The People's Moss Landing Water Desal Project

Draft Process Design Report

February 27, 2015

Prepared by:

WATEK®
ENGINEERING CORPORATION
604 South Frederick Avenue, Suite 309
Gaithersburg, Maryland 20877

Table of Contents

Executive Summary

The People's Moss Landing Water Desalination Project (PMLD) is a proposed desalination plant in Moss Landing that will produce 13,404 acre-feet per year (AFY) of potable water. The overall purpose of the PMLD is to rehabilitate existing facilities at the Moss Landing Green Commercial Park to develop a desalination project in order to provide potable water to the North Monterey County area and to the Monterey Peninsula. This project proposes to provide 3,652 AFY of "new water" to customers in North Monterey County and 9,752 AFY to the Monterey Peninsula. This capacity was selected based on historical water use, expected future planned demands and additional water supply needs.

The proposed desalination plant would be located at the Moss Landing Business Park, which is the location of the former Kaiser Refractories Magnesium Extraction and Brick Production Plant that ceased production in February 1999. One of the biggest advantages of the site is having significant infrastructure in place. The site is considered to be ideal for a desalination plant since it has access to a major roadway for deliveries, is adjacent to a power plant and high voltage grid and is an industrial zoned property. Approximately 16 to 18 acres of the 186 acre site is required for locating the desal plant.

Three different sources with some variation in seawater quality were considered. Due to this variation and the impact on the process equipment sizing and selection, three alternatives were evaluated:

Alternative A: Intake is from the harbor at the location of the existing intake pump station

Alternative B: Intake is from the open sea in the bay

Alternative C: Intake is from subsurface system

The purpose of this report is to address water quality issues, evaluate the various alternatives and provide calculations, sizing and equipment layouts for these alternatives. The report also provides estimates for Capital and Operation/Maintenance costs as well as power, chemical, by-products handling and staffing requirements.

Conservative assumptions were made establishing the design seawater quality based on the available historical seawater quality data. The final product water goal was set to not only meet, but also surpass the drinking water standards set by the United States Environmental Protection Agency (USEPA), the California drinking water quality requirements as well as California Title 22 recommendations.

For each alternative, detailed calculations were performed and process selections were made. Conservative loading and sizing rates were utilized for all equipment for purposes of sizing to meet industry standards and guidelines.

Based on the technical, environmental, water quality and economical considerations discussed in this report, Alternative A (Harbor Intake) is not recommended for implementation. From the 2014 hydro-geological feasibility study conducted by by CapRock Geology Inc., it appears that Alternative C (Subsurface Intake) is not a reasonably feasible option. Therefore, the Project Team is planning to proceed and implement Alternative B (Open Bay Intake).

The total estimated cost of producing the 13,404 AFY at the proposed facility (without distribution system) ranges from $1500 to $ 1600 per Acre Feet.

The cost for the delivery system (pipelines and tanks) for 9,752 AFY from project site to CalAm's terminal in Seaside and delivery of 3,652 AFY to customers in North Monterey County would be approximately an additional $400 per Acre Feet. Although the delivery system for North County is still under development, including the number of pipelines required and their routes, preliminary costs of pipelines and terminal storage tanks are included in these estimates.

1.0 Introduction

This section of the report will give a summary of the purpose of this report and project background.

1.1 Report Purpose and Scope

This report will establish the design criteria for the site, intake, outfall and all major plant components. The level of design included in this document is about 20%. Preliminary process design and equipment sizing and layouts have been prepared based on this level of design.

Included in this report are the following:

- Process Flow Diagrams (PFDs)
- Preliminary equipment layouts
- Preliminary major equipment selection
- Verification of infrastructure capacity
- Power and chemical usage estimates
- Office space requirements
- Staffing needs
- Capital and operation/maintenance cost estimates

1.2 Project Description and Background

The People's Moss Landing Water Desalination Project (PMLD) is a proposed desalination plant in Moss Landing that will produce 13,404 acre-feet per year (AFY) of potable water. The overall purpose of the PMLD is to rehabilitate existing facilities at the Moss Landing Green Commercial Park to develop a desalination project in order to provide potable water to the North Monterey County area and to the Monterey Peninsula. This project proposes to provide 3,652 AFY of "new water" to customers in North Monterey County and 9,752 AFY to the Monterey Peninsula. This capacity was selected based on historical water use, expected future planned demands and additional water supply needs.

