIG intake rate of 2.5 MGD accounting for 6% of the intake requirements (i.e., 2.5 MGD out of a total of 40 MGD) would range between $53M and $113M, or $21.2M and $45.2M per MGD of capacity, respectively. This translates to approximately four times of the estimated total costs of the WWS only option or, on a cost-per-unit-volume-water-intake basis, more than 70 times more expensive than the WWS only option.

Table 4.3
Life Cycle Cost Analysis for Alternative Intake Designs

SIG Intake Rate (MGD)	2.5		5		10		20		30		40	WWS Only
SIG Intake Rate (%)	**6%**		**13%**		**25%**		**50%**		**75%**		**100%**	
Life-Cycle Cost	**SIG**	**WWS**	**SIG**	**WWS**	**SIG**	**WWS**	**SIG**	**WWS**	**SIG**	**WWS**	**SIG**	
Total Capital Cost PW	$ 57,391,000	$ 6,465,000	$ 64,267,000	$ 6,465,000	$120,170,000	$ 6,465,000	$156,685,000	$ 6,465,000	$228,761,000	$ 6,465,000	$ 264,272,000	$ 6,465,000
Total Annual O&M Cost	$ 104,000	$ 707,000	$ 131,000	$ 707,000	$ 231,000	$ 707,000	$ 355,000	$ 707,000	$ 555,000	$ 707,000	$ 679,000	$ 707,000
Total O&M PW	$ 1,466,000	$ 9,964,000	$ 1,846,000	$ 9,964,000	$ 3,256,000	$ 9,964,000	$ 5,003,000	$ 9,964,000	$ 7,822,000	$ 9,964,000	$ 9,570,000	$ 9,964,000
Total PW (Capital and O&M)	$ 58,857,000	$ 16,429,000	$ 66,113,000	$ 16,429,000	$123,426,000	$ 16,429,000	$161,688,000	$ 16,429,000	$236,583,000	$ 16,429,000	$ 273,842,000	$ 16,429,000
Total PW Intake Cost	**$75,286,000**		**$82,542,000**		**$139,855,000**		**$178,117,000**		**$253,012,000**		**$273,842,000**	**$16,429,000**
% Increase from WWS Only	358%		402%		751%		984%		1440%		1567%	
Total PW Intake Cost (-30%)	$52,700,000		$57,779,000		$97,899,000		$124,682,000		$177,108,000		$191,689,000	$11,500,000
Total PW Intake Cost (+50%)	$112,929,000		$123,813,000		$209,783,000		$267,176,000		$379,518,000		$410,763,000	$24,644,000

Notes:

Discount Rate = 5%

Project Life = 25 years

Annualized Cost is provided per acre-foot of product water

MGD = Million Gallons per Day

PW = Present Worth

O&M = Operation and Maintenance

Total O&M PW = Annual O&M Cost*((1+Discount Rate)^Project Life-1)/(Discount Rate*(1+Discount Rate)^Project Life)

