APPENDIX I1

Open-Water and Subsurface Intakes

Open-Water Intakes

Open-water intakes can be installed in a variety of locations and built in a range of sizes. In the United States, open-water intakes are often used by coastal power plants that require large quantities of ocean water for cooling. Sometimes, power plant intakes provide opportunities for the conversion of existing infrastructure to, or co-location with, desalination plant intakes.

The chief environmental concern associated with open-water intakes is entrainment and impingement of marine organisms.[1] Where subsurface intakes are infeasible, proposals for open-water intakes must include entrainment and impingement studies to determine impacts to marine resources. To be considered adequate, an entrainment and impingement study must be prepared in accordance with default protocols under Clean Water Act Section 316(b) (CCC, 2004).[2] Apart from the impacts of the intake process itself, the impacts to marine resources associated with the offshore portion of the intake pipeline must also be evaluated, particularly if the pipeline would be supported on the ocean floor or in the water column.

Consistent with the findings of an expert review panel convened by the SWRCB, *Desalination Plant Entrainment Impacts and Mitigation* (finalized October 9, 2013), and SWRCB's 2014 proposed Desalination Amendment to the California Ocean Plan (SWRCB, 2014b), this EIR assumes that all open-water intake options would be equipped with a passive, cylindrical wedge-wire screen at the western terminus of the intake pipeline with slot openings sized to meet regulatory and/or permitting requirements[3] and would have a design velocity of 0.5 feet per second unless otherwise noted.

Construction of Open-Water Intakes

There are several possible construction methods for installing open-water intakes beneath the ocean floor. All of the new open water intakes described below would be constructed using either horizontal directional drilling (i.e., drilling a boring between two pits and either using a barge to pull the pipe through the boring or deploying the pipe on the ocean floor and pulling it through the boring from the onshore pit) or microtunneling (i.e., pushing the pipe behind a microtunnel boring machine). Both of these methods require the use of drilling fluids. Under both methods, the intake pipe would be fused in advance of drilling/tunneling and laid out in a linear manner near the entry pit. The boring for the intake pipeline would tunnel under the beach/onshore portion and ocean floor to the point it "daylights" (emerges) on the ocean floor, where the screened intake structure (attached to the end of the intake pipe) would be mounted on a riser

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[1] In this context, entrainment refers to marine organisms entering the desalination plant intake, being drawn into the intake system, and passing through to the treatment facilities. Impingement would occur if organisms were sufficiently large to avoid going through the intake screens but were trapped against them by the force of the flowing water.

[2] In some cases, different study parameters may be proposed, and in some cases, a recently completed 316(b) study for a nearby site may be used if applicable to the proposed desalination intake site (CCC, 2004).

[3] The SWRCB is considering an amendment to the 2012 Ocean Plan to address issues associated with desalination facilities. According to the 2014 proposed Desalination Amendment to the California Ocean Plan (Section L(2)(d)(1)(c)(ii)), the SWCRB intends to select a single slot size but is soliciting comments on whether 0.5 millimeter (0.02 inch), 0.75 millimeter (0.03 inch), 1.0 millimeter (0.04 inch), or some other slot size is most appropriate to minimize intake and mortality of marine life.

approximately 3 feet off the ocean floor. This analysis assumes approximately 0.25 acre of land disturbance on the ocean floor for construction of the screened riser. The permanent footprint of a screened riser on the ocean floor is approximately 20 square feet. Unless otherwise specified, it is assumed that the construction methodology for all new open-water intakes would be generally consistent with these techniques.

Operations and Maintenance Considerations for Open-Water Intakes

As noted, the primary environmental impact associated with open-water intakes is entrainment and impingement. The SWRCB, California Coastal Commission, and Monterey Bay National Marine Sanctuary require proponents of open-water intakes to include entrainment and impingement studies in the corresponding permit applications, and to implement (or fund through fee-based mitigation) compensatory mitigation for operation of the intakes. The mitigation fees would be used for habitat creation, restoration projects that replace the lost production, or other projects viewed equivalent by the SWRCB (SWRCB, 2014b). Additionally, the funding could be used to create marine-protected areas or to clean up or abate environmental contaminants. The fee would be based on a broad range of organisms impacted at the intakes.