The proposed desalination plant would be located at the Moss Landing Business Park southeast of the intersection of Dolan Road and Highway 1, and across Dolan Road from the Moss Landing Power Plant facility. The Moss Landing Business Park is the location of the former Kaiser Refractories Magnesium Extraction and Brick Production Plant that ceased production in February 1999. Figure 1 (in Appendix) shows the overall location of the existing site and the proposed desalination plant in the shaded area.

To the extent possible, the proposed desalination plant will incorporate existing infrastructures and service facilities located at the Moss Landing Business Park including some of the tanks, structures and pipelines.

1.3 Desalination Plant Capacity

The proposed desalination plant's net production capacity will be 11.97 Million Gallons per Day (MGD), which is equivalent to 13,404 acre-feet per year (AFY). Actual product water from the plant is slightly more (12.05 MGD) to accommodate internal water uses such as process wash water needs, process analyzers flows, bathrooms, sinks and other miscellaneous uses.

This capacity was selected based on historical water use, expected future planned demands and additional water supply needs. For the basis and calculations of the plant capacity, refer to the project Environmental Impact Report (EIR).

2.0 Water Quality Considerations

In addition to the plant capacity, water quality of the source water and expected water quality of the final product water in a desalination plant will have the most significant impact on the process equipment efficiency, selection and sizes. These water qualities will also dictate the volume and quality of the outfall and by-products.

For the purposes of this report, three different sources, with some variation in seawater quality are considered. Due to this variation and the impact on the process equipment sizing and selection, three alternatives are being evaluated.

- **Alternative A:** Intake is from the harbor at the location of the existing intake pump station
- **Alternative B:** Intake is from the open sea in the bay
- **Alternative C:** Intake is from subsurface system

Refer to Figure 1 for location of the desal plant and intake alternatives.

2.1 Seawater Quality

Significant water quality data for the bay and the harbor is available from previously published studies and reports, which is summarized and is being utilized as the Design Seawater Quality Basis. A comprehensive report by Marine Pollution Studies Laboratory and Moss Landing Marine Laboratories (Surface Water Ambient Monitoring Program, 2007) provided the major water quality data needed for this report.

Table 2.1 is a summary of the available water quality data. Conservative assumptions were made in order to establish the design seawater quality used for the three alternatives, as shown in the right three columns of this table.

Additional data collection and proof pilot studies are planned for confirmation of the basis of design during the next engineering and design phase.

Table 2.1 : Seawater Intake Design Water Quality

							Conservative Design Value Used After Balancing Ions		
		From Previous Reports and literature			Surface Water Ambient Monitoring Program Report (Stations 14 and 30)		Alternative A	Alternative B	Alternative C
Parameter	**Unit**	**Minimum**	**Maximum**	**Average Value**	**Minimum**	**Maximum**	**Design Value**	**Design Value**	**Design Value**
Ammonia	mg/L				0	0.12	0.12	0.12	0.12
Potassium	mg/L						390	390	390
Sodium	mg/L						10760	10760	10760
Magnesium	mg/L						1400	1400	1400
Calcium	mg/L						500	500	500
Strontium	mg/L						13	13	13
Barium	mg/L						0.1	0.1	0.1
Bicarbonate	mg/L			143			145	145	145
Nitrate	mg/L				0	0.015	0.1	0.015	0.015
Chloride	mg/L	16900	20800	19400			19822	19822	19822
Sulfate	mg/L			2700			2700	2700	2700
Boron	mg/L	3.6	5	4.5			5	5	5
Total Dissolved Solids (TDS)	mg/L	32500	34500	33200	33200	34200	35800	35800	35800
pH	Units	7.3	8.1	7.6	8	8.5	8	8	8
Turbidity	NTU	5	40	26			50	10	5
Total Suspended Solids (TSS)	mg/L	5	45	26	15	55	60	10	5
Chlorophyll a	ug/L				0.2	4.2	5	2	1
Total Organic Carbon (TOC)	mg/L				0.2	3	5	2	2
Temperature	°C	10	15	12	12	17	7-17	5-17	5-17
Potential for Agricultural Contaminants							High	Low	Very Low
Potential for Petroleum Contaminants							High	Low	Very Low
Potential for Synthetic Organic Chemicals (SOCs)							High	Low	Very Low
Potential for Volatile Organic Chemicals (VOCs)							High	Low	Very Low

