

Draft

BRACKISH WATER DESALINATION FACILITY PROJECT

Adaptive Management Framework

Prepared for
City of Antioch

April 2020



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CHAPTER 1

Introduction

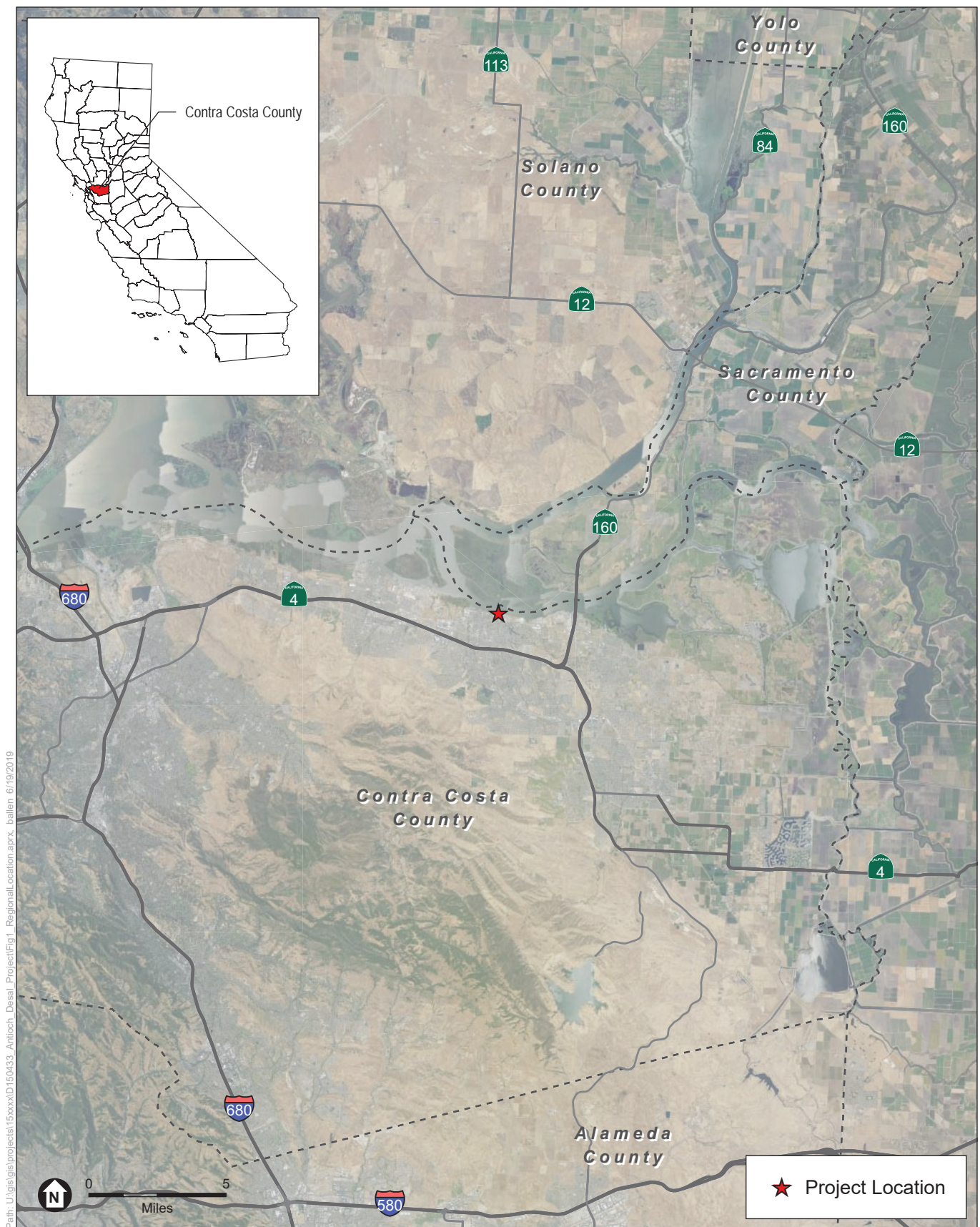
1.1 Project Background

The City of Antioch (City) is proposing the Brackish Water Desalination Project (Project), which consists of the construction of a desalination facility at the City's water treatment plant (WTP) with the capacity to produce up to 6 million gallons per day (mgd) of finished water; demolition of the existing San Joaquin River intake pump station; construction of a new intake pump station; approximately 3,000 feet of pipeline from the existing raw water pipeline underneath Lone Tree Way to the City's WTP to allow a direct connection to maximize use of existing infrastructure; and approximately 4 miles of pipeline from the desalination facility to the Delta Diablo wastewater treatment plant (WWTP) to discharge brine with the WWTP effluent through the existing Delta Diablo outfall to New York Slough. The Project facilities would be located in the cities of Antioch and Pittsburg, California (**Figure 1**), at the western edge of the San Joaquin-Sacramento Delta (Delta). The main objectives of the Project are to improve water supply reliability and water quality for its customers; develop a reliable and drought-resistance water source to reduce dependency on purchased water supplies; maximize and preserve the use of the City's pre-1914 water rights; and provide cost effective operational flexibility for the City.

1.2 Goals and Objectives

The main objectives of the project are to:

- Improve water supply reliability and water quality for customers.
- Develop a reliable, and drought-resistant water source to reduce dependency on purchased water supplies by maximizing the use of the City's pre-1914 water rights.
- Maximize the use of existing infrastructure to maintain economic feasibility.
- Provide cost effective operational flexibility to allow the City to respond to changes in source water quality, emergencies, changes in climate and Delta conditions.
- Preserve the value of the City's pre-1914 water rights.



SOURCE: NAIP, 2016; ESRI, 2012; ESA, 2019

City of Antioch Desalination Project

Figure 1
Regional Location

CHAPTER 2

Project Summary

2.1 Overview

Brackish water desalination as a component of the City’s water supply portfolio has been evaluated in State-approved water planning documents including the City’s 2015 Urban Water Management Plan (West Yost Associates, 2016) and East Contra Costa County Integrated Regional Water Management Plan (East County Water Management Association, 2019).

Developing the Project required an understanding of the brackish water treatment processes, the source water quality (San Joaquin River), and the finished desalinated water quality goals. The Project components as proposed were defined through the preparation of several technical memoranda spanning topics from desalination facility siting considerations, intake pump station siting and intake technology, pipeline alignments, and alternative brine disposal processes. The technical memoranda evaluated alternatives for the potential components and feasibility based on available technical and scientific information. Information from these studies informed the basis of design, operating concepts, estimated capital, operations and maintenance, and life cycle costs.

Project facilities would be located in the cities of Antioch and Pittsburg, California. The proposed desalination facility would be located within the fenceline of the City’s existing WTP at 401 Putnam Street, and the pipeline routes would generally follow road rights-of-way. The river intake pump station is located at the City marina near McElheny Road and Fulton Shipyard Road. The Project setting is predominantly developed and urban, characterized by mostly residential, commercial, and industrial development.

Table 1 summarizes the Project components. **Figure 2** depicts overall Project facilities and pipeline alignments at a larger scale.

TABLE 1
FACILITIES SUMMARY OF THE PROJECT

Facility	Description	Purpose
Intake Pump Station Replacement and Raw Water Pipeline Connection		
Intake Pump Station	<p>Existing Intake Pump Station</p> <ul style="list-style-type: none"> Existing intake pump station (approximately 30 feet x 30 feet) housed at the end of an existing wooden pile supported pier extending approximately 200 feet from shore over the San Joaquin River will have pump, piping, electrical gear, and fish screen removed. <p>New Intake Pump Station</p> <ul style="list-style-type: none"> Built on concrete foundation footings approximately 3,500 square feet in area. The pump station will be equipped with three 8 mgd vertical turbine pumps, each 600 hp (two active and one standby) for a total intake firm capacity of 16 mgd. Two new 42-inch-diameter offshore intake pipelines to replace the existing pipeline with two new 48-inch-diameter fish screens meeting CDFW/NOAA requirements. Electrical and instrumentation equipment. 	<p>The existing pier and pump station would remain in place to continue to house a DWR sampling station.</p> <p>The intake pump station would draw river water for use as source water for the proposed desalination plant.</p> <p>The fish screens would protect sensitive aquatic species in the Delta.</p>
Raw Water Pipeline Connection	<ul style="list-style-type: none"> 3,000-foot-long, 30-inch-diameter pipeline. 	This pipeline would convey the raw source water from the existing pipeline in Lone Tree Way directly to the WTP for treatment.
Desalination Facilities		
Pretreatment	<ul style="list-style-type: none"> Existing conventional treatment processes at Plant A will be used for pre-treatment. Miscellaneous repairs including new coatings will be made to existing facilities to improve reliability. Two pipelines approximately 600 feet each for the filtered water and RO permeate, and associated valves. Three (3) 100-hp pumps at 4 mgd each for pumping filtered water to RO pumps. Two would be on duty, one for standby. 	This pipeline and pumps would convey the pretreated source water (RO feed water) to the RO system.
Reverse Osmosis (RO) System	<ul style="list-style-type: none"> Four (4) RO trains consisting of: <ul style="list-style-type: none"> Four (4) RO feed pumps 2 mgd and 250-hp each (one for each RO train). Four (4) RO booster pumps, 1 mgd and 100-hp each (one for each RO train). Clean-in-place recirculation pump (1,000 gpm, 25-hp). The RO units and cleaning systems would be housed within a 10,700-square-foot membrane process building. 	The RO system would remove salts and other minerals from the pretreated source water.

