STAFF REPORT

DESALINATION AND SAN FRANCISCO BAY

January 20, 2005

SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION

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PREFACE

The alchemy of changing seawater into potable, or fresh drinking water is called desalination. As the demand and competition for the many uses of water (agriculture, commercial, industrial, residential and environmental) in California increases and traditional ways of increasing water supply (construction of dams, aqueducts and pipelines) becomes less publicly acceptable, alternative ways of developing new water sources are being scrutinized. A primary alternative source of new water—desalination—long relegated to the "impracticable dream" file, is receiving renewed and serious attention.

In September 2002, AB 2717 (Hertzburg) was signed into law directing the Department of Water Resources to convene a Water Desalination Task Force "to make recommendations to the Legislature on potential opportunities and impediments for using seawater [which includes estuarine waters found in San Francisco Bay] and brackish water [primarily inland saline ground water] desalination and report on the role, if any, the state should play in furthering the use of desalination technology." Representatives of the Commission staff served on the Task Force and much of the information in this staff report is based on the thorough and comprehensive work of that group.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions. Desalinated seawater can provide a new, reliable source of fresh drinking water for the needs of Bay Area communities. Although prohibitively expensive in the past, recent improvements in membrane technology have helped lower the cost of desalination to the point that the process has become a viable alternative source of new fresh water. However, desalination has high-energy costs and can have aquatic environmental impacts, such as entrainment of plankton and eggs and larvae of fish and other aquatic organisms. Moreover, desalination plants and pipelines can displace and adversely affect terrestrial habitats. However, measures are available to avoid and, where avoidance is impracticable, minimize these environmental impacts. Economically and environmentally acceptable desalination can be considered part of a balanced water portfolio to meet the water needs of the Bay Area.

Recommendations. The staff recommends that the Commission amend the *San Francisco Bay Plan* in the following manner:

Add the following new findings to the Bay Plan section Other Uses of the Bay and Shoreline (Page 62):

d. Desalination is the process of removing salt, other minerals and contaminants from saline water to produce fresh drinking water. The intake of Bay water to a desalination plant can pull (entrain) small aquatic organisms (e.g., larvae, eggs, plankton) into the water intake structure where they can become trapped and die. Entrainment can be minimized by such measures as locating the water intake away from areas of high aquatic organism productivity, reducing the volume and velocity of water intake, adequately engineering and screening the intake pipeline, and temporarily reducing or ceasing intake at times when eggs and larvae are present. The discharge of concentrated brine from a desalination plant into the Bay can severely impact fish and other aquatic organisms in the vicinity of the discharge unless the brine is diluted to approximately the same salinity as the Bay. The Regional Water Quality Control Board sets standards for brine discharged into the Bay, and a National Pollutant Discharge Elimination System permit is required from the Regional Board for any desalination plant discharge.

e. A desalination plant does not need to be located adjacent to the Bay; therefore, except for pipelines and directly related facilities needed for Bay water intake and brine discharge, Bay fill is not needed for desalination plants.

Change Policy 9 of Bay Plan section Other Uses of the Bay and Shoreline (Page 64) as follows with the double lined out language deleted from the policy and the double underlined language added to the policy:

9. Power plants may be located in any area where they do not interfere with and are not incompatible with residential, recreational, or other public uses of the Bay and shoreline, provided that any pollution problems resulting from the discharge of large amounts of heated brine into Bay waters, and water vapor into the atmosphere, can be precluded.

Add new policies to the Bay Plan section Other Uses of the Bay and Shoreline (page 64) as follows:

10. Desalination projects should be located, designed and operated in a manner that: (a) avoids or minimizes to the greatest practicable extent adverse impacts on fish, other aquatic organisms and wildlife and their habitats; (b) ensures that the discharge of brine into the Bay is properly diluted and rapidly disperses into the Bay waters to minimize impacts; and (c) is consistent with the discharge requirements of the Regional Water Quality Control Board.
11. Because desalination plants do not need to be located in the Bay or directly on the shoreline: (a) no Bay fill should be approved for desalination plants except for a minor amount of fill needed for pipelines and other directly related facilities that provide Bay water to a plant and discharge diluted brine from the plant back into the Bay; and (b) maximum feasible public access consistent with the project should be included as part of any desalination project that uses Bay waters.

Renumber existing Bay Plan Other Uses of the Bay and Shoreline section (Page 64) policies 10 through 12 as policies 12 through 14.

INTRODUCTION

Desalination is the process by which salts are removed from saline water to produce potable, or drinking quality water. The process is also referred to as desalinization or desalting. Fresh water in California serves many uses and is also very scarce in the State's highly populated regions. For the foreseeable future, California's population is projected to increase by approximately 400,000 persons per year, a number roughly equal to the population of the City of Oakland. Population increase in California will continue to affect the demand for water. Current sources of fresh water in California needed to meet the State's municipal, industrial, agricultural and environmental needs are under stress. Economically and environmentally acceptable desalination can play a role in augmenting the California's fresh water supply and, therefore, should be considered an integral part of a balanced State water portfolio to help meet the State's future water needs.

Although the use of desalinated seawater for domestic consumption is well established in other parts of the world, particularly in the Middle East and the Caribbean and Mediterranean Sea regions, desalination technology has been used in the United States primarily to desalt brackish groundwater. Seawater desalination has played a minimal role in providing fresh drinking water to consumers in this country. However, it appears that desalination may play a much more significant role as a future source of drinking water in California and the San Francisco Bay Area. Over the past decade, significant technological advances have been made in membrane technology and the application of that technology to the process of desalination. These technological advances have helped reduce the cost of desalting water to the point where the cost of desalted water is becoming competitive with the cost of water imported from other sources including the State water project.

While currently there are no desalination plants using water from San Francisco Bay, in 1990 the Marin Municipal Water District (MMWD) successfully tested a small pilot desalination plant located in San Rafael[1] at the end of the Richmond-San Rafael Bridge. Moreover, MMWD and a partnership of Bay Area water districts (Contra Costa Water District, East Bay Municipal Utility District, Santa Clara Valley Water District and the San Francisco Municipal Utility District) are studying the possible development of two new Bay desalination projects—one by the MMWD in San Rafael and the other by the partnership in Oakland. In addition, a third plant is being studied by the water district

1 BCDC Permit No. M 90-55.

partnership in the Sacramento-San Joaquin River Delta at the Mirant power plant in Pittsburg, Contra Costa County, just outside the Commission's jurisdiction. A fourth possible plant is being studied by the partnership in San Francisco near Ocean Beach on the Pacific Ocean. Consequently, it appears likely that the Commission will receive an application for at least one desalination plant within the next few years.

The Commission's law, the McAteer-Petris Act, provides that desalination plants are "essential to the public welfare of the bay area" and therefore the Act provides that the Commission's *San Francisco Bay Plan* "should make provision for adequate and suitable location" for these facilities.[2] Further, the Act specifies that desalination plant water intake and discharge lines are water-oriented uses for which the Commission may allow Bay fill, provided the fill meets the other fill tests set in the Act and the Bay Plan.[3]

Although the Bay Plan does not specify the geographic locations for possible desalination plants, the Plan does contain a policy regarding desalination facilities. The policy, adopted by the Commission in 1968, provides that desalination facilities "may be provided in any area where they do not interfere with and are not incompatible with residential, recreational or other public use of the shoreline."[4] The policy does not, however, address environmental issues important in siting and operating a desalination plant in the Bay, such as fish and other aquatic organisms entrainment (pulling organisms into and trapping them inside the plant water intake structure), possible impingement (pulling and pinning fish and other aquatic organisms against water intake structure screens) and the disposal of the brine, the highly saline waste solution left over from the desalting process. Moreover, the Bay Plan contains no findings to support the desalination policy.