2.2 Product Water Quality

The product water from the proposed desal plant will be post treated, disinfected, re-mineralized and conditioned to meet and surpass the regulatory requirements of the US-EPA Drinking Water Regulations, Safe Drinking Water Act and the California Title 22 Code requirements and recommendations (July 1, 2013) as shown in Table 2.2.

The project team also reviewed the 2012 existing water quality report on the California American Water Company (CalAm) website and has set a goal to produce a lower hardness and dissolved solids from the proposed plant finished water. Hard water contributes to an inefficient and costly operation of water-using appliances such as boilers, water heaters and heat exchangers. Heated hard water forms a scale of calcium and magnesium minerals that can contribute to an inefficient operation or premature failure of such appliances. Pipes can become clogged with scale buildup, which reduces water flow, causing more power consumption and ultimately may require pipe repair or replacement. Hard water also interferes with almost every cleaning task in households and Laundromats. The hardness in water affects the amount of soap and detergent necessary for cleaning.

A hardness target of 100 mg/L was established for this report, which is well below the current CalAm's 2012-reported finished water hardness of 183 mg/L (average) to 310 mg/L (high) values.

We also considered the Monterey Peninsula Regional Water Authority Consultant's recommendations (Final Report, Jan 2013) by Separation Processes, Inc. (SPI) in establishing the design product water quality.

The Total Dissolved Solids (TDS) of less than 380 mg/L was established for the purposes of equipment selection and sizing in this report, which surpasses California Title 22 requirement (<1000 mg/L), California Title 22 recommendations (<500 mg/L) and meets SPI's recommendation (<380 mg/L).

Table 2.2 is a summary of the proposed product water quality goals set for the PMLD product water and provides a comparison to the above-referenced water quality parameters.

Table 2.2: Finished Water Design Water Quality								
		California American Water (2012 Water Quality Report)			California Title 22 Regulations (MCL or SMCL)	California Title 22 Regulations (Recommended)	Recommended by Monterey Peninsula Regional Water Authority (Final Report, Jan 2013) Separation Processes, Inc.	Design Product Water Quality Goal
Parameter	**Unit**	Low	High	Average				**After Post Treatment**
Gross Alpha Prticles Radio-Activity	pCi/L	0.1	0.4	0.3	15			**ND**
Combined Radium	pCi/L	ND	3	1.7	5			**ND**
Uranium	pCi/L	0.1	0.4	0.3	20			**ND**
Radon	pCi/L	163	638	322				**ND**
Arsenic	ug/L	ND	8	1.2	10			**ND**
Nitrate (As NO3)	mg/L	ND	26.9	10.1	45			**<10**
Selenium	ug/L	ND	7	3	50			**<1**
Total Trihalomethanes (TTHM)	ug/L	3.9	61.2	29.3	80			**<40**
Haloacetic Acids (HAAs)	ug/L	1.3	28.7	14.4	60			**<30**
Sulfate	mg/L	60	80	69	500	250		**<50**
Total Dissolved Solids (TDS)	mg/L	136	618	417	1000	500	380	**<380**
Chloride	mg/L	32	136	84	500	250	60	**<100**
Boron	mg/L	ND	1.1	0.23			0.5	**0.5-1.0**
Calcium	mg/L	17	86	48			40 as CaCO3	**40**
Alkalinity	mg/L	48	242	151			40 as CaCO3	**40**
pH	Unit	6.2	8.4	7.3			>8	**8**
Magnesium	mg/L	ND	25	15				
Sodium	mg/L	48	91	70				**<100**
Total Hardness	mg/L	42	310	183				**<100**
Sodium Adsorpbtion Ratio (SAR)	Unit							**<5**
LSI	Unit							**>0**

2.3 Outfall Water Quality

The quality and quantity of outfall is a function of the treatment system and the plant recovery. Refer to section 3.19 for discussion of the outfall water quality and characteristics.