TABLE 3-2 (CONTINUED)
FACILITIES SUMMARY OF THE PROPOSED PROJECT

Facility	Description	Purpose
Chemical Storage	<ul style="list-style-type: none"> The following treatment chemicals would be housed in a 2,600-square-foot chemical storage building: <ul style="list-style-type: none"> Scale inhibitor – three 300-gallon storage tanks Sulfuric acid – one 6,500-gallon storage tank Calcium chloride – two 7,750-gallon storage tanks Sodium hydroxide (caustic soda) – existing Antioch WTP storage would be used. 	<p>The scale inhibitor is used in the treatment process to reduce fouling and protect the RO membranes.</p> <p>Sulfuric acid is used to adjust the pH of the water entering the RO system and is also used to clean the RO membranes.</p> <p>Calcium chloride is used for hardness adjustment and corrosion control.</p> <p>Sodium hydroxide would adjust the pH and alkalinity of the desalinated product water. Desalinated water would be disinfected using existing sodium hypochlorite facilities in accordance with drinking water requirements.</p>
Brine Disposal		
Brine Disposal Pipeline and Connection to Delta Diablo WWTP	<ul style="list-style-type: none"> 4.3-mile-long, 12-inch-diameter brine discharge pipeline. The pipeline connection to the Delta Diablo WWTP would be on Delta Diablo property downstream of wastewater facilities. Pipeline will be located in existing roadways and cross several small creeks and drainages at existing culvert locations. 	<p>Brine (i.e. concentrate) produced during the RO process would be conveyed to the Delta Diablo WWTP to be blended with their treated wastewater effluent prior to discharge through the outfall.</p>



SOURCE: USDA, 2018; ESRI, 2012; City of Antioch, 2019; Corollo, 2109; ESA, 2019

City of Antioch Desalination Project

Figure 2
Overall Project Site Plan

2.2 Constructed Elements

2.2.1 Intake Pump Station Replacement and Raw Water Pipeline Connection

The existing pump station and intake pipeline would be demolished and replaced under the Project (**Figure 3**). The intake capacity of the new intake pump station for river water would remain at a firm capacity of 16 mgd. The intake would be connected to the pump station by two 42-inch diameter submerged pipelines extending approximately 135 feet into the river. Each of the pipelines would be equipped with a fish screen that meets the protective criteria of the California Department of Fish and Wildlife (CDFW) and National Marine Fisheries Service (NMFS) (see **Table 2**). Other intake screen alternatives are also being evaluated to meet protection criteria.

TABLE 2
PROPOSED CITY OF ANTIOCH INTAKE SCREEN CRITERIA

Criteria	Units	Value	Comments
Number of Screens	-	2	
Design Flow	mgd	16	Each screen
Screen Center Line Elevation	ft	- 11.0	
Screen Submergence	ft	5.0	@ low tide
Screen Type	-	-	Tee Screen
Material	-	-	T304 stainless steel
Diameter	in.	48	
Screen Length	in.	184	Overall length
Approach Velocity	Feet per second (fps)	0.2	Maximum
Sweeping Velocity	fps	n/a	Intertidal location
Cleaning	-	-	Airburst
Cleaning Frequency	min.	15	
Screen Clear Space	mm	1.75	
Screen Porosity	%	27	Minimum

The new pump station would be located approximately 225 feet inland from shore within the existing parking lot with an approximate area of 3,500 square feet. The pump station would house three 8 mgd pumps (two active and one standby) which would allow the pump station to continue operating at 16 mgd if one of the pumps are out of service for maintenance. The variable speed pumps would allow operations at a lower speed if needed, providing flexibility in operations. The pump station building would be designed to allow for sea level rise by the year 2100 without mechanical or electrical room flooding during high river flow coincident with the highest estimated tide.



SOURCE: Sacramento County, 2018; ESRI, 2012; City of Antioch, 2019; Corollo, 2109; ESA, 2019

City of Antioch Desalination Project

Figure 3
Intake and Pump Station

The new pump station would connect to and convey river water through the City's existing 30-inch-diameter raw water pipeline for the majority of the distance between the pump station and the WTP. The existing raw water conveyance pipeline is located within road rights-of-way and connects the intake pump station to the Antioch Municipal Reservoir via Fulton Shipyard Road, Cavallo Road, East Tregallas Road, Sunset Lane, Worrell Road, and Lone Tree Way. A new 30-inch-diameter pipeline up to 3,000-feet-long would tee off of the existing pipeline on Lone Tree Way and provide a direct connection between the river's pump station and the WTP. The pipeline would be constructed of ductile iron. Valves would be installed at the tee to allow flow to be directed to either the Reservoir or the WTP.

2.2.2 Brackish Water Desalination Plant

The City would construct the desalination plant and related facilities within the fenceline of the existing WTP at 401 Putnam Street. The existing WTP site is approximately 25 acres, and the desalination plant would be located on approximately 10,700 square feet to the south and east of existing Plant A. The facilities to be built at the desalination plant include piping and valves to connect Plant A to the raw water pipeline, a new pipeline and on-site pumps to allow pretreated water from Plant A to flow to the desalination facility, an RO system, a post-treatment system, desalinated water pipeline connection to the existing plant clearwell, and a pipeline from the desalination plant that connects to a dedicated brine disposal pipeline. Existing roads would provide access to the site. The Project would create approximately 0.3-acre of impervious surfaces associated with the desalination facilities, buildings, driveways, parking, and maintenance areas. The subsections that follow describe these facilities.

Pretreatment System

Locating the desalination facility at the WTP would allow the use of existing infrastructure as part of the overall treatment process including use of Plant A's conventional treatment for removal of solids prior to RO treatment. The purpose of the pretreatment system would be to improve the quality of source water being treated by the RO system by filtering particulates, microorganisms, and organics (e.g., sand, silt, clay) out of the source water. Piping and valves would be installed to connect Plant A to the raw water pipeline. A new pipeline would be constructed to allow the pretreated water from Plant A to flow to the new desalination facility.

Plant A can reliably treat up to 17 mgd and its conventional treatment processes include flash mixing, coagulation and flocculation, solids contact sedimentation, and dual media filtration (sand and granulated activated carbon). Coagulation and flocculation serve as mechanisms for conditioning particles in the water to bind directly to filter media, and to build particles large enough to be removed by the filter media. Flash mixing is used to quickly disperse the coagulant chemicals and create a uniform concentration throughout the water undergoing treatment. Flocculation induces contact between particles through the controlled addition of mixing energy. Introducing controlled levels of turbulence allows the particles to group together and progressively grow into larger and larger flocs. The amount of energy input during flocculation is controlled to facilitate the growth of the flocs, and to limit the shearing apart of flocs that have reached a size

that allows them to be removed by sedimentation and filtration. Flocculation basins are designed to provide the mixing and retention time desired to optimize the formation of floc particles.

Sedimentation, following coagulation and flocculation, is used to reduce the particle concentration delivered to granular media filters. The sedimentation basins allow and facilitate settling of particles. The accumulated particles on the bottom of the basins are commonly referred to as sludge and are mechanically removed. The main particle removal mechanism in a granular media filter bed is depth filtration, a process where particles are transported to, and attach themselves onto, the surface of the media or previously deposited particles. Chemical coagulants are used to enhance the ability of particles to attach to the media and to themselves.

In addition to particle removal, granular bed filters also perform other water treatment functions. The use of granular activated carbon (GAC) as a support layer in granular media filtration can play a dual role since it also commonly hosts a biofilm that is useful for removing taste- and odor-causing compounds.

This treatment process would continue to be used at the WTP and would provide pretreatment for the RO system as part of the Project. No changes to Plant A's capacity would occur. However, treating the high-TDS water directly from the River may require changes to the coagulant type and/or dosing, increasing the frequency of media filter backwashing, increasing the media filter loading rate, and incorporating corrosion protection upgrades for higher TDS water. Existing concrete and metallic surfaces of Plant A that will be in contact with brackish water will be coated to provide additional corrosion protection.

The pretreatment process for the Project at Plant A would produce approximately 8 mgd of pretreated, filtered source water. The pretreated source water (aka RO feed water) would then be pumped directly to the RO system using three new pumps (two active and one standby, 4 mgd and 100 hp each) installed near the inlet to the existing Plant A clearwell.

Reverse Osmosis System

RO is a pressure-driven separation process that uses semi-permeable membranes to separate water from dissolved salts. Pretreated source water is forced at very high pressures through RO membranes. Water molecules, which are smaller than salt and many other impurities, are able to pass through the membranes. A portion of the source water passes through the RO membranes to produce "permeate," or desalinated water; the source water that does not pass through the membranes increases in salt concentration and is discharged as brine, as described in more detail below.

The RO system would consist of four RO trains housed in an approximately 18-foot-tall, 10,700 square-foot membrane process building. This building would also house the cartridge filters, four RO feed pumps (2 mgd and 250 hp each), four RO booster pumps (1 mgd and 100 hp each), chemical dosing pumps, clean-in-place (CIP) recirculation pump (1,000 gpm and 25 hp), and electrical room for the RO membranes. Once the water from Plant A reaches the RO facility, it would undergo additional pretreatment to minimize RO membrane fouling and consist of chemical addition by the chemical dosing pumps. A low dose of scale inhibitor (approximately 4 mg/L) is needed to mitigate the impact of highly concentrated salts on the feed side of the RO

membranes to prevent scaling. The water would then go through cartridge filters which provide additional protection for the RO membrane elements to capture any final particles of suspended solids that may enter the feed stream. RO feed pumps would supply the pressure needed to force the water through the RO membranes removing the dissolved salts from the RO feed water.