The purpose of this report is to: (1) provide basic information to the Commission on desalination methods and technologies and facility siting and operations with a focus on issues that should be addressed in any proposed desalination project in San Francisco Bay; and (2) recommend changes to the *San Francisco Bay Plan* findings and policies regarding desalination to better guide the Commission in evaluating proposed desalination projects requiring a Commission permit. Chapter 1 describes various methods and technologies used worldwide to separate salt from water with a focus on

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[2] California Govt. Code Sec. 66602

[3] California Govt. Code Sec. 66605.

[4] *San Francisco Bay Plan*. Other Uses of the Bay and Shoreline. Policy 9, page 64.

reverse osmosis membrane technology, the desalination technology that would most likely be used in San Francisco Bay. Chapter 2 describes the siting and operation issues for plants that might be proposed around the Bay with a focus on facilities that use reverse osmosis technology. The issues the Commission will likely face in evaluating an application for a proposed desalination facility are discussed in Chapter 3, and the staff recommended changes to the Bay Plan desalination policy and new findings are contained in Chapter 4.

CHAPTER 1

DESALINATION METHODS AND TECHNOLOGY

Although there are a number of methods and technologies available to desalt water, methods that use membranes and thermal distillation technologies are the most prevalent worldwide. Salt water has been commercially turned into fresh water around the globe for at least 50 years, primarily in the world's arid regions—the Middle East, the Caribbean islands, and areas bordering the Mediterranean Sea. In addition to removing salts, desalination methods also remove other contaminants from water, such as dissolved minerals (e.g., calcium, magnesium), heavy metals (e.g., copper, zinc), dissolved organic matter, pathogens (bacteria and viruses) and known carcinogens (cancer causing agents). Desalination plants that utilize thermal energy are used almost exclusively in Middle Eastern countries where petroleum-based energy is abundant and relatively low cost. Membrane technology is the primary method of desalination in other parts of the world, and the exclusive desalination process used in the United States.

Until recently, high cost has severely limited the development of desalination facilities for domestic water consumption in the United States. However, advances in membrane technology in the past few years have contributed greatly to reducing the cost of producing fresh water from salt water to the point that desalination, in some cases, has become economically competitive with the full cost of other water supplies including importing water from the State Water Project. Over the past 20 years, reverse osmosis membrane technology has improved so much that it is the process of choice where energy costs are an essential criterion to project development. Continued advances in reverse osmosis technology should lead to a further lowering of costs for this technology. Reverse osmosis technology is already the most economic process of desalination in the United States and it appears that reverse osmosis will be the method used in any desalination project proposed in San Francisco Bay. Consequently, this report will focus in greater detail on that method of desalination but in this chapter will also briefly discuss the other frequently used desalination methods.

Membrane Technology. Membranes are used in two important methods of desalting water: reverse osmosis and electrodialysis. Although each of these methods of desalination uses semipermeable membranes to separate salt and other contaminants from water, they each use a different approach to separate salt from water. Reverse osmosis relies on high pressure from pumps to force water molecules through the membrane leaving the salts and other contaminants behind. In electrodialysis, on the other hand, an electrical current is applied to extract salts and contaminants from saline water, leaving the fresh water behind.

1. **Reverse Osmosis**. Osmosis is the natural process in which, given even pressure, a solution of a lower concentration of solvents (a liquid that has dissolved other substances, such as salts) moves through a semi-permeable membrane into a solution of a higher concentration of solvents thereby diluting the higher concentrate solution to a point where equilibrium between the two liquids is reached. The reverse osmosis process reverses natural osmosis and relies on high pressure (up to 1,000 pounds per square inch) to overcome and reverse the osmotic pressure difference and water flow (see Figure 1). Pressure is applied to the source water forcing the water molecules through the semi-permeable membrane. The holes in the membrane—a membrane pore size is 0.0001 micron[5]—are large enough to permit the water molecules to pass through, but too small for salt and other contaminants to pass through. The salts and contaminants accumulate on the pressure side of the membrane in a highly saline solution referred to as the "brine" or "concentrate." Roughly one out of every two gallons of seawater processed in a reverse osmosis system is converted into fresh water. The remaining gallon is brine that must be responsibly disposed.

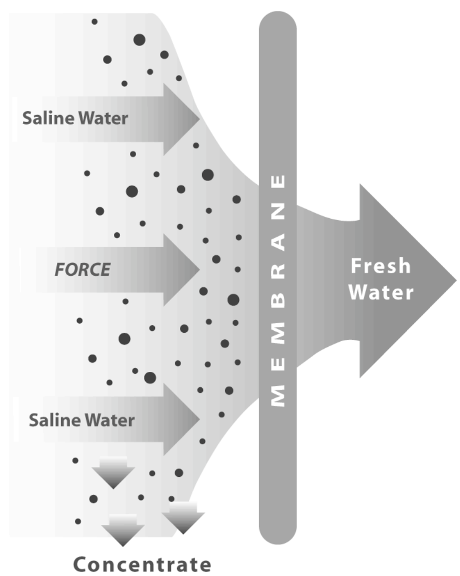

FIGURE 1: Reverse Osmosis Process

(Source: Adapted from *The ABCs of Desalination*)

In desalination plants (see discussion in Chapter 2), high-pressure pumps force the source water through membrane cartridges, essentially tubes filled with thin plastic

[5] By comparison, the average human hair is approximately 50 microns (1 micron = 1/25,400th of an inch) thick.

membranes that resemble the glossy backing of self-adhesive postage stamp sheets. The fresh or "product" water forced through the membranes collects in the center of the cartridge and flows out through a tube to a tank for post-treatment where the product water pH and other parameters are adjusted for compatibility with the water chemistry of the domestic water system by adding lime and other minerals (see discussion in Chapter 2).

As discussed above, the pore size in the membranes used in reverse osmosis technology can filter out contaminants down to the ionic range (.0001 microns). In addition to salts, these membranes can remove from water such contaminants as heavy metals, pesticides, herbicides, viruses and algae toxins.[6]

2. **Electrodialysis**. Electrodialysis use in desalination is a process by which electrically charged salt particles are transferred through an ion exchange membrane by an electrical force leaving water molecules on the other side of the membrane. Voltage is applied across a pair of electrodes causing positive charged ions to move towards one electrode (the cathode) and negatively charged ions to move toward the other electrode (the anode). The membranes are placed between the two electrodes forming several cells or compartments. As the source water flows along a passage lined with membranes, electrically charged salts are attracted by either the cathode or anode through the membrane leaving the fresh water behind.

Thermal Processes. Approximately one-half of the world's desalted water is produced using heat to distill source water into water vapor that in turn is condensed as fresh water. Thermal processes are used primarily in Middle Eastern countries that have a plentiful supply of relatively cheap oil for fuel to heat the source water. Two forms of thermal technology are commonly used to desalt source water: multi-stage flash and multi-effect distillation. A third thermal method, vapor compression, is not as widely used.

1. **Multi-Stage Flash**. In multi-stage flash technology, the thermal process of choice, source water is heated in tubes and passed through a series of chambers, or stages, each of which is maintained at progressively lower pressure so that water "flashes" into steam at each of the stages. Steam from one stage is used to heat the next stage so that the heat is transferred and the vapor condensed.

[6] Desalination Task Force. "Desalination and Public Health" prepared by the Monterey County Health Department, Division of Environmental Health and California Department of Health Services. August 21, 2003. Page 3.

2. **Multi-Effect Distillation.** In the multi-effect distillation method, heated steam from source water is directed inside tubes where the heat is transferred to the tubes and then to a thin layer of source water that flows over the outside of the heated tube. The heated source water is converted to steam, which in turn is conducted to the next tube thereby heating that tube. The condensed vapor from the tube heating process is collected as fresh water.
3. **Vapor Compression.** The vapor compression process differs from the above distillation methods in that the heat for evaporating the source water comes from the compression of vapor by mechanical means rather than directly applied heat. Compression, which produces the heat, is created by an electrical or diesel powered motor.