3.0 Treatment Process Description

The design team has evaluated all available data, water quality goals and previous studies and is considering the following major process units for this conceptual design. Conservative approach is utilized in sizing unit processes. Also as shown, redundant units are being proposed for a reliable and dependable system with minimum need for shutdowns. The unit process sizing and loading rates will be refined as additional water quality and pilot test data is made available and as the design progresses.

As discussed, for the purposes of this report, three different sources with some variation in seawater quality are considered. Due to this variation and the impact on process equipment sizing and selection, three alternatives are being evaluated.

- **Alternative A:** Intake is from the harbor at the existing intake pump station location
- **Alternative B:** Intake is from the open sea in the bay at the location of the existing abandoned intake
- **Alternative C:** Intake is from subsurface system

Conceptual sizes and layouts are also included in this section for the following major process units. Some unit processes listed below are not used in certain alternatives as discussed in the relevant sections.

- Intake System and Screens
- Elector-chlorination Unit
- Coagulation
- Contact basins
- Flocculation
- Dissolved Air Floatation
- Two Stage Media Filtration
- Ultrafiltration (for Alternative A only)
- Cartridge Filtration
- First Pass Reverse Osmosis (RO) Desalination
- Energy Recovery System on first pass RO
- Partial Second Pass RO
- Calcite Remineralization with pH adjustment
- Disinfection
- Packed Tower Aeration (for Alternative A only)
- On site water storage tank
- Distribution Pumping and pipeline
- Backwash treatment
- Solids and Residual handling
- Concentrate blending system
- Auxiliary equipment such as Clean In Place for membrane systems

Preliminary Process Flow Diagrams (PFDs) are shown in Figures 3 through 11 for all major equipment with major pipe sizes for the three alternatives. Although extreme, worst-case values have been considered in equipment selection, these PFDs represent average seawater quality and temperatures.

3.1 Intake Options

The water source for a Seawater Reverse Osmosis (SWRO) facility has a direct impact on the level of pretreatment required, plant efficiency, the achievable treated water quality, and often the degree of subsequent operational issues, which may be encountered. Most of the world's experience with seawater intakes is a result of their use in the electric power generation industry, where seawater is commonly used for cooling purposes in large condensers. Thermal desalination processes have intake water quality requirements, which are virtually identical to power plant condensers. Membrane SWRO systems, however, benefit greatly from a finer level of screening and pretreatment than is typically used in power plants.

In general, seawater intakes can be broadly categorized as open intakes, where water is collected above the seabed, and subsurface intakes, where water is collected via beach wells, infiltration galleries, or from other locations beneath the seabed. The most appropriate location and type of the intake can only be determined after a thorough site assessment and careful consideration of the environmental and permitting impacts, commercial impacts and technical feasibility.

A reliable intake design will not only protect downstream equipment and reduce environmental impacts on marine life, but also will improve the performance and reduce the operating cost of the treatment facility.

For large plants, surface intakes are most common due to limited ability of subsurface intakes to deliver sufficient volumes of seawater. Risks associated with poor water quality are highest with surface intakes. Therefore, care must be given to ensure adequate intake depths and screening are maintained.

For a conceptual plan of the three intake options, refer to Figure 14.

Alternative A: Existing Harbor Intake

The existing surface intake pump station in the harbor was originally constructed in the 1940s to serve the Kaiser Refractories Plant and was upgraded in 1968. The existing intake system currently consists of nine pumps, which are housed in a building and supported on a concrete structure. The system was used to provide up to 60 MGD of seawater for the purpose of removing calcium and magnesium as part of the magnesia production.

If this alternative is selected, this structure will be rehabilitated and modified by dredging the harbor and installing walls around the existing platform (to form a wet well) and installing passive screens as described in the following sections and as shown in Figure 14. All existing pumps and motors will be removed and replaced with the numbers and sizes shown. A new pump and control building will be constructed. The new structure will house the screen air burst and Electro-Chlorination Unit (ECU), as described in the following sections. Use of a cofferdam will be necessary for a majority of the underwater construction. Boats and marine activities in the harbor will be significantly impacted with this alternative, both during construction as well as long term.

