POSEIDON WATER

Appendix II
Addendum to Intake Discharge Feasibility Report

Renewal of NPDES CA0109223
Carlsbad Desalination Project

CDP Intake/Discharge Structure Feasibility Study Addendum

Poseidon Water

Carlsbad Desalination Plant

Carlsbad, CA

August 12, 2016

1. Executive Summary

Poseidon contracted with HDR, Inc. (HDR) to prepare this addendum to the Carlsbad Desalination Plant (CDP) Intake/Discharge Feasibility Assessment (Feasibility Study) dated August 27, 2015. The original Feasibility Study was designed to determine the best available site, design, technologies, and mitigation feasible to minimize intake and mortality of all forms of marine life while transitioning the CDP to long term stand-alone operation and increasing plant production to capture recent improvements in the reverse osmosis technology installed at the CDP.

The Regional Water Quality Control Board (RWQCB) recommended that the Supplement to the Environmental Impact Report (SEIR) be amended to evaluate the marine life impacts of alternative intake options such as wedgewire screens, installation of traveling screens located at the edge of the lagoon, and an offshore intake structure. To that end, HDR has prepared this addendum to the Feasibility Study to provide the additional information requested by the RWQCB. Together with the original Feasibility Study (provided as Appendix B), this addendum provides a comprehensive assessment of marine life impacts and other feasibility criteria for 10 different combinations of intake and discharge technologies (including the technologies recommended by the RWQCB).

For purposes of Chapter III.M., "feasible" was defined as:

> *"capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors."*

This addendum evaluates each of these feasibility criteria for each of the six additional combinations of intake/discharge approaches considered. With the four other intake/discharge approaches evaluated in the original Feasibility Study, 10 intake/discharge approaches have been evaluated in total:

1. Surface Screened Intake with Flow Augmentation
2. Surface Screened Intake with Multiport Diffuser
3. Subsurface Intake with Flow Augmentation
4. Subsurface Intake with Diffuser
5. Offshore Wedgewire Screen with Flow Augmentation
6. Offshore Wedgewire Screen with Diffuser
7. Lagoon Wedgewire Screen with Flow Augmentation
8. Lagoon Wedgewire Screen with Diffuser
9. Lagoon Traveling Screen with Flow Augmentation
10. Lagoon Traveling Screen with Diffuser Offshore Wedgewire Screen with Diffuser

The results of the Feasibility Study and Addendum are summarized in Table ES-1 below (Overall Feasibility Assessment). The Feasibility Study concluded that the screened intake with discharge flow augmentation is the only feasible intake/discharge technology for the CDP when it begins long term stand-alone operation. When compared to the other alternative technologies, the proposed modifications were found to result in marginally higher marine life mortality (99.8

acres) than the two lowest ranked alternatives (Table ES-2 Comparison of Marine Life Mortality Impacts). The alternative using the subsurface intake with flow augmentation was found to have the lowest marine life mortality impacts (87.5 acres). However, the subsurface intake with flow augmentation was found to be infeasible with respect to the other four criteria: (1) economically infeasible (capital cost of $1,037 million and total annual cost of $159 million); (2) longest implementation period (10.2 years) resulting in $424 million in the loss of fixed capital and fixed operating costs (debt and equity payments, plant maintenance, utility charges) not recovered while the plant is out of service; (3) technically infeasible due to the physical size of the subsurface intake, associated interconnecting piping and pump stations; and (4) socially infeasible due extensive impacts to the marine resources and recreational in Agua Hedionda Lagoon. The alternative using the lagoon wedgewire screen with flow augmentation was found to have the next lowest marine life mortality impacts (99.6 acres). However, the lagoon wedgewire screen with flow augmentation was found to be infeasible with respect to three criteria: (1) economically infeasible (capital cost of $126 million and total annual cost of $34 million); (2) longest implementation period (6 years) resulting in the loss of $200 million in fixed capital and fixed operating costs (debt and equity payments, plant maintenance, utility charges) not recovered while the plant is out of service; and (3) technically infeasible due to the lack of sweeping currents in the lagoon which are necessary to prevent fouling of the screen.

When calculated per the requirements set forth in the Ocean Plan, the marine life mortality impact associated with the alternatives ranged from 87.5 acres to 123.1 acres. The proposed modifications would impact 99.8 acres prior to mitigation (lowest impact after elimination of the subsurface intake with flow augmentation and the lagoon wedgewire screen with flow augmentation). In terms of time required for project completion, the alternatives ranged from 2.5 years (proposed modifications) to 10.2 years (subsurface intake with flow augmentation), with the proposed modifications requiring less than half the implementation period of the next closest alternative (Table ES-3) Comparison of Time Required for Project Completion). The potential delay costs (the fixed capital and fixed operating costs not recovered while the CDP was out of service) associated with the CDP potentially losing access to source water if the timeline for project completion extend beyond 2018, ranged from $0 for the proposed modifications to $424 million for the subsurface intake with flow augmentation.

Lastly, in terms of economic impacts, a detailed analysis of the life-cycle cost for the CDP subsurface intake/discharge alternatives is presented in Appendix OO of the Submittal to the RWQCB. The findings of this analysis are included in Table ES-4 (Economic Analysis of Intake/Discharge Alternatives). The life cycle costs provide a relative comparison of the net incremental cost and savings of each of the alternatives. Costs considered include permitting, design, land acquisition, financing, construction, operations, maintenance, mitigation, equipment replacement, insurance, taxes, management, and energy consumption over the lifetime of the facility and fixed capital and operating costs not recovered while the plant is out of service after 2018. Savings considered include construction and operating allowances provided for in the WPA that are applicable to each of the alternatives and operational savings due reduced chemical consumption, extended membrane life, and reduced membrane cleaning frequency that is applicable to the subsurface intake alternatives.

The findings of the economic analysis indicate that $94 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with SIG with the multiport diffuser alternative and $159 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with the SIG with flow augmentation alternative. The primary difference between these figures and the lifecycle costs of these alternatives shown in Appendix B is the inclusion of the fixed capital and operating costs not recovered while the plant is out of service after 2018.

Chapter III.M of the Ocean Plan provides the following guidance for assessing the feasibility of subsurface intakes:

Subsurface intakes shall not be determined to be economically infeasible solely because subsurface intakes may be more expensive than surface intakes. Subsurface intakes may be determined to be economically infeasible if the additional costs or lost profitability associated with subsurface intakes, as compared to surface intakes, would render the desalination facility not economically viable.

Therefore, the RWQCB's determination of the economic feasibility of the SIG alternatives turns on the basis of whether the additional costs or lost profitability associated with these alternatives would render the desalination facility not economically viable. One measure of economic viability is whether the anticipated plant revenues would cover cost of one or both of the SIG alternatives.

The annual costs would be approximately $94 million per year for the subsurface intake with a multiport diffuser and approximately $159million per year for the subsurface intake with flow augmentation. Absent an additional source of revenue, the SIG alternatives are economically infeasible.

The economic analysis summarized in Table ES-4 indicates that approximately $8 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with proposed surface water intake with flow augmentation. The annual cost of the other intake/discharge alternatives under consideration (WWS and lagoon based intakes with flow augmentations or diffuser) range from $29 million to $76 million, rendering these alternatives economically infeasible.

Table ES-1

Overall Feasibility Assessment Intake and Discharge Alternatives

	Project Capable of Being Accomplished in a Reasonable Period of Time?	Is Project Economically Feasible?	Marine Life Mortality Ranking	Socially Feasible	Technically Feasible	Overall Feasibility
Alternatives	Yes/No	Yes/No	Ranked Lowest to Highest Impact	Yes/No	Yes/No	Yes/No
Surface Screened Intake with Flow Augmentation	Yes	Yes	3	Yes	Yes	Yes
Surface Screened Intake with Multiport Diffuser	No	No	7	Yes	Yes	No
Subsurface Intake with Flow Augmentation	No	No	1	No	No	No
Subsurface Intake with Multiport Diffuser	No	No	6	No	Yes	No
Offshore Wedgewire Screen with Flow Augmentation	No	No	5	Yes	Yes	No
Offshore Wedgewire Screen with Diffuser	No	No	10	Yes	Yes	No
Lagoon Wedgewire Screen with Flow Augmentation	No	No	2	Yes	No	No
Lagoon Wedgewire Screen with Diffuser	No	No	8	No	Yes	No
Lagoon Traveling Screen with Flow Augmentation	No	No	4	Yes	Yes	No
Lagoon Traveling Screen with Diffuser	No	No	9	Yes	Yes	No

Table ES-2

Comparison of Marine Life Mortality Impacts at Maximum Production of 60 MGD

Feasibility Assessment Intake and Discharge Alternatives

Impacts	Intake Water Potentially Exposed to 100% Mortality	Flow Augmentation Water Potentially Exposed to 100% Mortality	Diffuser Water Potentially Exposed to 100% Mortality	Total Water Potentially Exposed to 100% Mortality	Area of Production Foregone	Brine Mixing Zone @ 35.5 ppt	Permanent Construction Impacts to Marine Environment	Total Area Impacted	Marine Life Mortality Ranking
Alternatives	MGD	MGD	MGD	MGD	Acres	Acres	Acres	Acres	Ranked Lowest to Highest
Surface Screened Intake with Flow Augmentation	128	171	0	299	84.3	15.5	0	99.8	3
Surface Screened Intake with Multiport Diffuser	128	0	217	345	103.3	14.4	1.5	118.9	7
Subsurface Intake with Flow Augmentation	0	0	0	0	0	15.5	72	87.5	1
Subsurface Intake with Multiport Diffuser	0	0	217	217	67	14.4	33	114.4	6
Offshore Wedgewire Screen with Flow Augmentation	127	171	0	298	92	15.5	2.0	109.5	5
Offshore Wedgewire Screen with Diffuser	127	0	217	344	106.2	14.4	2.5	123.1	10
Lagoon Wedgewire Screen with Flow Augmentation	127	171	0	298	84	15.5	0.1	99.6	2
Lagoon Wedgewire Screen with Diffuser	127	0	217	344	103	14.4	1.6	119	8
Lagoon Traveling Screen with Flow Augmentation	128	171	0	299	84.3	15.5	0.1	99.9	4
Lagoon Traveling Screen with Diffuser	128	0	217	345	103.3	14.4	1.6	119.3	9

Table ES-3

Comparison of Time Required for Project Completion

Feasibility Assessment Intake and Discharge Alternatives

	Permitting and Property Acquisition	Construction, Commissioning and Startup	Total Time Required for Project Completion	Potential Duration CDP Is Without Source Water After 2018	Fixed Capital and Operating Costs Not Recovered While Plant is Out of Service After 2018	Project Capable of Being Accomplished in a Reasonable Period of Time?
Alternatives	Years	Years	Years	Years	$	Yes/No
Surface Screened Intake with Flow Augmentation	1	1.5	2.5	0	$0	Yes
Surface Screened Intake with Multiport Diffuser	3	3	6	3.5	$199,925,313	No
Subsurface Intake with Flow Augmentation	3	7.2	10.2	7.7	$423,770,193	No
Subsurface Intake with Multiport Diffuser	3	3.8	6.8	4.3	$242,696,411	No
Offshore Wedgewire Screen with Flow Augmentation	3	3	6	3.5	$199,925,313	No
Offshore Wedgewire Screen with Diffuser	3	3	6	3.5	$199,925,313	No
Lagoon Wedgewire Screen with Flow Augmentation	3	3	6	3.5	199,925,313	No
Lagoon Wedgewire Screen with Diffuser	3	3	6	3.5	$199,925,313	No
Lagoon Traveling Screen with Flow Augmentation	3	3	6	3.5	$199,925,313	No
Lagoon Traveling Screen with Diffuser	3	3	6	3.5	$199,925,313	No

Table ES-4

Economic Analysis

Feasibility Assessment Intake and Discharge Alternatives

	Total Project Cost	Fixed Capital and Operating Costs Not Recovered While Plant is Out of Service After 2018	Financing Period	Capital Charge	Out of Service Charge	O&M and Other Annual Costs	Total Annual Cost	Is Project Economically Feasible?
Alternatives	$	$	Years	$/Year	$/Year	$/Year	$/Year	Yes/No
Surface Screened Intake with Flow Augmentation	$49,061,041	$0	27.5	$4,077,205	$0	$4,455,035	**$8,532,239**	**Yes**
Surface Screened Intake with Multiport Diffuser	$428,639,220	$199,925,313	24	$37,464,471	$17,481,175	$6,790,828	**$61,736,474**	**No**
Subsurface Intake with Flow Augmentation	$1,037,702,060	$423,770,193	19.8	$100,112,270	$37,988,099	$20,965,196	**$159,065,565**	**No**
Subsurface Intake with Multiport Diffuser	$676,862,341	$242,696,411	23.2	$59,971,724	$21,509,330	$12,903,385	**$94,384,439**	**No**
Offshore Wedgewire Screen with Flow Augmentation	$285,490,487	$199,925,313	24	$24,952,799	$17,481,175	$6,566,746	**$49,000,720**	**No**
Offshore Wedgewire Screen with Diffuser	$576,823,866	$199,925,313	24	$50,416,311	$17,481,175	$8,211,320	**$76,108,807**	**No**
Lagoon Wedgewire Screen with Flow Augmentation	$126,904,462	$199,925,313	24	$11,100,60	$17,481,175	$5,246,746	**$33,828,529**	**No**
Lagoon Wedgewire Screen with Diffuser	$416,573,734	$199,925,313	24	$36,409,907	$17,481,175	$6,781,320	**$60,672,403**	**No**
Lagoon Traveling Screen with Flow Augmentation	$80,783,075	$199,925,313	24	$7,060,814	$17,481,175	$4,960,539	**$29,502,528**	**No**
Lagoon Traveling Screen with Diffuser	$405,778,290	$199,925,313	24	$35,466,357	$17,481,175	$6,719,356	**$59,666,888**	**No**

Contents

2. Description of the Intake/Discharge Alternative

A. Surface Intake/Discharge Alternatives – General Description

i. 1-mm Offshore WWS Surface Intake with Flow Augmentation

a. Site

A new offshore structure would be constructed west of the existing outfall jetty 4,000 feet offshore at a depth of 58 feet to support the array of cylindrical wedgewire screens (WWS). The screens would be mounted, with risers, on a new common header that connects to an intake pipeline. The intake pipeline would convey water from the offshore screening point to an onshore wet well from which the existing SWRO Pump Station would draw feedwater and flow augmentation water flow. The wet well would be sufficiently sized to also house the Flow Augmentation Pump Station ("Fish-friendly Pumping Structure"). The new wet well would be located between the existing EPS intake tunnels to the west and the SWRO Pump Station to the east. Feedwater and flow augmentation water for the CDP would be withdrawn through the new offshore WWS array, representing a change from the current source waterbody (Agua Hedionda Lagoon). The new offshore intake structure would require significant offshore construction activity. Construction would be done from a derrick barge moored above the offshore intake location and with tunnel boring machines below the seabed.

Brine from the CDP would be mixed with augmentation flow in the existing EPS discharge tunnel and ultimately be discharged to the Pacific Ocean. There would be no change in the receiving waterbody nor would the discharge plan require any structural modification to the existing EPS discharge pond or ocean outfall. A general schematic of the layout is provided in Figure 1.

A new lease agreement would be required from the State Lands Commission (SLC) for the offshore installation site. Based on the dimensions of the design (and allowing 5 feet on each side of installed equipment), a lease of approximately 1.95 acres would be required for the intake pipeline and the offshore WWS array.

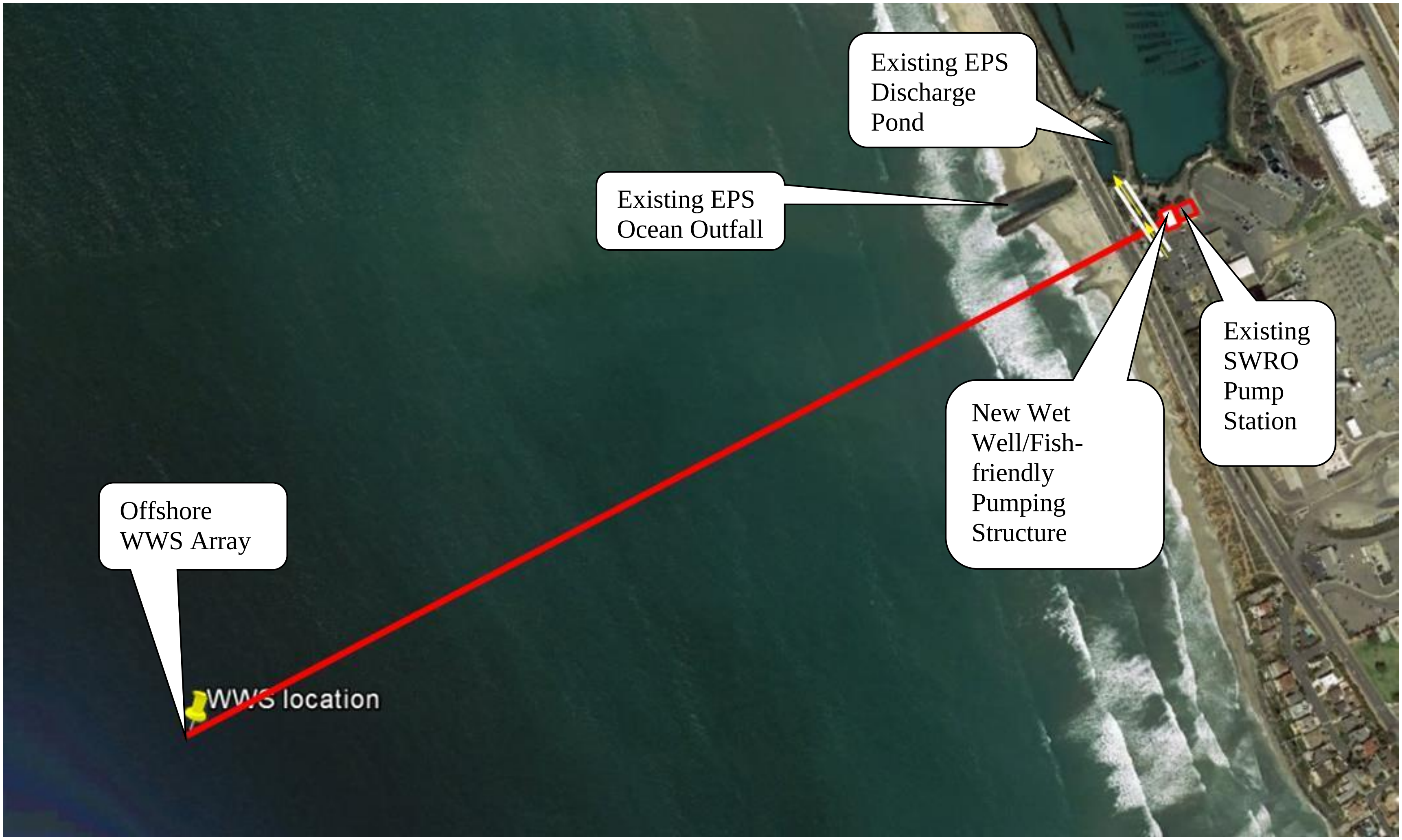

Figure 1. General schematic of the layout of the CDP with an offshore screened intake and discharge flow augmentation.

Under this option, the source water for the seawater desalination plant and the seawater required for brine dilution would be withdrawn from Pacific Ocean offshore of the plant. Approximately 298 MGD of seawater would be withdrawn from the Pacific Ocean -- 127 MGD for processing by the CDP and 171 MGD for brine dilution. Up to 60 MGD of the diverted seawater would be converted to fresh water which would be piped to the San Diego County Water Authority (Water Authority) delivery system in the City of San Marcos. The remaining flow (67 MGD) would be returned to the EPS discharge tunnel for blending with seawater prior to discharge to the Pacific Ocean. The discharge would consist of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the discharge prior to dilution would be approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge channel is 33.5 ppt. Poseidon is proposing an initial dilution of the brine to 42 ppt prior to discharge. This would be accomplished by mixing the CDP discharge with 171 MGD of the seawater withdrawn from Pacific Ocean along with the RO feedwater. The combined CDP discharge and dilution water flow rate would be 238 MGD. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

The Desalination Amendment provides that the discharge shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured at the edge of the brine mixing zone (BMZ) 200 meters (656 feet.) seaward of the end of the outfall channel. Over the last 20 years, the natural background salinity at the closest reference site (Scripps Pier) has measured a minimum salinity of 30.4 ppt, maximum salinity of 34.2 ppt, and an average salinity of 33.5 ppt (Jenkins 2016). Therefore, under average conditions, the discharge shall not exceed a daily maximum of 35.5 ppt at the edge of the BMZ (200 meter [656 foot] radius).

b. Design

Intake and Discharge Design

The offshore WWS would be mounted, with risers, on a new common header that connects to an intake pipeline. The header would be oriented parallel to the shoreline and perpendicular to the intake pipeline. The screens would be oriented perpendicular to the header and shoreline. The intake pipeline would convey water from the offshore screening point to an onshore wet well from which the existing SWRO Pump Station would draw feedwater flow. The general construction sequence for the intake system components would be as follows:

- Bore tunnel
- Dredge to pipe header invert
- Drive pile foundations, as needed
- Set pipe header with integrated screen risers
- Attached pipe header to pile foundations, as needed

- Connect header to tunnel
- Backfill header with native fill
- Set wedgewire screens
- Place rip rap
- Commence flow through wedgewire screens

The WWS array would be located 4,000 ft offshore. This distance was selected to minimize two potential impacts: 1) exposing kelp-associated organisms to entrainment and 2) recirculation of brine to the intake. Figure 2 illustrates the intake location versus the location of the kelp stand and the BMZ.

Figure 2. Location of wedgewire screen array relative to existing kelp beds and brine mixing zone. Location of kelp beds was estimated based on Google Earth aerial and MBC 2013.

The WWS array would be comprised of seven 120-inch diameter WWS (6 plus 1 redundant) with 1.0-mm slot width (Figure 3). The length of each screen would be approximately 30 feet. Screens would be spaced one half of a screen diameter from each other to maximize the sweeping velocities between screens to sweep debris and organisms away. In addition, the screens would be oriented perpendicular to the shoreline.

To minimize the risk posed by biofouling in the open ocean, the screens will be constructed of a copper nickel alloy (Z Alloy) or a similar material to prevent biofouling. Due to the distance offshore (4,000 feet), a shore-based air burst system would not be feasible; therefore, provisions could be made to allow temporary connection of a boat-based compressor to clean the screens. In addition, the screens will be manually cleaned periodically by divers.

The screens are designed to maintain a through-slot velocity of 0.5 ft/sec or less under all expected operating conditions. The concept design includes a fouling factor of 15%, meaning that under a clean condition, the design through-slot velocity is 0.43 ft/sec. All seven screens will be operable when the CDP enters long-term standalone operational mode, meaning the through-slot velocity will be well below 0.5 ft/sec. In the event one screen is taken out of service, the intake system is designed to maintain a through-slot velocity below 0.5 fps.

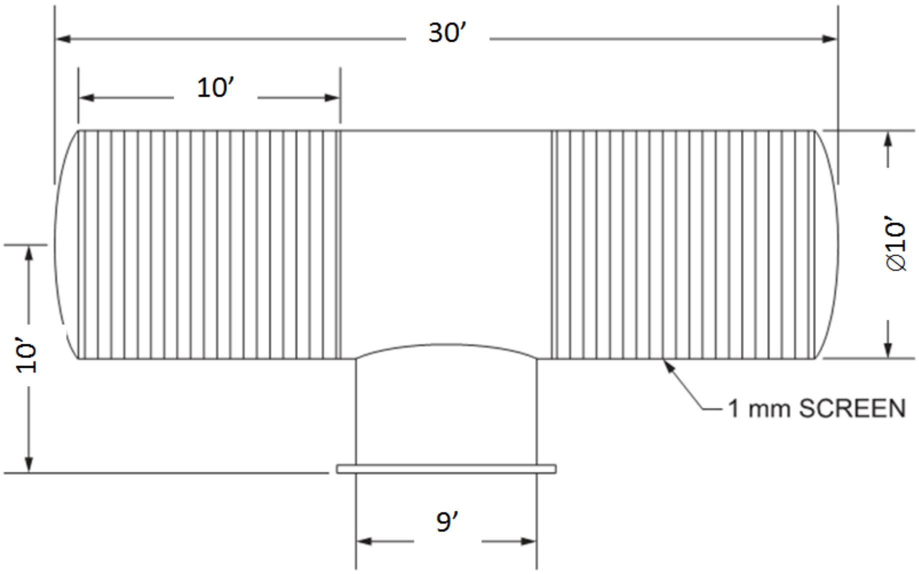

Figure 3. 120-in diameter cylindrical wedgewire screen.

The new 1-mm offshore WWS array would be located approximately 4,000 feet offshore (approximately 4,500 feet from the existing SWRO Pump Station). A 10-ft diameter intake pipeline would convey the withdrawn water from the WWS array to a new onshore wet well west of the SWRO Pump Station. The intake pipeline would be tunneled approximately 5 feet below the sea floor, depending on bed materials, site conditions, and construction approach. The new wet well would function as a common plenum from which SWRO process water flow would be drawn by the existing pumps at the SWRO Pump Station and from which augmentation flow would be drawn by fish-friendly axial flow pumps. A total flow of 298 MGD would be withdrawn: 127 MGD through the process water side and 171 MGD through the flow augmentation side. Figure 4 and Figure 5 provide plan and section views, respectively, of the new offshore WWS intake structure.