Other Processes. Other desalination processes include freezing, membrane distillation, solar humidification and wind-driven desalination facilities. These kinds of facilities represent a mere fraction of the operating desalination plants worldwide and are not considered, at least at this time, to be commercially viable. In the freezing process, saline water is chilled to the freezing point and the salts are naturally excluded from the ice crystals formed. In the membrane desalination process, the saline water is heated to produce vapor. The vapor passes through a membrane but the liquid, the saline water, does not. Solar humidification relies on the sun to heat a vessel of seawater to the point of vaporization (humidification). The water vapor is then condensed on a cool surface producing fresh water. Other kinds of processes use solar or wind energy to heat water or drive motors to desalinate water but these processes are not, at least at this time, cost effective for large-scale desalination.

CHAPTER 2

DESALINATION PLANT SITING AND OPERATATION

Seawater desalination plants cannot be located just anywhere; they need: (1) a site close to the water supply (also referred to as the "source" water or "feed water"); (2) a reliable and economical source of electric power; and (3) a location near a municipal water delivery system to convey the fresh water (also called "product" water) to the consumer. Desalination plants do not need to be located on the shoreline; they can be located inland. However, the plants do need access to the water supply, which normally involves extending a pipeline or similar water intake structure from the plant into the source water either at a near-shore or offshore site. The distance a desalination plant can be located inland from the shoreline is limited by the cost of pumping water from the intake point to the plant and is therefore dependant on local site conditions and energy costs. Access to the water source for discharge of the brine is also required.

A reverse osmosis desalination plant requires a considerable amount of electric power to pump the source water from the intake point to the plant; through a pre-treatment process that filters out the solids such as sediment and other larger impurities; through the treatment membranes, the heart of a desalination process; to storage facilities and to the municipal water distribution system. In addition, power is needed to pump the brine to a discharge facility, which normally would be a co-located thermal power plant or municipal sewage treatment plant discharge system.

Following is a general description of a seawater desalination process using reverse osmosis membrane technology.

Water Intake Systems. Feedwater systems are designed and located to provide a reliable high-quality source of seawater to the desalination plant. Seawater intake systems are of two types: surface and sub-surface.

A surface intake, the most commonly used system, involves pumping seawater directly from the source (such as the Bay) through a pipeline. When on land, the pipeline is normally buried in a trench but it can be laid on the ground surface as well. When in the water, the pipeline can either be suspended from a structure built over the water, such as a pier, buried in an excavated trench or placed on the floor of the water body. Most likely, surface intake systems will be the source water intake systems of choice for desalination projects proposed for San Francisco Bay. The intake pipe and appurtenant fish and other aquatic organisms screening mechanisms could extend into either the deeper waters of the Bay or, possibly, shallow water areas.

A subsurface intake involves pumping water from ground wells normally sunk into fine-grained granular material. These facilities are referred to as Rainey wells or beach wells.[7] Beach wells require a favorable geology and soil stratification not found around San Francisco Bay. The Bay shoreline does not have the expanse of granular material underlying the Bay or on its shoreline as found in areas along the ocean coast. Consequently, a beach well system would not work well in the Bay and therefore it can be expected that a beach well system would not be part of any proposed Bay desalination facility.

Desalination plants that take their water directly from the Bay or ocean are referred to as "stand-alone" facilities (See Figure 2). However, desalination plants do not require that their water be taken directly from the Bay or the ocean. They can take their water from other users of

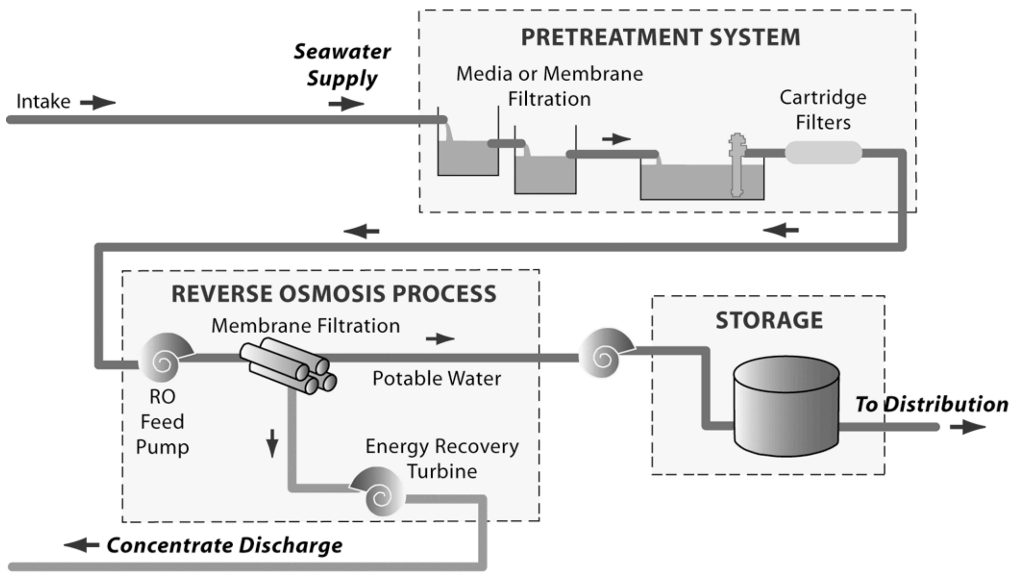

FIGURE 2: Stand Alone Desalination Plant

(Source: Adapted from Poseidon Resources)

seawater such as a thermal power plant that utilizes a once-through cooling system.[8] There are considerable advantages for a desalination plant to co-locate with a power plant. First, the desalination plant can take its water directly from the power plant, either the power plant's

[7] Subsurface desalination is primarily used in the desalting of brackish inland subsurface water. Beach wells can also be used on the ocean coast where a large expanse of sand is located, such as the Marina Coast Water District's seawater desalination project in the City of Marina, Monterey County.

[8] In Monterey, California, the Monterey Bay Aquarium has co-located its desalination facility with the Aquarium. The desalination facility takes its feed water from the Aquarium water intake structure and mixes the brine from the desalination process with the Aquarium water discharge into Monterey Bay. All the water used in the Aquarium, other than the fish tanks, is desalted water from the Aquarium's desalination facility.

intake structure or its discharge line, eliminating the need to construct separate intake and discharge lines. Second, the desalination plant can, if the operators choose, take warmed water from the power plant's discharge system, that is more easily processed in a reverse osmosis system and requires less power to separate water molecules from salts and other minerals. Third, the desalination facility can blend and dilute the residue brine with the power plant's return water for disposal to the Bay. And fourth, the desalination plant can often directly purchase power from the power plant if located on the power plant site property (referred to as "inside the fence") rather than purchase power from the grid, thereby realizing lower electric power rates.

Under a co-location arrangement, water is taken from the power plant's water intake or discharge structure and routed through the desalination plant. The brine residue from the desalination process is mixed and blended with the power plant discharge stream before being returned to the source water (see Figure 3). This process has the advantage of a stable source of water (even should the power plant be shut down, a lesser amount and volume of water can be run through the plant to maintain the desalination operation) that does not require additional intake of water from the source water, a ready system for brine disposal (see discussion of brine disposal later in this chapter) and potentially cheaper energy costs (see discussion of energy costs later in this chapter).