The RO feed water would then go through a two-stage, single pass RO process. In a single-stage system, one stream enters the membrane element and two streams exit. The entering stream is the RO feed water with a high TDS concentration, and the two streams exiting the membrane are permeate and brine. In the two-stage system, the brine from the first phase becomes the feed water for the second stage. Permeate from the second stage combines with permeate from the first stage and, since all of the permeate only pass through a membrane once, it is considered a one-pass system.

The brine produced by RO systems is saturated with dissolved salts, which can result in the accumulation of salts or mineral scaling on the RO membranes, which can cause fouling and reduces the membrane performance. One commonly practiced technique to minimize the opportunity for scale to form on membranes is flushing the membranes with feed water or permeate prior to shutting down an RO train. Flushing the trains displaces the highly concentrated brine away from the membranes, decreasing the opportunity for clusters of atoms to form small seed crystals that can grow and eventually cover the membranes in scale. An RO flushing system consists of additional valves and piping as required to supply the RO train with permeate or low pressure feed water. The pretreatment system described above would reduce fouling of the RO membranes, increasing the efficiency of the RO system and extending the useful life of the RO membranes. However, the RO system would still require cleaning up to two times per year. The RO CIP system would be housed in the same building as the RO system and would include cleaning solution tank with heater, pump, cartridge filter, and associated valves and pipes. Citric acid and sodium hydroxide (approximately 1,200 gallons per month) are used in the CIP system to clean the RO membranes.

Post-Treatment System

After leaving the RO system, the desalinated water would undergo post-treatment to make the water compatible with the City's other water supply sources and provide disinfection prior to distribution to customers. Facility operators would use metering pumps and chemical feedlines to dose the post-treatment chemicals (sodium hydroxide and calcium chloride) into the RO permeate. Caustic soda would be added to adjust pH; calcium chloride would be added for hardness adjustment and corrosion control; and liquid ammonium sulfate and sodium hypochlorite would be added for disinfection. Liquid ammonium sulfate, sodium hydroxide, and sodium hypochlorite are already in use at the WTP and would not represent new chemical storage at the site. All treatment chemicals would be transported, stored and used in accordance with regulatory requirements.

Desalinated Water Conveyance

Following the post-treatment system, the desalinated product water would flow by gravity into Plant A's existing 1.0 MG clearwell for distribution. No changes to the existing Plant A clearwell

would be required with the exception of the installation of up to 1,200 feet of piping within the WTP site to connect the inlet to the clearwell to the RO facility. The piping would be constructed of cement mortar lined steel. Existing pumps at the WTP would convey water to the distribution system.

Brine Disposal

Delta Diablo provides wastewater resource recovery services for the Cities of Antioch and Pittsburg, and the unincorporated community of Bay Point, serving a population of approximately 208,000. The City of Antioch's sanitary sewer system includes approximately 292 miles of gravity sewer mains that conveys wastewater to Delta Diablo's Wastewater Treatment Plant (WWTP). The RO process would generate approximately 2 mgd of brine. Brine from the RO system would be conveyed through an approximately 4.3-mile long, 12-inch-diameter dedicated pipeline from the desalination facility to the existing Delta Diablo WWTP. The brine disposal pipeline would be constructed of high-density polyethylene (HDPE) or polyvinyl chloride (PVC) and would connect to the WWTP effluent channel at the north end of the plant. The brine would be mixed with treated wastewater from the WWTP prior to discharge through the existing WWTP outfall.

The majority of the brine disposal pipeline would be constructed within roadway rights-of way in the cities of Antioch and Pittsburg along Elizabeth Court/D Street, Tregallas Road, Fitzuren Road, Contra Loma Boulevard/L Street, West 10th Street/Pittsburg Antioch Highway, and Arcy Lane. As alternative alignments for crossing the highway/railroad and entering the WTP, G Street, East 18th Street, Putnam Street, Lone Tree Way, and private easement may be used.

The existing Delta Diablo WWTP outfall pipeline ends approximately 500 feet offshore. The outfall is at an elevation depth of 26 feet. The diffuser port diameter is approximately 42 inches, with 50 3-inch diameter ports spaced 8 feet apart in alternating directions. No construction or modifications to the Delta Diablo WWTP outfall would be required.

2.3 Uncertainties

There are uncertainties about Project actions and expected outcomes. These uncertainties include:

- The modeling accurately predicts the behavior of the discharged brine plume
- If the modeling greatly overestimates the dilution rate of the brine plume, what will be the effect of the plume on nearby DWR Fish Restoration Program sites (e.g., Browns, Winter and Kimball Islands)
- The relative risk of entrainment of smelt eggs and young larvae which lack motility (the effect on entrainment of other life stages of smelt are considered minimal given their volitional movement and the low approach velocity at the fish screen)
- The effect of future changes in Delta water management on water quality in the western Delta. The state's single tunnel Delta Conveyance effort has the potential to significantly increase the salinity at Antioch's intake in almost all months and year. This could result in increases in both chloride and bromide concentrations at Antioch's intake.

CHAPTER 3

Site Conditions

3.1 Site Setting

The Project facilities would be located in the cities of Antioch and Pittsburg, California. These cities are located in eastern Contra Costa County at the western edge of the Delta. The Project setting is predominantly developed and urban, characterized by mostly residential, commercial, and industrial development.

3.2 Land Use

3.2.1 City of Antioch

The city of Antioch encompasses approximately 50 square miles and is bordered by the city of Pittsburg to the west, San Joaquin River to the north, cities of Oakley and Brentwood to the east, and unincorporated Contra Costa County to the south. Open space uses, including agriculture, open water, recreational lands, and vacant lands account for approximately half the land within the city (City of Antioch, 2003). Within the developed portion of the city, single-family residential uses cover the largest area (approximately 23 percent). Industrial areas account for approximately 3 percent of the land and generally concentrated in the northern portion of the city. Commercial areas account for nearly 3 percent of land and are generally concentrated along major roadway corridors.

3.2.2 City of Pittsburg

The city of Pittsburg encompasses approximately 12 square miles and is bordered by Bay Point to the northeast, Contra Costa County to the south, and Antioch to the west. Residential development covers the largest area (approximately 32 percent). Industrial areas account for approximately 12 percent of the land area and are generally located along the waterfront. Commercial areas account for 5 percent of the land area and are generally located along the City's major transportation corridors.

3.2.3 Land Uses Around Project Elements

River Intake Pump Station Site

The existing river intake pump station is located approximately 200 feet offshore in a 1-acre parking lot site owned by the City. The parking lot site is at the terminus of Fulton Shipyard

Road. The General Plan designates the site as Public/Institutional. The site is bordered by the San Joaquin River to the north, industrial/manufacturing uses to the east, a diner/restaurant and lot used for staging construction material, and a fenced grassy open space area to the west.

Water Treatment Plant Site

The proposed desalination facility would be located within the fenceline of the existing 25-acre WTP at 401 Putnam Street. Land uses surrounding the WTP site include a public school (Park Middle School) to the northwest and undeveloped open space areas to the northwest and east. The nearest private residences are directly west along View Drive, south along Terranova Drive, and northeast along Elizabeth Lane. The WTP site is closed to the public and includes several structures and facilities associated with water treatment. Land cover is predominantly paved surfaces and structures. There are no sensitive habitats in the vicinity of the WTP, and the site is not within any habitat or natural communities' conservation plans.

Pipelines

The new raw water pipeline would be located in the city of Antioch and would follow one of two routes. From the connection with the existing raw water pipeline, the proposed route would head west along Putnam Street, then south along D Street before entering the WTP site; the optional route would head south along Lone Tree Way, and then west across the WTP's southern property line. In the vicinity of the WTP, portions of the new brine disposal pipeline would be co-located with the new raw water pipeline. The proposed brine disposal pipeline route would head north across the WTP property and cross Putnam Street; the optional alignment would head east across the WTP's southern property line, north along Lone Tree Way, and then west along Putnam Street. Land uses adjacent to the raw water pipeline and brine disposal pipeline routes are generally residential and commercial.

To reach the connection with the Delta Diablo WWTP in the city of Pittsburg, the majority of the new brine disposal pipeline would continue along rights-of-way through the city of Antioch, with a minor portion crossing into city of Pittsburg rights-of-way. Land uses adjacent to the pipeline would be residential, public/institutional, and commercial.

Delta Diablo WWTP

The Delta Diablo WWTP is located at 2500 Pittsburg-Antioch Highway and the site located within both the cities of Antioch and Pittsburg. This is an industrial facility that provides secondary treatment of wastewater, consisting of screening, grit removal, primary and secondary clarification, biological treatment by trickling towers and/or aeration basins, chlorination, and de-chlorination. The WWTP has an average dry weather design capacity to provide secondary level treatment for 19.5 mgd. Treated wastewater is discharged through a deep-water outfall to New York Slough.