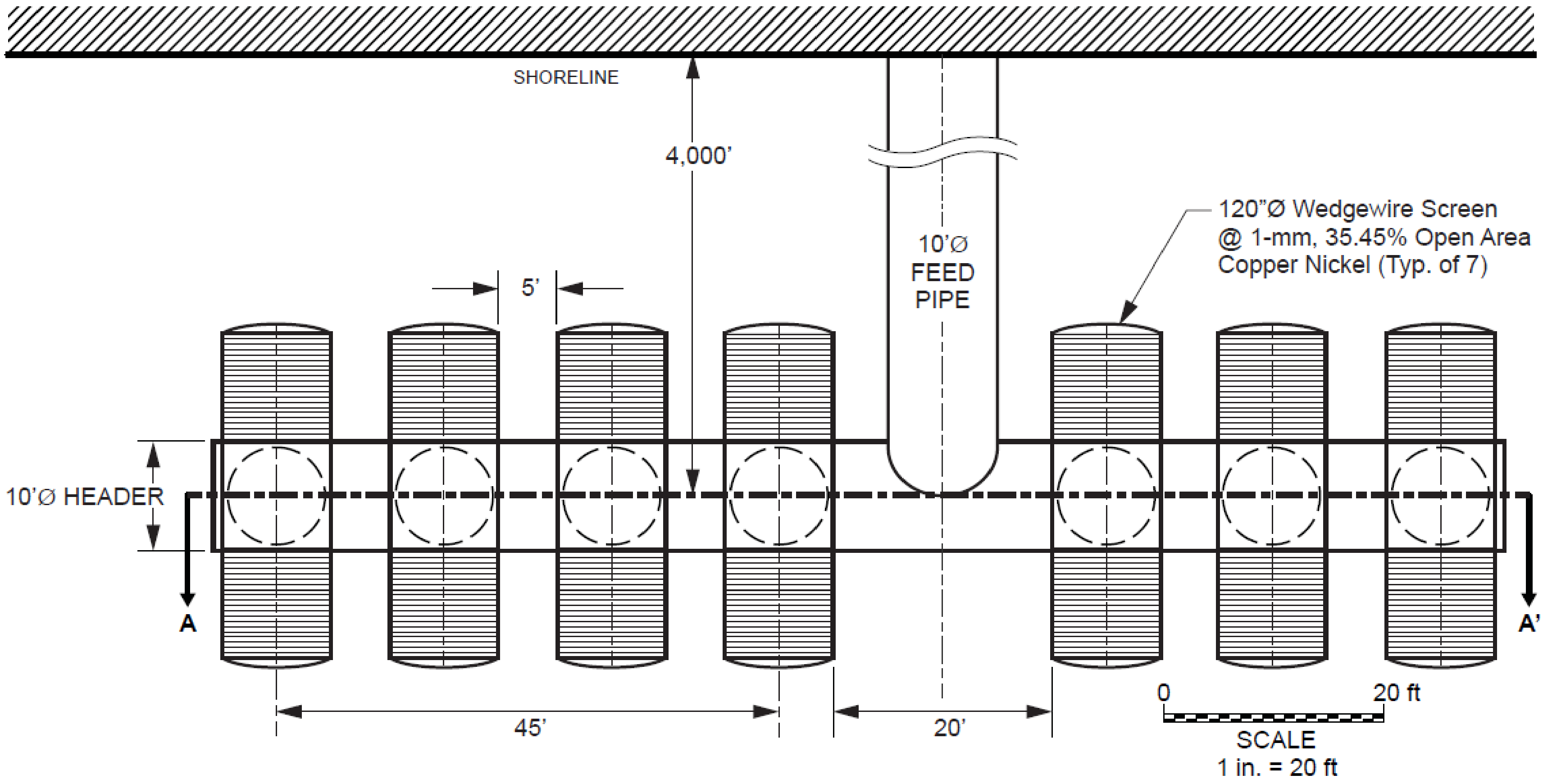

Figure 4. 1-mm offshore wedgewire screens for long-term stand-alone operation, plan view.

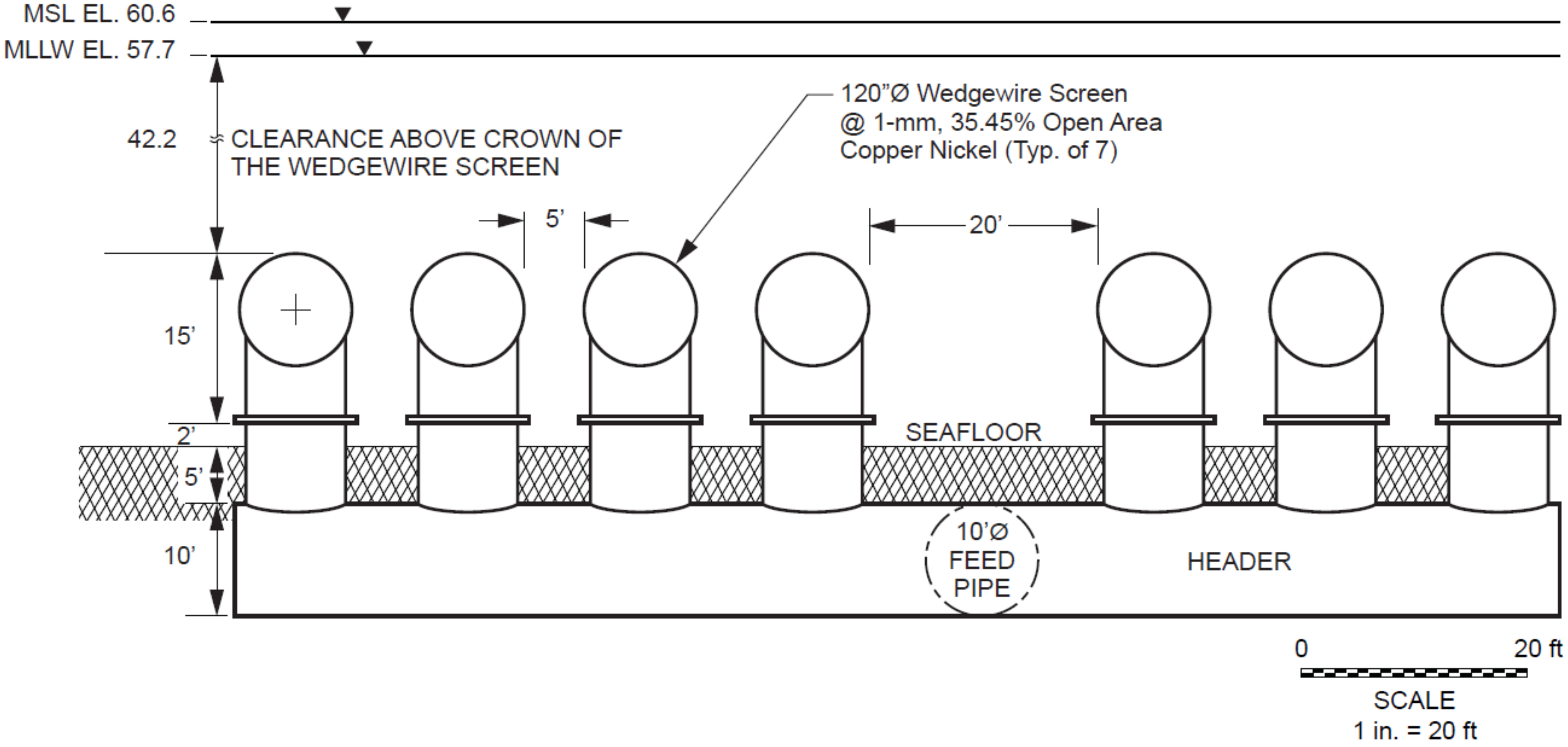

Figure 5. 1-mm offshore wedgewire screens for long-term stand-alone operation, section view.

c. *Technology*

Intake Screening Technology

Narrow-slot cylindrical WWS have been proven for reducing impacts to marine organisms at water intakes. WWS are also designed to reduce impingement of organisms by providing a low through-slot velocity (0.5 ft/sec or less). At this low velocity, impingement is widely considered to be a non-issue (Gulvas and Zeitoun 1979; Zeitoun et al. 1981; Tenera 2010) and meets the requirements of the OPA for minimizing impingement. Entrainment may be reduced with the presence of ambient currents (e.g., ocean, tidal) which can transport debris and non-motile early life stages with weak swimming abilities past or away from the intake.

Cylindrical WWS utilize wire that is V- or wedge-shaped in cross-section. The wire is welded to a framing system to form a slotted screening element (Figure 6).

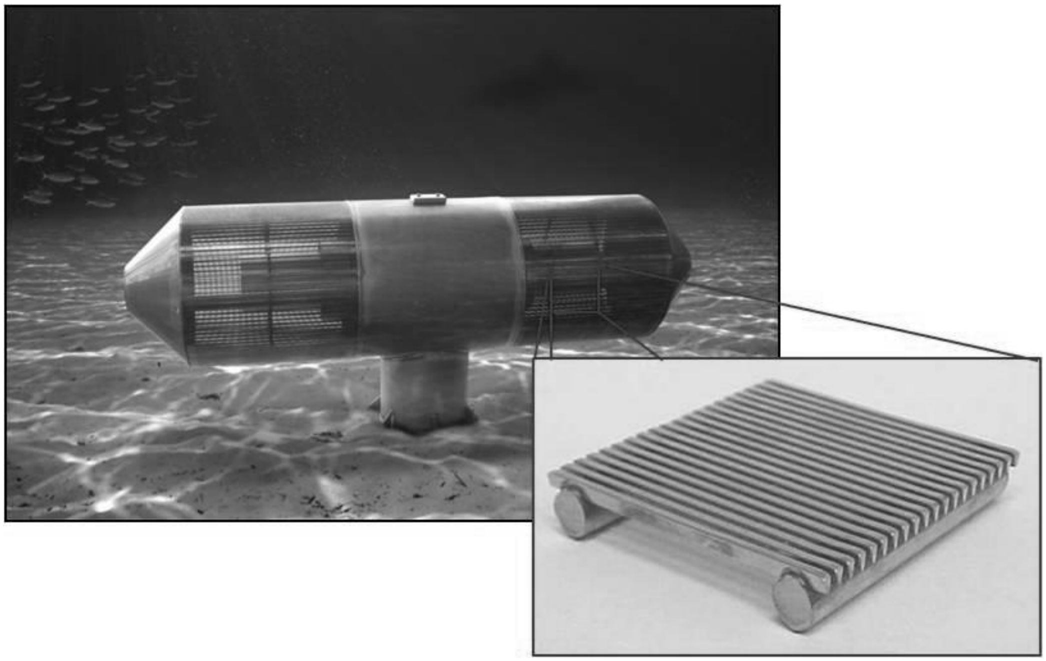

Figure 6. Cylindrical wedgewire screen, showing detail of v-shaped wedgewire (Image courtesy of Bilfinger Water Technologies, formerly Johnson Screens).

These screens have been biologically effective in preventing entrainment and impingement of fish and have not caused unusual maintenance problems in freshwater applications. However, the potential for clogging and biofouling remains a major concern in a marine environment with narrow-slot and few data are available on the performance in marine waters.

Discharge Flow Augmentation Technologies

Flow augmentation at the CDP would be accomplished by drawing additional flow through the offshore WWS to mix with the brine flow generated by the SWRO process. Poseidon has committed to using fish-friendly flow augmentation pumps to minimize entrainment mortality. Fish-friendly pumps were originally designed for transferring fish in the aquaculture industry. Such pumps have demonstrated the capacity to transfer fish with little or no injury. Since their inception, fish-friendly pumps have been used in fish passage and protection facilities to convey fish to a safe release location. There are several types of fish-friendly pumps available, each designed with the common goal of safely transferring live fish. Each fish-friendly pump type employs certain fundamental principles that reduce the potential injury and mortality to fish. To varying degrees, fish-friendly pump designs limit fish exposure to stressors, such as pressure, shear, and impeller blade strike. More specifically, fish-friendly pumps limit fish exposure to:

- dramatic pressure differentials and high rates of pressure change;
- shear forces caused by rapid flow acceleration or deceleration;
- potential for blade strike by limiting the number of blades on the impeller and/or increasing blade thickness; and
- other sources of mechanical injury (e.g., pinching in gaps between the impeller and housing)

Poseidon has evaluated fish-friendly Archimedes screw pumps, fish-friendly centrifugal pumps, and fish-friendly axial flow pumps. Fish-friendly axial flow pumps have the greatest advantages for the CDP site and are described in greater detail below.

Fish-friendly Axial Flow Pumps

The Bedford Pumps fish-friendly axial flow pump consists of a impeller within a pipe driven by a sealed motor (Figure 7). These pumps are smaller in dimension than many conventional pumps and are designed for low heads and high flows. The low head design of the pumps (approximately 5 psi) should minimize the potential for pressure-related injuries. These pumps have been designed and used to safely pass live fish for pumping applications worldwide.

The pump specified for this application has a two-bladed impeller, a pumping capacity of 57 MGD, and is fully submersible. A total of four pumps would be installed with three in service and one as a backup. The model of pump specified for the CDP underwent independent fish survival testing in 2012 and demonstrated that survival was very good (Vis and Kemper 2012).

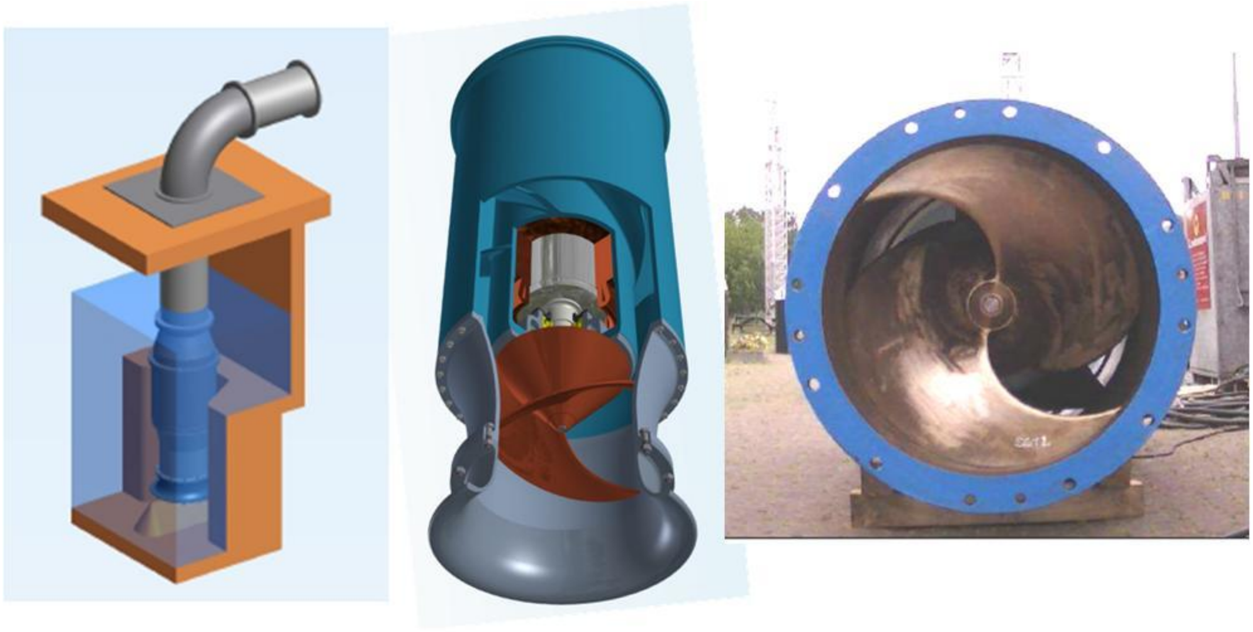

Figure 7. Bedford Pumps axial flow submersible pump: left: general installation arrangement similar to the approach at the CDP, middle: cutaway of the pump, right: photo of pump impeller (courtesy Bedford Pumps and VisAdvies Ecological Consultancy and Research).

ii. 1-mm Offshore WWS Surface Intake with Diffuser

a. Site

A new offshore structure would be constructed west of the existing outfall jetty 4,000 feet offshore at a depth of 58 feet to support the array of WWS. The screens would be mounted on a new common header with a riser that connects to an intake pipeline. The intake pipeline would convey water from the offshore screening point to an onshore wet well from which the existing SWRO Pump Station would draw feedwater flow. The new wet well would be located between the existing EPS intake tunnels to the west and the SWRO Pump Station to the east. Feedwater for the CDP would be withdrawn through the new offshore WWS array, representing a change from the current withdrawal point in Agua Hedionda Lagoon. The new offshore intake structure would require significant offshore construction activity. Construction would be done from a derrick barge moored above the offshore intake location.

A new multiport diffuser system would be located approximately 4,000 feet offshore of the Agua Hedionda Lagoon mouth, approximately 3,280 feet northwest of the kelp beds and approximately 2,000 feet from the WWS array. The diffuser system would be designed to maximize dilution, minimize the size of the BMZ, minimize the suspension of benthic sediments, and minimize marine life mortality in accordance with the provisions of the Ocean Plan. A general schematic of the layout is provided in Figure 8 with additional detail of the terminus provided in Figure 9.

A new lease agreement would be required from the SLC for the offshore installation sites (WWS array and discharge diffuser). Based on the dimensions of the WWS design (and allowing 5 feet on each side of installed equipment), a lease of approximately 1.63 acres would be required for the intake system. Based on the dimensions of the discharge diffuser design (and allowing 5 feet on each side of installed equipment), a lease of approximately 1.47 acres would be required for the discharge diffuser system. The total leased area required would be approximately 3.09 acres.

Figure 8. General schematic of the layout of the CDP with an offshore screened intake and discharge diffuser.

Figure 9. General schematic of the layout of the CDP discharge diffuser array. Note the WWS array has been omitted from the drawing for clarity.

Under this option, the source water for the seawater desalination plant would be withdrawn from Pacific Ocean offshore of the plant. Approximately 127 MGD of seawater would be withdrawn from the Pacific Ocean for processing by the CDP. Approximately 60 MGD of the diverted seawater is converted to fresh water which is piped to the Water Authority's delivery system in the City of San Marcos. The remaining flow (67 MGD) would be discharged directly to the Pacific Ocean through the offshore diffusers. The discharge consists of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the brine prior to discharge is approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge is 33.5 ppt. The multiport diffuser system would rapidly dilute and disperse the brine effluent. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

The Desalination Amendment provides that the discharge shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured at the edge of the BMZ 100 meters (328 feet) radially from the point of discharge. Over the last 20 years, the natural background salinity at the closest reference site (Scripps Pier) has measured a minimum salinity of 30.4 ppt, maximum salinity of 34.2 ppt, and an average salinity of 33.5 ppt (Jenkins 2016). Therefore, under average conditions, the discharge shall not exceed a daily maximum of 35.5 ppt at the edge of the BMZ (100 meter [328 foot] radius).

b. Design

Intake Design

The offshore WWS would be mounted, with risers, on a new common header that connects to an intake pipeline. The header would be oriented parallel to the shoreline and perpendicular to the intake pipeline. The screens would be oriented perpendicular to the header and shoreline. The intake pipeline would convey water from the offshore screening point to an onshore wet well from which the existing SWRO Pump Station would draw feedwater flow. The general construction sequence for the intake system components would be as follows:

- Bore tunnel
- Dredge to pipe header invert
- Drive pile foundations, as needed
- Set pipe header with integrated screen risers
- Connect header to tunnel
- Backfill header with native fill
- Set wedgewire screens
- Place rip rap
- Commence flow through wedgewire screens

The WWS array would be located 4,000 feet offshore. This distance was selected to minimize two potential impacts: 1) exposing kelp-associated organisms to entrainment and 2) recirculation of brine to the intake. Figure 10 illustrates the intake location versus the location of the kelp stand and the discharge diffuser.

Figure 10. Location of wedgewire screen array relative to existing kelp beds. Location of kelp beds was estimated based on Google Earth aerial and MBC 2013.

The WWS array would be comprised of seven 108-inch diameter WWS (3 plus 1 redundant) with 1.0-mm slot width (Figure 11). The length of each screen would be approximately 27 feet.

Screens would be spaced one half of a screen diameter from each other to maximize the sweeping velocities between screens to sweep debris and organisms away. In addition, the screens would be oriented perpendicular to the shoreline.

To minimize the risk posed by biofouling in the open ocean, the screens will be constructed of a copper nickel alloy (Z Alloy) or a similar material to prevent biofouling. Due to the distance offshore (4,000 feet), a shore-based air burst system would not be feasible; therefore, provisions could be made to allow temporary connection of a boat-based compressor to clean the screens. In addition, the screens will be manually cleaned periodically by divers.

The screens are designed to maintain a through-slot velocity of 0.5 ft/sec or less under all expected operating conditions. The concept design includes a fouling factor of 15%, meaning that under a clean condition, the design through-slot velocity is 0.43 ft/sec. All four screens will be operable when the CDP enters long-term standalone operational mode, meaning the through-slot velocity will be well below 0.5 ft/sec. In the event one screen is taken out of service, the intake system is designed to maintain a through-slot velocity below 0.5 fps.

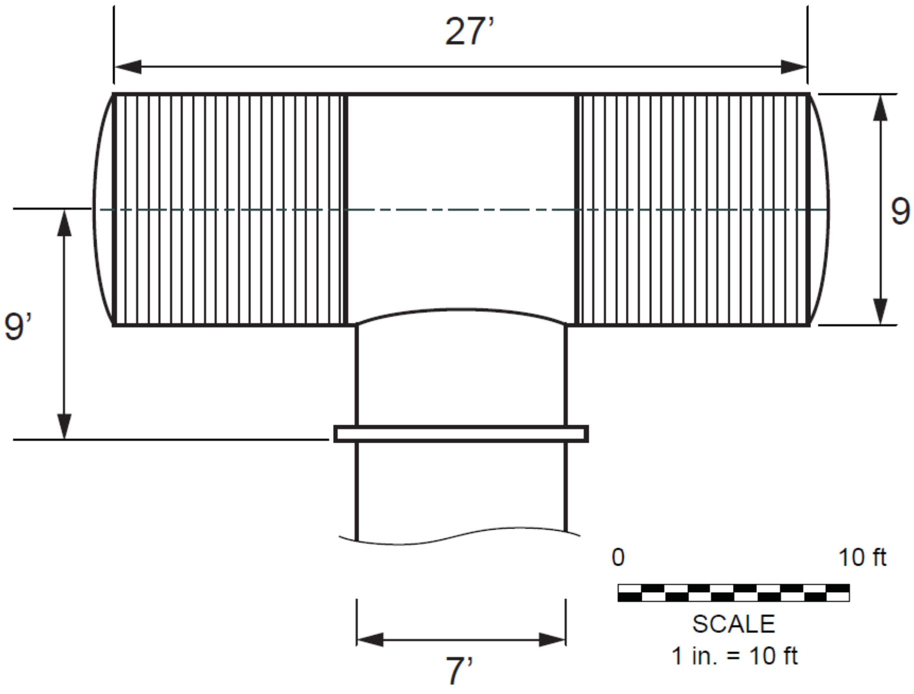

Figure 11. 108-in diameter cylindrical wedgewire screen.

The new 1-mm offshore WWS array would be located approximately 4,000 feet offshore (approximately 4,500 feet from the existing SWRO Pump Station). A 7-ft diameter intake pipeline would convey the withdrawn water from the WWS array to a new onshore wet well west of the SWRO Pump Station. The intake pipeline would be tunneled approximately 5 feet below the sea floor, depending on bed materials, site conditions, and construction approach. The new wet well would function as a common plenum from which SWRO process water flow would be drawn by the existing pumps at the SWRO Pump Station. A total flow of 127 MGD would be withdrawn. Figure 12 and Figure 13 provide plan and section views, respectively, of the new offshore WWS intake structure.

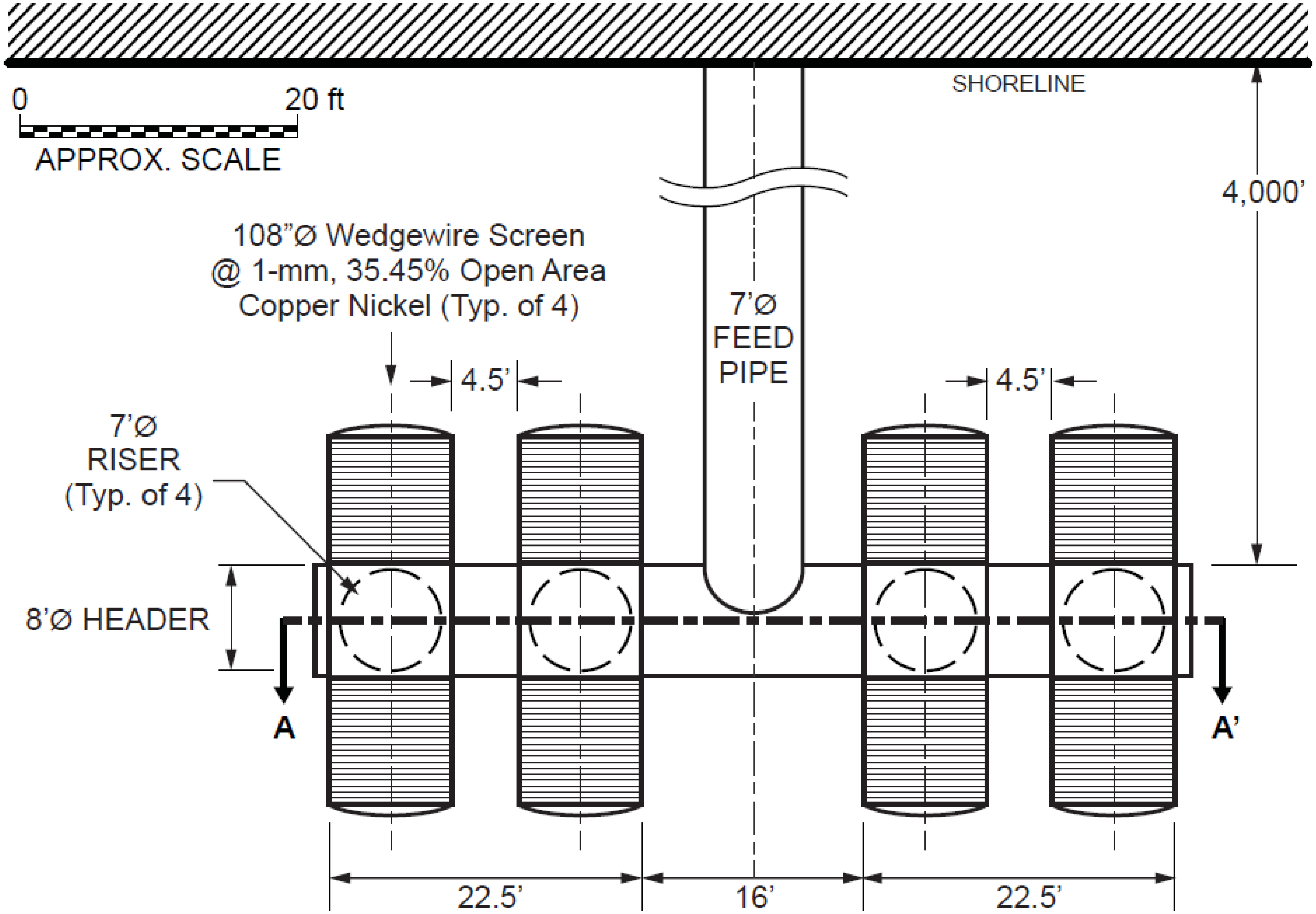

Figure 12. 1-mm offshore wedgewire screens for long-term stand-alone operation, plan view.