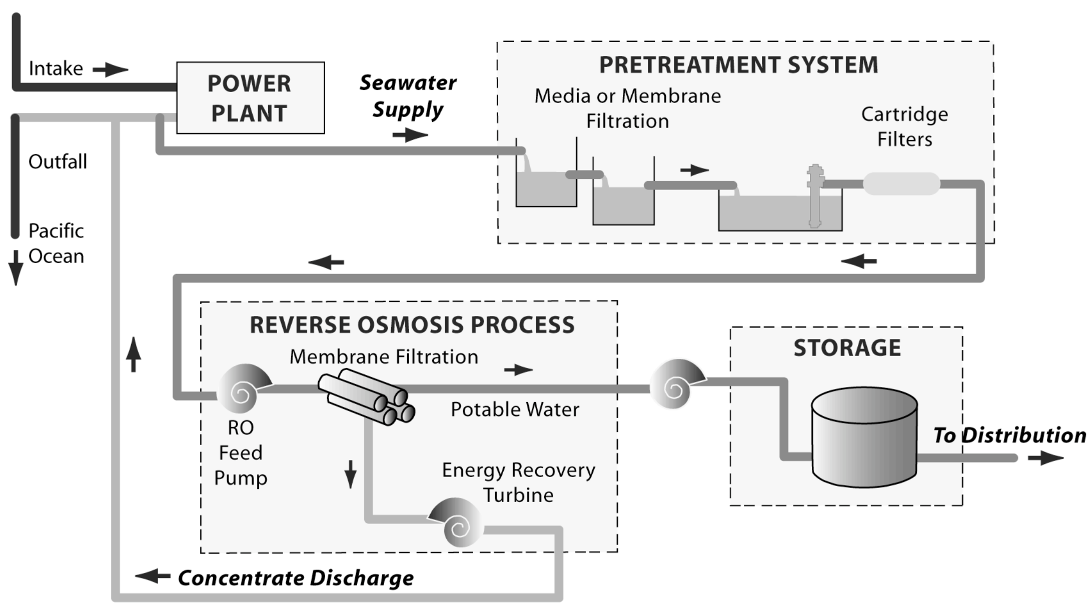

FIGURE 3: Desalination Plant Co-Located With Power Plant

(Source: Adapted from Poseidon Resources)

There are drawbacks to co-locating desalination plants with thermal power plants, however. Most once-through cooling system power plants use fossil fuel that has significant impacts on air quality. Moreover, a once-through cooling system has substantial adverse environmental effects on fish and other aquatic organisms. Once-through cooling systems, because of the considerable volume and velocity of the source water drawn into the plant by powerful pumps, cause impingement (the pinning and trapping of fish and other aquatic organisms against the screens on water intake structures, causing injury or death to the organisms) and entrainment (drawing of small aquatic organisms into a water intake structure past any screening device and subjecting the organisms to changes in water pressure and temperature, chemical exposure or mechanical injury that can lead to severe damage to the organism or death) of fish and other aquatic organisms (see discussion of impingement and entrainment in Chapter 4). For example, the Potrero Unit 3 thermal power plant in San Francisco, the larger of the two remaining once-through cooling system power plants in the Commission's jurisdiction, annually pulls in an amount of water equal to one-sixth of the entire volume of the water in the Bay between the Oakland Bay Bridge and its southern terminus at San José.[9] Co-location of a desalination facility with a thermal power plant may provide justification for the continued use of an environmentally disastrous and dated power plant beyond its scheduled life. Once a community becomes reliant on the water from a desalination plant co-located with a once-through cooling system power plant, it may be difficult to terminate the operation of the power plant and thus the desalination plant.

Stand-alone desalination plants draw considerably less water at a far lower velocity than once through power plants. Although there is considerable information and studies conducted on the environmental effects of once-though cooling systems power plants, there is a lack of information on the environmental impacts of water intake in stand-alone desalination facilities.

Source Water Quality. The quality of the water is important in locating and operating a desalination plant. The amount of total dissolved solids (TDS) in the source water has a direct relationship to the cost of producing fresh water using a reverse osmosis system.[10] The greater the amount of TDS in source water, the greater the amount of pressure required forcing water molecules through the membrane. Greater pressure requires increased energy, and therefore cost, to produce the same amount of water as can be produced with lower energy demands for

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9 Communities for a Better Environment. Letter to Bruce Wolfe, Executive Officer, Regional Water Quality Control Board, San Francisco Bay Region. September 29, 2004. Page 2.
10 United States Department of the Interior. *Desalting Handbook for Planners*. July 2003. Page 151.

source water with lower TDS.[11] The amount of dissolved solids in ocean water around the world is fairly constant, approximately 3.5 percent or 35 parts per thousand (ppt).[12] Estuarine waters have a lower level of dissolved salts and other minerals and the amount varies depending on location in relation to the ocean, riverine inflow, the season and tidal cycle. In San Francisco Bay, dissolved salts range from approximately 15 ppt to 30 ppt. The quality of water in estuaries is affected by the amount and condition of fresh water inflow from the tributary riverine systems and can vary with local storm water runoff. The quality of estuarine water, with its high sediment and organic life, directly impacts the intensity and type of pretreatment required for successful desalination.

Source Water Pretreatment. Pretreatment of source water is essential to keep the reverse osmosis membranes clean. Without clean membranes, the desalination process will break down. Pretreatment screens out suspended solids and microorganisms, matter that can plug and clog membrane pores. Pretreatment is particularly important in estuaries, such as San Francisco Bay, because of the high level of suspended sediments and microorganisms. Usually, pretreatment consists of filtering the source water through fine granular sands. However, recent experience with the Tampa Bay desalination plant in Tampa Bay, Florida,[13] which has ceased operation in part because of membrane fouling (the build up of biological growth) has highlighted the need for additional and more sophisticated pretreatment of source water, particularly in estuaries. Like San Francisco Bay, Tampa Bay is an estuary. In part, because of the pretreatment problems experienced at the Tampa Bay plant, a greater level of pretreatment is being considered for desalination plants proposed for San Francisco Bay, including the use of membrane technology.

Source Water Treatment. As discussed in Chapter 1, semi-permeable membranes in a reverse osmosis system are the key element in the desalination plant process. The membranes are made of special paper-thin plastic sheets rolled into tubes or cartridges. The pretreated water is forced through the membranes in each cartridge, collecting in the center of the cartridge where the fresh water flows out in a tube to the post treatment stage. In the Tampa Bay, Florida desalination plant, 10,032 membranes were installed in 2,002 cartridges in that plant's reverse osmosis system. If all the membranes in the Tampa Bay plant were stretched out on the ground, they would cover 85.6 acres.[14] Membrane technology has improved and the cost of membranes has

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[11] Ibid.
[12] United States Department of the Interior. *Desalting Handbook for Planners*. July 2003. Page 38.
[13] The Tampa Bay desalination plant, which is co-located with a thermal power plant, is the most recently constructed desalination plant in the United States. Designed to initially produce 25 million gallons of water per day, financial problems and the clogging of the reverse osmosis membranes with tiny Asian green mussels, an invasive, have caused the plant to be placed on standby to allow an analysis of the plant's condition and membrane cleaning and future fouling prevention options to be conducted.
[14] Tampa Bay Water. "Tampa Bay Seawater Desalination Facts." (Undated.)

dropped significantly over the past decade. Membranes are now much stronger and the membrane pore sizes more uniform than in the past. Ten years ago, according to a spokesman for the desalination company Poseidon Resources Corporation, each reverse osmosis cartridge cost about $1,200 and lasted about three years. Today, the cartridges cost approximately $550 each and last seven to eight years.[15] It is expected that membrane technology will improve and the cost of membranes will continue to decline in the future.

Post Treatment of Product Water. Fresh water from a desalination plant requires post-treatment before it can be used for domestic purposes. Although desalted water is basically free of viruses and pathogens, state and county health departments require that a disinfectant, usually chlorine, be applied to the water for all municipal drinking water systems to assure that disinfection residual is maintained in the drinking water system.[16] Moreover, because most minerals have been stripped from the water in the desalting process, the product water is highly corrosive and minerals such as calcium, bicarbonate and lime and a change in pH will "stabilize" the product water so that it can be added to the domestic water supply system. In addition, water managers seek to balance the taste of the desalted water with the water of the municipal water so that the consumer will not detect a difference in the two waters.