Maintenance of open-water intake screens would occur every 3 to 5 years. Maintenance activities include mechanical cleaning, air blasting and hand-scraping the intake screens to remove organic matter and debris.

Subsurface Intakes

Subsurface intakes -- which include vertical wells, infiltration galleries, horizontal wells, slant wells, and Ranney collectors -- can avoid or minimize some of the environmental effects associated with open-water intakes. Specifically, subsurface intakes can avoid or minimize direct impacts to the ocean floor and benthic[4] organisms during construction, and impingement and entrainment during operations. Subsurface intakes can avoid impingement because they collect source water through the ocean bottom and coastal aquifer sediments. Subsurface intakes are generally considered a low-impact technology with respect to impingement and entrainment. However, the magnitude of potential entrainment of marine species into the bottom sediments caused by continuous subsurface intake operations has not been systematically and scientifically studied to date (WateReuse, 2011).

Subsurface intakes generally have the following advantages compared to open water intakes: (1) the potential to reduce or eliminate the impingement or entrainment of marine organisms; (2) natural water filtration and pretreatment provided by ocean floor sediments, which in some cases can reduce the need for some treatment chemicals during the desalination process; and (3) minimal growth of marine organisms that occurs inside the intake pipeline (Kennedy/Jenks, 2011). In general, source water derived from subsurface intakes requires significantly less

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[4] Relating to the bottom of an ocean, sea or lake, or to the organisms that live there.

filtration when compared to raw seawater (SGD, 1992). However, if not appropriately sited, subsurface intakes can adversely affect coastal aquifers and increase the risk of saltwater intrusion in freshwater aquifers (CCC, 2004).

Key factors that determine whether a subsurface intake is technically feasible and practical include: the transmissivity/productivity of the geologic formation/aquifer; the thickness of the production aquifer deposits; and the existence of nearby freshwater source aquifers.

The following subsections describe each subsurface intake type, including typical suitable locations, examples of existing technology, general construction methodology, operation and maintenance, and capabilities and limitations of each technology.

Vertical Wells

Vertical wells are shallow intake wells that make use of beach sand or other geologic mediums to filter water. A vertical beach well consists of a casing, well screen, and vertical turbine pump. The suitability of a site for vertical wells is determined by drilling test wells and conducting a detailed hydrogeologic investigation to ascertain the formation transmissivity and substrate characteristics. Source water yield from a vertical well can range between 0.1 and 1.5 mgd (Hunt, 2008). It is preferable to locate beach wells as close to the coastline as possible to minimize impacts on inland aquifers. Four vertical beach wells (two active, two standby) are used to draw brackish source water for the 300-afy Sand City Coastal Desalination Plant (Water Technology, 2012). Vertical wells are typically constructed with a track-mounted drill rig and require an area of approximately 100 feet by 100 feet at each well location (SGD, 1992). Like subsurface slant wells, vertical wells require dewatering during well development, and the effluent produced during well development is discharged either directly to the ocean or to temporary onsite settling basins (SGD, 1992; Feeney, 2002). This analysis assumes that the wellhead and associated electrical box for a vertical well would be buried below grade, and that submersible pumps would be used. Each wellhead would result in approximately 400 square feet of permanent disturbance and a permanent easement would be required for maintenance access (SGD, 1992). Vertical wells are typically spaced approximately 300 feet apart from each other to reduce well interference (SGD, 1992). Maintenance of vertical wells is limited to replacing the submersible pumps; however, the small-diameter pumps used in vertical wells have a shorter service life and must be replaced more frequently than other types of well pumps. Since the wells would be buried, pump replacement would require excavation around the wellhead to allow service access.

To provide the 24 mgd of source water needed for the 9.6-mgd desalination plant proposed under the proposed project, a large number of vertical wells spaced over a wide area of beach would be required. Although the total number of vertical wells needed would depend on the underlying hydrogeologic characteristics of the intake site, based on a best-case scenario in which each well has 1.0 mgd of capacity, at least 24 vertical wells would be needed over a linear distance of at least one mile. This analysis assumes that other alternative subsurface intake technologies would have a smaller construction footprint and permanent footprint because other subsurface intakes would require fewer wells to generate the same volume of source water. The sheer number of vertical wells that would be needed to provide a reliable source water flow to the desalination plant is considered infeasible, both from a construction and operational perspective and in terms of economic, legal (permitting) and environmental factors. Therefore, vertical wells are not considered further.