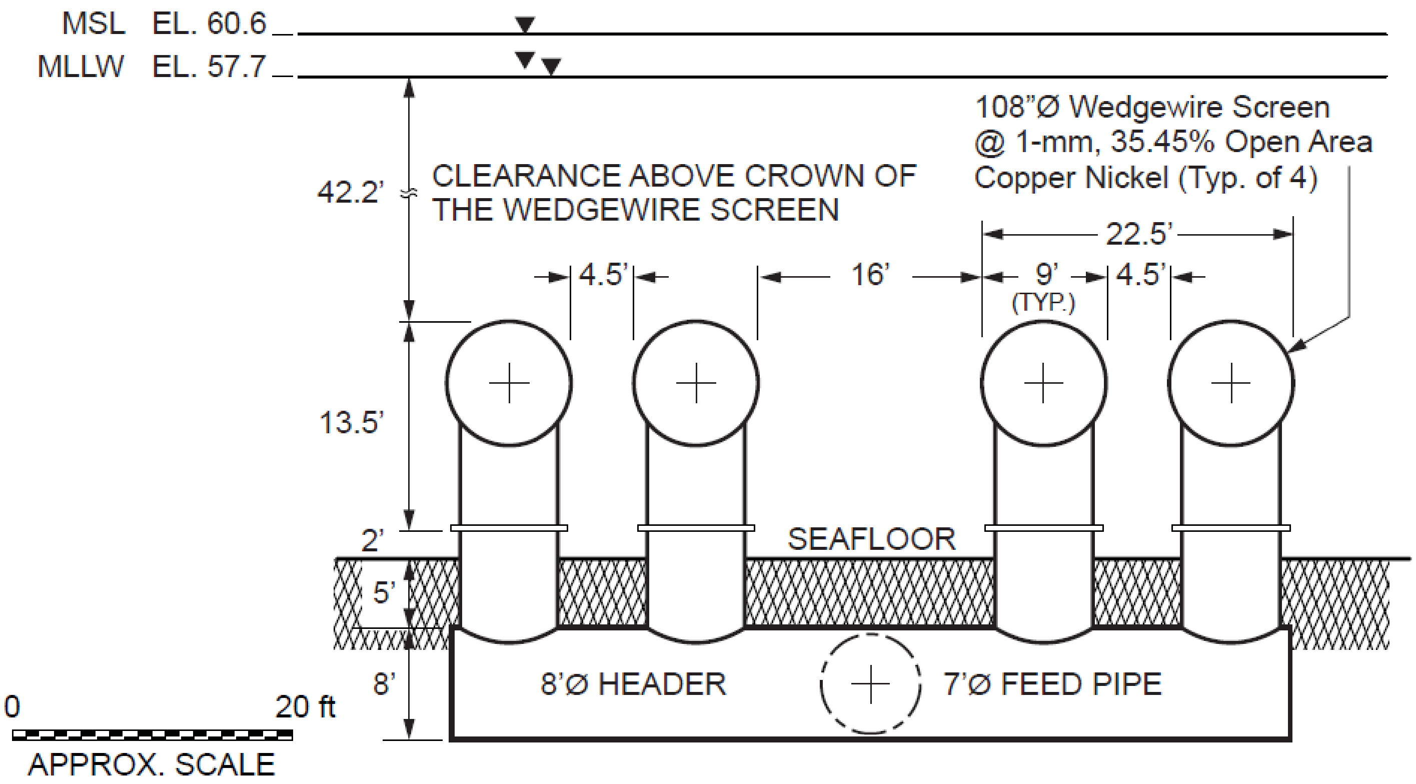

Figure 13. 1-mm offshore wedgewire screens for long-term stand-alone operation, section view.

Discharge Design

A 72” outfall pipeline extending approximately 4,000 feet offshore of the Agua Hedionda Lagoon mouth would convey the brine discharge from the SWRO building to the multiport diffuser system where four duck-bill diffuser ports spaced 100 feet apart would eject the brine into the water column at a high velocity to promote rapid diffusion and dispersion.

Installation of the outfall pipeline would require tunneling and pipeline placement under the existing EPS site, Carlsbad Boulevard, and approximately 4,000 linear feet of seafloor. Anchoring of the outfall pipeline to the seafloor would be coordinated to minimize impacts to the local reef and kelp beds offshore of the desalination plant. The spacing, number, and orientation of the four diffuser heads has been designed to maximize brine mixing in accordance with the provisions of the Desalination Amendment.

c. Technology

Intake Screening Technology

See Section 1.A.i.c for more details on the intake screening technology.

Discharge Diffuser Technology

A new multiport diffuser system would be designed to maximize dilution, minimize the size of the BMZ, minimize the suspension of benthic sediments, and minimize marine life mortality in accordance with the provisions of the Desalination Amendment. As provided in the Desalination Amendment, the BMZ extends 100 m (328 feet) laterally from each of the points of discharge. As shown in Figure 9, the design features include:

- Tie-In to the exiting CDP brine outfall line
- Installation of 5,600 linear feet (1,600 feet onshore and 4,000 feet offshore) of 72-inch conveyance tunnel
- Installation of four high pressure diffusers spaced approximately 100 feet apart
- Elevating the diffusers off the seafloor and orienting the diffusers so to minimize suspension of benthic sediments
- A BMZ of approximately 14.4 acres.

iii. 1-mm Lagoon-Based WWS Surface Intake with Flow Augmentation

a. Site

A new structure would be constructed in the Lagoon to support the array of cylindrical wedgewire screens (WWS). The screens would be mounted, with risers, on a new common header that connects to an intake pipeline. The intake pipeline would convey water from the screening point in the Lagoon to an onshore wet well from which the existing SWRO Pump Station would draw feedwater and flow augmentation water flow. The wet well would be sufficiently sized to also house the Flow Augmentation Pump Station ("Fish-friendly Pumping Structure"). The new wet well would be located downstream of the WWS intake pipeline. Feedwater and flow augmentation water for the CDP would be withdrawn through the new WWS array from the existing source water body (Agua Hedionda Lagoon). The new WWS array would require significant in-water construction activity. Construction would be done from a derrick barge moored in the Lagoon.

Brine from the CDP would be mixed with augmentation flow in the existing EPS discharge tunnel and ultimately be discharged to the Pacific Ocean. There would be no change in the receiving waterbody nor would the discharge plan require any structural modification to the existing EPS discharge pond or ocean outfall. A general schematic of the layout is provided in Figure 14.

An amendment to the lease agreement would be required from NRG for the Lagoon installation site. Based on the dimensions of the design (and allowing 5 feet on each side of installed equipment), a lease of approximately 0.13 acres would be required for the intake pipeline and the Lagoon-based WWS array.

Figure 14. General schematic of the CDP with Lagoon-based 1-mm wedgewire screens and flow augmentaion.

Under this option, approximately 298 MGD of seawater would be withdrawn directly from the Lagoon -- 127 MGD for processing by the CDP and 171 MGD for brine dilution. Approximately 60 MGD of the diverted seawater would be converted to fresh water which would be piped to the Water Authority's delivery system in the City of San Marcos. The remaining flow (67 MGD) would be returned to the EPS discharge tunnel for blending with seawater prior to discharge to the Pacific Ocean. The discharge would consist of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the discharge prior to dilution would be approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge channel is 33.5 ppt. Poseidon is proposing an initial dilution of the brine to 42 ppt prior to discharge. This would be accomplished by mixing the CDP discharge with 171 MGD of the seawater withdrawn from Pacific Ocean along with the RO feedwater. The combined CDP discharge and dilution water flow rate would be 238 MGD. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

The Desalination Amendment provides that the discharge shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured at the edge of the BMZ 200 meters (656 feet.) seaward of the end of the outfall channel. Over the last 20 years, the natural background salinity at the closest reference site (Scripps Pier) has measured a minimum salinity of 30.4 ppt, maximum salinity of 34.2 ppt, and an average salinity of 33.5 ppt (Jenkins 2016). Therefore, under average conditions, the discharge shall not exceed a daily maximum of 35.5 ppt at the edge of the BMZ (200 meter [656 foot] radius).

b. Design

Intake and Discharge Design

The wedgewire screens would be mounted, with risers, on a new common header that connects to an intake pipeline. The header would be oriented parallel to the shoreline and perpendicular to the intake pipeline. The screens would be oriented perpendicular to the header and shoreline. The intake pipeline would convey water from the Lagoon screening point to an onshore wet well from which feedwater and flow augmentation water flow would be drawn.

The WWS array would be comprised of eight 84-inch diameter WWS (7 plus 1 redundant) with 1.0-mm slot width (Figure 15). The length of each screen would be approximately 30 feet. Screens would be spaced one half of a screen diameter from each other and would be equipped with an air burst cleaning system. Even with an air burst cleaning system, though, keeping the screens clean will be a challenge in this location since there is no natural sweeping current to carry away dislodged debris. To minimize the risk posed by biofouling in the open ocean, the screens would be constructed of a copper nickel alloy (Z Alloy) or a similar material to prevent biofouling. Screens could be cleaned periodically by divers if biofouling accumulated on the screens

The screens are designed to maintain a through-slot velocity of 0.5 ft/sec or less under all expected operating conditions. The concept design includes a fouling factor of 15%, meaning that under a clean condition, the design through-slot velocity is 0.43 ft/sec. All eight screens would be operable when the CDP enters long-term standalone operational mode, meaning the through-slot velocity would be well below 0.5 ft/sec. In the event one screen is taken out of service, the intake system is designed to maintain a through-slot velocity below 0.5 fps.

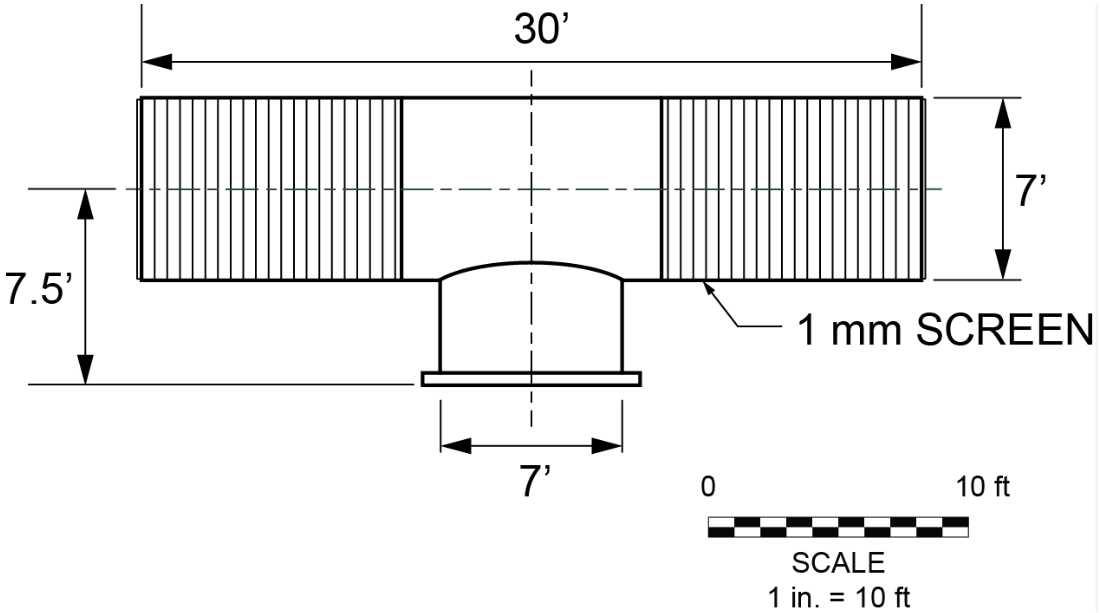

Figure 15. 84-in diameter cylindrical wedgewire screen on a 7-ft diameter riser.

The WWS array would be located in the Lagoon approximately 100 feet from the existing intake trash rack at a depth of 8 feet below MLLW. This distance was selected to provide the submergence required for the WWS and to minimize use conflicts with the Carlsbad Aquafarm. A 9-ft diameter intake pipeline would convey the withdrawn water from the WWS array to a new wet well west of the SWRO Pump Station. The intake pipeline would be buried approximately 5 feet below the sea floor, depending on bed materials, site conditions, and construction approach. The new wet well would function as a common plenum from which SWRO process water flow would be drawn by the existing pumps at the Intake Pump Station and from which augmentation flow would be drawn by fish-friendly axial flow pumps. A total flow of 298 MGD would be withdrawn: 127 MGD through the process water side and 171 MGD through the flow augmentation side. Figure 16 and Figure 17 provide plan and section views, respectively, of the new WWS intake structure in the Lagoon.

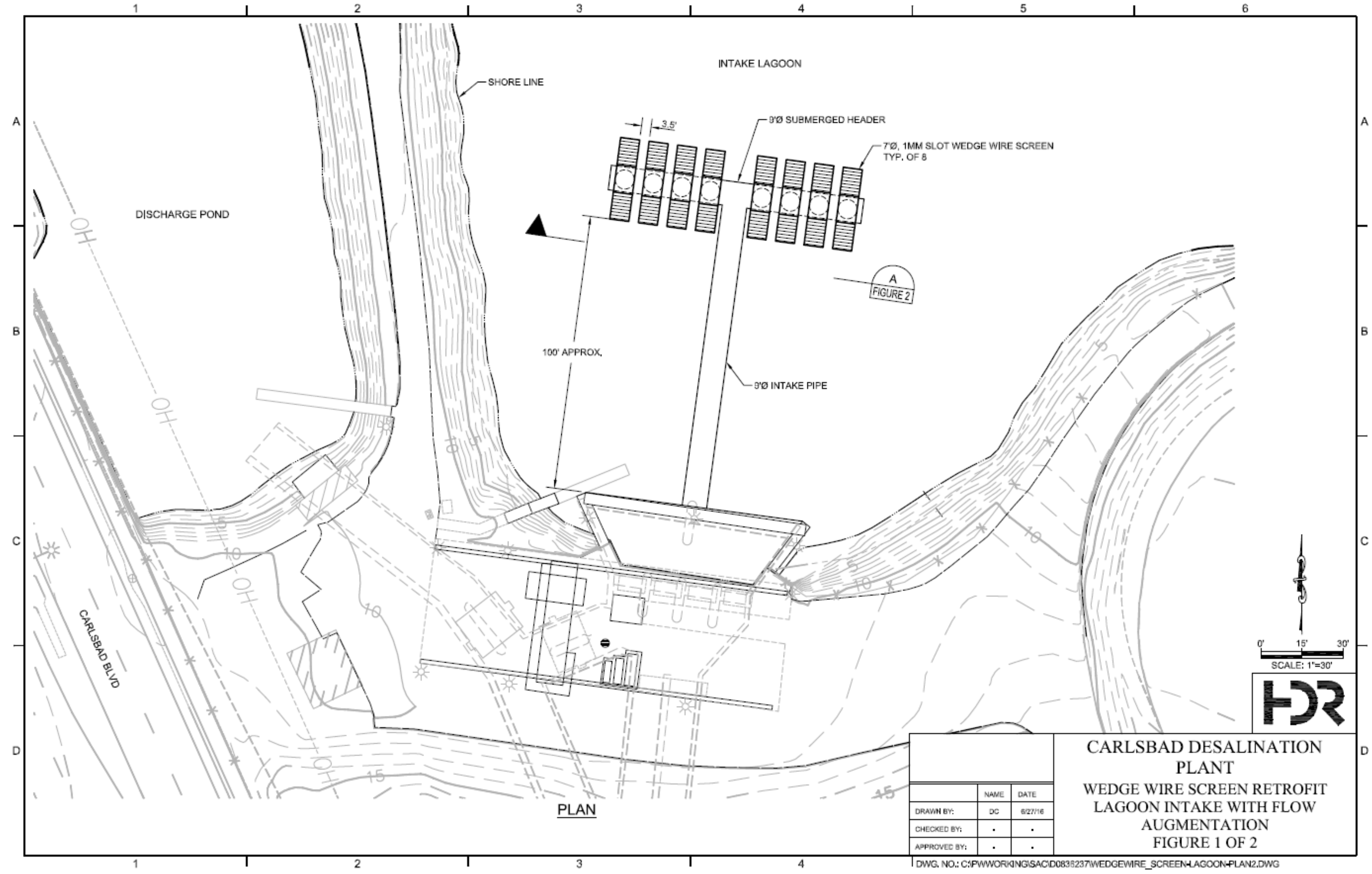

Figure 16. Lagoon-based 1-mm wedgewire screens with flow augmentation for long-term stand-alone operation, plan view.

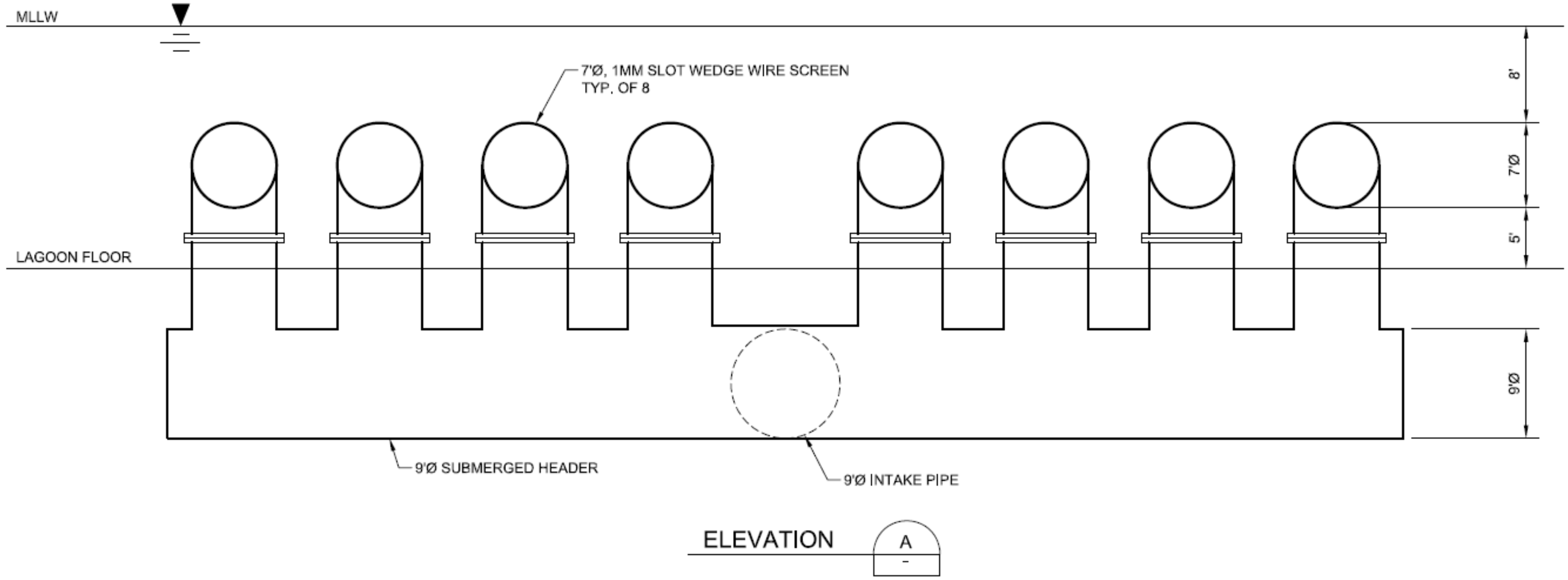

Figure 17. Lagoon-based 1-mm wedgewire screens with flow augmentation for long-term stand-alone operation, section view.

c. Technology

Intake Screening Technology

See Section 1.A.i.c for more details on the intake screening technology.

Discharge Flow Augmentation Technologies

See Section 1.A.i.c for more details on the discharge technology.

iv. 1-mm Lagoon-Based WWS Surface Intake with Diffuser

a. Site

A new structure would be constructed in the Lagoon to support the array of cylindrical wedgewire screens (WWS). The screens would be mounted, with risers, on a new common header that connects to an intake pipeline. The intake pipeline would convey water from the screening point in the Lagoon to an onshore wet well from which the existing SWRO Pump Station would draw feedwater flow. The new wet well would be located downstream of the WWS intake pipeline. Feedwater for the CDP would be withdrawn through the new WWS array from the existing source water body (Agua Hedionda Lagoon). The new WWS array would require significant in-water construction activity. Construction would be done from a derrick barge moored in the Lagoon.

A new multiport diffuser system would be located approximately 4,000 feet offshore of the Agua Hedionda Lagoon mouth, approximately 3,280 feet northwest of kelp beds. The diffuser system would be designed to maximize dilution, minimize the size of the BMZ, minimize the suspension of benthic sediments, and minimize marine life mortality in accordance with the provisions of the Ocean Plan. A general schematic of the layout is provided in Figure 18 with additional detail of the terminus provided in Figure 9.

An amendment to the lease agreement would be required from NRG for the Lagoon installation site. Based on the dimensions of the design (and allowing 5 feet on each side of installed equipment), a lease of approximately 0.08 acres would be required for the intake system. Based on the dimensions of the discharge diffuser design (and allowing 5 feet on each side of installed equipment), a lease of approximately 1.47 acres would be required from the SLC for the discharge diffuser system. The total leased area required would be approximately 1.55 acres.

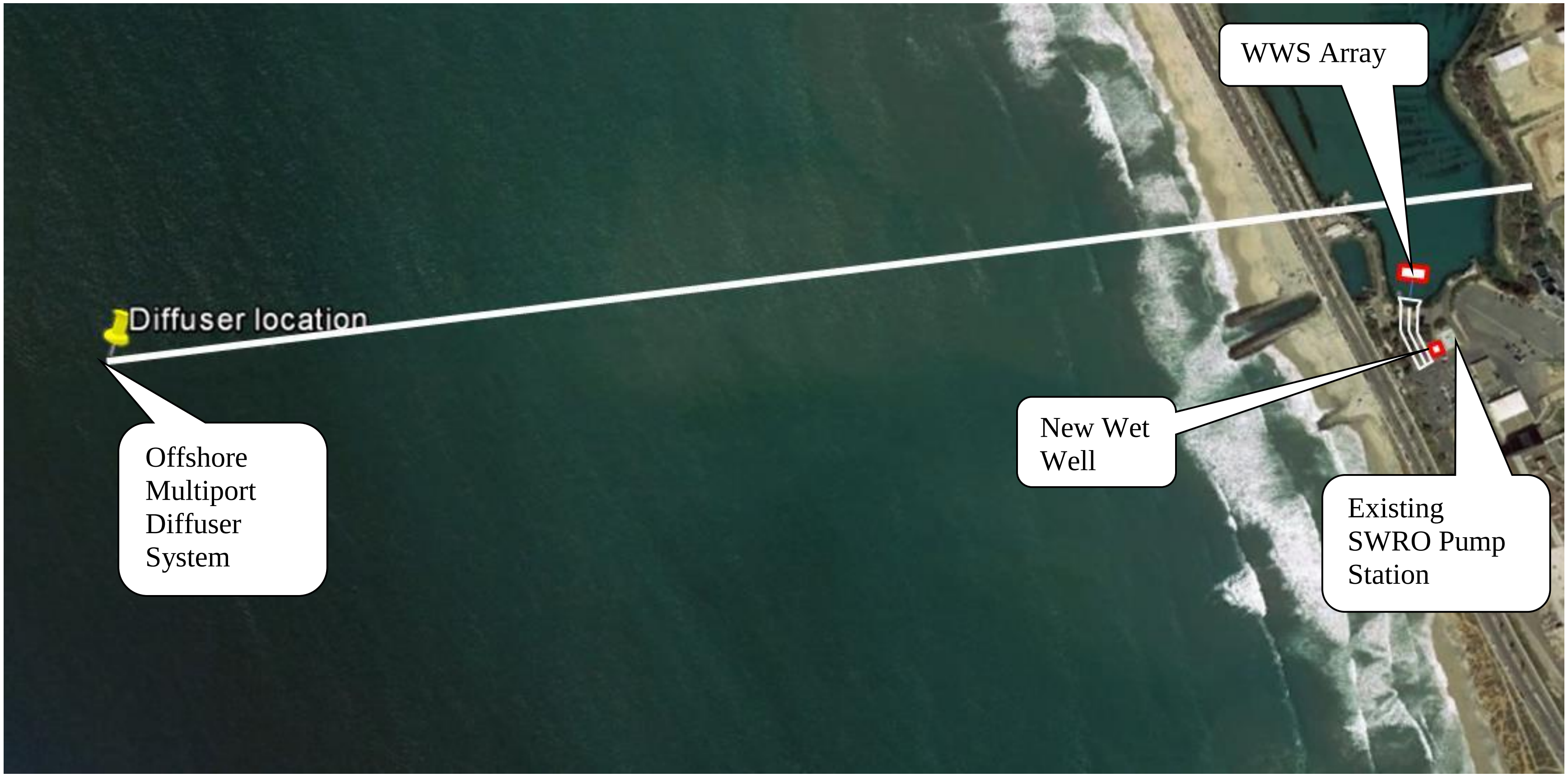

Figure 18. General schematic of the CDP with Lagoon-based 1-mm wedgewire screens and discharge diffuser.