Brine Disposal. A desalination plant produces two streams of water: the desalted "product" water that is routed to the domestic water distribution system and the wastewater stream of concentrated brine. Brine has a much higher salt concentration than the intake seawater. Therefore, brine discharge represents a primary environmental issue in the design, location and operation of a seawater desalination plant. Brine concentrate includes not only the salts removed from the intake water, but potentially heavy metals and chemicals that were in the intake water or may have been added in the desalination process. Seawater desalination plants generally convert from 35 to 50 percent of the plant feedwater to potable water.[17] The remainder of the water becomes the brine. Typically, salt concentration in ocean water is between 33 and 35 parts per thousand (ppt). Estuarine water like San Francisco Bay contains on average about 26 ppt, although the salt concentration varies depending on season, tidal cycle and proximity of the intake structure to fresh water inflow to the Bay. Brine concentrate is about 69 ppt.[18] Concentrates at this level can have a severe adverse impact on fish and other aquatic organisms if discharged directly to the Bay in a concentrated form. Therefore much care must be given to the siting, design and operation of a desalination brine discharge system to ensure that the content

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[15] Pat Storey. "Carlsbad Desalination Unit Up and Running." North County Times. March 8, 2003.
[16] United States Department of the Interior. *Desalting Handbook for Planners*. July 2003. Page 123
[17] California Water Desalination Task Force Draft Working Paper. "Concentrate Management Issues Associated with Desalination Facilities." June 20, 2003. Page 1.
[18] Ibid.

and temperature of the discharged brine does not pollute the receiving waters. In San Francisco Bay, under the federal Clean Water Act standards are set and regulated by the California Regional Water Quality Control Board, San Francisco Bay Region (Regional Board). A National Pollutant Discharge Elimination System permit from the Regional Board is required for the discharge of brine by a desalination plant into the Bay. The primary way to meet discharge standards would be to dilute the brine prior to Bay discharge.

Two common methods to dilute brine are to (1) mix the brine with the discharge water from a power plant using a once-through cooling system or (2) blend the brine with the effluent from a sewage treatment plant. When co-located with a sewage treatment plant or a power plant, the relatively low volume of brine from a desalination plant can be effectively blended with the effluent from the treatment plant and the discharge water from the power plant in a Regional Board approved wastewater discharge line, as illustrated in Figure 4 for a treatment plant and Figure 3 for a power plant. In such cases, the blended discharge has roughly the same level of dissolved salts as the receiving water. For example, at the Tampa Bay, Florida desalination plant, which is co-located with a power plant, the salinity level of the blended power plant/desalination plant discharge is expected to be less than two percent above the level of

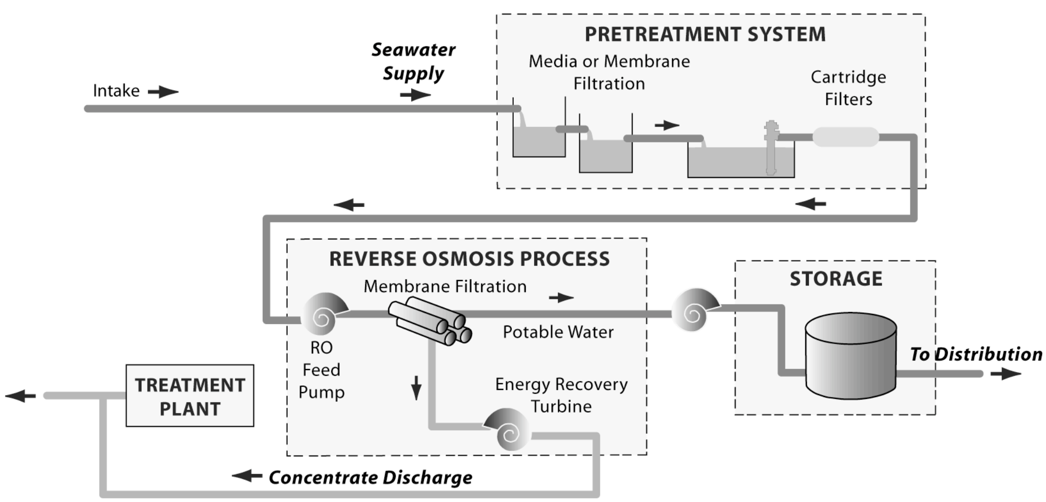

FIGURE 4: Desalination Plant Co-located With Treatment Plant

(Source: Adapted from Poseidon Resources) total dissolved solids in the Tampa Bay estuary.[19] This mixture, when discharged at the proper location using diffuser pipes, should disburse and mix with the receiving water quickly, minimizing impacts on aquatic life.

Discharge of brine with effluent from a treatment plant dilutes the brine. The introduction of brine to a treatment plant discharge can be beneficial, when properly mixed with the effluent, because fresh water discharges have an inherent toxicity in marine systems. If a proper salinity level in the wastewater discharge can be achieved by blending brine with the treatment plant effluent, environmental problems associated with discharge of fresh water effluent may be alleviated.

In addition, temperature not being a factor, the blended discharge, which is more saline than normal treatment plant effluent, will tend to sink and disperse along the bottom of the receiving waters rather than rise and mix with the upper, biologically productive, top layer of the receiving waters. Nonetheless, important bottom benthic habitats and aquatic organism species that inhabit the floor of the Bay, such as sand dabs, halibut and Dungeness crabs, must be monitored to ensure that important species and habitat are not adversely effected.

Desalination waste disposal is not limited to the liquid brine. Solids such as magnesium, iron and copper that accumulate on and are cleaned from the pre-treatment and treatment filters require special disposal, normally at a sanitary landfill. The desalination process solid waste material can also be used beneficially as part of the land cover spread over the compact refuse on a daily basis.

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[19] Jensen, James H. "Desalination Becomes a Reality in Tampa Bay, Florida." Parsons Brinckerhoff, a Division of Parsons Brinckerhoff Quade & Douglas, Inc. San Diego. (No date).

CHAPTER 3

DESALINATION PROPOSALS AND ENVIRONMENTAL ISSUES

Desalination projects around San Francisco Bay are being studied by the Marin Municipal Water District (MMWD) which serves approximately 185,000 people in a 147-square-mile area in central and southern Marin County, and by a partnership of water districts consisting of the Contra Costa Water District, East Bay Municipal Utility District, San Francisco Public Utilities Commission and the Santa Clara Valley Flood Control and Water District. The water districts are the Bay Area's four largest and serve about 5.4 million residents and businesses. The MMWD evaluated seven sites for the location of a desalination plant and the water district partnership analyzed 13 possible sites including a floating facility in San Francisco Bay. The MMWD chose a site near the end of the Richmond-San Rafael Bridge as its preferred site and the regional partnership selected three possible sites: one in Oakland near the Oakland Bay Bridge at the East Bay Municipal Utilities District Waste Water Treatment Plant, another in San Francisco near the Oceanside Water Pollution Control Plant on the Pacific Ocean, and the other in Pittsburg at the Mirant power plant (see Figure 5).