Infiltration Galleries

Infiltration galleries consist of a series of submerged slow sand media filtration beds located beneath the ocean floor. Multiple collector screens and intake pipes within the filtration beds draw seawater to a single intake well located onshore. Water is pumped through onshore intake pumps. Infiltration galleries are most appropriately implemented in locations where geologic conditions are relatively impermeable or of insufficient thickness and depth to support groundwater extraction (Pankratz, 2008).

Infiltration galleries require construction on the beach as well as on the ocean floor. The design surface loading rate of the sand filter media is typically between 0.05 to 0.10 gallons per minute (gpm) per square foot. Using a 42 percent recovery rate, an infiltration gallery for a 9.6-mgd desalination plant would need to draw at least 24 mgd (16,650 gpm) of source water. Based on a loading rate of 0.075 gpm per square foot, approximately 222,000 square feet (or 5 acres) of the seabed in Monterey Bay would need to be excavated at a depth of 6 to 8 feet to install an active infiltration bed for the MPWSP Desalination Plant. Once constructed, periodic removal or replacement of the surface layer of the filtration beds is needed to maintain intake capacity (WateReuse, 2011). Based on the extent of temporary and permanent disturbance that an infiltration gallery would have on the sand dunes and sensitive marine habitat in the Monterey Bay National Marine Sanctuary, this technology is considered infeasible based upon environmental, social and legal factors and is not discussed further.

Horizontal Wells

Horizontal wells, which are installed using HDD technology, draw seawater from shallow offshore aquifers. Horizontal wells would be constructed in clusters of three or four wells, each well equipped with a well pump and extending horizontally approximately 2,400 feet and at a depth of roughly 180 feet below sea level. Approximately 10 to 12 horizontal wells would be needed to provide sufficient source water for the 9.6-mgd MPWSP Desalination Plant. The source water collected by each horizontal well cluster would be pumped from each well to a common caisson and then from the caisson to the MPWSP Desalination Plant.

Horizontal wells are not evaluated further for the following reasons: (1) the amount of pipeline that would be pushed under the sea floor (upwards of 2,500 feet) would be challenging in terms of construction time, physical limitations and the disposal of drilling sludge (and consequently much more expensive than other options); (2) installing artificial filter packs to stabilize unconsolidated formations like those found in the project area has yet to be demonstrated successfully and on a consistent basis, and; (3) HDD would not avoid or minimize any of the impacts associated with the proposed action.

Ranney Wells

A Ranney well is a radial well comprised of a vertical caisson (a large diameter shaft where the water is collected from each well and then pumped) extending below the water table from which horizontally placed perforated screens are extended (SGD, 1992). The use of multiple horizontal laterals means that production of each radial well is greater than a single vertical well (Feeney, 2002). A single Ranney well can yield between 0.1 to 25 mgd, which is five to ten times the yield of a vertical well (Hunt, 2008). Examples of Ranney wells in marine environments include three Ranney wells at the Salina Cruz Power Plant in Mexico that draw between 9 and 14 mgd of seawater, and one at the Steinhart Aquarium at the California Academy of Sciences in San Francisco (Hunt, 2008; Feeney, 2013).

Construction of Ranney wells involves excavating a large shaft for the central caisson, then installing the horizontal laterals outward from the vertical shaft. The central caisson may range from 8 to 20 feet in diameter (SGD, 1992). The laterals are advanced by either jacking outward (seaward) from the vertical shaft under hydraulic pressure, or by jetting them into place (Geoscience, 2008). This analysis assumes that the central caisson would be approximately 16 feet in diameter, be buried at a depth of approximately between 90 to 260 feet, and have a permanent aboveground electrical control building to house pumps and other associated headworks (SGD, 1992).