Under this option, approximately 127 MGD of seawater would be withdrawn directly from the Lagoon for processing by the CDP. Approximately 60 MGD of the diverted seawater would be converted to fresh water which would be piped to the Water Authority's delivery system in the City of San Marcos. The remaining flow (67 MGD) would be discharged directly to the Pacific Ocean through the offshore diffusers. The discharge would consist of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the brine prior to discharge would be approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge is 33.5 ppt. The multiport diffuser system would rapidly dilute and disperse the brine effluent. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

The Desalination Amendment provides that the discharge shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured at the edge of the BMZ 100 meters (328 feet) radially from the point of discharge. Over the last 20 years, the natural background salinity at the closest reference site (Scripps Pier) has measured a minimum salinity of 30.4 ppt, maximum salinity of 34.2 ppt, and an average salinity of 33.5 ppt (Jenkins 2016). Therefore, under average conditions, the discharge shall not exceed a daily maximum of 35.5 ppt at the edge of the BMZ (100 meter [328 foot] radius).

b. Design

Intake Design

The wedgewire screens would be mounted, with risers, on a new common header that connects to an intake pipeline. The header would be oriented parallel to the shoreline and perpendicular to the intake pipeline. The screens would be oriented perpendicular to the header and shoreline. The intake pipeline would convey water from the Lagoon screening point to an onshore wet well from which the existing SWRO Pump Station would draw feedwater flow.

The WWS array would be comprised of four 84-inch diameter WWS (3 plus 1 redundant) with 1.0-mm slot width (Figure 19). The length of each screen would be approximately 30 feet. Screens would be spaced one half of a screen diameter from each other and would be equipped with an air burst cleaning system. Even with an air burst cleaning system, though, keeping the screens clean will be a challenge in this location since there is no natural sweeping current to carry away dislodged debris. To minimize the risk posed by biofouling in the open ocean, the screens would be constructed of a copper nickel alloy (Z Alloy) or a similar material to prevent biofouling. Screens could be cleaned periodically by divers if biofouling accumulated on the screens.

The screens are designed to maintain a through-slot velocity of 0.5 ft/sec or less under all expected operating conditions. The concept design includes a fouling factor of 15%, meaning that under a clean condition, the design through-slot velocity is 0.43 ft/sec. All four screens will be operable when the CDP enters long-term standalone operational mode, meaning the through-slot velocity will be well below 0.5 ft/sec. In the event one screen is taken out of service, the intake system is designed to maintain a through-slot velocity below 0.5 fps.

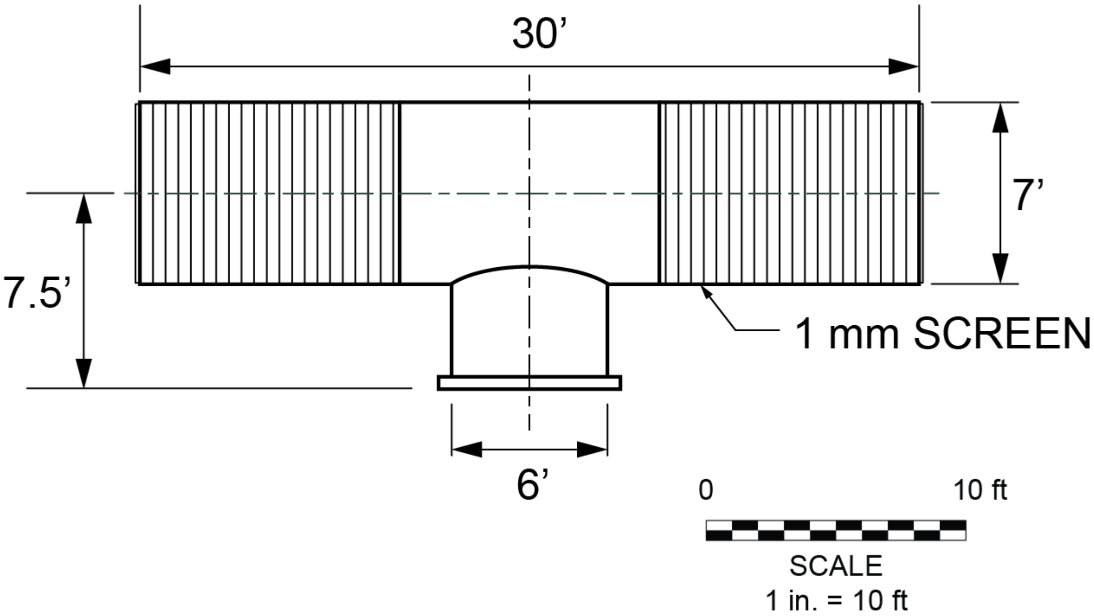

Figure 19. 84-in diameter cylindrical wedgewire screen on a 6-ft diameter riser.

The WWS array would be located in the Lagoon approximately 100 feet from the existing intake trash rack at a depth of 8 feet below MLLW. This distance was selected to provide the submergence required for the WWS and to minimize use conflicts with the Carlsbad Aquafarm. A 6-ft diameter intake pipeline would convey the withdrawn water from the WWS array to a new wet well west of the SWRO Pump Station. The intake pipeline would be buried approximately 5 feet below the sea floor, depending on bed materials, site conditions, and construction approach. The new wet well would function as a common plenum from which SWRO process water flow would be drawn by the existing pumps at the SWRO Pump Station. The total flow withdrawn would be 127 MGD. Figure 20 and Figure 21 provide plan and section views, respectively, of the new WWS intake structure in the Lagoon.

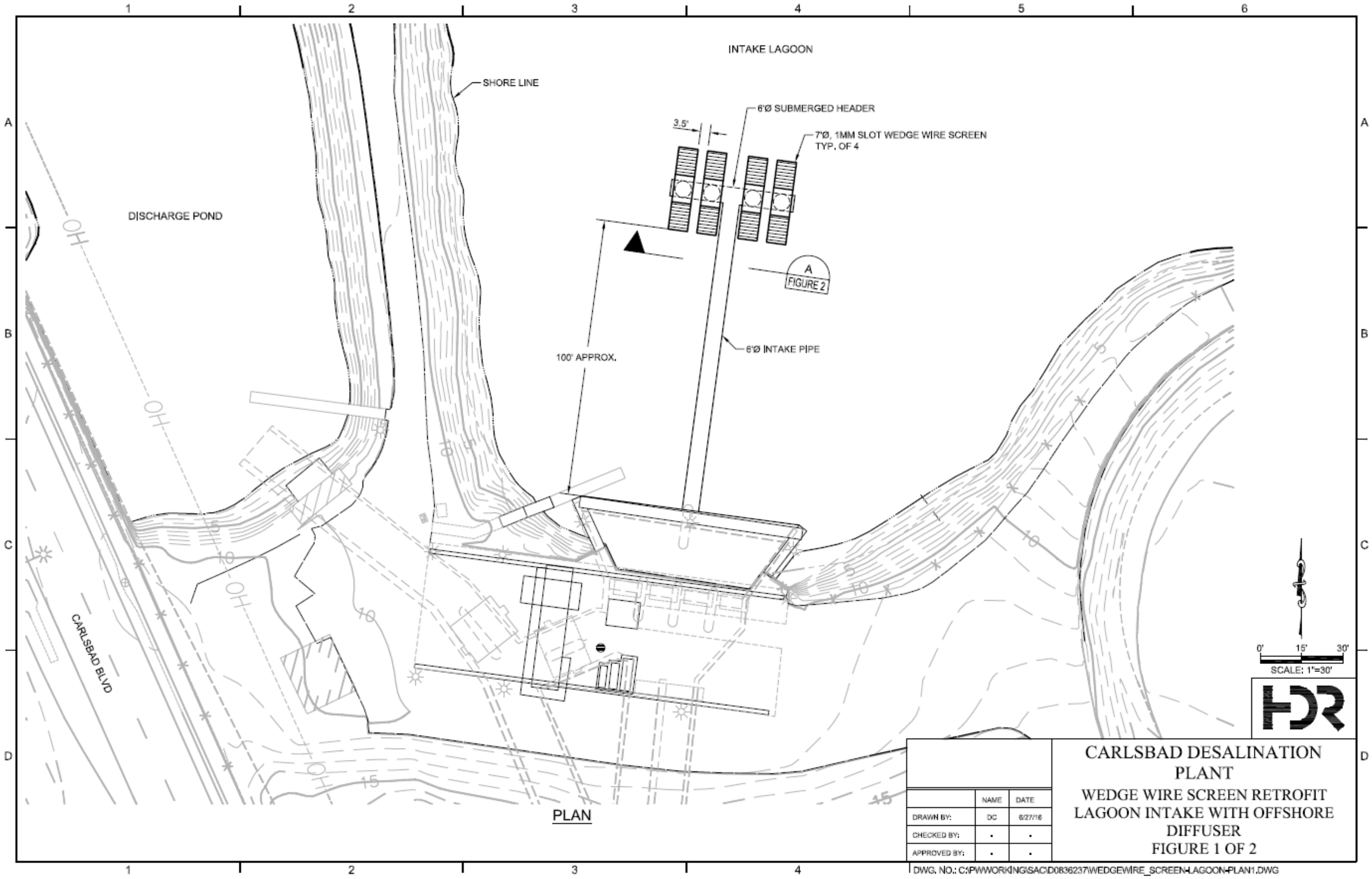

Figure 20. Lagoon-based 1-mm wedgewire screens with discharge diffuser for long-term stand-alone operation, plan view.

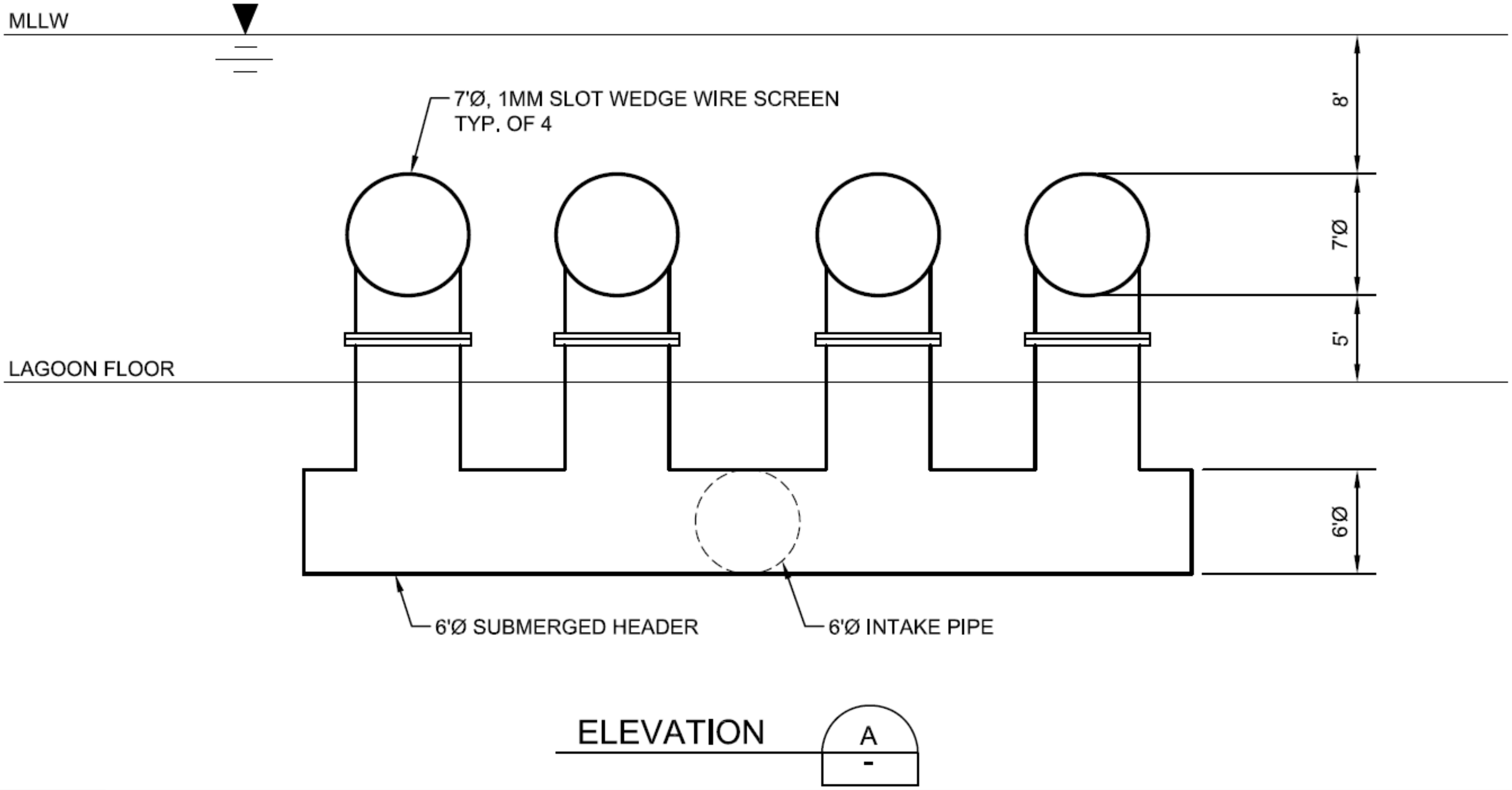

Figure 21. 1-mm offshore wedgewire screens with discharge diffuser for long-term stand-alone operation, section view.

Discharge Design

A 72” outfall pipeline extending approximately 4,000 feet offshore of the Agua Hedionda Lagoon mouth would convey the brine discharge from the SWRO building to the multiport diffuser system where four duck-bill diffuser ports spaced 100 feet apart would eject the brine into the water column at a high velocity to promote rapid diffusion and dispersion.

Installation of the outfall pipeline would require tunneling and pipeline placement under the existing EPS site, Carlsbad Boulevard, and approximately 4,000 linear feet of seafloor. Anchoring of the outfall pipeline to the seafloor would be coordinated to minimize impacts to the local reef and kelp beds offshore of the desalination plant. The spacing, number, and orientation of the four diffuser heads has been designed to maximize brine mixing in accordance with the provisions of the Desalination Amendment

c. Technology

Intake Screening Technology

See Section 1.A.i.c for more details on the intake screening technology.

Discharge Diffuser Technology

See Section 1.A.ii.c for more details on the discharge technology.

v. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Flow Augmentation

a. Site

A new structure would be constructed on the shoreline of the Lagoon to house the traveling water screens to be installed upstream of the SWRO Pump Station as well as the screens and pumps for the Flow Augmentation Pump Station (collectively the "New Screening/Fish-friendly Pumping Structure"). The structure would be located northwest of the SWRO Pump Station along the Lagoon shoreline. Feedwater and flow augmentation water for the CDP would be withdrawn directly from the Lagoon; there would be no change in the source waterbody. Installation of the New Screening/Fish-friendly Pumping Structure would require heavy shoreline construction in the Lagoon.

Brine from the CDP would be mixed with augmentation flow in the existing EPS discharge tunnel and ultimately be discharged to the Pacific Ocean. There would be no change in the receiving waterbody nor would the discharge plan require any structural modification to the existing EPS discharge pond or ocean outfall. A general schematic of the layout is provided in Figure 22.

An amendment to the lease agreement would be required from NRG for the Lagoon installation site. Approximately half of the intake/discharge structure would be outside of the existing NRG easement. Based on the dimensions of the design (and allowing 5 feet on each side of installed equipment), a lease of approximately 0.13 acres would be required.

Figure 22. General schematic of the CDP with Lagoon-based Shoreline 1-mm traveling water screens and flow augmentation.

Under this option, approximately 299 MGD of seawater would be withdrawn directly from the Lagoon -- 127 MGD for processing by the CDP, 171 MGD for brine dilution and approximately 1 MGD for screen wash and fish return. Approximately 60 MGD of the diverted seawater would be converted to fresh water which would be piped to the Water Authority's delivery system in the City of San Marcos. The remaining flow (67 MGD) would be returned to the EPS discharge tunnel for blending with seawater prior to discharge to the Pacific Ocean. The discharge would consist of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the discharge prior to dilution would be approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge channel is 33.5 ppt. Poseidon is proposing an initial dilution of the brine to 42 ppt prior to discharge. This would be accomplished by mixing the CDP discharge with 171 MGD of the seawater withdrawn from Pacific Ocean along with the RO feedwater. The combined CDP discharge and dilution water flow rate would be 238 MGD. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

The Desalination Amendment provides that the discharge shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured at the edge of the BMZ 200 meters (656 feet.) seaward of the end of the outfall channel. Over the last 20 years, the natural background salinity at the closest reference site (Scripps Pier) has measured a minimum salinity of 30.4 ppt, maximum salinity of 34.2 ppt, and an average salinity of 33.5 ppt (Jenkins 2016). Therefore, under average conditions, the discharge shall not exceed a daily maximum of 35.5 ppt at the edge of the BMZ (200 meter [656 foot] radius).

b. Design

Intake and Discharge Design

The New Screening/ Fish-friendly Pumping Structure would be located northwest of the SWRO Pump Station. The overall footprint of the New Screening/Fish-friendly Pumping Structure would be approximately 141 feet long and 65 feet wide with an invert of El. -15 feet. The overall structure would be divided into SWRO process water flow and augmentation flow. An average flow of 299 MGD would be withdrawn, 127 MGD through the process water portion, 171 MGD through the flow augmentation portion and approximately 1 MGD for screen washing and fish return flow. A common plenum downstream of the screens would provide flow to both the process and dilution sides of the structure. Figure 23 provides a plan view of the New Screening/Fish-friendly Pumping Structure.

Figure 24 and Figure 25 provide section views through the process and flow augmentation portions, respectively.

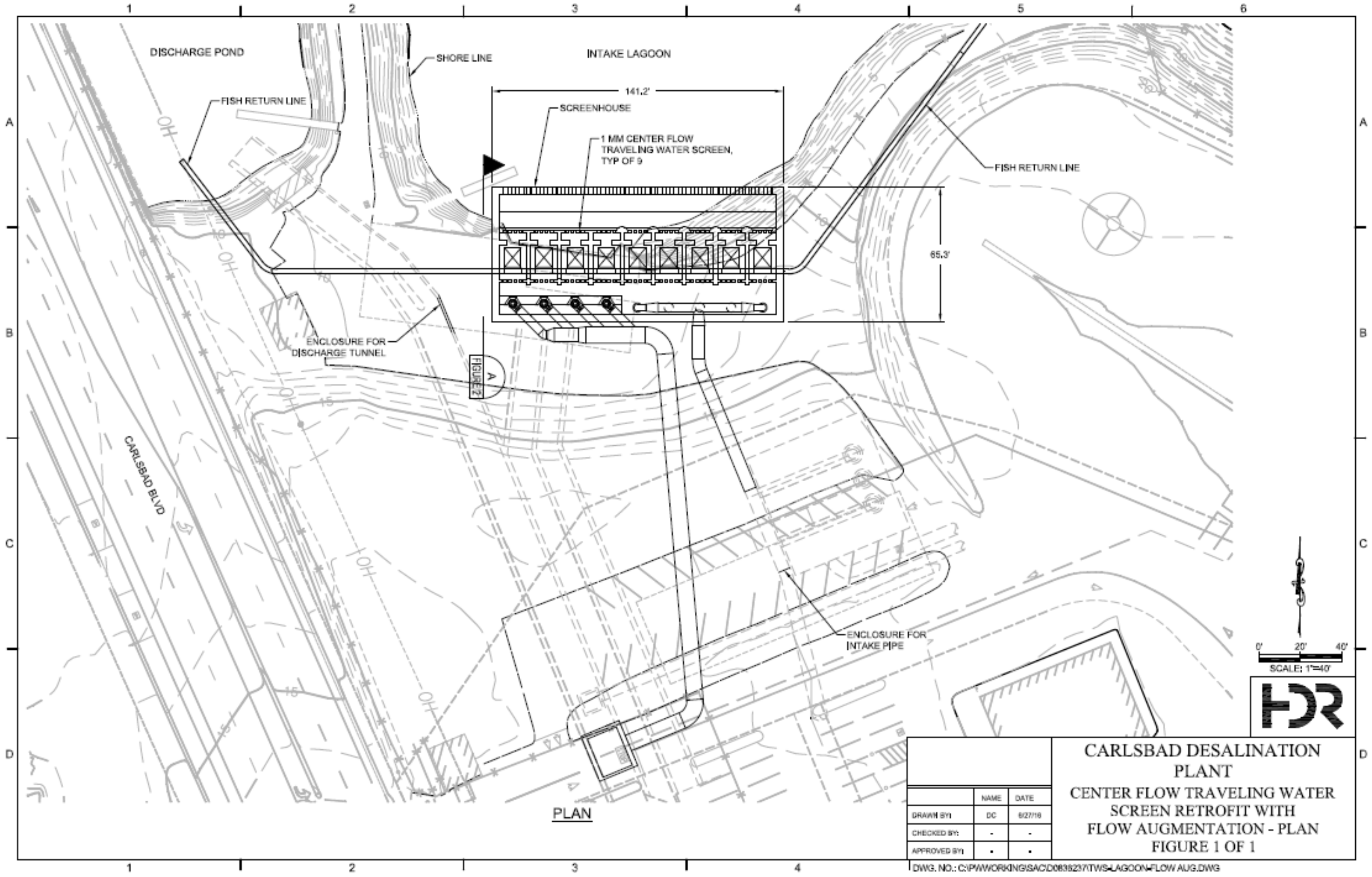

Figure 23. Lagoon-based Shoreline 1-mm traveling water screens with flow augmentation for long-term stand-alone operation, plan view.

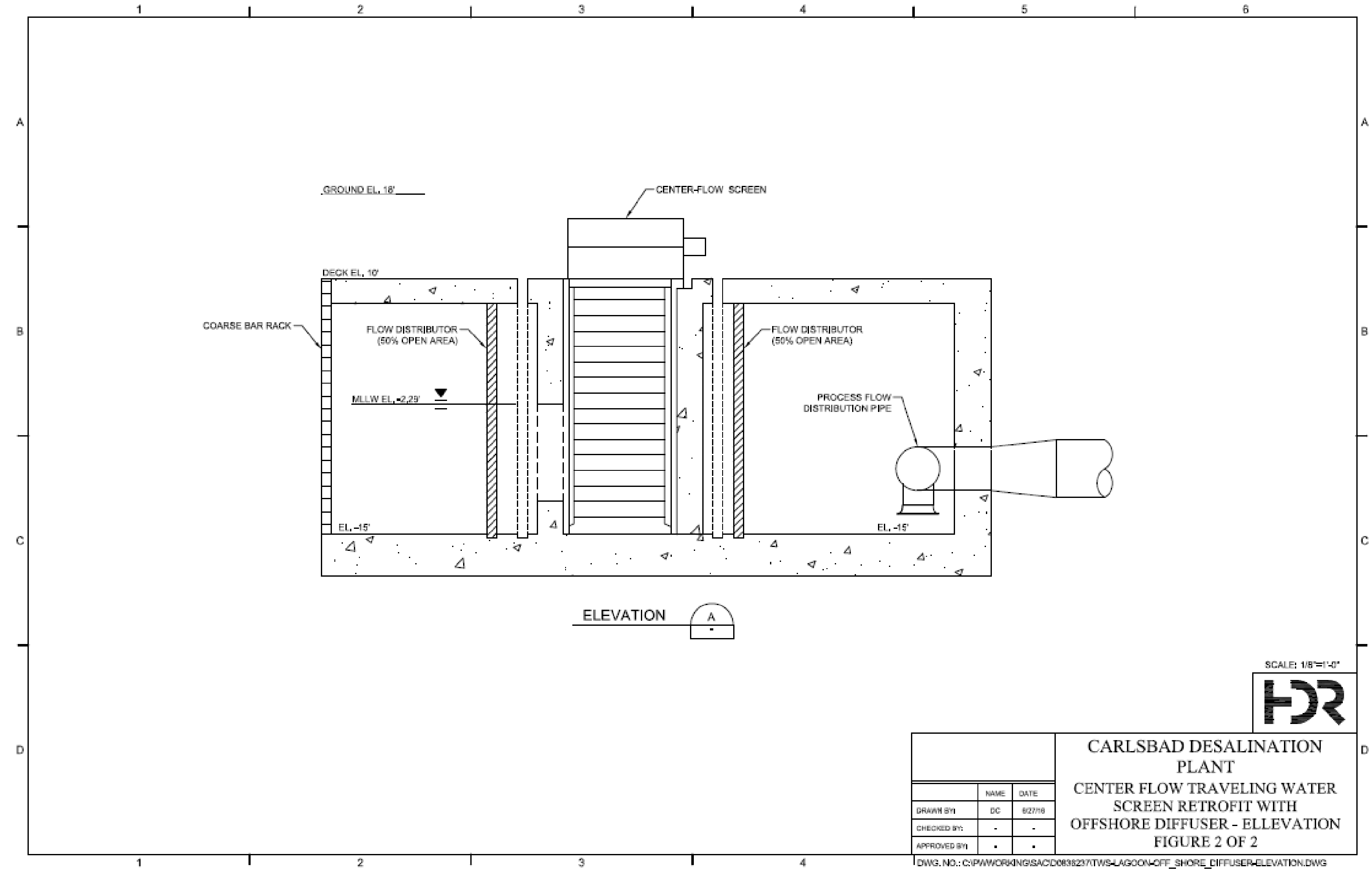

Figure 24. Lagoon-based Shoreline 1-mm traveling water screens, section view through process portion.