3.3 Hydrology

The project area lies south of the San Joaquin River and within the East Antioch, West Antioch, and Kirker Creek Watersheds, with the River Intake Pump Station extending into the river. All three watersheds generally drain from south to north into the San Joaquin River.

San Joaquin River

The San Joaquin River flows east to west, and drains into San Pablo Bay, then San Francisco Bay to the west. The existing intake pump station extends about 200 feet from the shore into the San Joaquin River with the pump intake about 8 feet above the river bed so as to minimize the intake of river bottom sediment. The existing Delta Diablo WWTP outfall pipeline also extends into the river at New York Slough.

East Antioch Creek Watershed

The proposed raw water pipeline connection, desalination facility, and the portion of the brine disposal pipeline north of East 18th Street would be located in the East Antioch Creek Watershed. The drainage area of 11 square miles includes the City of Antioch and some unincorporated parts of Contra Costa County. East Antioch Creek and several unnamed tributaries drain the watershed from south to north into the San Joaquin River. None of the creeks are listed on the States 303(d) Impaired Water Bodies list. Rainfall averages about 13 inches per year. Impervious surfaces make up approximately 60 percent of the watershed. None of the project components would cross East Antioch Creek. The portion of the raw water pipeline that crosses the creek is an existing section of pipeline.

West Antioch Creek Watershed

The portion of the proposed brine disposal pipeline from west of G Street to Auto Center Drive would be located in the West Antioch Creek Watershed. The drainage area of 13 square miles includes the City of Antioch and some unincorporated parts of Contra Costa County. Markley Canyon Creek, West Antioch Creek, and several unnamed tributaries drain the watershed from south to north into the San Joaquin River. None of the creeks are listed on the States 303(d) Impaired Water Bodies list. Rainfall averages about 15 inches per year. Impervious surfaces make up approximately 35 percent of the watershed. The brine disposal pipeline would cross the constructed portion of the West Antioch Creek.

Kirker Creek Watershed

The portion of the brine disposal pipeline west of Auto Center Drive would be located in the Kirker Creek Watershed. The drainage area of about 16 square miles includes the City of Pittsburg and some unincorporated parts of Contra Costa County. Kirker Creek and several unnamed tributaries drain the watershed from south to north into the San Joaquin River. None of the creeks are listed on the States 303(d) Impaired Water Bodies list. Rainfall averages about 16 inches per year. Impervious surfaces make up approximately 30 percent of the watershed. The section of the brine disposal pipeline on 10th Street would cross the Los Medanos Waterway.

3.3.1 Flooding and Drainage

The Federal Emergency Management Agency (FEMA) delineates regional flooding hazard areas in Contra Costa County as part of the National Flood Insurance Program. Areas that have a 1 percent chance of flooding in any given year are referred to as 100-year flood hazard zones. The 100-year flood hazard zones along the coast experience flooding coincident with high tide events typically combined with a wintertime storm surge. The proposed intake pump station and intake pipelines, and the brine disposal pipeline where it crosses the Los Medanos Waterway would both be sited within 100-year flood hazard zones, as shown on **Figure 4** (FEMA, 2015). None of the other project facilities would be located within designated flood hazard areas.

3.3.2 Tidal Characteristics

Antioch and Delta Diablo are located in a strongly tidally influenced area characterized by high tidal flows, and strong seasonal variability that is heavily influenced by upstream flows and management activities. Twice daily tidal cycles at Antioch cause water to ebb and flow at high rates, with peak flows ranging from 70,000 cfs to 200,000 cfs or more. At high and low tides, the waterway temporarily achieves slack water conditions, with limited movement, twice during each tidal cycle. Delta outflow past the City is measured as the net movement of water, discounting tidal flows, out of the Delta. Seasonally, hydrology in the vicinity of the City and the project components (i.e. the diffuser site and the existing intake pump station), reflects the patterns and seasonality trends discussed previously for the Delta. **Table 3** provides the tidal datum for Port Chicago, located about 11 miles west of the project area.

TABLE 3
PORT CHICAGO TIDAL DATUMS

Tidal Datum	Elevation (ft NAVD88)
Mean Higher High Water (MHHW)	6.01
Mean Tide Level (MTL)	3.67
Mean Lower Low Water (MLLW)	1.10
Source: NOAA 2019	

3.4 Habitats

Habitat types occurring within the project footprint were directly observed by ESA biologists during a site visit in December 2017 and derived from review of satellite imagery. Habitats in the project footprint consist of barren and urban (developed) habitats and aquatic habitat in the Delta. Other habitats that occur in the local vicinity of the project include non-native annual grasslands and riparian. The Antioch WTP and the Delta Diablo WWTP facilities support developed habitat that was examined using aerial imagery analysis.



River Intake Pump Station Area



Brine Disposal Pipeline Area Crossing Los Medanos Waterway

Areas shaded in light blue are in 100-year flood zone

3.4.1 Developed Habitats

The most abundant habitat type in the project footprint can be classified as urban. This habitat type includes unvegetated areas occupied by buildings, roads, parking lots, paved areas, and other developed facilities, as well vegetated areas that support ornamental landscaping (e.g., tree groves, street strips, shade tree/lawn, lawn, and shrub cover) or heavily disturbed areas. The project is located mainly in the unvegetated road rights-of-way throughout the cities of Antioch and Pittsburg.

Urban portions of the project footprint are landscaped with non-native plant species, with few native species. Species observed in these habitats include eucalyptus species (*Eucalyptus* spp.), Washington fan palm (*Washingtonia robusta*), olive trees (*Olea* spp.), coast live oak (*Quercus agrifolia*), Italian stone pine (*Pinus pinea*), lemon tree (*Citrus limon* sp.), fig tree (*Ficus carica*), California black walnut (*Juglans californica*), Peruvian pepper tree (*Schinus molle*), coast redwood (*Sequoia sempervirens*), and maple trees (*Acer* spp.). Other species observed include: giant reed (*Arundo donax*), crabgrass (*Digitaria* spp.), and tobacco tree (*Nicotiana glauca*).

Landscape hedges and trees, which could support nesting birds tolerant of human activity, such as house sparrows, are present across the project vicinity. Eucalyptus trees and groves can serve as roosts, perches, and nest sites for raptors, such as red-tailed hawk (*Buteo jamaicensis*) and other birds, including American crow (*Corvus brachyrhynchos*). Wildlife species in urban areas must be able to tolerate the presence of humans and their activities and are typically generalists, capable of utilizing the limited food sources available, such as garbage and horticultural plants and their fruit. Urban wildlife species observed in developed areas of the project component sites include common grackle (*Quiscalus quiscula*), American crow, Eurasian collared-dove (*Streptopelia decaocto*), gull species (*Larus* spp.), and western scrub jay (*Aphelocoma californica*).

3.4.2 Riverine

The riverine habitat type along the shoreline margins may provide resources for specific plants and birds and therefore is briefly discussed here. In the project vicinity near the existing river intake pump station, a narrow band of tules (*Scirpus* spp.) and floating vegetation including water hyacinth (*Eichhornia crassipes*) and other aquatic vegetation species are present at the waters' edge. The edge of the San Joaquin River in the project vicinity is characterized by development and riprap along the banks, and by a lack of near-shore structure, shading, and backwater areas, with relatively swift currents. Upland habitat near the water's edge within the project footprint includes a paved parking lot, paved boat launch, and a maintained non-native turfgrass field with landscaping trees including palms.

3.4.3 Annual Grasslands

There is no annual grasslands habitat directly within the project footprint, although there are several locations where a chain-link fence is all that separates grasslands from the road rights-of-way. The largest such area is to the north of the Pittsburg-Antioch Highway near the Delta Diablo WWTP and at the Antioch Dunes NWR.

Annual grasslands consist of sparse to dense coverage of non-native grasses often associated with numerous other annual and perennial herbs. These grasslands typically occur on deeper soils in the gaps between oak and riparian forests, and also form the understory of several other plant communities. Annual grassland includes mostly non-native annual grasses and few non-native herbaceous forbs. Exotic grassland species generally respond well to moderate disturbance, such as grazing, which may have played a role in their widespread establishment. Annual grasslands provide a nearly continuous ground coverage, and generally have low habitat structure and diversity as a result of historic management and disturbances. Ruderal species, which are typically aggressively-growing, nonnative plants, appear where repeated disturbance such as vehicular traffic alters the natural ecosystem.

The dominant grass species observed in the project vicinity was wild oat (*Avena fatua*). Other common species associated with annual grasslands include: annual ryegrass (*Lolium multiflorum*), ripgut brome (*Bromus hordaceus*), and foxtail barley (*Hordeum murinum* var. *leporinum*). Herbaceous forbs observed include: great valley gumplant (*Grindelia camporum*), black mustard (*Brassica nigra*), and prickly Russian thistle (*Salsola tragus*). Other common species associated with annual grasslands include: California burclover (*Medicago polymorpha*), ox-tongue daisy (*Picris echioides*), star-thistles (*Centaurea* spp.), wild radish (*Raphanus sativa*), Italian thistle (*Carduus pycnocephalus*), filaree (*Erodium cicutarium*) and uncommonly, California poppy (*Eschscholzia californica*), California buttercup (*Ranunculus californica*), and dove lupine (*Lupinus bicolor*).