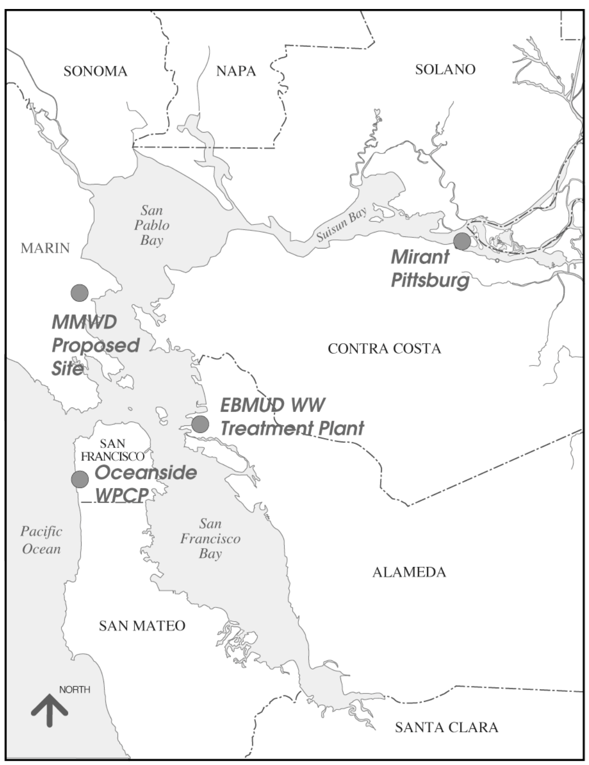

FIGURE 5: Proposed Desalination Plants in Bay Area

(Source: San Francisco Bay Conservation and Development Commission)

The siting and operation of a desalination plant can have several kinds of environmental impacts that can broadly be categorized into two areas: terrestrial and aquatic. Terrestrial impacts can occur from the siting of the desalination plant and ancillary facilities, such as fencing and power supply lines, and water intake and discharge structures and pipelines. Aquatic impacts include entrainment of aquatic organisms such as larvae, eggs and plankton, brine discharge, water intake and discharge location, and impacts associated with excavating trenches for intake or discharge pipeline or placing the pipelines directly on the Bay floor. In addition, desalination projects can have energy consumption, visual, construction, environmental justice and public access issues. On their own, reverse osmosis desalination plants do not create light, glare or noise impacts

This chapter identifies the state of desalination plant proposals around San Francisco Bay, the likely principal environmental issues associated siting and operating a plant in the Bay and measures that can be taken to avoid or minimize possible project environmental impacts.

Marin Municipal Water District Proposed Project. In 1989, the Marin Municipal Water District (MMWD) recommended in its Water Supply Master Plan that an additional 10,000 acre-feet-per-year of water needed to be secured to meet short falls in the event of a drought and to supply water to accommodate projected growth in MMWD's service area. One option for securing the additional supply of water, the District determined, is from desalination.

In August 1990, the Commission issued a permit (M90-55) to the MMWD to construct and operate a temporary (four months) pilot desalination plant at the foot of the Richmond-San Rafael Bridge in San Rafael (see Figure 5). The purpose of the $300,000 pilot project was to evaluate the potential use of desalinated Bay water for domestic water consumption by MWWD's customers. The small reverse osmosis desalination plant, approximately 1,800 square feet in area, or about the size of a modest single-family home, was sited on the Bay shoreline on land owned by the State of California (Caltrans). Two three-inch PVC pipes, one for Bay water intake and the other for discharge of the desalted water, extended from the plant, along the shoreline, and out along the deck of the Marin Rod and Gun Club's fishing pier. The pipes extended along the surface of the pier deck to the end of the pier, approximately 2,000 feet from the shoreline. At that point, the pipes were reduced to two-inch pipes and extended into the Bay. A submersible one-horsepower electric pump, capable of pumping 35 gallons of Bay water per minute, was attached to the end of the intake pipe in the Bay approximately two feet above the Bay floor in water approximately six feet deep at mean lower low water. To minimize aquatic life entrainment, the pump intake was screened to the specifications set by the California Department of Fish and Game, with openings no greater than 3/32 of an inch. In addition, water intake velocity was restricted to less than one-third-foot-per-second perpendicular velocity. This design, according to MMWD, prevented the entrainment of fish and other aquatic organisms except for plankton.[20] The brine from the desalination plant was combined with the product water and returned to the Bay. Samples of brine were mixed and discharged with the effluent from the nearby Central Marin Sanitation Agency's sewage treatment plant effluent and bioassays were performed on the blended discharge, as required by the Regional Water Quality Control Board, to assure that the discharge was not harmful to Bay aquatic organisms.

From its study, the MWWD concluded that to produce water of a quality (taste and salt content) equal to the existing quality of water provided its customers; it should use a partial two-pass reverse osmosis process. According to MMWD, single-pass desalinated water contains between 200 and 300 parts-per-million (ppm) salt. MMWD, by using a two-pass system, was able to provide water that had higher purity than its existing water system. In a blind taste test, according to MMWD, 95 percent of the participants preferred the taste of the desalinated water to MMWD's domestic water.[21] The bioassay tests showed, according to MMWD, that this discharge mixture would have no adverse environmental effect on Bay aquatic organisms. In addition, the contaminants in the sludge from the pretreatment system did not exceed 10 percent of limit set for disposal in a sanitary landfill.

The MMWD also analyzed the pilot plant's energy consumption. As previously discussed, the amount of energy required to force water molecules through a semi-permeable membrane decreases with the rise in source water temperature. Because the Bay is warmer and less salty than the ocean, desalination energy costs should be less for desalination projects in the Bay when compared to projects on the ocean. MMWD has calculated that the amount of energy required to desalt enough water for the average annual use by a single family residence in its service area is comparable to the energy cost for the average kitchen refrigerator.

In 2001, MMWD authorized a new study of desalination as an alternative source of water for the District's needs and has preliminarily concluded that a site on Pelican Way in San Rafael would be the location of choice for a possible new plant. The District, however, continues to study various options before it makes a final decision on whether to construct and operate the plant. To provide additional information to assist it in determining whether or not to proceed with a plant, in early October 2004 MMWD approved another small pilot desalination plant close to the site of the 1990 demonstration project plant. Once in operation, the pilot plant will operate for 12 months and the District will analyze the performance of the plant before determining whether to proceed with the larger desalination plant.

[20] Bob Castle, Marin Municipal Water District, personal communication. May 6, 2004.
[21] Bob Castle, Marin Municipal Water District, personal communication. May 6, 2004.

Bay Area Regional Desalination Project. The East Bay Municipal Utility District, Contra Costa Water District, Santa Clara Valley Water District and the San Francisco Public Utilities Commission have come together to explore developing one or more regional desalination facilities designed to: (1) provide an alternative source of water during emergencies, such as an earthquake, and extended drought periods; (2) permit parts of the water delivery system, such as treatment plants and transmission mains, to be taken out of service for long-term maintenance and repairs; and (3) add to the agencies' water supply portfolios to maintain water supply reliability.

The agencies evaluated 20 potential desalination plant sites on or near San Francisco Bay before narrowing the choice to the 13 sites. In October 2003, the agencies chose three of the sites, the Mirant Pittsburg power plant in Pittsburg just outside the Commission's jurisdiction, the East Bay Municipal Utilities District's sewage treatment plant in Oakland near the Bay Bridge, and the Oceanside waste water treatment plant site in San Francisco on the Pacific Ocean, also outside the Commission's jurisdiction. The partner agencies are currently studying which, if not all, of the proposed projects should be pursued.

Environmental Effects. Desalination projects can adversely effect the terrestrial and aquatic environment unless thoughtfully planned, designed, located and operated. Measures are available to avoid, or if avoidance cannot occur, significantly minimize the impacts of desalination projects on the environment.

The primary environmental concerns with desalination plants in San Francisco Bay are the entrainment of the eggs and larvae of fish and other aquatic organisms and small aquatic organisms, such as phytoplankton and zooplankton, in the water intake structure, and the effect of highly concentrated brine discharged into the Bay on aquatic organisms. Impingement, which occurs when fish and other aquatic organisms are trapped against water intake structure screens or other filtering mechanisms, should not occur with stand-alone desalination plants. As discussed in Chapter 2, the kinds and amounts of fish and other aquatic organisms that are impinged and entrained in a water intake system are directly related to the volume and velocity of water taken into the system. Although once-through cooled power plants take in copious volumes of water at relatively high velocities and power plant pumps can suck in prodigious numbers of aquatic organisms, stand-alone desalination plants do not require anywhere near the volume of water required by a power plant. For example, the Tampa Bay Power Plant discussed earlier in this report draws in 1.4 billion gallons of water per day for cooling purposes. The desalination plant, which is co-located with the power plant, takes (when operational) 44 million gallons of the power plant's daily intake water for its purposes.[22]

[22] www.tampabaywater.org

Because of the relatively low volumes and velocity of water intake, stand-alone desalination facilities should not have impingement problems. Entrainment, however, will be an issue with stand-alone desalination plants, particularly with small aquatic organisms such as phytoplankton, zooplankton and fish and other invertebrate larvae and eggs. There are however, methods to prevent or minimize entrainment including the location of the source water intake, the use of screens and similar filtering mechanisms and closure of the intake system during times of the year that eggs and larvae, particularly of threatened or endangered species, are present.