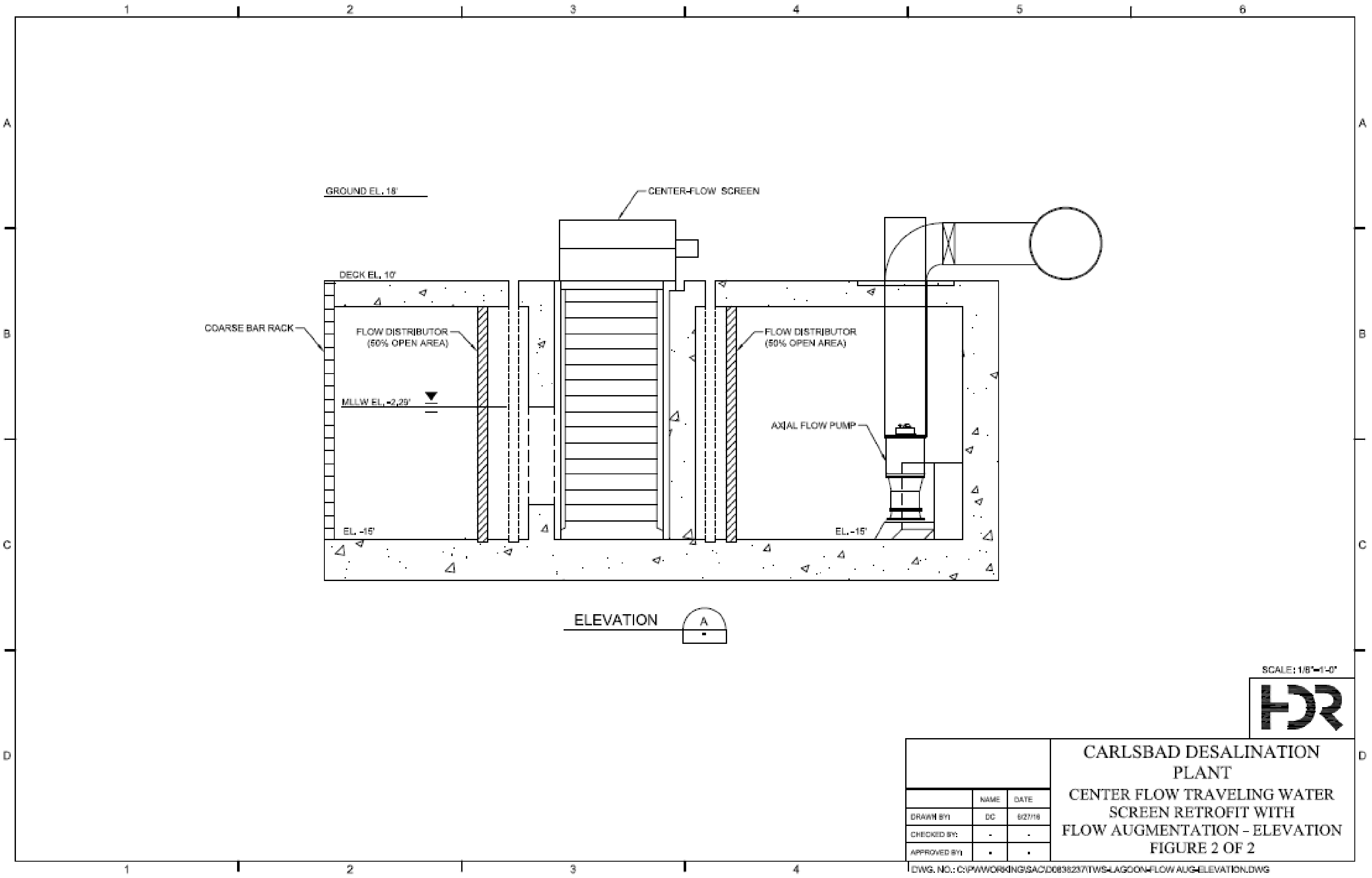

Figure 25. Lagoon-based Shoreline 1-mm traveling water screens, section view through flow augmentation portion.

The flow would be screened by nine (eight plus a shared redundant) screens. The redundant screen would be in service during normal operations. Screens would be Bilfinger Water Technologies (BWT) center-flow traveling water screens (or equal) with 1.0-mm mesh. The screens would be modified with fish protection features (fish lifting buckets on each screen basket, low pressure spraywash, and fish return system). The intake structure is designed for a through-screen velocity of 0.5 ft/sec or less with eight screens in service and 15% fouling. If all nine screens are in service, the through-screen velocity would be well below 0.5 ft/sec. Each screen bay includes upstream and downstream stoplog slots to allow each bay to be dewatered and each screen isolated. All fish collected in the traveling screen fish buckets would be returned to either Agua Hedionda Lagoon or to the Pacific Ocean via the discharge pond. A Tee-shaped manifold with five inlets would convey flow from downstream of the screens to the SWRO Pump Station while dilution flow would be pumped with fish-friendly axial flow pumps. The flow augmentation system would pump flow using four (three plus one redundant) fish-friendly, axial flow pumps (Bedford submersible or equal). This augmentation flow would be conveyed to a new vault adjacent to and just south of the existing brine vault. The brine and augmentation flows would mix in the discharge tunnel in transit to the existing EPS discharge pond and then to the ocean. Flow distributors are included upstream and downstream of the screens to create a more uniform flow through the screens and approaching the downstream suction points.

c. Technology

Intake Screening Technology

The intake screening technology selected for the screened intake with discharge flow augmentation is the BWT center-flow traveling water screen (Figure 26) (or equal). This screen type is oriented perpendicular to the flow and both the ascending and descending sides of the screen provide screening area. The increased screening area represents a distinct advantage over traditional through-flow screens in which only the ascending side provides screening area. In addition, the potential for carryover of debris is greatly reduced with this type of screen.

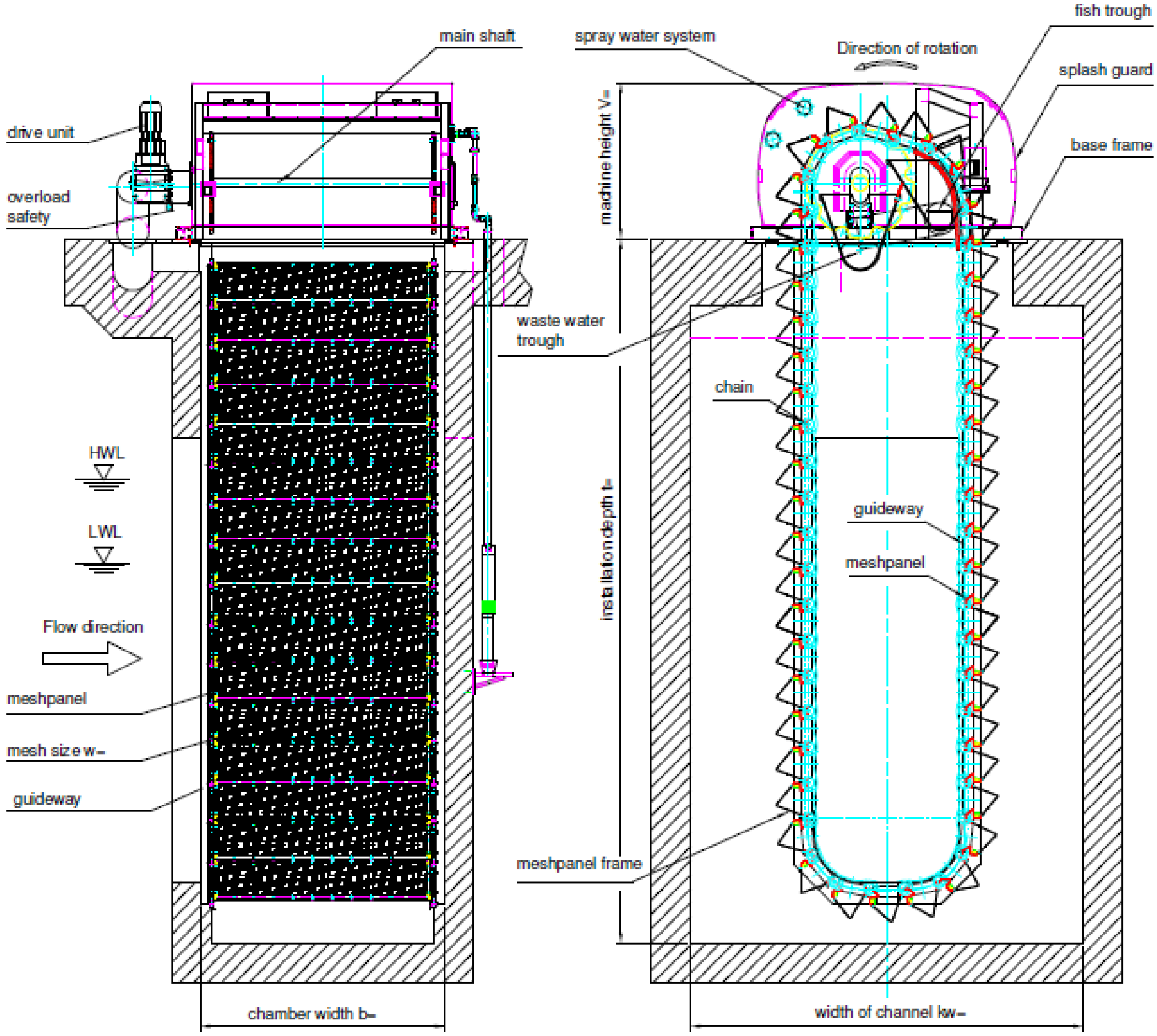

Figure 26. Sample profile and section view of a typical BWT center-flow traveling water screen (courtesy Bilfinger Water Technologies).

Operational Principle

As shown in Figure 27, the BWT center-flow traveling screen (or equal) is designed to draw water into the center of the screen and out through both the ascending and descending screen faces, resulting in two flows leaving the screen and coalescing downstream. Center-flow traveling screens are widely used throughout Europe, but less so in the U.S. They offer a number of substantial advantages over standard through-flow and even dual-flow designs. Center-flow screens prevent carryover of debris by keeping all filtered debris on the upstream side of the screen. Also, the in-to-out flow pattern is unique in that it prevents the potential for uncollected debris from becoming jammed on the descending side of the screen (as can be the case in dual-flow screens with an out-to-in flow pattern.

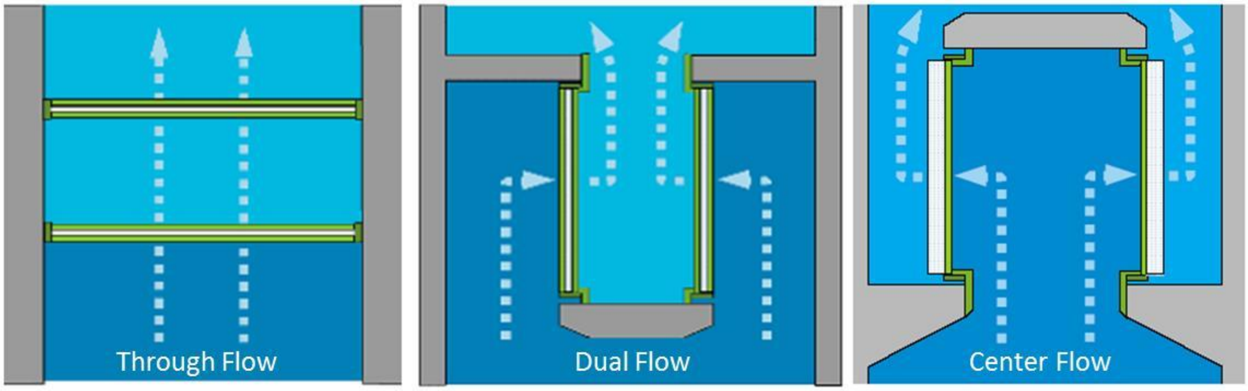

Figure 27. Schematic of the flow patterns through various traveling water screen types (courtesy Bilfinger Water Technologies).

Mesh Size

Screening mesh size directly impacts the size of the screening structure. For the same design flow, an intake utilizing smaller mesh would require a larger footprint to keep the through-screen velocity constant. The new intake/discharge structure required for the long term stand-alone CDP utilizes screens with 1.0-mm mesh on both the SWRO Pump Station side and the Flow Augmentation Pump Station side to minimize intake and mortality of marine life.

It is important to note that not just the mesh size, but also the panel shape can affect hydraulic capacity. As shown in Figure 28, the BWT center-flow traveling screen uses v-shaped, instead of flat, screen panels. This v-shape increases overall screening area by approximately 40%, reducing the overall footprint of the installation.

Fish-Friendly Screen -Features

Fish-friendly traveling water screens are also referred to as “modified” and “Ristroph” traveling water screens. Screens modified for fish protection purposes share a number of common features, each of which is listed below with a description of those features included on the BWT center-flow traveling screens (or equal) specified for the CDP.

Screen mesh type

Fish-friendly screens use a mesh with a smooth surface to minimize the risk of scale loss during the impingement process. The fish-friendly mesh on the BWT screens (or equal) for the CDP would be fabricated of woven stainless steel wire as shown in Figure 28.

Figure 28. Example of BWT center-flow traveling screen panel mesh (courtesy Bilfinger Water Technologies).

<u>Fish lifting buckets</u>

Fish-friendly screens have fish lifting buckets attached to the lower section of each screen panel. The buckets provide a sheltered area for organisms that cannot escape the intake flow to congregate and prevent them from becoming trapped against the screen mesh. The buckets are also designed to hold water to minimize air exposure during the collection and return process. The BWT screens (or equal) would have fish lifting buckets as shown in Figure 29.

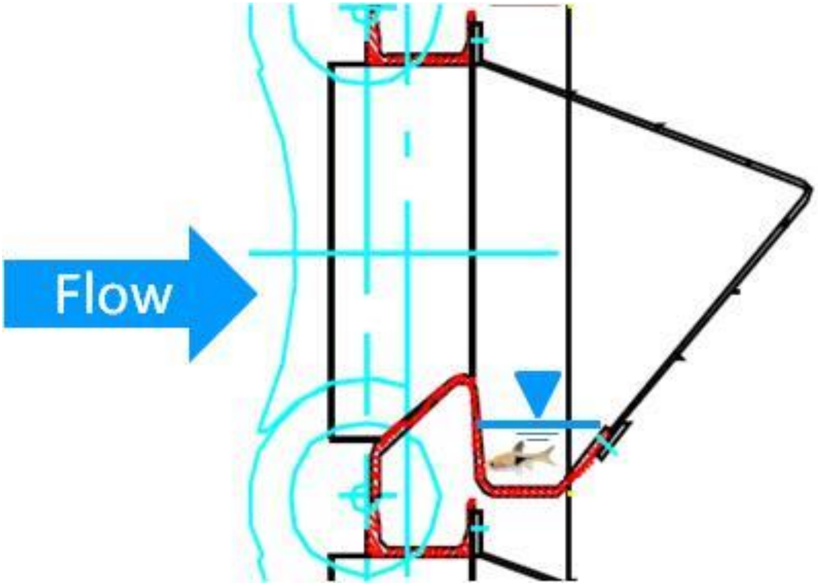

Figure 29. Example of BWT center-flow traveling screen fish lifting bucket (modified from a Bilfinger Water Technologies figure).

Low-pressure spraywash

Fish-friendly screens have low pressure spraywash system (in addition to the standard high-pressure one used to clean the screen of debris) to gently rinse collected fish from the screen into a fish return system. The spraywash pressure is typically below 20 psi and the location and orientation of the nozzles is optimized for best performance. The BWT screens (or equal) would have a low-pressure spraywash to gently rinse marine organisms into the fish return trough.

Rotation speed

Fish-friendly screens are designed to operate continuously in comparison to standard traveling water screens that typically rotate on a schedule or a set pressure differential. The BWT screens (or equal) would be designed to operate continuously.

Fish return system

Fish-friendly screens require fish return systems to safely transport collected organisms from the screen back to the ocean. The fish return design must minimize abrasion, turbulence, shear, and velocity for transported fish. It is critical that the fish return have sufficient water depth to transport organisms, sufficient velocity to flush organisms towards the discharge point, a means of protection from avian and/or terrestrial predators, and a discharge point that minimizes the risk of recirculating organisms back to the intake. The fish return for the BWT screens (or equal) is designed to meet all of these considerations.

Once organisms are removed from the BWT center-flow traveling screens (or equal), they must be safely returned back to the Agua Hedionda Lagoon or to the Pacific Ocean via the discharge pond. The current design includes a single new combined fish and debris return trough. Fish and debris removed by both the low- and high-pressure spray washes, respectively, would combine into a single pipe before being returned to one of two alternative discharge points (Figure 23).

The Lagoon discharge point would be approximately 205 feet north east of the existing intake structure. The fish return would discharge into a quiescent area in the southeast corner of the Lagoon which is separated from the deep channel that connects the intake to the Pacific Ocean, thereby minimizing the potential for recirculation of returned organisms into the intake flow (Figure 30).

The discharge point in the discharge pond would be just to the west of the discharge tunnel outlet. This location would discharge organisms close to the exit of the Pond (Figure 31).

A combined trough provides another opportunity for safe passage for organisms that may not have been dislodged by the low-pressure wash and allows for a greater volume of wash water associated with the high-pressure spray wash system to maintain proper flow in the return system. The flows used to size the fish return are based on the spray wash capacity of each screen (114.5 gpm) or 1,145 gpm for all ten screens.

For the return that would discharge to the Lagoon, the combined return trough would be mounted to the intake deck on the downstream side of the screens. A 2.0-foot diameter half-round trough with a slope of 1/16 inch per foot was chosen for this stage of design. Shortly after leaving the screening structure, the return trough would transition into a 2.0-foot diameter pipe that continues for a run of approximately 382 feet. The velocity and depth of flow in the pipe would be optimized for fish transport to the discharge point during the advanced design process. Except for a short section adjacent to the screening structure, the fish return would be buried. Two cleanouts would be located along its length to facilitate cleaning and inspection of the return pipe. At the point of discharge, the fish return would be an open trough, from El. 0.0 feet to below the low water level, to ensure that organisms are returned to the Lagoon during all anticipated water levels. The discharge location would extend out into the Lagoon to ensure sufficient water depth during low water. Depending on the final arrangement, this section could be anchored directly to the seafloor, supported by small piles, or attached to the piers supporting the dock.

For the return that would discharge to the discharge pond, the combined return trough would be mounted to the intake deck on the downstream side of the screens. A 2.0-foot diameter half-round trough with a slope of approximately 1/8 inch per foot was chosen for this stage of design. Shortly after leaving the screening structure, the return trough would transition into a 2.0-foot diameter pipe, make a gradual drop, and then transition into a run of approximately 280 ft. The velocity and depth of flow in the pipe would be optimized for fish transport to the discharge point during the advanced design process. Except for a short section adjacent to the screening structure, the fish return would be buried. Two cleanouts would be located along its length to facilitate cleaning and inspection of the return pipe. At the point of discharge, the fish return would be an open trough, from El. 0.0 feet to below the low water level, to ensure that organisms are returned to the Pond during all anticipated water levels. The discharge location would extend out into the Pond to ensure sufficient water depth during low water. Depending on the final arrangement, this section could be anchored directly to the Pond bottom or supported by small piles.

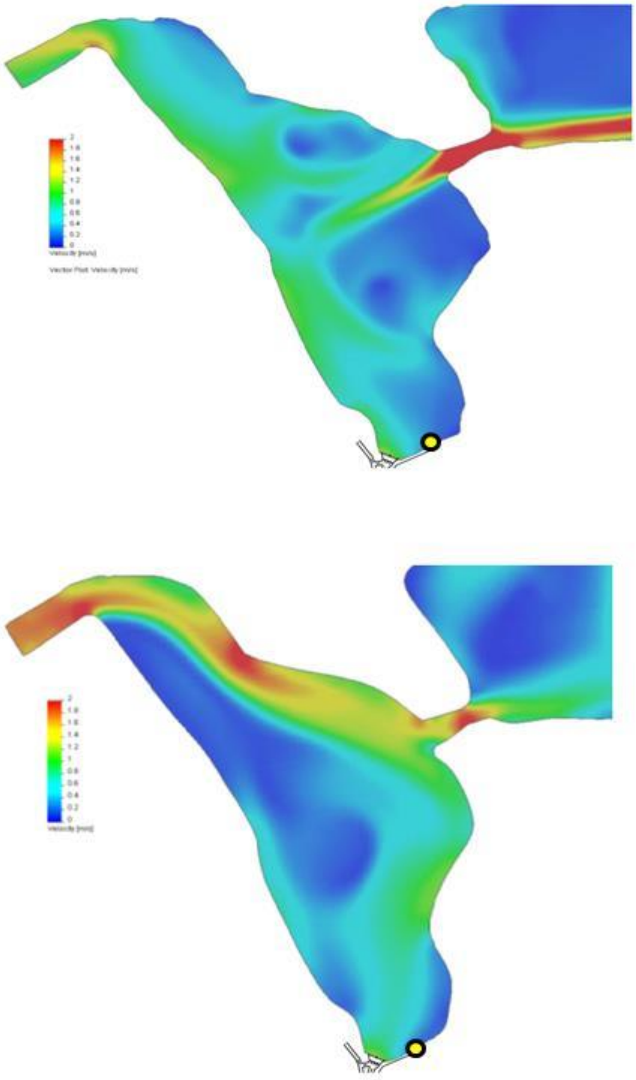

Figure 30. Velocity contours for maximum ebb (top) and flood (bottom) Spring tide, plant flow rate 300 MGD. Yellow dots indicate proposed Lagoon fish return discharge location.

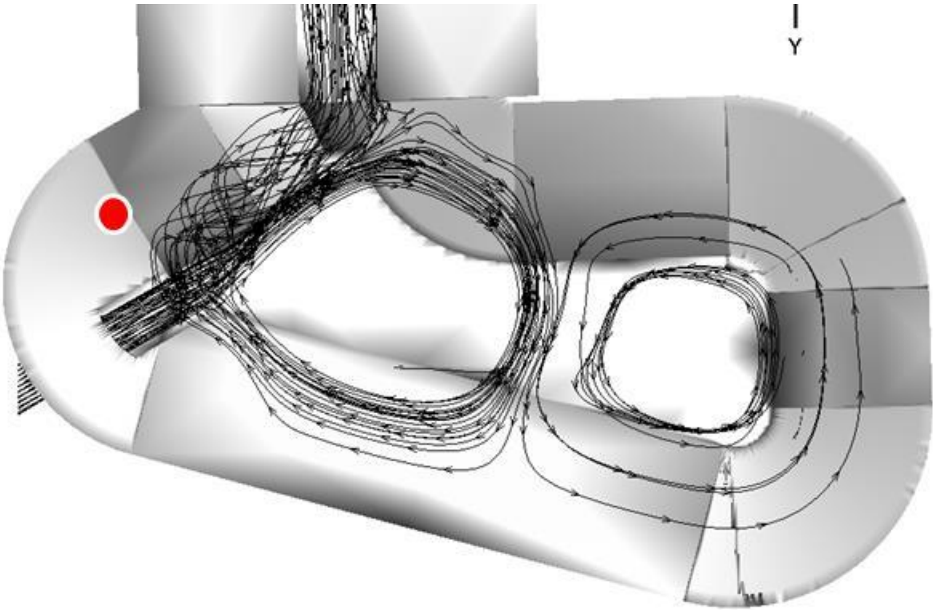

Figure 31. Flow streamlines within the EPS discharge pond with the approximate fish return location indicated with a red dot (figure from Alden 2015).

Discharge Flow Augmentation Technologies

See Section 1.A.i.c for more details on the discharge technology.

vi. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Diffuser

a. Site

A new structure would be constructed on the shoreline of the Lagoon to house the traveling water screens to be installed upstream of the SWRO Pump Station. The structure would be located to the north of the SWRO Pump Station along the Lagoon shoreline. Feedwater for the CDP would be withdrawn directly from the Lagoon; there would be no change in the source waterbody. Installation of the New Screening Structure would require heavy shoreline construction in the Lagoon.

A new multiport diffuser system would be located approximately 4,000 feet offshore of the Agua Hedionda Lagoon mouth, approximately 3,280 feet northwest of kelp beds. The diffuser system would be designed to maximize dilution, minimize the size of the BMZ, minimize the suspension of benthic sediments, and minimize marine life mortality in accordance with the provisions of the Ocean Plan. A general schematic of the layout is provided in Figure 32 with additional detail of the terminus provided in Figure 9.

An amendment to the lease agreement would be required from NRG for the Lagoon installation site. Approximately half of the intake/discharge structure would be outside of the existing NRG easement. Based on the dimensions of the design (and allowing 5 feet on each side of installed equipment), a lease of approximately 0.07 acres would be required for the intake system. Based on the dimensions of the discharge diffuser design (and allowing 5 feet on each side of installed equipment), a lease of approximately 1.47 acres would be required from the SLC for the discharge diffuser system. The total leased area required would be approximately 1.54 acres.

Figure 32. General schematic of the CDP with Lagoon-based Shoreline 1-mm traveling water screens and discharge diffuser.

Under this option, approximately 127 MGD of seawater would be withdrawn directly from the Lagoon for processing by the CDP. Approximately 60 MGD of the diverted seawater would be converted to fresh water which would be piped to the Water Authority's delivery system in the City of San Marcos. The remaining flow (67 MGD) would be discharged directly to the Pacific Ocean through the offshore diffusers. The discharge would consist of brine produced by the reverse osmosis process (60 MGD) and treated backwash water from the pretreatment filters (7 MGD). The salinity of the brine prior to discharge would be approximately 65 ppt (67 ppt with no backwash water included), whereas the average salinity of the seawater in the vicinity of the discharge is 33.5 ppt. The multiport diffuser system would rapidly dilute and disperse the brine effluent. As compared to the existing project operations, the CDP operations described above would achieve a 10% average annual increase in fresh drinking water production while reducing total quantity of seawater required for processing and flow augmentation purposes.