5. REFERENCES

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APPENDIX A

Detailed Cost Estimates

Table A.1

Capital Costs for 2.5 MGD SIG

Description	QTY	UOM	Subcontract Unit Rate	Subtotal
Staging/Pre-Assembly of Cofferdam Frame(s)	1	LS		$ 1,680,000
Land/Dock Rental	24	MO	$ 10,000	$ 240,000
Pre-Assembly of Cofferdam Frame(s)	720	LF	$ 2,000	$ 1,440,000
Float in Transport of Pre-Assembled Frame(s)	1	LS	$ -	$ 720,000
Transportation of Cofferdam Frame(s) to/from SIG Cell Location	720	LF	$ 1,000	$ 720,000
Installation of Pre-Assembled Cofferdam Frame(s)	1	LS	$ -	$ 2,160,000
Installation of Sheet Pile Frame(s)	720	LF	$ 3,000	$ 2,160,000
Excavation of SIG Cell(s) Including Disposal of Material	1	LS	$ -	$ 2,677,000
Installation of Truss Bridge(s) for Dredging	1	EA	$ 1,000,000	$ 1,000,000
Dredging of Sig Cell(s)	14,259	CY	$ 50	$ 713,000
Transport/Disposal of Seafloor Material	14,259	CY	$ 15	$ 214,000
Removal of Truss Bridge(s) for Dredging	1	EA	$ 750,000	$ 750,000
Installation of SIG Cell Piping Grid(s)	1	LS	$ -	$ 1,155,000
Pre-Assembly of SIG Cell Piping Grid(s)	1,540	LF	$ 300	$ 462,000
Trasportation of SIG Cell Piping Grid(s) to SIG Cell Location	1,540	LF	$ 150	$ 231,000
Installation of SIG Cell Piping Grid(s)	1,540	LF	$ 300	$ 462,000
Installation of SIG Cell(s) Bedding	1	LS	$ -	$ 5,297,000
Install Gantry Bridge(s) for Gravel Placement	1	EA	$ 1,000,000	$ 1,000,000
Place Sig Cell(s) Filter Bedding	41,202	TN	$ 80	$ 3,297,000
Removal of Gantry Bridges(s)	1	EA	$ 1,000,000	$ 1,000,000
Installation of Collector Main Tunnel Piping to Pump Station (Beach Location)	1	LS	$ -	$ 26,727,000
Beach Staging Area Prep/Restore	3	AC	$ 150,000.00	$ 450,000
Trestle Contruction for 1,000 LF @ 25' Wide	25,000	SF	$ 250.00	$ 6,250,000
Excavation for Tunnel Piping - First 1,000'	15,062	CY	$ 50.00	$ 754,000
Excavation for Tunnel Piping	82,840	CY	$ 50.00	$ 4,142,000
Installation of 28'' Collector Main Piping - First 1,000'	1,020	LF	$ 1,000.00	$ 1,020,000
Installation of 28'' Collector Main Piping	5,610	LF	$ 900.00	$ 5,049,000
Connect Collector Main Piping to Pump Station (Beach Location)	1	EA	$ 300,000.00	$ 300,000
Backfill Tunnel Piping - First 1,000'	14,903	CY	$ 80.00	$ 1,193,000
Backfill Tunnel Piping	81,968	CY	$ 80.00	$ 6,558,000
Trestle Removal for 1,000 LF @ 25' Wide	25,000	SF	$ 40.00	$ 1,000,000
Dispose of Dredging Spoils	1,029	CY	$ 10.00	$ 11,000
Onshore Pump	23	HP	$ 10,000	$ 229,000
Direct Construction Subtotal	1	LS		$ 40,645,000
Mobilization/Demobilization - 4.7%	1	LS		$ 1,911,000
Bonds & Insurance - 1.5%	1	LS		$ 610,000
Overhead & Profit - 15%	1	LS		$ 6,097,000
Un-priced Allowance (Contingency) - 20%	1	LS		$ 8,129,000
Total Capital Cost	1	LS		$ 57,392,000

Notes:

Detailed Construction Assumptions are provided in Table A.7

Table A.2

Capital Costs for 5 MGD SIG

Description	QTY	UOM	Subcontract Unit Rate	Subtotal
Staging/Pre-Assembly of Cofferdam Frame(s)	1	LS		$ 2,560,000
Land/Dock Rental	24	MO	$ 10,000	$ 240,000
Pre-Assembly of Cofferdam Frame(s)	1,160	LF	$ 2,000	$ 2,320,000
Float in Transport of Pre-Assembled Frame(s)	1	LS	$ -	$ 1,160,000
Transportation of Cofferdam Frame(s) to/from SIG Cell Location	1,160	LF	$ 1,000	$ 1,160,000
Installation of Pre-Assembled Cofferdam Frame(s)	1	LS	$ -	$ 3,480,000
Installation of Sheet Pile Frame(s)	1,160	LF	$ 3,000	$ 3,480,000
Excavation of SIG Cell(s) Including Disposal of Material	1	LS	$ -	$ 3,604,000
Installation of Truss Bridge(s) for Dredging	1	EA	$ 1,000,000	$ 1,000,000
Dredging of Sig Cell(s)	28,519	CY	$ 50	$ 1,426,000
Transport/Disposal of Seafloor Material	28,519	CY	$ 15	$ 428,000
Removal of Truss Bridge(s) for Dredging	1	EA	$ 750,000	$ 750,000
Installation of SIG Cell Piping Grid(s)	1	LS	$ -	$ 2,310,000
Pre-Assembly of SIG Cell Piping Grid(s)	3,080	LF	$ 300	$ 924,000
Trasportation of SIG Cell Piping Grid(s) to SIG Cell Location	3,080	LF	$ 150	$ 462,000
Installation of SIG Cell Piping Grid(s)	3,080	LF	$ 300	$ 924,000
Installation of SIG Cell(s) Bedding	1	LS	$ -	$ 5,614,000
Install Gantry Bridge(s) for Gravel Placement	1	EA	$ 1,000,000	$ 1,000,000
Place Sig Cell(s) Filter Bedding	45,164	TN	$ 80	$ 3,614,000
Removal of Gantry Bridges(s)	1	EA	$ 1,000,000	$ 1,000,000
Installation of Collector Main Tunnel Piping to Pump Station (Beach Location)	1	LS	$ -	$ 26,329,000
Beach Staging Area Prep/Restore	3	AC	$ 150,000.00	$ 450,000
Trestle Contruction for 1,000 LF @ 25' Wide	25,000	SF	$ 250.00	$ 6,250,000
Excavation for Tunnel Piping - First 1,000'	14,591	CY	$ 50.00	$ 730,000
Excavation for Tunnel Piping	80,251	CY	$ 50.00	$ 4,013,000
Installation of 28'' Collector Main Piping - First 1,000'	1,020	LF	$ 1,000.00	$ 1,020,000
Installation of 28'' Collector Main Piping	5,610	LF	$ 900.00	$ 5,049,000
Connect Collector Main Piping to Existing Seawater Intake	1	EA	$ 300,000.00	$ 300,000
Backfill Tunnel Piping - First 1,000'	14,433	CY	$ 80.00	$ 1,155,000
Backfill Tunnel Piping	79,380	CY	$ 80.00	$ 6,351,000
Trestle Removal for 1,000 LF @ 25' Wide	25,000	SF	$ 40.00	$ 1,000,000
Dispose of Dredging Spoils	1,029	CY	$ 10.00	$ 11,000
Onshore Pump	46	HP	$ 10,000	$ 458,000
Direct Construction Subtotal	1	LS		$ 45,515,000
Mobilization/Demobilization - 4.7%	1	LS		$ 2,140,000
Bonds & Insurance - 1.5%	1	LS		$ 683,000
Overhead & Profit - 15%	1	LS		$ 6,828,000
Un-priced Allowance (Contingency) - 20%	1	LS		$ 9,103,000
Total Capital Cost	1	LS		$ 64,269,000

Notes:

Detailed Construction Assumptions are provided in Table A.7

Table A.3

Capital Costs for 10 MGD SIG

Description	QTY	UOM	Subcontract Unit Rate	Subtotal
Staging/Pre-Assembly of Cofferdam Frame(s)	1	LS		$ 4,940,000
Land/Dock Rental	30	MO	$ 10,000	$ 300,000
Pre-Assembly of Cofferdam Frame(s)	2,320	LF	$ 2,000	$ 4,640,000
Float in Transport of Pre-Assembled Frame(s)	1	LS	$ -	$ 2,320,000
Transportation of Cofferdam Frame(s) to/from SIG Cell Location	2,320	LF	$ 1,000	$ 2,320,000
Installation of Pre-Assembled Cofferdam Frame(s)	1	LS	$ -	$ 6,960,000
Installation of Sheet Pile Frame(s)	2,320	LF	$ 3,000	$ 6,960,000
Excavation of SIG Cell(s) Including Disposal of Material	1	LS	$ -	$ 7,208,000
Installation of Truss Bridge(s) for Dredging	2	EA	$ 1,000,000	$ 2,000,000
Dredging of Sig Cell(s)	57,037	CY	$ 50	$ 2,852,000
Transport/Disposal of Seafloor Material	57,037	CY	$ 15	$ 856,000
Removal of Truss Bridge(s) for Dredging	2	EA	$ 750,000	$ 1,500,000
Installation of SIG Cell Piping Grid(s)	1	LS	$ -	$ 4,620,000
Pre-Assembly of SIG Cell Piping Grid(s)	6,160	LF	$ 300	$ 1,848,000
Trasportation of SIG Cell Piping Grid(s) to SIG Cell Location	6,160	LF	$ 150	$ 924,000
Installation of SIG Cell Piping Grid(s)	6,160	LF	$ 300	$ 1,848,000
Installation of SIG Cell(s) Bedding	1	LS	$ -	$ 11,180,000
Install Gantry Bridge(s) for Gravel Placement	2	EA	$ 1,000,000	$ 2,000,000
Place Sig Cell(s) Filter Bedding	89,738	TN	$ 80	$ 7,180,000
Removal of Gantry Bridges(s)	2	EA	$ 1,000,000	$ 2,000,000
Installation of Collector Main Tunnel Piping to Pump Station (Beach Location)	1	LS	$ -	$ 46,963,000
Beach Staging Area Prep/Restore	3	AC	$ 150,000.00	$ 450,000
Trestle Contruction for 1,000 LF @ 25' Wide	25,000	SF	$ 250.00	$ 6,250,000
Excavation for Tunnel Piping - First 1,000'	20,162	CY	$ 50.00	$ 1,009,000
Excavation for Tunnel Piping	110,891	CY	$ 50.00	$ 5,545,000
Installation of 63'' Tunnel Piping - First 1,000'	1,000	LF	$ 1,600.00	$ 1,600,000
Installation of 63'' Tunnel Piping	5,500	LF	$ 1,500.00	$ 8,250,000
Installation of 28'' Collector Main Piping - First 1,000'	2,040	LF	$ 1,000.00	$ 2,040,000
Installation of 28'' Collector Main Piping	11,220	LF	$ 900.00	$ 10,098,000
Connect Collector Main Piping to Existing Seawater Intake	2	EA	$ 300,000.00	$ 600,000
Backfill Tunnel Piping	19,360	CY	$ 80.00	$ 1,549,000
Backfill Tunnel Piping	106,482	CY	$ 80.00	$ 8,519,000
Trestle Removal for 1,000 LF @ 25' Wide	25,000	SF	$ 40.00	$ 1,000,000
Dispose of Dredging Spoils	5,211	CY	$ 10.00	$ 53,000
Onshore Pump	92	HP	$ 10,000	$ 915,000
Direct Construction Subtotal	1	LS		$ 85,106,000
Mobilization/Demobilization - 4.7%	1	LS		$ 4,000,000
Bonds & Insurance - 1.5%	1	LS		$ 1,277,000
Overhead & Profit - 15%	1	LS		$ 12,766,000
Un-priced Allowance (Contingency) - 20%	1	LS		$ 17,022,000
Total Capital Cost	1	LS		$ 120,171,000

Notes:

Detailed Construction Assumptions are provided in Table A.7

Table A.4

Capital Costs for 20 MGD SIG

Description	QTY	UOM	Subcontract Unit Rate	Subtotal
Staging/Pre-Assembly of Cofferdam Frame(s)	1	LS		$ 7,260,000
Land/Dock Rental	30	MO	$ 10,000	$ 300,000
Pre-Assembly of Cofferdam Frame(s)	3,480	LF	$ 2,000	$ 6,960,000
Float in Transport of Pre-Assembled Frame(s)	1	LS	$ -	$ 3,480,000
Transportation of Cofferdam Frame(s) to/from SIG Cell Location	3,480	LF	$ 1,000	$ 3,480,000
Installation of Pre-Assembled Cofferdam Frame(s)	1	LS	$ -	$ 10,440,000
Installation of Sheet Pile Frame(s)	3,480	LF	$ 3,000	$ 10,440,000
Excavation of SIG Cell(s) Including Disposal of Material	1	LS	$ -	$ 10,812,000
Installation of Truss Bridge(s) for Dredging	3	EA	$ 1,000,000	$ 3,000,000
Dredging of Sig Cell(s)	85,556	CY	$ 50	$ 4,278,000
Transport/Disposal of Seafloor Material	85,556	CY	$ 15	$ 1,284,000
Removal of Truss Bridge(s) for Dredging	3	EA	$ 750,000	$ 2,250,000
Installation of SIG Cell Piping Grid(s)	1	LS	$ -	$ 6,930,000
Pre-Assembly of SIG Cell Piping Grid(s)	9,240	LF	$ 300	$ 2,772,000
Trasportation of SIG Cell Piping Grid(s) to SIG Cell Location	9,240	LF	$ 150	$ 1,386,000
Installation of SIG Cell Piping Grid(s)	9,240	LF	$ 300	$ 2,772,000
Installation of SIG Cell(s) Bedding	1	LS	$ -	$ 16,698,000
Install Gantry Bridge(s) for Gravel Placement	3	EA	$ 1,000,000	$ 3,000,000
Place Sig Cell(s) Filter Bedding	133,724	TN	$ 80	$ 10,698,000
Removal of Gantry Bridges(s)	3	EA	$ 1,000,000	$ 3,000,000
Installation of Collector Main Tunnel Piping to Pump Station (Beach Location)	1	LS	$ -	$ 53,516,000
Beach Staging Area Prep/Restore	3	AC	$ 150,000.00	$ 450,000
Trestle Contruction for 1,000 LF @ 25' Wide	25,000	SF	$ 250.00	$ 6,250,000
Excavation for Tunnel Piping - First 1,000'	20,162	CY	$ 50.00	$ 1,009,000
Excavation for Tunnel Piping	110,891	CY	$ 50.00	$ 5,545,000
Installation of 63'' Tunnel Piping - First 1,000'	1,000	LF	$ 1,600.00	$ 1,600,000
Installation of 63'' Tunnel Piping	5,500	LF	$ 1,500.00	$ 8,250,000
Installation of 28'' Collector Main Piping - First 1,000'	3,091	LF	$ 1,000.00	$ 3,091,000
Installation of 28'' Collector Main Piping	16,999	LF	$ 900.00	$ 15,300,000
Connect Collector Main Piping to Existing Seawater Intake	3	EA	$ 300,000.00	$ 900,000
Backfill Tunnel Piping - First 1,000'	19,360	CY	$ 80.00	$ 1,549,000
Backfill Tunnel Piping	106,482	CY	$ 80.00	$ 8,519,000
Trestle Removal for 1,000 LF @ 25' Wide	25,000	SF	$ 40.00	$ 1,000,000
Dispose of Dredging Spoils	5,211	CY	$ 10.00	$ 53,000
Onshore Pump	183	HP	$ 10,000	$ 1,831,000
Direct Construction Subtotal	1	LS		$ 110,967,000
Mobilization/Demobilization - 4.7%	1	LS		$ 5,216,000
Bonds & Insurance - 1.5%	1	LS		$ 1,665,000
Overhead & Profit - 15%	1	LS		$ 16,646,000
Un-priced Allowance (Contingency) - 20%	1	LS		$ 22,194,000
Total Capital Cost	1	LS		$ 156,688,000

Notes:

Detailed Construction Assumptions are provided in Table A.7

Table A.5

Capital Costs for 30 MGD SIG

Description	QTY	UOM	Subcontract Unit Rate	Subtotal
Staging/Pre-Assembly of Cofferdam Frame(s)	1	LS		$ 11,960,000
Land/Dock Rental	36	MO	$ 10,000	$ 360,000
Pre-Assembly of Cofferdam Frame(s)	5,800	LF	$ 2,000	$ 11,600,000
Float in Transport of Pre-Assembled Frame(s)	1	LS	$ -	$ 5,800,000
Transportation of Cofferdam Frame(s) to/from SIG Cell Location	5,800	LF	$ 1,000	$ 5,800,000
Installation of Pre-Assembled Cofferdam Frame(s)	1	LS	$ -	$ 17,400,000
Installation of Sheet Pile Frame(s)	5,800	LF	$ 3,000	$ 17,400,000
Excavation of SIG Cell(s) Including Disposal of Material	1	LS	$ -	$ 15,019,000
Installation of Truss Bridge(s) for Dredging	5	EA	$ 1,000,000	$ 5,000,000
Dredging of Sig Cell(s)	142,593	CY	$ 50	$ 7,130,000
Transport/Disposal of Seafloor Material	142,593	CY	$ 15	$ 2,139,000
Removal of Truss Bridge(s) for Dredging	1	EA	$ 750,000	$ 750,000
Installation of SIG Cell Piping Grid(s)	1	LS	$ -	$ 11,550,000
Pre-Assembly of SIG Cell Piping Grid(s)	15,400	LF	$ 300	$ 4,620,000
Trasportation of SIG Cell Piping Grid(s) to SIG Cell Location	15,400	LF	$ 150	$ 2,310,000
Installation of SIG Cell Piping Grid(s)	15,400	LF	$ 300	$ 4,620,000
Installation of SIG Cell(s) Bedding	1	LS	$ -	$ 27,595,000
Install Gantry Bridge(s) for Gravel Placement	5	EA	$ 1,000,000	$ 5,000,000
Place Sig Cell(s) Filter Bedding	219,926	TN	$ 80	$ 17,595,000
Removal of Gantry Bridges(s)	5	EA	$ 1,000,000	$ 5,000,000
Installation of Collector Main Tunnel Piping to Pump Station (Beach Location)	1	LS	$ -	$ 69,942,000
Beach Staging Area Prep/Restore	3	AC	$ 150,000.00	$ 450,000
Trestle Contruction for 1,000 LF @ 25' Wide	25,000	SF	$ 250.00	$ 6,250,000
Excavation for Tunnel Piping - First 1,000'	24,324	CY	$ 50.00	$ 1,217,000
Excavation for Tunnel Piping	133,782	CY	$ 50.00	$ 6,690,000
Installation of 90'' Tunnel Piping - First 1,000'	1,000	LF	$ 1,600.00	$ 1,600,000
Installation of 90'' Tunnel Piping	5,500	LF	$ 1,500.00	$ 8,250,000
Installation of 28'' Collector Main Piping - First 1,000'	5,223	LF	$ 1,000.00	$ 5,224,000
Installation of 28'' Collector Main Piping	28,727	LF	$ 900.00	$ 25,855,000
Connect Collector Main Piping to Existing Seawater Intake	5	EA	$ 300,000.00	$ 1,500,000
Backfill Tunnel Piping - First 1,000'	22,688	CY	$ 80.00	$ 1,816,000
Backfill Tunnel Piping	124,783	CY	$ 80.00	$ 9,983,000
Trestle Removal for 1,000 LF @ 25' Wide	25,000	SF	$ 40.00	$ 1,000,000
Dispose of Dredging Spoils	10,636	CY	$ 10.00	$ 107,000
Onshore Pump	275	HP	$ 10,000	$ 2,746,000
Direct Construction Subtotal	1	LS		$ 162,012,000
Mobilization/Demobilization - 4.7%	1	LS		$ 7,615,000
Bonds & Insurance - 1.5%	1	LS		$ 2,431,000
Overhead & Profit - 15%	1	LS		$ 24,302,000
Un-priced Allowance (Contingency) - 20%	1	LS		$ 32,403,000
Total Capital Cost	1	LS		$ 228,763,000

Notes:

Detailed Construction Assumptions are provided in Table A.7

Table A.6

Capital Costs for 40 MGD SIG

Description	QTY	UOM	Subcontract Unit Rate	Subtotal
Staging/Pre-Assembly of Cofferdam Frame(s)	1	LS		$ 14,280,000
Land/Dock Rental	36	MO	$ 10,000	$ 360,000
Pre-Assembly of Cofferdam Frame(s)	6,960	LF	$ 2,000	$ 13,920,000
Float in Transport of Pre-Assembled Frame(s)	1	LS		$ 6,960,000
Transportation of Cofferdam Frame(s) to/from SIG Cell Location	6,960	LF	$ 1,000	$ 6,960,000
Installation of Pre-Assembled Cofferdam Frame(s)	1	LS		$ 20,880,000
Installation of Sheet Pile Frame(s)	6,960	LF	$ 3,000	$ 20,880,000
Excavation of SIG Cell(s) Including Disposal of Material	1	LS		$ 17,873,000
Installation of Truss Bridge(s) for Dredging	6	EA	$ 1,000,000	$ 6,000,000
Dredging of Sig Cell(s)	171,111	CY	$ 50	$ 8,556,000
Transport/Disposal of Seafloor Material	171,111	CY	$ 15	$ 2,567,000
Removal of Truss Bridge(s) for Dredging	1	EA	$ 750,000	$ 750,000
Installation of SIG Cell Piping Grid(s)	1	LS		$ 13,860,000
Pre-Assembly of SIG Cell Piping Grid(s)	18,480	LF	$ 300	$ 5,544,000
Trasportation of SIG Cell Piping Grid(s) to SIG Cell Location	18,480	LF	$ 150	$ 2,772,000
Installation of SIG Cell Piping Grid(s)	18,480	LF	$ 300	$ 5,544,000
Installation of SIG Cell(s) Bedding	1	LS		$ 32,972,000
Install Gantry Bridge(s) for Gravel Placement	6	EA	$ 1,000,000	$ 6,000,000
Place Sig Cell(s) Filter Bedding	262,143	TN	$ 80	$ 20,972,000
Removal of Gantry Bridges(s)	6	EA	$ 1,000,000	$ 6,000,000
Installation of Collector Main Tunnel Piping to Pump Station (Beach Location)	1	LS		$ 76,676,000
Beach Staging Area Prep/Restore	3	AC	$ 150,000.00	$ 450,000
Trestle Contruction for 1,000 LF @ 25' Wide	25,000	SF	$ 250.00	$ 6,250,000
Excavation for Tunnel Piping - First 1,000'	24,324	CY	$ 50.00	$ 1,217,000
Excavation for Tunnel Piping	133,782	CY	$ 50.00	$ 6,690,000
Installation of 90'' Tunnel Piping - First 1,000'	1,000	LF	$ 1,600.00	$ 1,600,000
Installation of 90'' Tunnel Piping	5,500	LF	$ 1,500.00	$ 8,250,000
Installation of 28'' Collector Main Piping - First 1,000'	6,305	LF	$ 1,000.00	$ 6,305,000
Installation of 28'' Collector Main Piping	34,675	LF	$ 900.00	$ 31,208,000
Connect Collector Main Piping to Existing Seawater Intake	6	EA	$ 300,000.00	$ 1,800,000
Backfill Tunnel Piping - First 1,000'	22,688	CY	$ 80.00	$ 1,816,000
Backfill Tunnel Piping	124,783	CY	$ 80.00	$ 9,983,000
Trestle Removal for 1,000 LF @ 25' Wide	25,000	SF	$ 40.00	$ 1,000,000
Dispose of Dredging Spoils	10,636	CY	$ 10.00	$ 107,000
Onshore Pump	366	HP	$ 10,000	$ 3,661,000
Direct Construction Subtotal	1	LS		$ 187,162,000
Mobilization/Demobilization - 4.7%	1	LS		$ 8,797,000
Bonds & Insurance - 1.5%	1	LS		$ 2,808,000
Overhead & Profit - 15%	1	LS		$ 28,075,000
Un-priced Allowance (Contingency) - 20%	1	LS		$ 37,433,000
Total Capital Cost	1	LS		$ 264,275,000

Notes:

Detailed Construction Assumptions are provided in Table A.7

Table A.7
Detailed SIG Construction Assumptions

	Cell Properties				Sheet Pile Wall	Excavation/Dredging	Backfill Cell						Piping					Conveyance Earthwork					
	L	W	H	No. Cells			1.5'' Gravel		1/2'' Gravel		Engineered Sand		12'' Screen	28'' Main In Cell	28'' Main Conveyance	63'' Tunnel	90'' Tunnel	Length	Width	Height	Dredging	Backfill	Spoils
	(LF)	(LF)	(LF)	(EA)	(SF)	(CY)	(CY)	(TN)	(CY)	(TN)	(CY)	(TN)	(LF)	(LF)	(LF)	(LF)	(LF)	(LF)	(LF)	(LF)	(CY)	(CY)	(CY)
2.5 MGD	220	140	23	1	16,200	14,259	7,335	13,570	1,141	2,167	5,704	6,844	1,540	220	6,630			6,500	30.5	13.3	97,901	96,872	1,029
5 MGD	440	140	23	1	26,680	28,519	14,670	27,140	2,281	4,335	11,407	13,689	3,080	440	6,630			6,500	30.5	12.9	94,842	93,812	1,029
10 MGD	440	140	23	2	53,360	57,037	29,022	53,691	4,563	8,670	22,815	27,378	6,160	880	13,260	6,500		6,500	33.5	16.3	131,053	125,842	5,211
20 MGD	440	140	23	3	80,040	85,556	43,055	79,652	6,844	13,004	34,222	41,067	9,240	1,320	20,090	6,500		6,500	33.5	16.3	131,053	125,842	5,211
30 MGD	440	140	23	5	133,400	142,593	70,166	129,807	11,407	21,674	57,037	68,444	15,400	2,200	33,950		6,500	6,500	35.5	18.5	158,106	147,471	10,636
40 MGD	440	140	23	6	160,080	171,111	83,244	154,001	13,689	26,009	68,444	82,133	18,480	2,640	40,980		6,500	6,500	35.5	18.5	158,106	147,471	10,636