Many wildlife species use both native and non-native grasslands for refugia, nesting and foraging materials. The wooded habitats and landscaped trees adjacent to grasslands in the project footprint provide shelter and breeding and nesting habitat. No amphibians or reptiles were observed during the reconnaissance-level survey. Although, common amphibians that can be found in this community include: western toad (*Anaxyrus boreas*), Pacific tree frog (*Pseudacris regilla*), and California slender salamander (*Batrachoseps attenuatus*). Common reptiles in grassland habitats include: western fence lizard (*Sceloporus occidentals*), western skink (*Eumeces skiltonianus*), gopher snake (*Pituophis melanoleucus*), and western rattlesnake (*Crotalus viridis*), which are often found in association with woody debris or rocks.

Mammals observed during the reconnaissance-level survey include: California ground squirrel (*Otospermophilus beecheyi*) and fox squirrel (*Sciurus niger*). Expected common mammals in grassland habitats include: blacktail jackrabbit (*Lepus californicus*), Audubon's cottontail (*Sylvilagus audubonii*), and Botta's pocket gopher (*Thomomys bottae*). Raptors (birds of prey) including red-tailed hawk (*Buteo jamaicensis*), white-tailed kite (*Elanus leucurus*), red-shouldered hawk (*Buteo lineatus*), and northern harrier (*Circus cyaneus*) will forage for small rodents in these grassland areas, and use the surround landscaped trees as perches. Birds that nest and forage locally in grasslands include western meadowlark (*Sturnella neglecta*), red-winged blackbird (*Agelaius phoeniceus*), and song sparrow (*Melospiza melodia*). Avian species observed during the reconnaissance-level survey include: red-shouldered hawk, savannah sparrow (*Passerculus sandwichensis*), and white-crowned sparrow (*Zonotrichia leucophrys*).

3.4.4 Riparian

There is no riparian habitat directly within the project footprint, although there are two locations where this habitat type occurs in close proximity to the project. Both riparian corridors occur to the north of the Pittsburg-Antioch Highway near the Delta Diablo's WWTP. Riparian habitat throughout the project vicinity is formed by vegetation along drainage corridors that are sparse to dense woodlands and scrub, and in some disturbed areas riparian habitat is displaced by nonnative annual grassland. The dominate species observed in these areas include: arroyo willow (*Salix lasiolepis*), California black walnut, coast live oak, and Fremont's cottonwood (*Populus fremontii*). Other species common in riparian habitats include: Oregon ash (*Fraxinus latifolia*), red willow (*S. laevigata*), California bay (*Umbellularia californica*), and big-leaf maple (*Acer macrophyllum*). Below the tree canopy, a relatively dense understory of shrubs and sapling trees occurred and included: California and Himalayan blackberry (*Rubus ursinus* and *R. discolor*), rough cocklebur (*Xanthium strumarium*), and various rushes (*Juncus* spp.). Other species common as an understory include: mulefat (*Baccharis salicifolia*) and California wild rose (*Rosa californica*).

Riparian woodland (including mixed riparian and willow riparian scrub) habitat provides food, water, migration and dispersal corridors, breeding sites, and thermal cover for many resident and migratory wildlife species. Wooded stream edges serve as nesting sites and escape habitat for many species. Foliage, bark, and ground substrates provide a variety of foraging areas. Avian species observed during the reconnaissance-level survey include: Nuttall's woodpecker (*Picoides nuttalli*), bushtit (*Psaltiriparus minimus*), and oak titmouse (*Baeolophus inornatus*). Other avian species that commonly forage for insects in riparian areas include: Bewick's wren (*Thryomanes bewickii*), black phoebe (*Sayornis nigricans*), and black-headed grosbeak (*Pheucticus melanocephalus*). Bark-insect foraging birds also occur in this habitat type include: acorn woodpecker (*Melanerpes formicivorus*), and white-breasted nuthatch (*Sitta canadensis*). Other bird species found in the riparian corridor include: dark-eyed junco (*Junco hyemalis*), chestnut-backed chickadee (*Poecile rufescens*), and brown creeper (*Certhia americana*).

No amphibians, reptiles or mammals were observed in the riparian corridor during the reconnaissance-level survey. Riparian woodlands provide habitat for reptiles and amphibians which include: western toad, Pacific tree frog, and Pacific slender salamander. Mammals that utilize these habits for nesting and foraging include: western harvest mouse (*Reithrodontomys megalotis*), deer mouse (*Peromyscus maniculatus*), western gray squirrel (*Sciurus griseus*), Virginia opossum (*Didelphis marsupialis*), and raccoon (*Procyon lotor*). Raptors such as red-shouldered hawk and red-tailed hawk, are attracted to these areas because of the presence of small rodents.

3.5 Special Status Species

For purposes of this assessment, "special status species" include plants and animals listed, proposed for listing, or candidates for listing as threatened or endangered under the Federal Endangered Species Act (FESA) or the California Endangered Species Act (CESA); animals listed as "fully protected" under the California Fish and Wildlife Code (Section 3511); animals

designated as “species of special concern” by the California Department of Fish and Wildlife (CDFW); and plants ranked as rare or endangered by the California Native Plant Society (CNPS).

The potential for the site to support special-status plant and wildlife species is discussed below. In addition to site reconnaissance surveys, background information was gathered to determine the potential for special-status species to occur on the project site:

- California Natural Diversity Database (CNDDDB)
- California Native Plant Society (CPPS) rare plant online inventory; and
- U.S. Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) environmental conservation online system.

3.5.1 Special Status Plants

No special-status plant species are expected to occur within the footprint of the Project either due to the absence of suitable habitat or because the Project is located outside of the known range of the species. As discussed previously, the Project is located in mostly developed areas that are largely paved. Habitat for rare plant species was not identified on the San Joaquin River waterfront.

3.5.2 Special Status Wildlife

Review of the CNDDDB and knowledge of the Project region identified seven terrestrial special-status wildlife species and ten special-status fish species that have at least a moderate potential¹ to be present on the project site, listed on **Table 4**.

¹ Based on a review of the biological literature of the region, information provided by the CNDDDB, and an evaluation of the habitat conditions of the project footprint and vicinity, a species was designated as:

- “none” if: (1) the species’ specific habitat requirements (e.g., serpentine grasslands, as opposed to grasslands occurring on other soils) are not present, or (2) the species is presumed, based on the best scientific information available, to be extirpated from the project footprint or region.
- “low” for occurrence if: (1) its known current distribution or range is outside of the project footprint and vicinity or (2) only limited or marginally suitable habitat is present within the project footprint and vicinity.
- “moderate potential” for occurrence if: (1) there is low to moderate quality habitat present within the project footprint or immediately adjacent areas or (2) the project footprint is within the known range of the species, even though the species was not observed during biological surveys.
- “high potential” for occurrence if: (1) moderate to high quality habitat is present within the project footprint, and (2) the project footprint is within the known range of the species.

TABLE 4
SPECIAL-STATUS WILDLIFE SPECIES WITH POTENTIAL TO OCCUR WITHIN THE PROJECT SITE

Common Name	Scientific Name	Federal Listing	State Listing
Swainson's hawk	<i>Buteo swainsoni</i>	None	Threatened
Burrowing owl	<i>Athene cunicularia</i>	None	Special Concern
White-tailed kite	<i>Elanus leucurus</i>	None	Fully Protected
American Peregrine Falcon	<i>Falco peregrinus anatum</i>	None	Fully Protected
Salt Marsh Common Yellowthroat	<i>Geothlypis trichas sinuosa</i>	None	Special Concern
Loggerhead Shrike	<i>Lanius ludovicianus</i>	None	Special Concern
Western red bat	<i>Lasiurus blossevillei</i>	None	Special Concern
Steelhead – Central Valley Distinct Population Segment	<i>Oncorhynchus mykiss</i>	Threatened	None
Chinook Salmon – Fall-/Late Fall-Run	<i>Oncorhynchus tshawytscha</i>	EFH	Special Concern
Chinook Salmon – Winter-Run	<i>Oncorhynchus tshawytscha</i>	Endangered, EFH	Endangered
Chinook Salmon – Spring-Run	<i>Oncorhynchus tshawytscha</i>	Threatened, EFH	Threatened
North American green sturgeon	<i>Acipenser medirostris</i>	Threatened	None
Delta smelt	<i>Hypomesus transpacificus</i>	Threatened	Endangered
Longfin smelt	<i>Spirinchus thaleichthys</i>	None	Threatened
Northern Anchovy	<i>Engraulis mordax</i>	EFH	None
Pacific Sardine	<i>Sardinops sagax caerulea</i>	EFH	None
Starry Flounder	<i>Platichthys stellatus</i>	EFH	None
Source: CDFW, 2018.			

CHAPTER 4

Conceptual Models and Science Basis

The Project will improve water supply reliability for the citizens of Antioch by allowing the City to maximize its pre-1914 water rights by desalinating water at its existing water supply intake location on the lower San Joaquin River. The intake capacity of the new intake pump station for river water would not be increased relative to the existing facilities – it would remain at 16 mgd. When the desalination facility is operating, 8 mgd would be diverted to the desalination facility and the City would have the ability to divert up to an additional 8 mgd to the conventional WTP or municipal reservoir to be used for blending depending on demands and water quality. The desalination facility would operate at an overall recovery rate of approximately 75 percent. Approximately 8 mgd of river water would be needed to produce 6 mgd of desalinated product water. When operated, the desalination facility would generally operate at its full capacity because steady flow velocity through the membranes at its rated capacity prevents the buildup of precipitates on the membranes.