Alternative B: Open Bay Intake

This intake option will be at the Bay Shore near location of the abandoned intake (near old pier) as shown in Figure 1. The old intake structure will be extended down and rehabilitated with a new pipe extended to the bay with new passive screens as shown in Figure 14. The intake structure will have a building on top to house the electrical gear and the screen air burst and Electro-Chlorination Unit (ECU), as described in the following sections.

For this alternative, dispersion and mixing models are planned to confirm the assumption that the PMLD concentrate will have no adverse impact on the quality of the intake for the PMLD plant. Based on our research of other desal plants, same arrangements (intake and outfall near each other) have been successfully used without any water quality issues, as long as proper diffusers and dispersion are implemented. An example is the Victorian

Desal plant in Australia, with a capacity of 117 MGD, which has been successfully operated without any water quality issues since December 2012. This plant uses a combined tunnel alignment for intake and outfall pipes, with intake and outfall ends within 984' of each other in the ocean and separated 165' horizontally.

Alternative C: Subsurface Intake

Subsurface intake systems considered for the project are the most common subsurface type intake systems with proven technology and include: beach wells, slant wells, vertical wells, infiltration galleries, Ranney Collectors and seabed filtration systems. Despite variation in type of subsurface intake, the common advantages of a subsurface system are better water quality with less environmental impacts on marine life (impingement and /or entrainment).

The limiting factor for any subsurface system is the ability to achieve sufficient yield. In order to produce the required 12 MGD (13,440 AFY) of Product Water for this proposed project, the intake facility needs to produce approximately 29-33 MGD of Source Water. Due to space constraints at the existing Moss Landing Commercial Park, there are only two realistic locations that are being considered for subsurface intake. The first is a Harbor Location – the 1500 feet long portion of PMLD west of Highway 1, including the area of the existing PMLD intake, adjacent to and/or within the Moss Landing Harbor. The second location is the Bay Location adjacent to Monterey Bay. There is an existing abandoned intake system located on the spit near the former Moss Landing Marine Labs (MLML) pier within the PMLD property.

In 2014, CapRock Geology, Inc. performed a feasibility study of various alternative intake sources for the proposed project at both the Harbor Location and the Bay Location. The feasibility study reports on the potential for developing desalination feed water facilities for the plant in the shallow (<60 feet) Sand Dune Aquifer water bearing zones that are hydraulically connected to the harbor and/or bay as well as a deeper water bearing zone (100-140 feet).

1) Subsurface Wells on MLCP Property: Based on CapRock's field observations during drilling of the two exploratory wells, the shallow sand dune zone (0-60 feet) does not produce enough source water to support the project. With respect to the deeper zone (100-140 feet), CapRock noted that a recent CalAm study conducted on the property concluded that individual sand lenses, as well as sand and gravel lenses, were neither vertically or aerially extensive in the Moss Landing area and were deemed ill-suited to producing the quantities of feed water needed for a desalination plant.

2) Subsurface Wells at Moss Landing Marine Lab / Beach: CapRock noted that results from the MLML Test Well "suggest geologic conditions that are unfavorable for a subsurface desalination intake requiring in excess of 2MGD." In addition, CapRock noted that there is space for one Horizontal Beach Ranney Collector Well adjacent to Monterey Bay on the existing MLCP abandoned intake caisson footprint on MLML property. The project requires 29-33 MGD of Source Water to produce 12 MGD of Product Water. An existing individual collector is estimated to supply between 0.5-5 MGD – and thus the project would require between 7 and 65 collectors and between 2500 feet and 4.5 miles of beachfront for installation of the collectors. CapRock further noted that "backup collectors (in case one collector goes offline) might be required, which would necessitate additional beachfront footage. The oceanfront site is subject to potentially significant tsunamis and beach erosion related to global sea level rise. In addition, shallow pumping of large quantities of groundwater could cause subsidence. For these and the other reasons specified in this section, the MLML Shore Lab is not a feasible site for feed water intake."

3) Harbor Location: Data collected to date indicate that even if sufficient quantity of water is available, the water quality of the subsurface water at the Harbor would not be sufficient due to previous contamination issues associated with the legacy operations of both the Moss Landing National Refractory and/or the Moss Landing Power Plant;

4) Current studies indicate that drawing subsurface water at the Harbor location and/or the Bay location would likely interfere with the 180 and/or the 400-foot aquifers and could cause seawater intrusion, adverse impacts to existing water rights, and therefore would be technically and/or politically infeasible.