Water intake should not be located in areas that are high in native aquatic organism biodiversity, such as tidal marshes, areas of subtidal vegetation (e.g., eelgrass beds), calm shallow water areas, oyster shell reefs and subtidal areas where tidal eddies, retention zones and fronts are present. Deeper parts of the Bay are frequented by larger fish and aquatic organisms that would not be entrained in a desalination plant intake pipe. In addition, there are less juvenile and larval fish and eggs in the deeper waters of the Bay. Shallow, protective waters of the Bay are frequently populated by fish and other aquatic organisms in the egg and larval stages as well as beds of aquatic vegetation and oyster reefs. Entrainment can be minimized and possibly avoided if intake pipes are located in the deeper parts of the Bay. There is, however, a trade-off with locating an intake pipe in deeper parts of the Bay because the salinity level is higher and the water temperature colder than the shallower regions of the Bay. Colder, saltier water would require additional energy to convert to fresh water in a reverse osmosis system.

In addition to intake structure siting, the design and application of screens and other filtering mechanisms at the intake point of water intake structures will help minimize entrainment of aquatic organisms. As discussed above, the Department of Fish and Game has required installation of cone-shaped screens with openings no greater than 3/32 of an inch on the MMWD's 1990 pilot desalination plant. Other kinds of screens can be employed as well, including rotating screens, depending on site conditions and kinds of aquatic organisms at risk. Intake pipes can also be designed to minimize the pulling force of water intake. Designs that include a right angle at the intake point of the pipe or a downward configured "J" design have been found to minimize aquatic organism intake. The Gunderboom Corporation, which specializes in the production of aquatic filter barrier systems, has designed what it terms the "Marine Life Exclusion System" to prevent intake structure entrainment as well as impingement. Gunderboom's system is a water-permeable barrier that, the company claims, keeps fish eggs, larva and other aquatic organisms a safe distance away from an intake structure. Moreover, according to the company, its system prevents both impingement and entrainment of plankton and juvenile aquatic life. The system resembles a floating boom with two layers of a suspended fabric, which creates a pocket between the layers, extending to the full water depth. This curtain is spread around the intake structure preventing aquatic organisms from getting near the water intake point. The company claims that the intake velocity on the open waterside of the barrier is 98 percent less than at the intake structure.[23]

Another method of minimizing entrainment with a desalination plant is to significantly reduce or stop operation of a plant during the egg and larval stages of fish and other aquatic organism life at the point of water intake. The egg and larval stages of various fish and aquatic organism are seasonal and are different in various parts of the Bay. Windows of operation can be set for different parts of the Bay to minimize entrainment of eggs and larvae of fish and aquatic organisms at locations and times of the year in which target species of fish eggs and larvae are not present. However, shutting down a desalination plant for periods of time would interrupt a constant and reliable source of water and therefore this method may only be practicable if the plant is only needed in periods of drought or in emergencies or another source of water is available during shutdown periods.

Other concerns regarding the aquatic environment include the direct effect of construction of pipelines and appurtenant intake structure on the aquatic environmental including tidal marsh, tidal flat and subtidal areas. Any excavation required to bury pipelines or the laying of pipelines in the Bay should avoid tidal marshes and tidal flats, aquatic vegetation such as eelgrass beds, and oyster beds because these areas are particularly productive areas for fish and other aquatic organisms.

Desalination facilities can, unless properly sited, displace terrestrial habitat and disturb terrestrial wildlife during the plant and intake and discharge structure construction. Desalination plants should be located in areas that will have a minimum adverse impact on wildlife habitat and pipelines should avoid productive habitat areas as much as possible and follow existing road rights-of-way or other developed areas as much as possible. Pipelines can also form barriers to wildlife and therefore should be buried whenever possible.

Visual Considerations. Proposed desalination facilities will look similar to other municipal or industrial kinds of public utility or service sites and including such facilities as buildings to house pretreatment filters and reverse osmosis membrane cylinders, storage tanks, pipelines, accessory buildings and security fences. While the area needed for a desalination plant varies depending on a plant's design capacity, a typical reverse osmosis plant (the kind of plant that would likely be located in the San Francisco Bay Area), requires about 100,000 square feet or about two and one-half acres for a plant producing about 5 million gallons per day.[24] The heart of a reverse osmosis plant consists of modules of tubular filters in a rack that are stacked one on the other. The modules are normally housed in a building resembling a warehouse. The shape

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[23] www.gunderboom.com/

[24] United States Department of the Interior. Desalting Handbook for Planners. July 2003. Page 152.

of the building and the building surface materials can be fairly flexible. Although industrial in nature, desalination facilities can and should be designed to fit into the surroundings and when near the shoreline can be designed to preserve views of the Bay and be complementary to the shoreline setting. Although the Commission's authority over the visual effects of projects on the shoreline is limited, the Bay Plan Appearance, Design, and Scenic Views policies encourage project developers to design shoreline projects to enhance the pleasure of the user or viewer of the Bay particularly from public access areas.[25] Every attempt should be made to site and design desalination plants so that they fit into and are complementary to their surroundings and provide view corridors to the Bay from upland areas, particularly public streets and other public rights-of-way.

Public Access and Desalination Facilities. In determining whether a proposed project is consistent with the McAteer-Petris Act and the Bay Plan, an important consideration for the Commission is whether the proposed project would provide maximum feasible public access consistent with the project to and along the Bay. The McAteer-Petris Act provides that "…existing public access to the shoreline and waters of the San Francisco Bay is inadequate and that maximum feasible public access, consistent with a proposed project, should be provided."[26] The *San Francisco Bay Plan* policies on public access provide that:

> …maximum feasible public access should be provided in and through every new development in the Bay or on the shoreline…except in cases where public access would be clearly inconsistent with the project because of public safety considerations or significant use conflicts…. In these cases, in lieu access at another location, preferably near the project, should be provided.[27]

The Bay Plan public access policies further provide that the access should be walkways, trails or other appropriate means, connected to the nearest public thoroughfare where convenient parking and public transportation may be available; be permanently guaranteed; consistent with the project and the physical environment; protect Bay resources; provide for the public's safety and convenience; and encourage diverse Bay-related activities and movement to and along the shoreline.

Because desalination plants do not require a site immediately on the water's edge, but can be located inland off the Bay, the provision of public access can and should be included as part of any proposed desalination project. Public access should be incorporated into the

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25 San Francisco Bay Conservation and Development Commission. Appearance, Design and Scenic Views Polices. *San Francisco Bay Plan*. Page 58-60.

26 California Government Code Section 66602.

27 San Francisco Bay Conservation and Development Commission. Public Access Policy 2. *San Francisco Bay Plan*. Page 56.

design of any proposed desalination project to ensure that the project and the access it provides to the Bay is pleasant, safe, and does not result in unreasonable visual or physical separation of the public from the shore. Although pipelines must cross the shoreline to access the Bay, the pipelines should be sited so as not to interfere with the public's access to the Bay. Burying the pipelines when they traverse the public access area or suspending them on a structure such as a bridge that crosses the access area can accomplish this.

Provision of public access is especially important where the desalination plant is located in large, industrial projects that have the potential to separate the public visually and physically from the shoreline for a long distance.

Environmental Justice. The location and operation of a desalination facility can create adverse impacts that are borne disproportionately by local residents. This particularly can be the case where the desalination facility is developed or co-located on the site of an existing facility such as a thermal power plant or a sewage treatment plant that may not have been designed and sited in the past in a way that minimizes impacts to local residents and communities.