4.1 Brine Dilution

The chemical constituents and physical behavior of brine discharge have the potential to pose a threat to aquatic organisms (Cooley et al. 2006). Extensive brine discharge, as it constitutes an increased saline layer that sinks towards the seabed due to its greater density, has the potential to affect local marine biota (Ahmed and Anwar 2012). Certain habitat types, organisms, and organismal life stages are at greater risk than others. Benthic organisms in the immediate vicinity of the discharge pipe are at the greatest risk from the effects of brine discharge (Cooley et al. 2006). Early life stages of fish species such as the egg and larval stages, are particularly vulnerable due to their limited or total lack of mobility to avoid plumes of high salinity water. Although estuarine species are familiar to this fluctuation of salinity concentrations, they may not survive on this sudden augmentation of salinity due to brine disposal (Ahmed and Anwar 2012).

The earliest life stages of fish (eggs and larvae) would be the most vulnerable to adverse effects of brine waste discharge due to their limited swimming abilities and inability to avoid the brine waste plumes. In particular, egg and larval life stages of delta smelt and longfin smelt have the potential to be present in the area around the intake during winter and spring months (CDFW 2009) and may be vulnerable to brine water discharge. Conversely, adult and juvenile fish will not occupy areas unsuitable for survival unless they have no other option. Therefore, while areas of brine water discharge may make habitat temporarily unavailable for juvenile and adult fishes, older life stages of fishes should be able to avoid direct effects of brine water plumes.

In addition, fish species such as Chinook salmon, steelhead, delta smelt, and longfin smelt are generally believed to move through the upper half of the water column when migrating, and thus typically do not move along the river bottom in relatively deep channels like the San Joaquin River (Moyle 2002). Therefore, the vulnerability of these species to brine water plumes located near the channel bottom would be anticipated to be low, if these species were present during operations.

The reverse osmosis desalination process would generate on average, approximately 2 mgd of brine waste. Brine from the reverse osmosis system would be conveyed through an approximately 4.3-mile long, 12-inch-diameter dedicated pipeline. The diffuser pipe is 400 feet long and 42 inches in diameter, with three-inch diameter ports spaced eight feet on center and offset side to side, for a total of 50 ports discharging brine waste.

4.2 Fish

The Delta serves as a migration corridor for all anadromous fish species in the Central Valley as they return to their natal rivers to spawn, and during juvenile outmigration downstream to the ocean. Adult Chinook Salmon move through the Delta during most months of the year (Moyle 2002). Chinook Salmon and Steelhead juveniles depend on the Delta as transient rearing habitat while they migrate through the system to the ocean; these juveniles could remain for several months, feeding in marshes, tidal flats, and sloughs. Numerous resident species live in the Delta year-round, such as delta smelt, longfin smelt, green sturgeon, Sacramento splittail (*Pogonichthys macrolepidotus*), and introduced threadfin shad (*Dorosoma petenense*) (Moyle 2002).

Since about 2002, four pelagic (occupying the open water) fish species have been subject to an area of study called Pelagic Organism Decline (POD) (Sommer et al. 2007). The POD refers to the sudden, overlapping declines of pelagic fishes in the Delta that were first recognized in data collected between 2002 and 2004. The species identified in the POD consist of delta smelt, longfin smelt, threadfin shad, and young-of-year striped bass. Together, these species account for most of the resident pelagic fish biomass in the tidal water upstream from X2, the position (isohaline) at which 2 parts per thousand (ppt) salinity occurs in the Delta. The causes of the POD and earlier declines are not fully understood, but studies are under way to evaluate potential causes. Among these potential causes are the stock-recruitment relationship (i.e., previous abundance), a decrease in habitat carrying capacity or production potential, predation and entrainment, and a decline (or changes) in primary productivity (Bennett 2005; Feyrer et al. 2007). In 2011, both delta smelt and longfin smelt populations increased, with delta smelt populations at their highest since 2001 and longfin smelt at their highest since 2006. However, these increases are still a fraction of historic abundances, and numbers significantly declined again in 2012, 2013, 2014, 2015, 2016, 2017, and 2018 (CDFW 2018 [unpublished data]).

4.2.1 Fish Entrainment/Impingement

Impingement is the involuntary contact and entrapment of fish on the screen surface due to approach velocity exceeding swimming capability. Screen entrainment is the movement of fish through, under, or around the fish screen resulting in a loss of fish from the population. Impingement and entrainment of fish could occur as a result of operating the proposed intake

facility. Physical injury can lead directly to mortalities. Injuries or disorientation can also increase the susceptibility to predation. Several factors have been identified as being important indicators for evaluating the potential for fish entrainment. These factors include species/life stages that are seasonally present during intake operation, and species/life stages that use habitat near the location of the intake. It is assumed that fish that prefer habitat areas near the location of intakes would have an increased vulnerability to entrainment and/or impingement. Likewise, because the earliest life stages of fish are smaller and have absent (i.e., eggs and larvae) or reduced (i.e., young juveniles) swimming capabilities, they would also have increased vulnerabilities to entrainment if present near the location of intakes. Conversely, adult fish that use habitat areas away from where intakes are located would be considered to have a reduced vulnerability to entrainment.

The proposed intake structure is designed to minimize the potential for entrainment and impingement. It would include a fish screen designed to meet or exceed applicable NMFS and CDFW criteria (and USFWS recommended guidelines for tidal waters), which would minimize the potential for fish entrainment and impingement for most species and life stages. Specifically, entrainment or impingement of Chinook salmon, steelhead, and green sturgeon is unlikely because these species would only be present in the vicinity of the intake as juvenile or adult life stages, which are not vulnerable to entrainment or impingement because fish screen design and operating criteria would be protective. Furthermore, fish species such as Chinook salmon, steelhead, delta smelt, and longfin smelt are generally believed to move through the upper half of the water column when migrating, and thus typically do not move along the river bottom in relatively deep channels like the San Joaquin River. The vulnerability of these species to entrainment into intakes generally located near the channel bottom would be anticipated to be low, if these species were present during operation of the pump intake. The intake would be located in a region of the Delta that is downstream of and within known delta smelt and longfin smelt spawning habitat (Moyle 2002; Bennett 2005; CDFW 2009). Therefore, it is possible that smelt eggs and larvae could be present in the vicinity of the intake and vulnerable to entrainment risk. Importantly, fish screen design and operation criteria cannot be protective of eggs and larvae because these life stages are extremely small and do not possess swimming capabilities.

4.3 Modeling

4.3.1 Analysis of Brine Discharge Effects

Near Field Effects

The Visual Plumes UM3 model was used to calculate the near-field dilution² of the Delta Diablo discharge. Visual Plumes is a widely used mixing-zone computer model developed in a joint effort led by USEPA and used to simulate single and multi-port submerged discharges using receiving water characteristics specified by the user. The Visual Plumes model was used to compute plume dilution, trajectory, and the dimensions of the plume at the edge of the zone of

² Dilution was calculated as the ratio of ambient water to diffuser effluent. For example, a 10:1 dilution means that 1 part of effluent is mixed with 10 parts of ambient water.

initial dilution (ZID). The ZID is defined as the area where mixing is driven primarily by the buoyancy and/or initial momentum of the discharge; beyond the ZID, mixing results mainly from ambient turbulence.

Near-field effects of the brine discharge were evaluated using the Visual Plumes model. A number of modeling scenarios were identified to evaluate a range of future Delta Diablo effluent discharge volumes and seasonal and water year-type variations in receiving water conditions. Each model run was conducted over a full tidal cycle. The only difference between with and without-Project runs for each modeling scenario was the addition of 2 mgd of desalination brine.

The modeling analyses included a number of additive conservative assumptions. For example, the desalination brine was assumed to have a constant TDS concentration of 32,000 mg/L, corresponding to a river TDS of 8,000 mg/L (i.e., the brine is four times as concentrated as the source water); a river TDS concentration of 8,000 mg/L is near the peak salinity simulated to occur at the City's intake in the existing condition DSM2 simulations over the 16-year period. Under actual operating conditions, the brine concentration will vary with the source water quality. The use of the peak brine concentration of 32,000 mg/L is a conservative assumption that will result in lower simulated dilution than using the brine TDS concentration calculated from the river (source) water for a given tidal cycle. Under actual Project operating conditions, the brine water discharge would be expected to have a TDS concentration of approximately four times the river source water and, like the river source water, its salinity will vary over the tidal cycle.

Analyses indicated that the lowest near-field dilution occurred during the fall season, indicating greatest potential for the Project to alter conditions during this period. Scenarios 1 and 3, which modeled receiving water conditions during fall months in dry-year and critically dry year types,³ represent the "worst case" scenario relative to receiving water quality. These scenarios were used to assess potential water quality impacts related to Project implementation. A summary of all modeled scenarios is provided in **Table 5**.