For these reasons, CapRock's study concludes that a subsurface intake does not appear to be a reasonably feasible option and a viable alternative for this proposed project.

Co-Locating Intake Option:

An option that was considered by a previous study is co-locating the desalination plant intake with the adjacent power plant cooling water. Refer to the Conceptual Design Report, Poseidon Resources Corporation, March 2006.

General advantages of co-locating at power plants include:

- Capital cost savings, due to the reduction of intake and outfall infrastructures
- If seawater is taken downstream of power plant condensers, there is potential savings in power consumption due to greater permeability of SWRO membranes at warmer temperature, but likely will be offset by power and chemical consumption of additional pretreatment equipment
- Potential ease of Permitting

General disadvantages of co-locating at power plants include:

- Environmental considerations still need to be addressed and existing power plant seawater intake permit may be compromised due to changes in use and discharge water quality
- Many commercial issues must be addressed with the power plant owner, including liability, seawater availability, costs, addition and/or removal of infrastructure at the power plant site, and dependency and risks associated with the power plant operations
- If seawater is taken downstream of the condensers, there is a risk of increased SWRO bio-fouling due to warmer seawater temperatures
- Cleaning and maintenance schemes used at the power plant may increase risk of spike events (e.g. increased chlorine loading, shards from mussels and other organisms sloughed from the intake) that could potentially damage or overload the desal plant pretreatment system
- Continuous chlorination as practiced by most power plants is not ideal for SWRO plants

Due to the above considerations and uncertainty of the long-term future of the adjacent power plant's intake and cooling system, the Co-Locating option is not evaluated in this report and an independent intake system is proposed.

3.2 Intake Screens

Alternatives A and B would require passive screens at the intake. In order to minimize the adverse impacts to aquatic organisms (by impingement and entrainment). The intake design will meet the recommendations of the EPA 316b Rule. In addition, the California Water Board (2014) has been carefully considering the velocity at which seawater is withdrawn and is recommending that 0.5 ft/sec (0.15 meters/sec) is appropriate to preclude most impingement of fish. They also found that 0.5 mm slot-sized fine mesh protects larvae and eggs. This report uses the EPA 316b Rule and the California Water Board guideline for sizing the screens.

The intake screens will be provided with an automatic air-burst system to keep the screens clean. The air-burst system is estimated to operate 10-12 times per day for Alternative A, while with alternative B, it would operate 3-5 times per day.

For Alternative A, the existing intake structure perimeter walls will be extended to the bottom of the harbor, to form a wet well, using cofferdams and passive screens installed on the wall of the structure. The harbor needs to be dredged to the original bottom (Elevation -15.0) to remove organic matter and deposits and provide a true open intake system. It is estimated that about 10' of the bottom sediments and deposits have to be dredged. Dredging needs to continue every few years and as needed to maintain the bottom level.

Alternative C does not require additional screening; since regardless of the subsurface type, screens are incorporated in the collector system.

Table 3.2 presents conceptual design of the screens for the applicable alternatives.

Table 3.2 Intake Screens

	Units	Alternative A	Alternative B	Alternative C[1]
Total Number of Screens	EA	3	3	N/A
Number of Screens in Service	EA	2	2	-
Screen Size	Inch	48	42	-
Capacity, each	gpm	12,000	10,400	-
Screen Opening Size	mm	0.5	0.5	-
Velocity Through Screen Slots	ft/sec	< 0.5	< 0.5	-

[1] None required for Alternative C, part of subsurface screen system.

3.3 Electro-Chlorination Unit

In order to minimize bio-growth in the piping and downstream unit processes, occasional chlorination of incoming seawater will be necessary. Instead of purchasing and transporting gas or liquid chlorine, many SWRO facilities use Electro-Chlorination Units (ECU) to generate chlorine on site. This approach is much safer and more environmentally friendly. ECU is an electrolysis process where chloride from seawater is converted into a sodium hypochlorite solution. Salt is composed of sodium and chloride, so when a direct current passes through titanium electrodes to the electrolyte, the chlorides disassociate to form chlorine.