Ranney wells must be spaced approximately 350 to 500 feet apart to reduce interference between adjacent Ranney wells. Although the final footprint for a Ranney well intake system can be relatively small compared to other types of wells (e.g., vertical), the construction area can be larger (Geoscience, 2008). Construction of a large caisson on the beach, even though the caisson would ultimately be buried, would require a large footprint for construction activities and dewatering operations. This analysis assumes each Ranney well would result in 1 acre of temporary construction disturbance. Conventional construction equipment, including a 60-ton crane, concrete trucks, and assorted support vehicles, would be used for excavation, forming, pouring and setting of the vertical concrete caisson, dewatering of the caisson, advancement of the laterals, development, and test pumping. During dewatering, lateral advancement development, and test pumping, water would need to be discharged to a portable holding tank to settle out suspended solids and the decanted effluent subsequently percolated into the ground in the beach area (SGD, 1992; Feeney, 2002). With the exception of electrical controls, this analysis assumes Ranney wells would be buried below grade. Each Ranney well would be constructed over approximately 6 to 9 months and could involve 24-hour construction (Geoscience, 2008).

Ranney well maintenance includes periodic cleaning of the screened laterals to prevent clogging, and repairs and/or replacement of the submersible pumps. Assuming Ranney wells would be buried in the beach, the sand around the pumps would need to be excavated to allow maintenance staff to access the caisson and screened laterals. Ranney well laterals are mechanically cleaned using a high-pressure rotating water jet blaster; a mechanical packer/surge-block device that surges water or air in isolated sections of the laterals; and/or a bore blast where a small quantity of nitrogen is used to create a pressure pulse down the length of the laterals. This analysis assumes that Ranney well laterals would require cleaning every 5 to 10 years; however, ongoing monitoring of Ranney well performance would be conducted to determine the frequency of cleaning and maintenance.

The submersible pumps for Ranney wells would be housed in the central caisson, which means that large pumps, even turbines, could be used. Larger infrastructure has larger electrical windings and typically requires less maintenance. The submersible pumps would be repaired or replaced approximately every 10 years (SGD, 1992; Feeney, 2002).

The restricted lateral lengths of Ranney wells, as well as issues related to construction in a beach environment, could place limitations on the use of this technology to provide desalination plant feed water supply. The length of the laterals is currently limited to approximately 127 to 240 feet for the traditional Ranney-type collector well, and 350 to 375 feet for collector wells using the Sonoma method[5] of construction (Geoscience, 2008). When used for water supply, the maximum length of the horizontal laterals is typically limited to 150 feet. There may also be limitations on the depth of installation (for example, the maximum depth of the caisson is dependent on the geologic substrate), in which case the laterals would need to be installed and operated within the shallow Dune Sands Aquifer. Ranney wells would occupy roughly the same physical area as slant wells (approximately 10 acres), and Ranney wells are further evaluated as an intake option in this EIR.

Slant Wells

Slant wells are installed at an angle below the sea floor using vertical well drilling technology. The yield from a slant well depends on the underlying geology. When compared to vertical wells and Ranney wells, slant wells can be screened at greater distances offshore and can result in fewer impacts on coastal groundwater aquifers. Slant wells can be drilled from behind sand dunes or from the active beach area (i.e., between the toe of the dunes and the open ocean). The wellheads can be buried beneath the sand or installed flush with the ground surface. Multiple slants wells can be grouped into clusters to extend from a single “pod.” Consistent with the slant wells proposed as part of the MPWSP, it is assumed that construction of each slant well pod (consisting of up to 4 wells) would result in 1 acre of temporary disturbance.

Slant wells would require maintenance every 5 years. During maintenance, the wellheads are excavated and exposed, and mechanical brushes are lowered into the wells to mechanically clean the screens. Ground disturbance associated with periodic maintenance is assumed to be similar in extent to construction disturbance (i.e., approximately 1 acre of disturbance for each well pod).

Slant well construction and maintenance requirements are described in greater detail in Chapter 3, Project Description. Any intake options that include slant well technology are assumed to be consistent with the slant wells proposed as part of the MPWSP, although the location and number of wells could vary.

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[5] The Sonoma method is a different configuration of a Ranney well that has been implemented on the Russian River in Sonoma County, California.