Table A.8
Detailed O&M Costs

SIG Capacity, mgd	2.5	5	10	20	30	40	WWS Only
Capacity, gpm (Q)	1,736	3,472	6,944	13,888	20,832	27,776	N/A
SIG, Conveyance Pipelines, & Intake Pump Station							
SIG Facilities Summary							N/A
No. of Conveyance Pipes	1	1	2	3	5	6	
Conveyance Pipeline Length (ft) (Distance to Shore)	6,500	6,500	6,500	6,500	6,500	6,500	
Conveyance Pipeline Diameter (in)	28	28	28	28	28	28	
SIG overall footprint size (sf)	30,800	61,600	123,200	184,800	308,000	369,600	
Intake Beach Pumps							
TDH (ft)	40	40	40	40	40	40	
Pump Efficiency	0.85	0.85	0.85	0.85	0.85	0.85	
Motor Efficiency	0.95	0.95	0.95	0.95	0.95	0.95	
VDF	0.95	0.95	0.95	0.95	0.95	0.95	
SIG Core Sampling Activity, days	1	1	2	3	5	6	
SIG Cell Rake Activity, days							
Setup	3	3	3	3	3	3	
Clean activities	4	7	14	21	35	42	
Breakdown	3	3	3	3	3	3	
Total Clean Duration	10	13	20	27	41	48	
Pump Station Horsepower							
Calculated Horsepower, HP	23	46	92	183	275	366	
*(HP = (TDH*Q)/(3956*eff.)*							
Annual O&M Costs ($/yr)							
(1) SIG Core Sampling	$ 18,000	$ 18,000	$ 36,000	$ 54,000	$ 90,000	$ 108,000	
(2) SIG Maintenance	$ 50,000	$ 65,000	$ 100,000	$ 135,000	$ 205,000	$ 240,000	
(3) Conveyance Pipe Maintenance	$ 25,000	$ 25,000	$ 49,000	$ 74,000	$ 123,000	$ 148,000	
(4) Pump Station Maintenance	$ 11,000	$ 23,000	$ 46,000	$ 92,000	$ 137,000	$ 183,000	
(5) Power Costs	$ 13,000	$ 25,000	$ 49,000	$ 98,000	$ 146,000	$ 195,000	
Unit Power $0.09/kWh, Online Factor (90%)							
Annual O&M SIG Cost	**$ 117,000**	**$ 156,000**	**$ 280,000**	**$ 453,000**	**$ 701,000**	**$ 874,000**	**$ -**
WWS							
WWS Intake	$ 664,000	$ 664,000	$ 664,000	$ 664,000	$ 664,000	$ 664,000	$ 664,000
Raw Water Pump Power	$ 564,000	$ 564,000	$ 564,000	$ 564,000	$ 564,000	$ 564,000	$ 564,000
Maintenance & Materials	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
Screen Replacement (4 screens replaced every 20-year)	$ 43,327	$ 43,327	$ 43,327	$ 43,327	$ 43,327	$ 43,327	$ 43,327
Annual O&M WWS Intake Cost	**$ 707,327**	**$ 707,327**	**$ 707,327**	**$ 707,327**	**$ 707,327**	**$ 707,327**	**$ 707,327**
Annual O&M Total Cost	**$ 824,000**	**$ 863,000**	**$ 987,000**	**$ 1,160,000**	**$ 1,408,000**	**$ 1,581,000**	**$ 707,000**