The Desalination Amendment provides that the discharge shall not exceed a daily maximum of 2.0 parts per thousand (ppt) above natural background salinity measured at the edge of the BMZ 100 meters (328 feet) radially from the point of discharge. Over the last 20 years, the natural background salinity at the closest reference site (Scripps Pier) has measured a minimum salinity of 30.4 ppt, maximum salinity of 34.2 ppt, and an average salinity of 33.5 ppt (Jenkins 2016). Therefore, under average conditions, the discharge shall not exceed a daily maximum of 35.5 ppt at the edge of the BMZ (100 meter [328 foot] radius).

b. Design

Intake Design

The New Screening Structure would be located northwest of the SWRO Pump Station. The overall footprint of the New Screening Structure would be approximately 81 feet long and 65 feet wide with an invert of El. -15 feet. An average flow of 127 MGD would be withdrawn for process water and an additional 0.5 MGD for screen washing and fish return flow. Figure 33 provides a plan view of the New Screening Structure. Figure 24 provides a section view through the New Screening Structure.

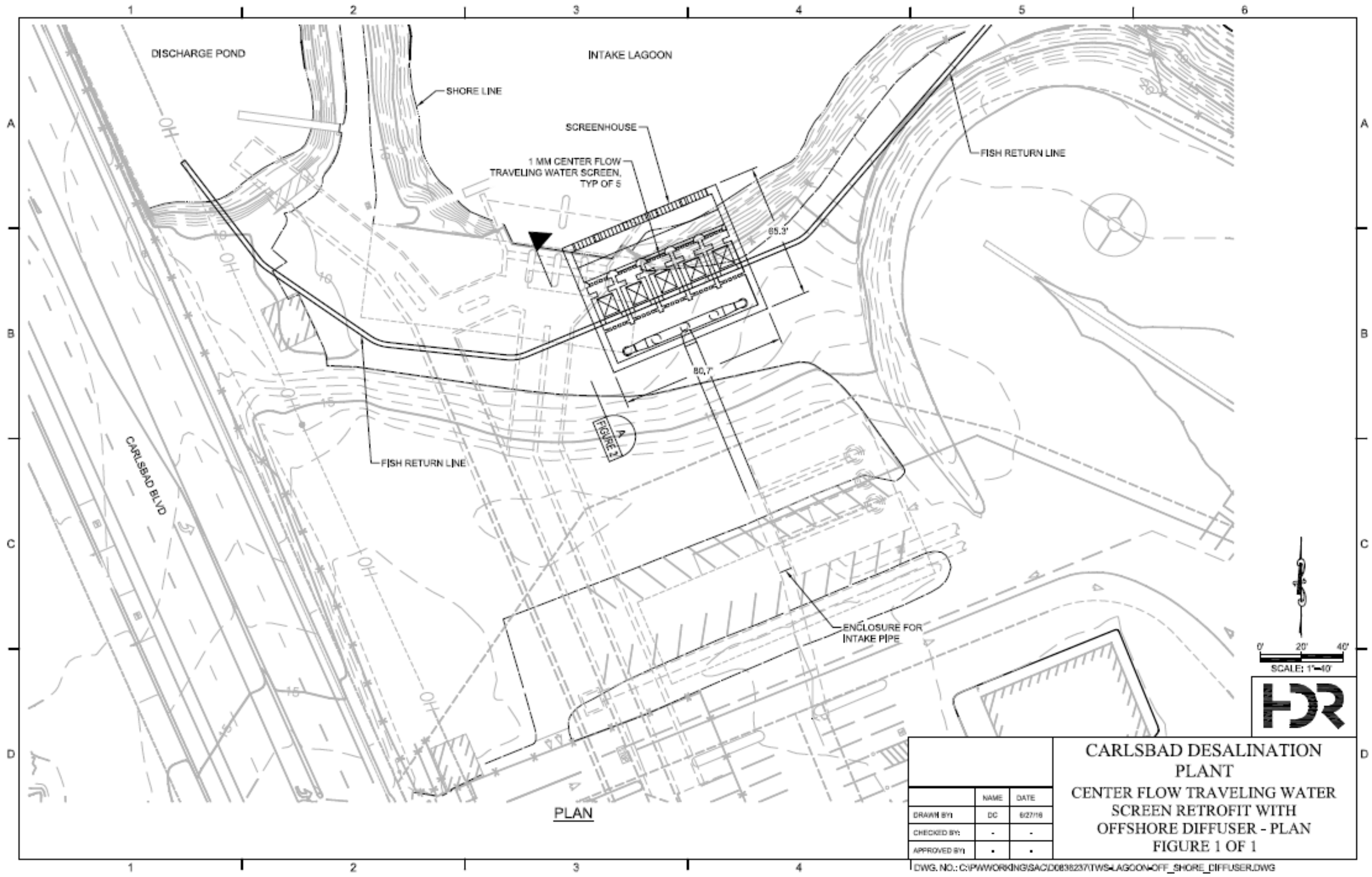

Figure 33. Lagoon-based Shoreline 1-mm traveling water screens with discharge diffuser for long-term stand-alone operation, plan view.

The New Screening Structure would be screened by five (four plus one redundant) screens. The redundant screen would be in service during normal operations. Screens would be BWT center-flow traveling water screens (or equal) with 1.0-mm mesh. The screens would be modified with fish protection features (fish lifting buckets on each screen basket, low pressure spraywash, and fish return system). The screens are designed for a through-screen velocity of 0.5 ft/sec or less with only four screens in service and 15% fouling. If all five screens are in service, the through-screen velocity would be well below 0.5 ft/sec. Each screen bay includes upstream and downstream stoplog slots to allow each bay to be dewatered and each screen isolated. All fish collected in the traveling screen fish buckets would be returned to either Agua Hedionda Lagoon or to the Pacific Ocean via the discharge pond. A Tee-shaped manifold with five inlets would convey flow from downstream of the screens to the SWRO Pump Station. Flow distributors are included upstream and downstream of the screens to create a more uniform flow through the screens and approaching the Tee-shaped manifold inlets.

Discharge Design

A 72” outfall pipeline extending approximately 4,000 feet offshore of the Agua Hedionda Lagoon mouth would convey the brine discharge from the SWRO building to the multiport diffuser system where four duck-bill diffuser ports spaced 100 feet apart would eject the brine into the water column at a high velocity to promote rapid diffusion and dispersion.

Installation of the outfall pipeline would require tunneling and pipeline placement under the existing EPS site, Carlsbad Boulevard, and approximately 4,000 linear feet of seafloor. Anchoring of the outfall pipeline to the seafloor would be coordinated to minimize impacts to the local reef and kelp beds offshore of the desalination plant. The spacing, number, and orientation of the four diffuser heads has been designed to maximize brine mixing in accordance with the provisions of the Desalination Amendment.

c. Technology

Intake Screening Technology

See Section 1.A.v.c for more details on the intake screening technology.

Discharge Diffuser Technology

See Section 1.A.ii.c for more details on the discharge technology.

3. Feasibility Analysis

A. Technical

i. 1-mm Offshore WWS Surface Intake with Flow Augmentation

The technical aspects of the offshore 1-mm WWS array with discharge flow augmentation are analyzed in greater detail below.

a. Site Constraints

Intake Site

The installation of a WWS array 4,000 feet offshore of the CDP presents construction-related site constraints. The intake pipeline would have to be tunneled from the plant to the offshore intake location in order to minimize impacts to benthic habitat. Placement of the WWS offshore would be accomplished with a derrick barge moored over the intake location.

Therefore, the schedule and duration of the installation effort is contingent upon the availability of a tunnel boring machine and an adequately sized derrick barge local to the area. The schedule duration will also rely, in part, on being able to do the work during a time of the year when the swells are small (most likely in spring to early summer).

At this location 4,000 feet offshore, the WWS array is a safe distance outside of the high energy surf zone at a depth of approximately 58 feet at MLLW (Figure 5). This depth also provides sufficient keel clearance for navigation.

In order to construct this offshore WWS array, a SLC lease of approximately 1.95 acres would be required. This area represents the footprint of the intake pipeline and the WWS array plus 5 feet on all sides of the installed equipment.

Discharge Site

The use of flow augmentation at this site does not present any technical constraints. There is sufficient space available to install the fish-friendly axial flow pumps and the related piping to route the dilution flow to the existing discharge tunnel at the EPS.

b. Equipment

Intake Equipment

The screening equipment required to construct the offshore long-term stand-alone CDP intake is commercially available and Poseidon has developed a preliminary cost estimate for the screens. Cylindrical WWS (or equal) with wide slot widths (3 to 9.5-mm) are a proven technology used widely throughout the world for screening large seawater flows; however, there are no data readily available on the performance of narrow-slot screens in fully marine environments. As a result, the biggest technical concern with the use of offshore WWS is the lack of information on the performance of narrow-slow WWS in a fully marine environment. A WWS with 1-mm slots has the potential to become clogged quickly under certain conditions. The fact that the installation location is 4,000 feet offshore introduces the complexity of not being able to use an onshore air burst technology due to the inefficiency of delivering compressed air that distance. Instead, the screens will have to be manually cleaned periodically by divers. In addition, an airburst flange could be provided on the screens to allow airbursting from a boat based compressor. A redundant screen will provide the ability to remove a screen for repair without affecting the intake flow rate and without exceeding the 0.5 ft/sec through-slot velocity.

Discharge Equipment

The use of flow augmentation will require the installation of fish-friendly axial flow pumps and the related piping to route the dilution flow to the existing discharge tunnel at the EPS. There are several types of axial flow fish-friendly pumps commercially available and one (Bedford Pumps or equal) has been recommended as an alternative.

ii. 1-mm Offshore WWS Surface Intake with Diffuser

The technical aspects of the offshore 1-mm WWS array with a discharge diffuser are analyzed in greater detail below.

a. Site Constraints

Intake Site

The installation of a WWS array 4,000 feet offshore of the CDP presents construction-related site constraints. The intake pipeline would have to be tunneled from the plant to the offshore intake location in order to minimize impacts to benthic habitat. Placement of the WWS offshore would be accomplished with a derrick barge moored over the intake location. Therefore, the schedule and duration of the installation effort is contingent upon the availability of a tunnel boring machine and an adequately sized derrick barge local to the area. The schedule duration will also rely, in part, on being able to do the work during a time of the year when the swells are small (most likely in spring to early summer).

At this location 4,000 feet offshore, the WWS array is a safe distance outside of the high energy surf zone at a depth of approximately 58 at MLLW (Figure 13). This depth also provides sufficient keel clearance for navigation.

In order to construct this offshore WWS array, a SLC lease of approximately 1.63 acres would be required. This area represents the footprint of the intake pipeline and the WWS array plus 5 feet on all sides of the installed equipment.

Discharge Site

The use of a multiport diffuser system at this site presents construction-related site constraints. The discharge pipeline would have to be tunneled from the plant to the offshore multiport diffuser system location in order to minimize impacts to benthic habitat. Therefore, the schedule and duration of the installation effort is contingent primarily upon the availability of a tunnel boring machine local to the area. The schedule duration will also rely, in part, on being able to do the work during a time of the year when the swells are small (most likely in spring to early summer).

In order to construct this offshore discharge diffuser system, a SLC lease of approximately 1.47 acres would be required. This area represents the footprint of the discharge pipeline with its integral diffuser ports plus 5 feet on all sides of the installed equipment.

b. Equipment

Intake Equipment

The screening equipment required to construct the offshore long-term stand-alone CDP intake is commercially available and Poseidon has developed a preliminary cost estimate for the screens. Cylindrical WWS (or equal) with wide slot widths (3 to 9.5-mm) are a proven technology used widely throughout the world for screening large seawater flows; however, there are no data readily available on the performance of narrow-slot screens in fully marine environments. As a result, the biggest technical concern with the use of offshore WWS is the lack of information on the performance of narrow-slow WWS in a fully marine environment. A WWS with 1-mm slots has the potential to become clogged quickly under certain conditions. The fact that the installation location is 4,000 feet offshore introduces the complexity of not being able to use an onshore air burst technology due to the inefficiency of delivering compressed air that distance. Instead, the screens will have to be manually cleaned periodically by divers. In addition, an airburst flange could be provided on the screens to allow airbursting from a boat based compressor. A redundant screen will provide the ability to remove a screen for repair without affecting the intake flow rate and without exceeding the 0.5 ft/sec through-slot velocity.

Discharge Equipment

The multiport diffuser system is typically custom-designed for each application. The pipeline leading to the offshore diffusers for the long term stand-alone CDP would be approximately 5,600 feet long (total of 4,000 feet offshore) and 72 inches in diameter. Consideration must be given to the impacts associated with the construction of a large offshore structure on benthic habitat. Tunneling under the seafloor will minimize benthic impacts.

iii. 1-mm Lagoon-Based WWS Surface Intake with Flow Augmentation

The technical aspects of the Lagoon-based 1-mm WWS array with discharge flow augmentation are analyzed in greater detail below.

a. Site Constraints

Intake Site

The hydrodynamics of the Lagoon present a substantial challenge to the reliable operation of WWS. By nature of its form, the principal velocities are focused in areas of constrictions (between the Lagoon basins and at the inlet from the Ocean). These areas are not conducive to WWS installations. Further, WWS installed near the existing EPS intake structure would not be sufficiently exposed to the ambient sweeping velocities that are critical to the efficient cleaning of air burst-cleaned WWS.

The installation of a WWS array in the Lagoon presents construction-related site constraints. The existing EPS intake structure at the Lagoon interface would have to be modified to create a new sealed bulkhead to accept the new intake pipeline. In addition, the intake pipeline would have to be buried from the new bulkhead to the withdrawal point approximately 100 feet offshore of the existing EPS intake structure.

Placement of the screens would be accomplished with a derrick barge moored over the intake location. Therefore, the schedule and duration of the installation effort is contingent upon the availability of an adequately sized derrick barge local to the area.

Poseidon has assumed that the minimum submergence required for the WWS array is 8 feet below MLLW.

In order to construct this Lagoon-based WWS array, an NRG lease of approximately 0.13 acres would be required. This area represents the footprint of the intake pipeline and the WWS array plus 5 feet on all sides of the installed equipment.

Discharge Site

The use of flow augmentation at this site does not present any technical constraints. There is sufficient space available to install a wet well between the existing intake tunnels and the SWRO Pump Station from which process and dilution flows can be drawn.

b. Equipment

Intake Equipment

Cylindrical WWS (or equal) with wide slot widths (3 to 9.5-mm) are a proven technology used widely throughout the world for screening large seawater flows; however, there are no data readily available on the performance of narrow-slot screens in fully marine environments. As a result, there are major technical concerns regarding the use of WWS in a dead-end Lagoon that does not have adequate sweeping currents to sweep dislodged debris from the screens.

Based on the potential installation location, we do not recommend the use of WWS since there is a high probability that debris will accumulate in the Lagoon, potentially compromising the performance of the intake and requiring more frequent dredging/debris removal efforts.

Discharge Equipment

The use of flow augmentation will require the installation of fish-friendly axial flow pumps and the related piping to route the dilution flow to the existing discharge tunnel at the EPS. There are several types of axial flow fish-friendly pumps commercially available and one (Bedford Pumps or equal) has been recommended as an alternative.

iv. 1-mm Lagoon-Based WWS Surface Intake with Diffuser

The technical aspects of the Lagoon-based 1-mm WWS array with discharge diffuser are analyzed in greater detail below.

a. Site Constraints

Intake Site

The hydrodynamics of the Lagoon present a substantial challenge to the reliable operation of WWS. By nature of its form, the principal velocities are focused in areas of constrictions (between the Lagoon basins and at the inlet from the Ocean). These areas are not conducive to WWS installations. Further, WWS installed near the existing EPS intake structure would not be sufficiently exposed to the ambient sweeping velocities that are critical to the efficient cleaning of air burst-cleaned WWS.

The installation of a WWS array in the Lagoon presents construction-related site constraints. The existing EPS intake structure at the Lagoon interface would have to be modified to create a new sealed bulkhead to accept the new intake pipeline. In addition, the intake pipeline would have to be buried from the new bulkhead to the withdrawal point approximately 100 feet offshore of the existing EPS intake structure.

Placement of the screens would be accomplished with a derrick barge moored over the intake location. Therefore, the schedule and duration of the installation effort is contingent upon the availability of an adequately sized derrick barge local to the area.

Poseidon has assumed that the minimum submergence required for the WWS array is 8 feet below MLLW.

In order to construct this Lagoon-based WWS array, an NRG lease of approximately 0.08 acres would be required. This area represents the footprint of the intake pipeline and the WWS array plus 5 feet on all sides of the installed equipment.

Discharge Site

The use of a multiport diffuser system at this site presents construction-related site constraints. The discharge pipeline would have to be tunneled from the plant to the offshore multiport diffuser system location in order to minimize impacts to benthic habitat. Therefore, the schedule and duration of the installation effort is contingent primarily upon the availability of a tunnel boring machine local to the area. The schedule duration will also rely, in part, on being able to do the work during a time of the year when the swells are small (most likely in spring to early summer).

In order to construct this offshore discharge diffuser system, a SLC lease of approximately 1.47 acres would be required. This area represents the footprint of the discharge pipeline with its integral diffuser ports plus 5 feet on all sides of the installed equipment.

b. Equipment

Intake Equipment

Cylindrical WWS (or equal) with wide slot widths (3 to 9.5-mm) are a proven technology used widely throughout the world for screening large seawater flows; however, there are no data readily available on the performance of narrow-slot screens in fully marine environments. As a result, there are major technical concerns regarding the use of WWS in a dead-end Lagoon that does not have adequate sweeping currents to sweep dislodged debris from the screens.

Based on the potential installation location, we do not recommend the use of WWS since there is a high probability that debris will accumulate in the Lagoon, potentially compromising the performance of the intake and requiring more frequent dredging/debris removal efforts.

Discharge Equipment

The multiport diffuser system is typically custom-designed for each application. The pipeline leading to the offshore diffusers for the long term stand-alone CDP would be approximately 5,600 feet long (total of 4,000 feet offshore) and 72 inches in diameter. Consideration must be given to the impacts associated with the construction of a large offshore structure on benthic habitat. Tunneling under the seafloor will minimize benthic impacts.

v. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Flow Augmentation

a. Site Constraints

Intake Site

The footprint available for the New Screening/Fish-friendly Pumping Structure is limited. Due to concerns over dewatering during construction, the existing invert elevation of the EPS intake tunnel (-15 feet) was maintained. Given the screening area required and the limitation on area available in which to construct, it is unlikely that it can be built while the EPS is still in service since a portion of the new structure may have to be built where components of the EPS intake structure currently exist.

A single fish return system would be sufficient for all nine screens in the New Screening/Fish-friendly Pumping Structure. The majority of the fish return pipe would be buried and would minimize aesthetic concerns. Two alternative fish return discharge locations are being considered (Figure 23). The terminus of the fish return routed to the Lagoon would be located approximately 205 feet from the existing EPS intake. The terminus of the fish return routed to the discharge pond would be just to the west of the discharge tunnel outlet (Figure 31).

In order to construct this Lagoon-based structure, an NRG lease of approximately 0.13 acres would be required. This area represents approximately half of the footprint of the structure which would fall outside of the existing easement.

Discharge Site

The use of flow augmentation at this site does not present the same technical constraints as described above for the discharge diffuser.

b. Equipment

Intake Equipment

The screening equipment required to construct the New Screening/Fish-friendly Pumping Structure is commercially available and Poseidon has received a preliminary cost estimate for the screens. The BWT center-flow traveling water screen (or equal) is a proven technology used widely throughout the world for screening large seawater flows. The equipment materials specified are marine grade to minimize corrosion and are designed with cleaning features to keep them clear of debris. The BWT screen design has numerous advantages over other fish-friendly traveling water screen designs including increased screening area associated with the two screening faces and the v-shaped screen baskets, elimination of debris carryover, and large screen height available to accommodate the increased invert elevation of the specified design.

Discharge Equipment

The use of flow augmentation will require the installation of fish-friendly axial flow pumps and the related piping to route the dilution flow to the existing discharge tunnel at the EPS. There are several types of axial flow fish-friendly pumps commercially available and one (Bedford Pumps or equal) has been recommended as an alternative.

vi. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Diffuser

a. Site Constraints

Intake Site

The footprint available for the New Screening Structure is limited. Due to concerns over dewatering during construction, the invert elevation was kept at no deeper than -15 feet. Given the screening area required and the limitation on area available in which to construct, it is unlikely that it can be built while the EPS is still in service since a portion of the new structure may have to be built where components of the EPS intake structure currently exist.

A single fish return system would be sufficient for all five screens in the New Screening Structure. The majority of the fish return pipe would be buried and would minimize aesthetic concerns. Two alternative fish return discharge locations are being considered (Figure 33). The terminus of the fish return routed to the Lagoon would be located approximately 205 feet from the existing EPS intake. The terminus of the fish return routed to the discharge pond would be just to the west of the discharge tunnel outlet (Figure 31).

In order to construct this Lagoon-based structure, an NRG lease of approximately 0.07 acres would be required. This area represents approximately half of the footprint of the structure which would fall outside of the existing easement.

Discharge Site

The use of a multiport diffuser system at this site presents construction-related site constraints. The discharge pipeline would have to be tunneled from the plant to the offshore multiport diffuser system location in order to minimize impacts to benthic habitat. Therefore, the schedule and duration of the installation effort is contingent primarily upon the availability of a tunnel boring machine local to the area. The schedule duration will also rely, in part, on being able to do the work during a time of the year when the swells are small (most likely in spring to early summer).

In order to construct this offshore discharge diffuser system, a SLC lease of approximately 1.47 acres would be required. This area represents the footprint of the discharge pipeline with its integral diffuser ports plus 5 feet on all sides of the installed equipment.

b. Equipment

Intake Equipment

The screening equipment required to construct the New Screening Structure is commercially available and Poseidon has received a preliminary cost estimate for the screens. See Section 2.A.v.b for more details on the intake equipment.

Discharge Equipment

See Section 2.A.iv.b for more details on the discharge equipment.

C. Economic

A detailed analysis of the life-cycle cost for the Expanded CDP subsurface intake/discharge alternatives is presented in Appendix OO. The findings of this analysis are included in Table 1. The life cycle costs provide a relative comparison of the net incremental cost and savings of each of the alternatives. Costs considered include permitting, design, land acquisition, financing, construction, operations, maintenance, mitigation, equipment replacement, insurance, taxes, management, and energy consumption over the lifetime of the facility and fixed capital and operating costs not recovered while the plant is out of service after 2018. Savings considered include operational savings due reduced chemical consumption, extended membrane life, and reduced membrane cleaning frequency that is applicable to the subsurface intake alternatives.

Table 1. Expanded CDP intake/discharge alternatives net incremental annual life-cycle cost/(savings) ($/year).

	Total Capital Cost	Fixed Capital and Operating Costs Not Recovered While Plant is Out of Service After 2018	Financing Period	Capital Charge	Out of Service Charge	O&M and Other Annual Costs	Total Annual Cost	Is Project Economically Feasible?
Alternatives	**$**	**$**	**Years**	**$/Year**	**$/Year**	**$/Year**	**$/Year**	**Yes/No**
Surface Screened Intake with Flow Augmentation	$47,725,035	$0	27.5	$3,968,806	$0	$4,455,035	**$8,423,840**	**Yes**
Surface Screened Intake with Multiport Diffuser	$427,267,380	$199,925,313	24	$37,360,094	$17,481,175	$6,790,828	**$61,632,098**	**No**
Subsurface Intake with Flow Augmentation	$1,039,567,521	$423,770,193	19.8	$100,205,412	$37,988,099	$20,965,196	**$159,158,707**	**No**
Subsurface Intake with Multiport Diffuser	$676,862,341	$242,696,411	23.2	$59,971,724	$21,509,330	$12,903,385	**$94,384,439**	**No**
Offshore Wedgewire Screen with Flow Augmentation	$284,137,047	$199,925,313	24	$24,844,348	$17,481,175	$6,566,745	**$48,892,269**	**No**
Offshore Wedgewire Screen with Diffuser	$575,435,533	$199,925,313	24	$50,315,591	$17,481,175	$8,211,320	**$76,008,086**	**No**
Lagoon Wedgewire Screen with Flow Augmentation	$125,595,622	$199,925,313	24	$10,982,283	$17,481,175	$5,246,746	**$33,710,204**	**No**
Lagoon Wedgewire Screen with Diffuser	$415,204,518	$199,925,313	24	$36,304,950	$17,481,175	$6,781,320	**$60,567,445**	**No**
Lagoon Traveling Screen with Flow Augmentation	$79,459,096	$199,925,313	24	$7,209,140	$17,481,175	$4,986,531	**$29,676,846**	**No**
Lagoon Traveling Screen with Diffuser	$405,778,290	$199,925,313	24	$35,466,357	$17,481,175	$6,719,356	**$59,666,888**	**No**

The findings of this analysis indicate that $94 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with SIG with the multiport diffuser alternative and $159 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with the SIG with flow augmentation alternative. The primary difference between these figures and the lifecycle costs of these alternatives shown in Appendix B is the inclusion of the fixed capital and operating costs not recovered while the plant is out of service after 2018.

Chapter III.M provides the following guidance for assessing the feasibility of subsurface intakes:

> *Subsurface intakes shall not be determined to be economically infeasible solely because subsurface intakes may be more expensive than surface intakes. Subsurface intakes may be determined to be economically infeasible if the additional costs or lost profitability associated with subsurface intakes, as compared to surface intakes, would render the desalination facility not economically viable.*

Thus, the Regional Water Board's determination of the economic feasibility of the SIG alternatives turns on the basis of whether the additional costs or lost profitability associated with these alternatives would render the desalination facility not economically viable. One measure of economic viability is whether the anticipated plant revenues would cover cost of one or both of the SIG alternatives.

The annual costs would be approximately $94 million per year for the subsurface intake with a multiport diffuser and approximately $159 million per year for the subsurface intake with flow augmentation. Absent an additional source of revenue, the SIG alternatives are economically infeasible.

The economic analysis summarized in Table 1 indicates that approximately $8 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with proposed surface water intake with flow augmentation. The annual cost of the other intake/discharge alternatives under consideration (WWS and lagoon-based intakes with flow augmentation or diffuser) range from $29 million to $76 million, rendering these alternatives economically infeasible.