³ The water year classifications used in the Project analyses were based on the Sacramento Valley Water Year Index available on DWR's California Data Exchange Center website: <http://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST>

TABLE 5
MODELING SCENARIOS APPLIED FOR THE NEAR-FIELD DILUTION ANALYSIS

Scenario ¹		Year Type	Season and Year	Flow (mgd)		
				Desal Brine	Blowdown and Dow Brine	Waste-water Effluent
1 Dry Year/ Max Recycled	a) Without-Project (Min DDSD)	Dry	Fall 2013	a) 0	2013 Seasonal Avg.	0
	b) Project (Min DDSD)			b) 2		
2 Dry Year/ Min Recycled	a) Without-Project (Typical DDSD)	Dry	Fall 2013	a) 0	2013 Seasonal Avg.	12
	b) Project (Typical DDSD)			b) 2		
3 Critical Dry Year/ Max Recycled	a) Without-Project (Min DDSD)	Critical	Fall 2015	a) 0	2015 Seasonal Avg.	0
	b) Project (Min DDSD)			b) 2		
4 Critical Dry Year/ Min Recycled	a) Without-Project (Typical DDSD)	Critical	Fall 2015	a) 0	2015 Seasonal Avg.	12
	b) Project (Typical DDSD)			b) 2		
5 Critical Dry Year Max Recycled-Spring	a) Without-Project (Typical DDSD)	Critical	Spring 2015	a) 0	2015 Seasonal Avg.	12
	b) Project (Typical DDSD)			b) 2		
6 Dry Year ADWF Baseline	a) Without-Project (16 mgd)	Dry	Winter 2013	a) 0	2013 Seasonal Avg.	16
	b) Project (16 mgd)			b) 2		
7 Dry Year Max Flow Winter	a) Without-Project (32 mgd)	Dry	Winter 2013	a) 0	2013 Seasonal Avg.	32
	b) Project (32 mgd)			b) 2		

Source: Exponent, 2018

NOTES:

- Scenarios 1 to 4 review receiving water conditions in fall months during Dry and Critically Dry Years. Scenario 5 evaluates the spring receiving water quality, relevant to fisheries. Scenarios 6 and 7 evaluated winter water receiving conditions.

Far Field Effects

Over the long-term, with continuous discharges, salinity concentrations from discharged effluent will reach a pseudo-steady state within the Delta, reflecting the balance between supply from the discharge location and the removal of discharged effluent from the Delta via advection and tidal flushing. The potential effects of the Project on Delta water quality and beneficial uses at several locations in the western Delta beyond the edge of the ZID (i.e., in the far-field, away from the near-field zone at the point of discharge plume) were evaluated using DSM2. DSM2 model output describing water quality were used as input to the Antioch operations model to compute City diversions and brine flow rates and salinity with and without the Project over a 16-yr simulation period.⁴ The discharge of brine by the City via the Delta Diablo diffuser was included in DSM2 simulations for the existing condition (EBC2) and future with-Project (Boundary 1) scenarios to evaluate far-field salinity impacts at several locations in the western Delta, including

⁴ In the near-field dilution evaluations, the salinity of the brine was assumed to be a constant 32,000 mg/L. In contrast, for the far-field model evaluations, the brine salinity was calculated for each hourly time step as a function of the ambient salinity (i.e., the salinity at the City's intake)."

Antioch's intake location, Contra Costa Canal at Pumping Plant #1, the CCWD intakes on Old River and Middle River, Emmaton, and Jersey Point. Hourly salinity over the 16-yr modeled period at the six Delta locations from the with-Project DSM2 simulations was compared to salinity from the without-Project DSM2 simulations to determine potential impacts (Exponent, 2018).

Based on modeling results, the Project will contribute less than 0.15 percent of total conductivity, on average, during all months and water year types. During wet years, the Project would contribute less than 0.1 percent of total conductivity during all months and at all identified locations. Project contributions range from 0.1 to 0.15 percent during September through January of Normal water years, during August through February in Dry water years, and during June through February of Critical water years. Outside of these months, Project contributions to conductivity at CCWD's intakes would be less than 0.1 percent.

These changes are identifiable, albeit very small, within these modeled scenarios; however, under far-field conditions, these changes are smaller than existing fluctuations in ambient water quality that occur over the course of a typical tidal cycle, and would be difficult to measure. Additionally, none of the modeled scenarios would result in an increase in electrical conductivity that would interfere with, or degrade, beneficial uses relevant to the Delta, and would likely be impossible to detect in most cases.

4.4 Climate Change

Climate change projections for the Sacramento-San Joaquin Delta include: earlier seasonal runoff, higher water temperatures and Delta salinity intrusion. The Project will increase operational flexibility and allow the City to prepare for the foreseeable implication of climate change by allowing it to continue to withdraw water during periods of poorer water quality intake due to reduced freshwater outflows and sea level increasing salinity levels.

CHAPTER 5

Monitoring

Monitoring is important to demonstrate the Project objectives are being achieved to detect the need for corrective management actions (triggers), and to reduce uncertainty and improve understanding of the system.

5.1 Monitoring

5.1.1 Brine Discharge Calibration Monitoring

The effects of the brine discharge will be a focus of resource agencies protecting the Delta because this Project represents the first desalination plant that will discharge such effluent into the Delta. As discussed earlier, Exponent used the Visual Plumes UM3 model to evaluate the effects of the brine discharge. The modeling approach employed conservative estimates to analyze the near-field effects of the brine plume; as such the actual effects of the project's brine effluent would be expected to be reduced compared to those calculated by the UM3 model.

During the Endangered Species Act consultation process, it was agreed that the City would implement a monitoring program to determine if conditions predicted by the UM3 model were observed in the field once the Project is operational. Findings from this monitoring effort will be useful for future calibration of Visual Plumes UM3 model runs. In the unlikely scenario that field sampling finds smaller dilution factors than those predicted by modelling runs, then the City will discuss with the resource agencies about whether additional studies are warranted.

Measurement Points

Measurements for the discharge plume water sampling will be collected at three stations: one station in the interior plume, two stations outside of plume (approximately 200 feet upstream/downstream limit of modeled plume extent). Dependent on the tide phase, the up- and downstream stations would represent the background condition and the extent of the plume (i.e., on the flood tide, the upstream station would be located to the west of the diffuser and would indicate background conditions, while the downstream station would be located east of the diffuser and would be used to characterize the distal extent of the plume). The specific location of stations will be based on operational conditions of Delta Diablo and Project brine discharge volume, and on prior model results for different operational conditions. Delta outflow conditions, tidal dynamics, and the position of the low salinity zone in the vicinity of the outfall diffuser will be considered when interpreting measurements of background salinity, dissolved oxygen (DO), and water temperature.

Measurement Parameters

Water quality metrics that will be analyzed include salinity (measured as electrical conductivity [EC]), DO, and water temperature. DO and temperature will be measured for background information, as these parameters were not modeled.

Measurement Intervals

A single set of four measurements at each station during each of the tide phase (i.e., flood, ebb, slack) in an approximate 12-hour period, for a total of 12 measurements taken.

5.2 Data Management

The monitoring program will include a plan for collecting, storing, documenting, and assuring quality in data management. This data management plan will be developed concurrent with the design of the monitoring program. The data management plan will address data handling from collection, processing, analysis, maintenance and sharing. Descriptions will include project history, detailed monitoring protocols and standard operating procedures (SOPs) for all field sampling and data entry activities, metadata, quality assurance/quality control process, SOPs for analyses, and data storage (including backup and security). Whenever possible, SOPs used will be comparable to those of existing Delta long-term regional monitoring programs to maximize data comparability. Metadata will be documented at all stages of data collection and processing, and stored in standard formats along with the data.

CHAPTER 6

Management Actions

6.1 Triggers

A trigger is the level or value of a metric that warrants a management response to address an undesired outcome. An example of a trigger can be a threshold of a critical ecological process (e.g., lack of extended inundation events of seasonal floodplain required for successful splittail spawning). A stressor can also be a trigger (e.g., excessively high cover of invasive plants).

6.1.1 Brine Dilution

The modeling approach employed conservative estimates to analyze the near-field effects of the brine plume; therefore, the effects of the project once operational would be expected to be reduced compared to those calculated by the Visual Plumes UM3 model. As a result, it is expected that field sampling results would find that actual dilution factors are greater than those predicted by the model.

The adaptive management trigger for brine dilution will be if salinity within the plume near the edge of the ZID will differ from the Visual Plumes UM3 model predictions by more than 50%. Additionally, a management trigger will be if the salinity outside of the plume is outside the range of background conditions (note: these factors already vary drastically depending on tides and freshwater outflow under current conditions).

6.1.2 Project Diversions

To reduce the risk of entrainment of life stages of smelt species which lack motility (e.g., eggs), the City will modify intake operations from the period from December through June (i.e., when early life stage delta smelt and longfin smelt are potentially present in the vicinity of the intake). Other management triggers initially considered for project diversions included reducing intake volumes immediately following the detection of larval or juvenile smelt via Interagency Ecological Program (IEP) fish sampling (e.g., smelt larval survey or spring Kodiak trawl) at sampling locations close to the intake site. However, given that delta smelt and longfin smelt are now only infrequently encountered in these sampling programs, and since sampling at a given site only occurs around every two weeks (or even less frequently), the City determined that relying upon IEP fish survey data was inadequate to definitely conclude that delta smelt and/or longfin smelt were not present in the area (i.e., a zero count does not mean the species are not there; it just means they were not detected). Based on known information about delta smelt and longfin smelt life history, it was determined smelt would be vulnerable to entrainment risk during the

winter and spring months. During other parts of the year, smelt eggs and larvae would not be present (having advanced to more mature life stages), and juvenile and adult smelt have sufficient swimming capabilities to avoid being entrained past or impinged on the fish screens.