Environmental justice, as defined in SB115 (Solis 1999) refers to "the fair treatment of people of all races, cultures, and income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

In siting projects, agencies must consider the potential for their actions or policies to place disproportionately high adverse human health or environmental effects on minority and low-income populations. Additionally, agencies developing desalination facilities should work with community groups in the area of the proposed project to ensure that the community is not adversely affected by environmental pollution and hazards.

A desalination plant could have a disproportionate impact on low-income and minority populations particularly if the desalination project is co-located with an existing or proposed thermal power plant. The addition of a desalination plant may prolong the life of an older, once-through cooling system power plant because of the need of the power plant to provide feed water for the desalination plant. Since many of the impacts caused by thermal power plants are local—noise, air pollution, physical appearance, public access—the communities where these facilities are located can be disproportionately impacted by the longevity of the plant brought on by the co-located desalination facility. Communities where desalination and/or power plants are located should not bear a greater burden, if burdens do exist, than those who receive the benefits of a desalination plant and who do not live near the project site where the impacts are experienced. The Commission should therefore evaluate proposed desalination projects for environmental justice concerns and the mitigation for any adverse impacts of the project should be located, to the maximum extent practicable, within the community where the impacts will occur. This action will ensure, to the maximum extent practicable, that the project will not result in additional impacts to communities already suffering from noise, air and water pollution, a lack of open space and public access and aesthetic impacts. The provision of public access at the project for the use of the local community as well as the citizens of the entire Bay Area can help provide local community benefits from a desalination project.

Energy Costs. The total cost of seawater desalination is the sum of many components of the desalination process. However the primary cost of desalination is energy, or more appropriately electricity. Whether or not desalination is economically feasible is normally dependent on the cost of electricity at the proposed desalination plant site. Energy is needed to power the pumps that force the water molecules though the reverse osmosis membranes. Desalination has been an energy-intensive process that proved too costly to be considered a realistic alternative to traditional sources of domestic water. Desalination can require pressure of up to 1,000 pounds per square-inch to force water molecules through earlier versions of membranes. However, in the 1980s thin-film composite membranes were introduced replacing older technology membranes and as a result, operating pressures for desalination were reduced and energy requirements dropped in half.[28] (These thin-film, plastic membranes resemble the backing on self-adhesive postage stamp packets that one purchases at the post office.) The new technology, operating at lower pressures, requires less electricity to produce product water. Consequently, as membrane technology improves and the amount of electricity needed to produce fresh water drops, desalination has become more reasonably priced.

Estuarine and ocean desalination plants currently use roughly 3,260 to 4,900 kilowatt hours (kWh) of energy to produce an acre-foot[29] of fresh water or about $359 to $539 per acre-foot. The energy cost of desalination will be a primary factor in determining whether desalination proponents will proceed with proposed projects. As discussed above, the Marin Municipal Water District has determined, based on the results of its 1990 desalination pilot project, that at the time of the pilot project, the annual cost of desalinating water for a typical single-family residence in its service area is approximately the same annual cost of running the family refrigerator.

Total Desalination Costs. Excluding land costs, the cost for desalting Bay water (ocean or estuarine water) at a new desalination plant, according to the Water Desalination Task Force, should range from approximately $700 per acre-foot (assuming wholesale energy costs of about five cents per kilowatt hour (kWh)) to about $1,200 per acre-foot (assuming retail energy costs of about 11 cents per kWh), including the amortized costs for planning, designing and

28 Brown and Caldwell. Desalination. Undated pamphlet. Page 2.
29 An acre-foot is the amount of water that would cover one acre to a depth of one foot (approximately 326,000 gallons), or about enough to meet the water needs of two average families for one year.

constructing the plant, and the operation costs (e.g., energy, chemicals brine discharge and solids disposal). In addition, the cost of distributing the product water to consumers should cost about $100 to $300.[30] Thus the approximate total cost (excluding land cost) of desalting and delivering Bay water to the user would fall within a range of $800 to $1,500 per acre-foot. From a pure cost standpoint, desalination project proponents must weigh the total costs of other kinds of alternate new water supplies with the approximate total cost of desalination in making decisions affecting their water supply portfolios.

30 California Department of Water Resources. Water Desalination, Findings and Recommendations. October 2003. Page 4.

CHAPTER 4

CHANGES TO THE SAN FRANCISCO BAY PLAN

The *San Francisco Bay Plan* desalination policy is now incorporated into the Bay Plan policy concerning power plant location. That policy addresses power plant location concerns—discharge of large amounts of heated brine and releasing water vapor into the atmosphere—and not desalination plant issues (desalination plants do not release heated brine or water vapor). Moreover the policy would require the Commission to deny issuing a permit for the construction of a desalination facility in the 100-foot shoreline band based on the use of the land (i.e., residential, recreation and other public uses). The McAteer-Petris Act does not give the Commission the authority to deny projects in the 100-foot shoreline band for use conflicts that do not involve designated priority use areas. Further, the Bay Plan contains no findings to support the desalination policy.

The staff believes new policies regarding desalination facilities should be added to the Plan; that the existing combined desalination and power plant policy should be changed to address power plants only and should be updated; and that new desalination findings should be added to support the staff proposed new policies.

The staff recommends that the Commission amend the *San Francisco Bay Plan* in the following manner:

Add the following new findings to the *San Francisco Bay Plan* section Other Uses of the Bay and Shoreline (Page 62):

d. Desalination is the process of removing salt, other minerals and contaminants from saline water to produce fresh drinking water. The intake of Bay water to a desalination plant can pull (entrain) small aquatic organisms (e.g., larvae, eggs, plankton) into the water intake structure where they can become trapped and die. Entrainment can be minimized by such measures as locating the water intake away from areas of high aquatic organism productivity, reducing the volume and velocity of water intake, adequately engineering and screening the intake pipeline, and temporarily reducing or ceasing intake at times when eggs and larvae are present. The direct discharge of concentrated brine from a desalination plant into the Bay can severely impact fish and other aquatic organisms in the vicinity of the discharge unless the brine is diluted to approximately the same salinity range level as the Bay at the point of discharge. The Regional Water Quality Control Board sets standards for brine discharged into the Bay, and a National Pollutant Discharge Elimination System permit is required from the Regional Board for any desalination plant discharge.

e. A desalination plant does not need to be located adjacent to the Bay; therefore, except for pipelines and directly related facilities needed for Bay water intake and brine discharge, Bay fill is not needed for desalination plants.

Change Policy 9 of Bay Plan section Other Uses of the Bay and Shoreline (Page 64) as follows with the double lined out language deleted from the policy and the double underlined language added to the policy:

9. Power plants may be located in any area where they do not interfere with and are not incompatible with residential, recreational, or other public uses of the Bay and shoreline, provided that any pollution problems resulting from the discharge of large amounts of heated brine into Bay waters, and water vapor into the atmosphere, can be precluded.

Add new policies to the Bay Plan section Other Uses of the Bay and Shoreline (page 64) as follows:

10. Desalination projects should be located, designed and operated in a manner that: (a) avoids or minimizes to the greatest practicable extent adverse impacts on fish, other aquatic organisms and wildlife and their habitats; (b) ensures that the discharge of brine into the Bay is properly diluted and rapidly disperses into the Bay waters to minimize impacts; and (c) is consistent with the discharge requirements of the Regional Water Quality Control Board.

11. Because desalination plants do not need to be located in the Bay or directly on the shoreline: (a) no Bay fill should be approved for desalination plants except for a minor amount of fill needed for pipelines, screening devices, and other directly related facilities that provide Bay water to a plant and discharge diluted brine from the plant back into the Bay; and (b) maximum feasible public access consistent with the project should be included as part of any desalination project that uses Bay waters.

Renumber existing Bay Plan Other Uses of the Bay and Shoreline section (Page 64) policies 10 through 12 as policies 12 through 14.

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