D. Schedule

Each intake and outfall technology features unique engineering and constructability characteristics which will impact the individual project schedules for each. Alternatives including the SIG, for example, will require longer construction periods. Table 2 below presents a summary of the schedules for each of the intake/discharge alternatives considered. The time required for project completion ranged from 2.5 years for the proposed modifications to 10.2 years for the subsurface intake with flow augmentation, with the proposed modifications requiring less than half the implementation period of the next closest alternative. The potential delay costs (the fixed capital and fixed operating costs not recovered while the CDP was out of service) associated with the CDP potentially losing access to source water if the timeline for project completion extend beyond 2018, ranged from $0 for the proposed modifications to $424 million for the subsurface intake with flow augmentation.

Table 2. Summary of permitting, construction, and operating terms and potential duration without access to source water for all intake/discharge alternatives considered.

	Permitting and Property Acquisition	Construction, Commissioning and Startup	Total Time Required for Project Completion	Potential Duration CDP Is Without Source Water After 2018	Fixed Capital and Operating Costs Not Recovered While Plant is Out of Service After 2018	Project Capable of Being Accomplished in a Reasonable Period of Time?
Alternatives	**Years**	**Years**	**Years**	**Years**	**$**	**Yes/No**
Surface Screened Intake with Flow Augmentation	1	1.5	2.5	0	$0	Yes
Surface Screened Intake with Multiport Diffuser	3	3	6	3.5	$199,925,313	No
Subsurface Intake with Flow Augmentation	3	7.2	10.2	7.7	$423,770,193	No
Subsurface Intake with Multiport Diffuser	3	3.8	6.8	4.3	$242,696,411	No
Offshore Wedgewire Screen with Flow Augmentation	3	3	6	3.5	$199,925,313	No
Offshore Wedgewire Screen with Diffuser	3	3	6	3.5	$199,925,313	No
Lagoon Wedgewire Screen with Flow Augmentation	3	3	6	3.5	$199,925,313	No
Lagoon Wedgewire Screen with Diffuser	3	3	6	3.5	$199,925,313	No
Lagoon Traveling Screen with Flow Augmentation	3	3	6	3.5	$199,925,313	No
Lagoon Traveling Screen with Diffuser	3	3	6	3.5	$199,925,313	No

The improvements needed for the transition to long-term, stand-alone operation need to be in place in advance of the decommissioning of the EPS cooling water pumps in order to minimize the interruption in the output from the CDP. Depending on the intake/discharge alternative selected, the duration over which the CDP could potentially be without source water varies. The economic analysis included herein assumes the cooling water pumps would no longer be available to support CDP operations after December 31, 2018. During the absence of source water flow, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply and the owner of the CDP would need to finance ongoing fixed cost obligations (debt and equity payments, maintenance, utility charges) while the CDP is out of service.

E. Environmental

i. 1-mm Offshore WWS Surface Intake with Flow Augmentation

The Desalination Amendment provides that Poseidon may submit a proposal to the Regional Water Board for flow augmentation as an alternative brine discharge technology. Poseidon must demonstrate to the Regional Water Board that flow augmentation provides a comparable level of intake and mortality of all forms of marine life as a multiport diffuser system if wastewater dilution is not available. Poseidon must evaluate all of the individual and cumulative effects of flow augmentation on the intake and mortality of all forms of marine life, including (where applicable):

- Intake-related entrainment impacts using an ETM/APF approach;
- Estimate degradation of all forms of marine life from elevated salinity within the BMZ, including osmotic stresses, the size of the impacted area, and the duration that all forms of marine life are exposed to the toxic conditions;
- Estimate intake and mortality of all forms of marine life that occurs as a result of water conveyance, in-plant turbulence or mixing and shearing stress at the point of discharge.

The Desalination Amendment provides that the owner or operator of a desalination facility that proposes flow augmentation using a surface water intake may submit a proposal to the Regional Water Board for approval of an alternative BMZ not to exceed 200 meters (656 feet.) laterally from the discharge structure. Poseidon must demonstrate, in accordance with the criteria listed above, that the combination of the alternative BMZ and flow augmentation using a surface water intake provide a comparable level of intake and mortality of all forms of marine life as the combination of the multiport diffuser system and the BMZ required for the discharge (100 meters [328 feet] laterally from the points of discharge). In addition to the analysis described above, Poseidon must also evaluate the individual and cumulative effects of the alternative BMZ on the intake and mortality of all forms of marine life.

The screened surface intake under consideration would be located offshore in the Pacific Ocean. Feedwater and flow augmentation for the Expanded CDP would be withdrawn through a new offshore 1-mm WWS array. This differs from the current co-located operation which draws flow from Agua Hedionda Lagoon. Organisms that could be potentially impacted by the surface water intake include those occurring near the water withdrawal point offshore. These are typically pelagic fishes commonly reported in the nearshore water-column habitat, including some species important to the commercial and sport fishing industries.

a. Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The offshore screens for the long-term stand-alone CDP intake/discharge structure would be designed as passive screens with a through-screen velocity that is 0.5 ft/sec or less. As passive screens, no active handling of fish would be required. Based on the passive design and the low through-slot velocity, the offshore WWS would meet the Desalination Amendment requirement for minimizing impingement at the New Screening/Fish-friendly Pumping Structure for the CDP.

b. Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the offshore WWS.

Based on intake-related entrainment through the 1-mm offshore WWS (127 MGD), the calculated APF associated with the operation of the intake serving the SWRO system is 39.2 acres (assuming 100% mortality) using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment. Each of the factors that could potentially contribute to entrainment mortality in the flow augmentation system is discussed in the sections below.

Pump Passage (Pressure and Blade Strike)

Entrained organisms would be exposed to hydraulic- and mechanical-related stresses passing through the flow augmentation pumps. In general, the stresses associated with pump passage include pressure changes (magnitude and rate), blade strike, mechanical grinding and shear. Most of the information on the effects of these stresses on fishes is from the hydropower industry.

Regarding pressure, gas-filled cavities within fish can be susceptible to pressure-induced damage (barotrauma). However, the low head design of the pumps (12 feet) should minimize the risk of barotrauma. This low head equates to a change in pressure of approximately 5.2 psi.

The low lift pumps specified for the CDP flow augmentation system would be fish-friendly axial flow Bedford pumps. These pumps have been designed and used to safely pass live fish for pumping applications worldwide. The pump specified for the CDP has been tested with juvenile and adult fish at a full scale for fish-friendliness (Vis and Kemper 2012). A total of 373 fish were passed through the pump operating at 330 rpm discharging 1.3m^3/sec (46 ft^3/sec) and survival was 100%. Only minor injuries (e.g., descaling, hemorrhage) were noted in the study results. Given the favorable performance for larger fish, smaller life stages are also presumed to fare well during pump passage.

Shear and Turbulence

Shear and turbulence are forces to which organisms entrained in the dilution flow would be exposed. These forces exist where water velocities change over a given distance; therefore, the greatest shear forces are likely to be encountered during pump passage and during mixing of the brine and dilution flows. The flow augmentation pumps would be operated at approximately 370 rpm to lift water approximately 12 feet. This speed is comparable to the speed (330 rpm) at which fish survival testing (Vis and Kemper 2012) was conducted. The location of entrained organisms within the pump passage would affect whether they would be exposed to the areas of high shear (typically near solid surfaces in a pump impeller). The low lift fish-friendly axial flow Bedford pumps are designed to minimize these impacts. Similarly, the location of entrained organisms when the dilution and brine flows are mixed would affect whether they would be exposed to areas of high shear in the discharge tunnel. The mixing point is being designed to minimize the creation of high shear zones while still promoting efficient mixing of the two flows.

Osmotic Stress

Osmotic stress results from the exposure of organisms to elevated salinity. The critical measure of risk is the exposure profile: the duration of exposure and the magnitude of increased salinity. The duration of exposure to elevated salinity in the CDP in-plant dilution system has been modeled and biological assays have been conducted by Poseidon to evaluate salinity tolerances for various key indicator species. Each effort is described in more detail below.

Hydrodynamic and CFD Modeling

Hydrodynamic modeling was conducted by Dr. Scott Jenkins (Report of Waste Discharge Appendix C) and Alden Research Laboratory (Report of Waste Discharge Appendix L) to determine the duration of larval exposure to elevated salinity. Table 3 presents the matrix of durations based on varying flows at the CDP during average ocean conditions. These exposure durations formed the basis of the biological assays conducted during Nautilus' salinity tolerance testing discussed below.

Table 3. Ichthyoplankton exposure durations.

Total Discharge Flow Rate	Total Discharge Salinity Level	Time Exposure for Salinity in Discharge Tunnel	Time Exposure for Salinity from Discharge Tunnel to BMZ (35.5 ppt)	Time Exposure for Salinity from BMZ (35.5 ppt) to Average Ambient Ocean (33.5 ppt)
184 MGD	44 ppt	2.8 min	24.2+ 5.5	26.5 min
238 MGD	42 ppt	2.2 min	22.2 + 5.5	24.5 min
304 MGD	40 ppt	1.7 min	20.7+ 5.5	21.9 min

[1.] Residence time in the discharge pond ranges from approximately one minute to ten minutes, with a median residence time of 5.5 minutes.

Salinity Tolerance Testing

Poseidon contracted with Nautilus Environmental (Nautilus) (Report of Waste Discharge Appendix I) to assess the potential effects of varying salinity levels on sensitive larval-stage marine organisms. The study design was focused on potential effects due to salinity fluctuations on organisms traveling into the intake from ambient seawater salinity in the receiving environment, through the brine dilution systems of the CDP, and then being discharged back into the receiving water. Species and endpoints evaluated for this study included red abalone (*Haliotis rufescens*) development and purple sea urchin (*Strongylocentrotus purpuratus*) development. These species were identified as two of the most sensitive to elevated salinity levels relative to other accepted monitoring species in the Ocean Plan, based on previous studies using standard EPA whole effluent toxicity (WET) tests (Philips et al. 2012).

The goal of this study was to determine the salinity-induced adverse effects to these organisms as they travel through the flow augmentation system. The study was designed to assess several potential operating scenarios involving differing salinity levels and residence times that were within the plant's operational capabilities. Procedures were established to simulate the salinity fluctuations an organism might experience as it moves through the brine dilution system, encountering elevated salinity as the brine discharge is mixed with seawater from the flow augmentation system then a reduction in salinity to 35.5 ppt as it travels through the discharge system to the edge of the BMZ, and finally a reduction from 35.5 ppt to ambient salinity.

There were three distinct phases common to each exposure scenario; only the maximum salinity and duration of each phase were varied:

- Phase 1 consisted of simulation of initial brine mixing with seawater from the flow augmentation system. The salinity was raised from ambient seawater (33.5 ppt) by adding 67 ppt brine at a rate calculated to reach the desired salinity within approximately one minute, and then held there for a specified amount of time depending on the scenario being tested.
- Phase 2 involved simulation of the dilution that occurs in the BMZ technology. Continuous addition of ambient seawater at a rate calculated to reach 35.5 ppt within a specified period.
- Phase 3 represents the return to ambient seawater salinity from 35.5 ppt, with the rate of return varied according to specification.

Results of the bench-top exposure trials are presented below in Table 4.

Table 4. Summary of results for bench-top exposure scenarios.

Scenario #	**Scenario Description**	**Test Date**	**Species Tested**	**Mean Normal Development**			
				Sample	**Phase 1**	**Phase 2**	**Phase 3**
1	P1: 44 ppt for 2.8 minutes; P2: 39 min.; P3: 30 min.	2/6/15	Abalone Development	Control	83.8	77.7	80.5
				Brine Exposure	76.7*	79.1	78.8
1	P1: 44 ppt for 2.8 min.; P2: 39 min.; P3: 30 min.	2/17/15	Urchin Development	Control	93.7	92.0	89.3
				Brine Exposure	91.3	90.3	91.3
2	P1: 42 ppt for 2.2 min.; P2: 36 min.; P3: 30 min.	1/30/15	Abalone Development	Control	94.0	93.7	94.3
				Brine Exposure	95.7	92.7	91.7
3	P1: 40 ppt for 1.7 min.; P2: 34 min.; P3: 30 min.	1/22/15	Abalone Development[a]	Control[a]	66.0	61.0	67.3
				Brine Exposure	68.5	67.0	60.3

P1, P2, P3 = Phase 1, 2, and 3

* An asterisk indicates a statistically significant decrease compared to the control ($p < 0.05$)

[a] The abalone test Scenario #3 conducted on January 22 did not meet the 80% test acceptability criterion for normal development; see QA section.

In summary, the brine dilution toxicity study focused on the species that is most sensitive to elevated salinity and concluded that these species experienced no significant toxic effects after being exposed elevated salinity conditions similar those that would exist during transit through proposed flow augmentation system offshore to the location where the salinity of the discharge would be match the surrounding seawater.

Notwithstanding the expected high rate of survival of all forms of marine life exposed to the cumulative effects of the flow augmentation system, for the purposes of demonstrating to the Regional Water Board that this technology provides a comparable level of intake and mortality of all forms of marine life to that of the multiport diffuser system, Poseidon has conservatively assumed the worst case outcome -- 100% mortality of all organisms passing through the flow augmentation system. Flow augmentation is expected to require 171 MGD of seawater for brine dilution purposes. Therefore, 171 MGD represents the volume of water, and associated ichthyoplankton, that Poseidon has assumed would be subject to 100% mortality. The calculated APF associated with the operation of the flow augmentation system is 92.0 acres using the methodology set forth in Appendix E of the OPA staff report (Report of Waste Discharge Appendix K).

c. Brine Mixing Zone

The BMZ, for the CDP is a 200 meter (656 foot) semi-circle originating from the terminus of the discharge channel in the ocean. Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 15.5 acres.

ii. **1-mm Offshore WWS Surface Intake with Diffuser**

The screened surface intake under consideration would be located offshore in the Pacific Ocean. Feedwater for the Expanded CDP would be withdrawn through a new offshore 1-mm WWS array. This differs from the current co-located operation which draws flow from Agua Hedionda Lagoon. Similarly, the discharge diffuser will be located offshore. Therefore, organisms that could be potentially impacted by the surface water intake and the discharge diffuser include those occurring near the water withdrawal and discharge points offshore. These are typically pelagic fishes commonly reported in the nearshore water-column habitat, including some species important to the commercial and sport fishing industries.

a. Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The offshore WWS for the long-term stand-alone CDP intake/discharge structure are designed as passive screens with a through-screen velocity that is 0.5 ft/sec or less. As passive screens, no active handling of fish is required. Based on the passive design and the low through-slot velocity, the offshore WWS would meet the Desalination Amendment requirement for minimizing impingement at the New Screening Structure for the CDP.

b. Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the offshore WWS.

Based on intake-related entrainment through the 1-mm offshore WWS (127 MGD), the calculated APF associated with the operation of the intake serving the SWRO system is 39.2 acres (assuming 100% mortality) using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment.

Entrainment relative to a discharge diffuser refers to secondary entrainment of ambient organisms in the ocean water entrained into the diffuser jets. The Substitute Environmental Documentation (SED) states in section 8.6.2.2.1 that "*organisms that are entrained into the brine discharge may experience high levels of shear stress for short durations, which is thought to cause some mortality*." In addition to shear stress, the ambient organisms would be exposed to osmotic stress associated with the higher salinity brine plume. Each of these factors that could potentially contribute to entrainment mortality in the discharge diffuser system is discussed in the section below.

Shear and Turbulence

As cited in the SED, modeling results from Foster et al. (2013) indicated that "*23 percent of the total entrained volume of dilution water may be exposed to lethal turbulence*." and more specifically, the SWRCB (2014) states in the SED that "*we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence*".

Under long term stand-alone operation, the diffuser would discharge 67 MGD of effluent (60 MGD brine and 7 MGD treated backwash water from the pretreatment filters) into the receiving water. The salinity of the effluent would be 65 ppt. In order to dilute the 67 MGD (at 65 ppt) to the receiving water limit of 35.5 ppt (2 ppt above background of 33.5 ppt), 945 MGD of dilution water would be entrained. Of the total dilution flow entrained, 23% (or 217 MGD) would expose ambient ichthyoplankton to lethal levels of shear. The duration of exposure to lethal shear in the CDP discharge diffuser plume is short: 10-50 seconds (per section 8.5.1.2 of the SED). Since there are no empirical data available on mortality caused by the diffuser jet, the SED states that "*until additional data are available, we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence.*"

Based on intake-related entrainment through the WWS (127 MGD), the calculated APF associated with the operation of the offshore WWS intake and the offshore diffuser are 39.2 acres and 67 acres, respectively, for a total of 106.2 acres using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment.

Osmotic Stress

Osmotic stress results from the exposure of organisms to elevated salinity. The critical measure of risk for an open-ocean diffuser system is the exposure profile: the duration of exposure and the area within which salinity is above critical thresholds for key indicator species. The duration of exposure and a salinity map can be estimated through modeling. Relative to the Screened Intake with Discharge Flow Augmentation alternative presented above, the duration of exposure for organisms entrained in the discharge plume would be less than that of organisms entrained through the flow augmentation system.

c. Brine Mixing Zone

The BMZ BMZ, for the CDP is a circle with a radius of 100 meters (328 feet) originating from the discharge diffuser ports in the ocean. The discharge diffuser system will be comprised of four duckbill diffuser spaced approximately 100 feet apart (Figure 9). Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 14.4 acres.

iii. **1-mm Lagoon-Based WWS Surface Intake with Flow Augmentation**

The Desalination Amendment provides that Poseidon may submit a proposal to the Regional Water Board for flow augmentation as an alternative brine discharge technology. Poseidon must demonstrate to the Regional Water Board that flow augmentation provides a comparable level of intake and mortality of all forms of marine life as a multiport diffuser system since wastewater dilution is not available. Poseidon must evaluate all of the individual and cumulative effects of flow augmentation on the intake and mortality of all forms of marine life, including (where applicable):

- Intake-related entrainment impacts using an ETM/APF approach;

- Estimate degradation of all forms of marine life from elevated salinity within the BMZ, including osmotic stresses, the size of the impacted area, and the duration that all forms of marine life are exposed to the toxic conditions;
- Estimate intake and mortality of all forms of marine life that occurs as a result of water conveyance, in-plant turbulence or mixing and shearing stress at the point of discharge.

The Desalination Amendment provides that the owner or operator of a desalination facility that proposes flow augmentation using a surface water intake may submit a proposal to the Regional Water Board for approval of an alternative BMZ not to exceed 200 meters (656 feet.) laterally from the discharge structure. Poseidon must demonstrate, in accordance with the criteria listed above, that the combination of the alternative BMZ and flow augmentation using a surface water intake provide a comparable level of intake and mortality of all forms of marine life as the combination of the multiport diffuser system and the BMZ required for the discharge (100 meters (328 feet) laterally from the points of discharge). In addition to the analysis described above, Poseidon must also evaluate the individual and cumulative effects of the alternative BMZ on the intake and mortality of all forms of marine life.

The screened surface intake under consideration would be located within the Lagoon. Feedwater and flow augmentation for the Expanded CDP would be withdrawn through a new 1-mm WWS array. The organisms that could be potentially impacted by the surface water intake include those occurring near the water withdrawal point. Previously entrainment sampling indicates that gobies and blennies are the dominant taxa.

a. Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The WWS in the array for the long-term stand-alone CDP intake/discharge structure are designed as passive screens with a through-screen velocity that is 0.5 ft/sec or less. As passive screens, no active handling of fish is required. Based on the passive design and the low through-slot velocity, the WWS would meet the Desalination Amendment requirement for minimizing impingement at the New Screening/Fish-friendly Pumping Structure for the CDP.

b. Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the offshore WWS.

Based on intake-related entrainment through the process water screens (127 MGD), the calculated APF is 36 acres. Based on intake-related entrainment through the flow augmentation system (171 MGD), the calculated APF is 48 acres. The total APF is 84 acres using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment. Each of the factors that could potentially contribute to entrainment mortality in the flow augmentation system is discussed in the sections below.

Pump Passage (Pressure and Blade Strike)

Entrained organisms would be exposed to hydraulic- and mechanical-related stresses passing through the flow augmentation pumps. In general, the stresses associated with pump passage include pressure changes (magnitude and rate), blade strike, mechanical grinding and shear. Most of the information on the effects of these stresses on fishes is from the hydropower industry.

Regarding pressure, gas-filled cavities within fish can be susceptible to pressure-induced damage (barotrauma). However, the low head design of the pumps (12 feet) should minimize the risk of barotrauma. This low head equates to a change in pressure of approximately 5.2 psi.

The low lift pumps specified for the CDP flow augmentation system would be fish-friendly axial flow Bedford pumps. These pumps have been designed and used to safely pass live fish for pumping applications worldwide. The pump specified for the CDP has been tested with juvenile and adult fish at a full scale for fish-friendliness (Vis and Kemper 2012). A total of 373 fish were passed through the pump operating at 330 rpm discharging 1.3m^3/sec (46 ft^3/sec) and survival was 100%. Only minor injuries (e.g., descaling, hemorrhage) were noted in the study results. Given the favorable performance for larger fish, smaller life stages are also presumed to fare well during pump passage.

Shear and Turbulence

Shear and turbulence are forces to which organisms entrained in the dilution flow would be exposed. These forces exist where water velocities change over a given distance; therefore, the greatest shear forces are likely to be encountered during pump passage and during mixing of the brine and dilution flows. The flow augmentation pumps would be operated at approximately 370 rpm to lift water approximately 12 feet. This speed is comparable to the speed (330 rpm) at which fish survival testing (Vis and Kemper 2012) was conducted. The location of entrained organisms within the pump passage would affect whether they would be exposed to the areas of high shear (typically near solid surfaces in a pump impeller). The low lift fish-friendly axial flow Bedford pumps are designed to minimize these impacts. Similarly, the location of entrained organisms when the dilution and brine flows are mixed would affect whether they would be exposed to areas of high shear in the discharge tunnel. The mixing point is being designed to minimize the creation of high shear zones while still promoting efficient mixing of the two flows.

Osmotic Stress

See Section 2.E.i.b for details on Osmotic stress in the flow augmentation system.

c. Brine Mixing Zone

The BMZ, for the CDP is a 200 meter (656 foot) semi-circle originating from the terminus of the discharge channel in the ocean. Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 15.5 acres.

iv. 1-mm Lagoon-Based WWS Surface Intake with Diffuser

The screened surface intake under consideration would be located offshore in the Lagoon. Feedwater for the Expanded CDP would be withdrawn through a new 1-mm WWS array. Therefore, organisms that could be potentially impacted by the surface water intake and the discharge diffuser include those occurring in the Lagoon and offshore at the discharge location. The organisms in the Lagoon that could be potentially impacted by the surface water intake include principally gobies and blennies. Offshore near the diffuser location is dominated primarily by nearshore pelagic fishes, including some species important to the commercial and sport fishing industries.

a. Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The WWS in the array for the long-term stand-alone CDP intake/discharge structure are designed as passive screens with a through-screen velocity that is 0.5 ft/sec or less. As passive screens, no active handling of fish is required. Based on the passive design and the low through-slot velocity, the offshore WWS would meet the Desalination Amendment requirement for minimizing impingement at the New Screening Structure for the CDP.

b. Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the offshore WWS.

Based on intake-related entrainment through the 1-mm WWS (127 MGD), the calculated APF associated with the operation of the intake serving the SWRO system is 36 acres (assuming 100% mortality) using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment.

Entrainment relative to a discharge diffuser refers to secondary entrainment of ambient organisms in the ocean water entrained into the diffuser jets. The Substitute Environmental Documentation (SED) states in section 8.6.2.2.1 that "*organisms that are entrained into the brine discharge may experience high levels of shear stress for short durations, which is thought to cause some mortality*." In addition to shear stress, the ambient organisms would be exposed to osmotic stress associated with the higher salinity brine plume. Each of these factors that could potentially contribute to entrainment mortality in the discharge diffuser system is discussed in the section below.

Shear and Turbulence

As cited in the SED, modeling results from Foster et al. (2013) indicated that "*23 percent of the total entrained volume of dilution water may be exposed to lethal turbulence*." and more specifically, the SWRCB (2014) states in the SED that "*we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence*".

Under long term stand-alone operation, the diffuser would discharge 67 MGD of effluent (60 MGD brine and 7 MGD treated backwash water from the pretreatment filters) into the receiving water. The salinity of the effluent would be 65 ppt. In order to dilute the 67 MGD (at 65 ppt) to the receiving water limit of 35.5 ppt (2 ppt above background of 33.5 ppt), 945 MGD of dilution water would be entrained. Of the total dilution flow entrained, 23% (or 217 MGD) would expose ambient ichthyoplankton to lethal levels of shear. The duration of exposure to lethal shear in the CDP discharge diffuser plume is short: 10-50 seconds (per section 8.5.1.2 of the SED). Since there are no empirical data available on mortality caused by the diffuser jet, the SED states that "*until additional data are available, we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence.*"

The calculated APF associated with the operation of the offshore diffuser is 67 acres. Along with the 36 acres required to mitigate the intake-related entrainment, the total acreage required to offset entrainment-related (intake and discharge) mortality is 103 acres (36 plus 67 acres). This acreage was calculated using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment.

Osmotic Stress

Osmotic stress results from the exposure of organisms to elevated salinity. The critical measure of risk for an open-ocean diffuser system is the exposure profile: the duration of exposure and the area within which salinity is above critical thresholds for key indicator species. The duration of exposure and a salinity map can be estimated through modeling. Relative to the Screened Intake with Discharge Flow Augmentation alternative presented above, the duration of exposure for organisms entrained in the discharge plume would be less than that of organisms entrained through the flow augmentation system.

c. Brine Mixing Zone

The BMZ, for the CDP is a circle with a radius of 100 meters (328 feet) originating from the discharge diffuser ports in the ocean. The discharge diffuser system will be comprised of four duckbill diffuser spaced approximately 100 feet apart (Figure 9). Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 14.4 acres.

v. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Flow Augmentation

The Desalination Amendment provides that Poseidon may submit a proposal to the Regional Water Board for flow augmentation as an alternative brine discharge technology. Poseidon must demonstrate to the Regional Water Board that flow augmentation provides a comparable level of intake and mortality of all forms of marine life as a multiport diffuser system since wastewater dilution is not available. Poseidon must evaluate all of the individual and cumulative effects of flow augmentation on the intake and mortality of all forms of marine life, including (where applicable):

- Intake-related entrainment impacts using an ETM/APF approach;

- Estimate degradation of all forms of marine life from elevated salinity within the BMZ, including osmotic stresses, the size of the impacted area, and the duration that all forms of marine life are exposed to the toxic conditions;
- Estimate intake and mortality of all forms of marine life that occurs as a result of water conveyance, in-plant turbulence or mixing and shearing stress at the point of discharge.