6.2 Adaptive Management Actions

If a trigger level is reached, then a management response may be warranted. Potential management responses can include further or more intensive monitoring of the situation, implementation of corrective actions, reevaluation of conceptual models and assumptions about system and project function, and/or adjustment of goals and triggers. Any decisions beyond implementation of established best practices would be coordinated among the City and relevant resource agencies.

6.2.1 Brine Dilution

If discrepancies are noted between field measurements and model results, the City will conduct additional investigations to better understand the reason for the discrepancy. If salinity values within the plume near the edge of the ZID exceed model predictions by more than 50%, additional confirmatory monitoring will be conducted to further assess conditions. Conversely, in the event that the salinity values of the plume are lower than model predictions by greater than 50%, then no additional monitoring would be considered necessary and the City could consider in what specific ways the modeling for the Project is overly conservative (i.e., predict more concentrated brine) and how the modeling inputs and assumptions could be better calibrated.

The 50% trigger was developed using best professional judgement of the aquatic ecologists involved in developing the monitoring approach and was considered appropriate by regulatory agency biologists. The 50% trigger is not meant to signify a threshold where the Project's effects may result in adverse effects – rather the trigger was set in place to ensure that any major deviations between field measurements and model results for the brine plume prompt further, focused evaluation. A trigger of a smaller variation (e.g., 10%) was considered to be inappropriate and overly sensitive given the inevitable error rate in modeling outputs and the highly dynamic environment of the Delta.

If the 50% trigger is exceeded, the first phase of the additional evaluation of the brine plume would likely prompt supplementary confirmatory monitoring efforts, such as taking more than four measurements per sampling station per tide phase and/or taking measurements over several tidal cycles. In the unlikely event that the additional confirmatory monitoring indicates that the 50% trigger is still exceeded, then the City will need to reevaluate the ecological implications that the brine plume may have by conferring with appropriate experts (e.g., consultants and/or university researchers). The primary focus of the reevaluation process is to determine whether the observed change in salinity has any biological significance to the Delta's aquatic foodweb, including phytoplankton, zooplankton, benthic macroinvertebrates, and fish. There is a distinct possibility that even if the 50% trigger is exceeded that no effects on the aquatic foodweb would occur. For example, a 50% deviation from a minute absolute change in salinity concentrations between pre- and post-Project conditions would still represent a very minor change in salinity and

thereby would not be expected to have a meaningful effect on the Delta ecosystem. One of the considerations that will be made will be to consider how the deviation in observed salinity concentrations may affect DWR's tidal wetland restoration sites at its Fish Restoration Program sites (Browns, Winter and Kimball Islands⁵), since the current modeling predicts that the brine plume would be so rapidly diluted that those sites would be unaffected. If warranted, additional confirmatory monitoring could include temporarily installing multi-parameter water quality sondes to take continuous water measurements (e.g., dissolved oxygen, salinity, temperature) within and/or in the immediate vicinity of these restoration sites. **Table 6** summarizes how the 50% trigger links up with subsequent evaluation and management response process.

TABLE 6
LINKAGES BETWEEN BRINE MONITORING AND POTENTIAL MANAGEMENT RESPONSES

Performance Target	Trigger Level	Trigger Scenarios	Evaluation Process	Management Response
Brine Plume Monitoring Results Reflect Modeling Results	Differences in Monitoring Results and Modeling Results exceed 50%	Monitoring results indicate brine concentrations >50% less than predicted by modeling	Consider how modeling may be excessively conservative (i.e., outputs overly predict more concentrated brine)	<ul style="list-style-type: none"> Consider changes in conceptual model and modeling inputs; Brine plume no longer considered a concern for similar sized small desalination projects (i.e., reduced uncertainty in the conceptual model)
		Monitoring Results show brine concentrations >50% greater than predicted by modeling	<ul style="list-style-type: none"> Evaluate how the observed brine concentration levels mechanistically affect biological resources (e.g., change is large enough to exceed salinity threshold tolerance for a native species) Seek input from local experts in aquatic biology, water quality, etc. 	<ul style="list-style-type: none"> Expanding monitoring approach <ol style="list-style-type: none"> Take additional samples Expand monitoring sites to include Fish Restoration Programs restoration sites Expand scope of analysis within monitoring program (e.g., conduct a benthic macroinvertebrate sampling) Re-evaluate modeling inputs

SOURCE: ESA

6.2.2 Project Diversions

During the period from December to June, the City will operate both fish screens in tandem to reduce approach velocities by 50% (i.e., from 0.2 feet per second to 0.1 foot per second; see Table 2). Although this approach will reduce the City's flexibility in maintaining the intake

⁵ The DWR Fish Restoration Program is focused on restoring 8,000 acres of tidal habitat in the Delta and Suisun Marsh to benefit Delta Smelt and 800 acres of low salinity habitat to benefit Longfin Smelt.

facilities (e.g., it is generally preferred to have one of the two screens shut down at any given time to simplify scheduling of maintenance actions), it was considered the best option to ensure adequate protection of delta and longfin smelt. This operational measure will provide additional protection for those early life stages that have limited swimming capabilities and may be most vulnerable to entrainment.

It is expected that there will be situations when the City will need to shut down one of the screens during the period from December to June in order to conduct maintenance or repair work (e.g., to clean the screen). To maintain water supply reliability, the remaining screen may be operated at capacity, increasing the approach velocity. However, these situations are expected to be short in duration and approach velocities will still never exceed 0.2 feet per second (versus 0.1 foot per second) - which is already considered to be protective of Delta fishes.

6.3 Reporting and Communications

A final report summarizing the results of the brine plume calibration monitoring will be prepared by the City. The report will include a summary of work completed to date, milestones, constraints, and recommendations for next steps (if applicable). The report will also divulge lessons learned from the process that will be important to inform future water supply infrastructure projects.

Forums such as the Association of California Water Agencies (ACWA) and Bay-Delta Science Conference are potential opportunities to communicate lessons learned to a broad audience of scientists, managers and decision-makers.

6.4 Long-Term Management and Maintenance

The new intake pump station will be able operate continuously for up to 24 hours a day. The desalination plant's operation schedule would vary each year depending on when chloride concentrations increase at the City's river intake. In general, the plant would be operated seasonally, turning on when river salinity increases and operating at full capacity until salinity at the City's intake returns to a suitable level for conventional treatment. Although pump station would typically be operated remotely, facility operators would conduct routine visits to the pump station sites to monitor operations, conduct general maintenance activities, and service the pumps. No new operators or support personnel would be required for the intake pump station.

General operations and maintenance activities associated with pipelines would include annual inspections, testing and servicing of valves, and repairs of minor leaks in buried pipeline joints or segments. Operation of the desalination facility at the WWTP could potentially require up to 7 new employees. This assumed number of new employees would consist of 5 operators (2 operators for each of the two day shifts, and 1 operator for the night shift), 1 instrument technician, and 1 mechanic/maintenance technician.

Trucks would deliver scale inhibitor, sulfuric acid, sodium hydroxide, calcium chloride, and RO cleaning chemicals to the WTP facility every 5 days to once a month, depending on the chemical to replenish the chemical storage supply for the desalination system.

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CHAPTER 7

References

- Ahmed, M., and R. Anwar, 2012. An assessment of the environmental impact of brine disposal in marine environment. *International Journal of Modern Engineering Research*, 2, 2756–2761.
- Bennett, W. A., 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. *San Francisco Estuary and Watershed Science*. Vol. 3, Issue 2 (September 2005), Article 1.
- Cooley, H., P. H. Gleick, G. Wolff, 2006. *Desalination, With a Grain of Salt: A California Perspective*. Pacific Institute for Studies in Development, Environment, and Security. Oakland, CA.
- California Department of Fish and Wildlife (CDFW), 2009. Longfin Smelt, California Endangered Species Act, Incidental Take Permit, Effects Analysis for the State Water Project. Sacramento, CA.
- California Department of Fish and Wildlife (CDFW), 2018. California Natural Diversity Database (CNDDDB) for 7.5-minute topographic quadrangles: *Diablo, Tassajara, Byron Hot Springs, Clayton, Antioch South, Brentwood, Honker Bay, Antioch North, Jersey Island*. Commercial Version.
- City of Antioch, 2003. City of Antioch General Plan. Prepared by LSA. November 23, 2003.
- East County Water Management Association. 2019. Contra Costa County Integrated Regional Water Management Plan. March 2019. Available:
https://static1.squarespace.com/static/5ca391a8a87b100001fc6975/t/5d362997dd48340001dfa60a/1563830701976/Plan_East+County+IRWM_March+2019+Update-with+App+A-H-reduced.pdf
- Exponent, 2018. Far-Field Dilution Analysis. Prepared by Ryan Thacher and Susan Paulsen. June 2018.
- FEMA, 2015. FEMA Flood Map Service Center, Maps 06013C0139G and 06013C0138G.
- Feyrer, F., M. Nobriga, and T. Sommer, 2007. Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA. *Canadian Journal of Fisheries and Aquatic Sciences* 64:723-734.

Moyle PB., 2002. Inland fishes of California, Revised and Expanded. Berkeley, CA: University of California Press.

National Oceanic and Atmospheric Association. 2019. Datums for 9415144, Port Chicago, CA. Available: <https://tidesandcurrents.noaa.gov/datums.html?id=9415144>. Accessed 7/3/2019.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco Estuary. Fisheries 32(6):270-277.

West Yost Associates, 2016. 2015 Urban Water Management Plan. Prepared for City of Antioch, May 2016.