The Desalination Amendment provides that the owner or operator of a desalination facility that proposes flow augmentation using a surface water intake may submit a proposal to the Regional Water Board for approval of an alternative BMZ not to exceed 200 meters (656 feet.) laterally from the discharge structure. Poseidon must demonstrate, in accordance with the criteria listed above, that the combination of the alternative BMZ and flow augmentation using a surface water intake provide a comparable level of intake and mortality of all forms of marine life as the combination of the multiport diffuser system and the BMZ required for the discharge (100 meters (328 feet) laterally from the points of discharge). In addition to the analysis described above, Poseidon must also evaluate the individual and cumulative effects of the alternative BMZ on the intake and mortality of all forms of marine life.

The screened surface intake under consideration would be located within the Lagoon. Feedwater and flow augmentation for the Expanded CDP would be withdrawn through a new 1-mm New Screening/Fish-friendly Pumping Structure. The organisms that could be potentially impacted by the surface water intake include those occurring near the water withdrawal point. Previously entrainment sampling indicates that gobies and blennies are the dominant taxa.

a. Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The screens for the New Screening/Fish-friendly Pumping Structure at the long-term stand-alone CDP are designed for 0.5 ft/sec or less through-screen velocity and would therefore meet the Desalination Amendment requirement for minimizing impingement at the New Screening/Fish-friendly Pumping Structure for the CDP.

b. Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the screens in the New Screening/Fish-friendly Pumping Structure.

Based on intake-related entrainment through the process water screens (128 MGD), the calculated APF is 36.3 acres. Based on intake-related entrainment through the flow augmentation system (171 MGD), the calculated APF is 48 acres. The total APF is 84.3 acres using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment. Each of the factors that could potentially contribute to entrainment mortality in the flow augmentation system is discussed in the sections below.

Pump Passage (Pressure and Blade Strike)

Entrained organisms would be exposed to hydraulic- and mechanical-related stresses passing through the flow augmentation pumps. In general, the stresses associated with pump passage include pressure changes (magnitude and rate), blade strike, mechanical grinding and shear. Most of the information on the effects of these stresses on fishes is from the hydropower industry.

Regarding pressure, gas-filled cavities within fish can be susceptible to pressure-induced damage (barotrauma). However, the low head design of the pumps (12 feet) should minimize the risk of barotrauma. This low head equates to a change in pressure of approximately 5.2 psi.

The low lift pumps specified for the CDP flow augmentation system would be fish-friendly axial flow Bedford pumps. These pumps have been designed and used to safely pass live fish for pumping applications worldwide. The pump specified for the CDP has been tested with juvenile and adult fish at a full scale for fish-friendliness (Vis and Kemper 2012). A total of 373 fish were passed through the pump operating at 330 rpm discharging 1.3m^3/sec (46 ft^3/sec) and survival was 100%. Only minor injuries (e.g., descaling, hemorrhage) were noted in the study results. Given the favorable performance for larger fish, smaller life stages are also presumed to fare well during pump passage.

Shear and Turbulence

Shear and turbulence are forces to which organisms entrained in the dilution flow would be exposed. These forces exist where water velocities change over a given distance; therefore, the greatest shear forces are likely to be encountered during pump passage and during mixing of the brine and dilution flows. The flow augmentation pumps would be operated at approximately 370 rpm to lift water approximately 12 feet. This speed is comparable to the speed (330 rpm) at which fish survival testing (Vis and Kemper 2012) was conducted. The location of entrained organisms within the pump passage would affect whether they would be exposed to the areas of high shear (typically near solid surfaces in a pump impeller). The low lift fish-friendly axial flow Bedford pumps are designed to minimize these impacts. Similarly, the location of entrained organisms when the dilution and brine flows are mixed would affect whether they would be exposed to areas of high shear in the discharge tunnel. The mixing point is being designed to minimize the creation of high shear zones while still promoting efficient mixing of the two flows.

Osmotic Stress

See Section 2.E.i.b for details on Osmotic stress in the flow augmentation system.

c. Brine Mixing Zone

The BMZ, for the CDP is a 200 meter (656 foot) semi-circle originating from the terminus of the discharge channel in the ocean. Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 15.5 acres.

vi. **1-mm Lagoon-Based Shoreline TWS Surface Intake with Diffuser**

The screened surface intake under consideration would be located within the Lagoon. Feedwater for the Expanded CDP would be withdrawn through a New 1-mm Screening Structure. The organisms that could be potentially impacted by the surface water intake include those occurring near the water withdrawal point. Previously entrainment sampling indicates that gobies and blennies are the dominant taxa.

a. Impingement

Impingement is the pinning of larger organisms against the screen mesh by the flow of the withdrawn water. The magnitude of impingement losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion impinged) and the subsequent mortality of those organisms (referred to as impingement mortality or IM).

Intake velocity is commonly accepted to be the strongest predictor of impingement. Furthermore, a through-screen velocity of 0.5 ft/sec or less has been identified for being protective of impingeable sized fish. Per the Desalination Amendment language at 2.d.(1)(c)iv., the SWRCB has prescribed a through-screen velocity no greater than 0.5 ft/sec in order to minimize impingement at surface water desalination intakes.

The screens for the New Screening Structure at the long-term stand-alone CDP are designed for 0.5 ft/sec or less through-screen velocity and would therefore meet the Desalination Amendment requirement for minimizing impingement at the New Screening Structure for the CDP.

b. Entrainment

Entrainment is the passage of smaller organisms through the screening mesh. The magnitude of entrainment losses for any species from intake operation is a function of the involvement of the species with the intake (number or proportion entrained) and the subsequent mortality of those organisms as they pass through the process equipment (referred to as entrainment mortality).

Per the Desalination Amendment language at 2.d.(1)(c)ii., the SWRCB has prescribed screens with 1.0-mm mesh in order to reduce entrainment at surface water desalination intakes. In accordance with the Desalination Amendment, Poseidon has selected a 1.0-mm slot width for the offshore WWS.

Based on intake-related entrainment through the 1-mm TWS (128 MGD), the calculated APF associated with the operation of the intake serving the SWRO system is 36.3 acres (assuming 100% mortality) using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment.

Entrainment relative to a discharge diffuser refers to secondary entrainment of ambient organisms in the ocean water entrained into the diffuser jets. The Substitute Environmental Documentation (SED) states in section 8.6.2.2.1 that "*organisms that are entrained into the brine discharge may experience high levels of shear stress for short durations, which is thought to cause some mortality*." In addition to shear stress, the ambient organisms would be exposed to osmotic stress associated with the higher salinity brine plume. Each of these factors that could potentially contribute to entrainment mortality in the discharge diffuser system is discussed in the section below.

Shear and Turbulence

As cited in the SED, modeling results from Foster et al. (2013) indicated that "*23 percent of the total entrained volume of dilution water may be exposed to lethal turbulence*." and more specifically, the SWRCB (2014) states in the SED that "*we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence*".

Under long term stand-alone operation, the diffuser would discharge 67 MGD of effluent (60 MGD brine and 7 MGD treated backwash water from the pretreatment filters) into the receiving water. The salinity of the effluent would be 65 ppt. In order to dilute the 67 MGD (at 65 ppt) to the receiving water limit of 35.5 ppt (2 ppt above background of 33.5 ppt), 945 MGD of dilution water would be entrained. Of the total dilution flow entrained, 23% (or 217 MGD) would expose ambient ichthyoplankton to lethal levels of shear. The duration of exposure to lethal shear in the CDP discharge diffuser plume is short: 10-50 seconds (per section 8.5.1.2 of the SED). Since there are no empirical data available on mortality caused by the diffuser jet, the SED states that "*until additional data are available, we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence.*"

The calculated APF associated with the operation of the offshore diffuser is 67 acres. Along with the 36.3 acres required to mitigate the intake-related entrainment, the total acreage required to offset entrainment-related (intake and discharge) mortality is 103.3 acres (36.3 plus 67 acres). This acreage was calculated using the methodology set forth in Appendix E of the Staff Report for the Desalination Amendment.

Osmotic Stress

Osmotic stress results from the exposure of organisms to elevated salinity. The critical measure of risk for an open-ocean diffuser system is the exposure profile: the duration of exposure and the area within which salinity is above critical thresholds for key indicator species. The duration of exposure and a salinity map can be estimated through modeling. Relative to the Screened Intake with Discharge Flow Augmentation alternative presented above, the duration of exposure for organisms entrained in the discharge plume would be less than that of organisms entrained through the flow augmentation system.

c. Brine Mixing Zone

The BMZ, for the CDP is a circle with a radius of 100 meters (328 feet) originating from the discharge diffuser ports in the ocean. The discharge diffuser system will be comprised of four duckbill diffuser spaced approximately 100 feet apart (Figure 9). Outside of the BMZ, salinity cannot exceed 2 ppt over ambient background salinity. Within the BMZ, entrained organisms will experience elevated salinity. The benthic area encompassed by the BMZ would be approximately 14.4 acres.

F. Social

i. 1-mm Offshore WWS Surface Intake with Flow Augmentation

a. Desalination Plant Operations

The improvements needed for the transition to long term stand-alone operation need to be in place in advance of the retirement of the EPS in order to minimize the interruption in the output from the CDP. If this alternative were to be selected, the CDP would be temporarily out of service during permitting and construction. Each of these project milestones is expected to take three years to complete, resulting in a six-year project completion schedule. Completing the hydraulic connection of the existing SWRO Pump Station to the new onshore wet well will require the suspension of intake flow at the CDP for up to five years; therefore, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply, and the owner of the CDP would be unable to pay its fixed operating cost obligations totaling nearly $200 million (debt service, equity return, fixed operating fee, and fixed electricity charge)..

b. Recreational

Recreational access to the offshore construction area would be restricted during mobilization, installation, and demobilization of construction equipment (e.g., tunnel boring machine and derrick barge). In addition, there is potential for the temporary resuspension of sediment leading to a localized increase in turbidity due to the offshore installation of the WWS array.

c. Commercial

Commercial access to the offshore construction area would be restricted during mobilization, installation, and demobilization of construction equipment (e.g., tunnel boring machine and derrick barge). Commercial fishing activity may also experience decreased catch rates if the species are sensitive to the temporary resuspension of sediment during construction.

ii. 1-mm Offshore WWS Surface Intake with Diffuser

a. Desalination Plant Operations

The improvements needed for the transition to long term stand-alone operation need to be in place in advance of the retirement of the EPS in order to minimize the interruption in the output from the CDP. If this alternative were to be selected, the CDP would be temporarily out of service during permitting and construction. Each of these project milestones is expected to take three years to complete, resulting in a six-year project completion schedule. Completing the hydraulic connection of the existing SWRO Pump Station to the new onshore wet well will require the suspension of intake flow at the CDP for up to five years; therefore, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply, and the owner of the CDP would be unable to pay its fixed operating cost obligations totaling nearly $200 million (debt service, equity return, fixed operating fee, and fixed electricity charge)..

b. Recreational

Recreational access to the offshore construction area would be restricted during mobilization, installation, and demobilization of construction equipment (e.g., tunnel boring machine and derrick barge). In addition, there is potential for the temporary resuspension of sediment leading to a localized increase in turbidity due to the offshore installation of the WWS array.

The EPS discharge acts as a manmade river mouth that delivers sand to the end of the jetties that form the discharge channel, creating a man-made sandbar. The result is a popular surfing break. Should the screened intake with the multiport diffuser be selected, the Expanded CDP discharge would be relocated offshore, thereby eliminating a significant source of sand replenishment for the sandbar. Additionally, per the terms of the CDP's State Lands Commission Lease, the jetties would have to be removed if the existing discharge channel is decommissioned. Thus, if the screened intake with the multiport diffuser is selected, an important recreational asset would be lost.

c. Commercial

Commercial access to the offshore construction area would be restricted during mobilization, installation, and demobilization of construction equipment (e.g., tunnel boring machine and derrick barge). Commercial fishing activity may also experience decreased catch rates if the species are sensitive to the temporary resuspension of sediment during construction.

iii. 1-mm Lagoon-Based WWS Surface Intake with Flow Augmentation

a. Desalination Plant Operations

The improvements needed for the transition to long term stand-alone operation need to be in place in advance of the retirement of the EPS in order to minimize the interruption in the output from the CDP. If this alternative were to be selected, the CDP would be temporarily out of service during permitting and construction. Each of these project milestones is expected to take three years to complete, resulting in a six-year project completion schedule. Completing the hydraulic connection of the existing SWRO Pump Station to the new onshore wet well will require the suspension of intake flow at the CDP for up to five years; therefore, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply, and the owner of the CDP would be unable to pay its fixed operating cost obligations totaling nearly $200 million (debt service, equity return, fixed operating fee, and fixed electricity charge).

b. Commercial

Construction and operation of a WWS array in the Lagoon has potential to impact the operation of the existing Carlsbad Aquafarm. The Aquafarm has 20 employees and helps reduce the toll that over-fishing takes on the ocean by providing high-quality farmed seafood. While construction may temporarily increase turbidity in the vicinity of the Aquafarm, long-term operation of the WWS array in a waterbody with little sweeping velocity may also encourage debris to accumulate in the south end of the Lagoon.

iv. 1-mm Lagoon-Based WWS Surface Intake with Diffuser

a. Desalination Plant Operations

The improvements needed for the transition to long term stand-alone operation need to be in place in advance of the retirement of the EPS in order to minimize the interruption in the output from the CDP. If this alternative were to be selected, the CDP would be temporarily out of service during permitting and construction. Each of these project milestones is expected to take three years to complete, resulting in a six-year project completion schedule. Completing the hydraulic connection of the existing SWRO Pump Station to the new onshore wet well will require the suspension of intake flow at the CDP for up to five years; therefore, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply, and the owner of the CDP would be unable to pay its fixed operating cost obligations totaling nearly $200 million (debt service, equity return, fixed operating fee, and fixed electricity charge).

b. Recreational

Recreational access to the offshore diffuser construction area would be restricted during mobilization, installation, and demobilization of construction equipment (e.g., tunnel boring machine and derrick barge). In addition, there is potential for the temporary resuspension of sediment leading to a localized increase in turbidity due to the offshore installation of the WWS array.

The EPS discharge acts as a manmade river mouth that delivers sand to the end of the jetties that form the discharge channel, creating a man-made sandbar. The result is a popular surfing break. Should the screened intake with the multiport diffuser be selected, the Expanded CDP discharge would be relocated offshore, thereby eliminating a significant source of sand replenishment for the sandbar. Additionally, per the terms of the CDP's State Lands Commission Lease, the jetties would have to be removed if the existing discharge channel is decommissioned. Thus, if the screened intake with the multiport diffuser is selected, an important recreational asset would be lost.

c. Commercial

Construction and operation of a WWS array in the Lagoon has potential to impact the operation of the existing Carlsbad Aquafarm. The Aquafarm has 20 employees and helps reduce the toll that over-fishing takes on the ocean by providing high-quality farmed seafood. While construction may temporarily increase turbidity in the vicinity of the Aquafarm, long-term operation of the WWS array in a waterbody with little sweeping velocity may also encourage debris to accumulate in the south end of the Lagoon.

Commercial access to the offshore diffuser construction area would be restricted during mobilization, installation, and demobilization of construction equipment (e.g., tunnel boring machine and derrick barge). Commercial fishing activity may also experience decreased catch rates if the species are sensitive to the temporary resuspension of sediment during construction.

v. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Flow Augmentation

a. Desalination Plant Operations

The improvements needed for the transition to long term stand-alone operation need to be in place in advance of the retirement of the EPS in order to minimize the interruption in the output from the CDP. If this alternative were to be selected, the CDP would be temporarily out of service during permitting and construction. Each of these project milestones is expected to take three years to complete, resulting in a six-year project completion schedule. Completing the hydraulic connection of the existing SWRO Pump Station to the new onshore wet well will require the suspension of intake flow at the CDP for up to five years; therefore, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply, and the owner of the CDP would be unable to pay its fixed operating cost obligations totaling nearly $200 million (debt service, equity return, fixed operating fee, and fixed electricity charge).

vi. 1-mm Lagoon-Based Shoreline TWS Surface Intake with Diffuser

a. Desalination Plant Operations

The improvements needed for the transition to long term stand-alone operation need to be in place in advance of the retirement of the EPS in order to minimize the interruption in the output from the CDP. If this alternative were to be selected, the CDP would be temporarily out of service during permitting and construction. Each of these project milestones is expected to take three years to complete, resulting in a six-year project completion schedule. Completing the hydraulic connection of the existing SWRO Pump Station to the new onshore wet well will require the suspension of intake flow at the CDP for up to five years; therefore, product water flow will also be suspended. During this period, the Water Authority would need to find an alternative water supply, and the owner of the CDP would be unable to pay its fixed operating cost obligations totaling nearly $200 million (debt service, equity return, fixed operating fee, and fixed electricity charge).

4. Mitigation

This section describes the mitigation required for each of the ten alternatives evaluated. Per section III.M.2.e of the Desalination Amendment, the impacts that require mitigation are associated with the construction and/or operation of the intake and discharge structures after having first minimized intake and mortality of all forms of marine life through best available site, design, and technology. Table 5 summarizes the individual and cumulative mitigation acreage required for each alternative evaluated.

Table 5. Comparison of marine life mortality impacts among intake/discharge alternatives at maximum production capacity (60 MGD).

Impacts	Intake Water Potentially Exposed to 100% Mortality	Flow Augmentation Water Potentially Exposed to 100% Mortality	Diffuser Water Potentially Exposed to 100% Mortality	Total Water Potentially Exposed to 100% Mortality	Area of Production Foregone	Brine Mixing Zone @ 35.5 ppt	Permanent Construction Impacts to Marine Environment	Total Area Impacted	Marine Life Mortality Ranking
Alternatives	**MGD**	**MGD**	**MGD**	**MGD**	**Acres**	**Acres**	**Acres**	**Acres**	**Ranked Lowest to Highest**
Surface Screened Intake with Flow Augmentation	128	171	0	299	84.3	15.5	0	99.8	3
Surface Screened Intake with Multiport Diffuser	128	0	217	345	103.3	14.4	1.5	118.9	7
Subsurface Intake with Flow Augmentation	0	0	0	0	0	15.5	72	87.5	1
Subsurface Intake with Multiport Diffuser	0	0	217	217	67	14.4	33	114.4	6
Offshore Wedgewire Screen with Flow Augmentation	127	171	0	298	92	15.5	2.06	109.5	5
Offshore Wedgewire Screen with Diffuser	127	0	217	344	106.2	14.4	2.5	123.1	10
Lagoon Wedgewire Screen with Flow Augmentation	127	171	0	298	84	15.5	0.1	99.6	2
Lagoon Wedgewire Screen with Diffuser	127	0	217	344	103	14.4	1.6	119.0	8
Lagoon Traveling Screen with Flow Augmentation	128	171	0	299	84.3	15.5	0.1	99.9	4
Lagoon Traveling Screen with Diffuser	128	0	217	345	103.3	14.4	1.6	119.3	9

5. Recommended Alternative

Poseidon has prepared this addendum to the original Feasibility Study (provided as Appendix B) at the request of the RWQCB. As with the original Feasibility Study, the addendum seeks to determine the best methods and technologies to comply with the requirements set forth in the Desalination Amendment. Together with the original Feasibility Study, this addendum concluded that the screened intake with discharge flow augmentation is the only feasible intake/discharge technology for the CDP when it begins long term stand-alone operation. When compared to the other alternative technologies, the proposed modifications were found to result in marginally higher marine life mortality (99.8 acres) than the two lowest ranked alternatives (Table 5 - Comparison of Marine Life Mortality Impacts). The alternative using the subsurface intake with flow augmentation was found to have the lowest marine life mortality impact (87.5 acres). However, the subsurface intake with flow augmentation was found to be infeasible with respect to the other four criteria: (1) economically infeasible (capital cost of $1,037 million and total annual cost of $159 million); (2) longest implementation period (10.2 years) resulting in $424 million in the loss of fixed capital and fixed operating costs (debt and equity payments, plant maintenance, utility charges) not recovered while the plant is out of service; (3) technically infeasible due to the physical size of the subsurface intake, associated interconnecting piping and pump stations; and (4) socially infeasible due extensive impacts to the marine resources and recreation in Agua Hedionda Lagoon. The alternative using the lagoon wedgewire screen with flow augmentation was found to have the next lowest marine life mortality impact (99.6 acres). However, the lagoon wedgewire screen with flow augmentation was found to be infeasible with respect to three criteria: (1) economically infeasible (capital cost of $126 million and total annual cost of $34 million); (2) implementation period (6 years) resulting in $200 million in the loss of fixed capital and fixed operating costs (debt and equity payments, plant maintenance, utility charges) not recovered while the plant is out of service; and (3) technically infeasible due to the lack of sweeping currents in the lagoon which are necessary to prevent fouling of the screen.

In terms of environmental impacts, when calculated per the requirements set forth in the Ocean Plan, the marine life mortality impact associated with the alternatives ranged from 87.5 acres to 123.1 acres. The proposed modifications would impact 99.8 acres prior to mitigation (lowest impact after elimination of the subsurface intake with flow augmentation and the lagoon wedgewire screen with flow augmentation). In terms of time required for project completion, the alternatives ranged from 2.5 years (proposed modifications) to 10.2 years (subsurface intake with flow augmentation), with the proposed modifications requiring less than half the implementation period of the next closest alternative (Table 2 - Comparison of Time Required for Project Completion). The potential delay costs (the fixed capital and fixed operating costs not recovered while the CDP is out of service) associated with the CDP potentially losing access to source water if the timeline for project completion extend beyond 2018, ranged from $0 for the proposed modifications to $424 million for the subsurface intake with flow augmentation.

Lastly, in terms of economic impacts, a detailed analysis of the life-cycle cost for the CDP subsurface intake/discharge alternatives is presented in Appendix OO of the Submittal to the RWQCB. The findings of this analysis are included in Table 1 - Economic Analysis). The life cycle costs provide a relative comparison of the net incremental cost and savings of each of the alternatives. Costs considered include permitting, design, land acquisition, financing, construction, operations, maintenance, mitigation, equipment replacement, insurance, taxes, management, and energy consumption over the lifetime of the facility and fixed capital and operating costs not recovered if the plant is out of service after 2018. Savings considered include operational savings due to reduced chemical consumption, extended membrane life, and reduced membrane cleaning frequency that is applicable to the subsurface intake alternatives.

The findings of the economic analysis indicate that $94 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with SIG with the multiport diffuser alternative and $159 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with the SIG with flow augmentation alternative. The primary difference between these figures and the lifecycle costs of these alternatives shown in Appendix B is the inclusion of the fixed capital and operating costs not recovered while the plant is out of service after 2018.

Chapter III.M of the Ocean Plan provides the following guidance for assessing the feasibility of subsurface intakes:

Subsurface intakes shall not be determined to be economically infeasible solely because subsurface intakes may be more expensive than surface intakes. Subsurface intakes may be determined to be economically infeasible if the additional costs or lost profitability associated with subsurface intakes, as compared to surface intakes, would render the desalination facility not economically viable.

Therefore, the RWQCB's determination of the economic feasibility of the SIG alternatives turns on the basis of whether the additional costs or lost profitability associated with these alternatives would render the desalination facility not economically viable. One measure of economic viability is whether the anticipated plant revenues would cover cost of one or both of the SIG alternatives.

The annual costs would be approximately $94 million per year for the subsurface intake with a multiport diffuser and approximately $159million per year for the subsurface intake with flow augmentation. Absent an additional source of revenue, the SIG alternatives are economically infeasible.

The economic analysis summarized in Table 1 indicates that approximately $8 million would need to be added to the annual operating budget of the CDP to pay for the capital and operating costs associated with proposed surface water intake with flow augmentation. The annual cost of the other intake/discharge alternatives under consideration (WWS and lagoon based intakes with flow augmentations or diffuser) range from $29 million to $76 million, rendering these alternatives economically infeasible.

The results of the Feasibility Study and Addendum are summarized in Table 6 below (Overall Feasibility Assessment). The Feasibility Study concluded that the screened intake with discharge flow augmentation is the only feasible intake/discharge technology for the CDP when it begins long term stand-alone operation.

Table 6. Overall feasibility assessment of intake and discharge alternatives.

	Project Capable of Being Accomplished in a Reasonable Period of Time?	Is Project Economically Feasible?	Marine Life Mortality Ranking	Socially Feasible	Technically Feasible	Overall Feasibility
Alternatives	**Yes/No**	**Yes/No**	**Ranked Lowest to Highest Impact**	**Yes/No**	**Yes/No**	**Yes/No**
Surface Screened Intake with Flow Augmentation	Yes	Yes	3	Yes	Yes	Yes
Surface Screened Intake with Multiport Diffuser	No	No	7	Yes	Yes	No
Subsurface Intake with Flow Augmentation	No	No	1	No	No	No
Subsurface Intake with Multiport Diffuser	No	No	6	No	Yes	No
Offshore Wedgewire Screen with Flow Augmentation	No	No	5	Yes	Yes	No
Offshore Wedgewire Screen with Diffuser	No	No	10	Yes	Yes	No
Lagoon Wedgewire Screen with Flow Augmentation	No	No	2	Yes	No	No
Lagoon Wedgewire Screen with Diffuser	No	No	8	No	Yes	No
Lagoon Traveling Screen with Flow Augmentation	No	No	4	Yes	Yes	No
Lagoon Traveling Screen with Diffuser	No	No	9	Yes	Yes	No

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