Capacities of the ECU systems for the three alternatives are shown in Table 3.3. For all alternatives, the ECU will have two completely separate sub-units, each rated for 50% maximum dosage.

Any chlorine must be neutralized prior to SWRO membranes, since these membrane elements are not chlorine tolerant. Sodium Meta-Bisulfite (SMBS) will be dosed at the outlet of cartridge filters in the desal plant (when chlorine is added to the intake) to neutralize any chlorine residual and protect SWRO membranes from chlorine damage.

Table 3.3 Electro-Chlorination Units (ECU)

	Units	Alternative A	Alternative B	Alternative C
Number	EA	1	1	1
Capacity, each	Pounds/hr	50	30	25

3.4 Intake Water Pipe

For Alternative A based on maximum expected flow rates, as shown in Table 3.4, one of the existing 36-inch pipes is adequate for transfer of the seawater to the desalination facility, with a velocity of 6.5 to 7.3 feet per second.

For Alternatives B and C (Bay location), a 32-inch pipes is planned generally within the existing abandoned 36-inch intake pipe. It is assumed that majority of the new pipes can be slip-lined within the existing pipes. For sections that the old pipes may have been removed (such as the segment adjacent to the bridge), Horizontal Directional Drilling (HDD) method will be used. Cost estimates reflect open cut access points, all new flexible pipes and HDD method where necessary. The new pipes will be pressure class pipe (80 psi rating) so the existing pipes are only used as a conduit and are not relied upon for internal pressures.

Table 3.4 Raw Water Pipes

	Units	Alternative A	Alternative B	Alternative C
Number	EA	1	1	1
Size, each	Inch	36	32	32
Velocity	ft/sec	7.3	10.0	10.0
Length	Feet	1,800	2,200	2,200

3.5 Pretreatment

The optimum RO pretreatment depends on raw water composition, seasonal and historical water quality changes and the RO system design and operational parameters. The primary objective of pretreatment for any membrane system is to make the feed water compatible with the membrane, which involves a total system approach for continuous, consistent and reliable operation.

Fouling is a major issue in RO applications with surface water sources and inadequate pretreatment. Fouling refers to entrapment of particulates, such as silt, clay, suspended solids, biological slime, algae, silica, iron flocs and other matters on the surface, or even worst, within the membrane pores. Depending on the operating conditions and water chemistry, some metals such as soluble iron and manganese oxidize once they are within the membrane system and can precipitate in the RO system. Similarly, microbes and bacteria can grow and spread throughout an entire RO system. Microbiological and organic fouling are perhaps the most common types of foulants and more difficult to control in surface water applications and thus have been the primary cause of failures in some systems with inadequate SWRO pretreatment.

Inadequate SWRO pretreatment can cause the following types of issues to occur, individually or in combination with one another:

- Particulate fouling
- Bio-fouling
- Organic fouling
- Colloidal fouling
- Increase in net driving pressure, and therefore higher energy costs
- Reduction in normalized permeate flow
- Degradation of treated water quality
- Increase in pressure drop across membranes, resulting in increased power consumption,

- Increase in membrane cleaning frequency
- Reduction of membrane life, as a consequence of increased cleaning
- Reduction of permeability, and therefore lower production
- Increase in plant downtime and shutdowns

Scaling refers to precipitation and deposition of sparingly soluble salts such as Calcium Sulfate, Barium Sulfate, Calcium Carbonates, Silica, Calcium Fluoride and any other super saturated salt on the immediate surfaces of the membrane. Once a crystal of scale forms within the membrane element, it acts as a nucleation site for additional scales to form and the rate of scale formation increases exponentially. Many custom formulated Scale Inhibitors will significantly reduce the scaling potential if properly chosen and adequately fed to the RO feed water. Scaling is not a major concern for the PMLD project due to the chemistry of the seawater. However, provisions have been made in the RO design for adjusting the feed water chemistry and applying a small dosage of food grade anti-foulant chemical.

In addition to minimizing scaling and fouling, optimum pretreatment is required to increase the efficiency and life expectancy of the SWRO membrane elements.

Pretreatment is generally considered to be sufficient when the SWRO cleaning is limited to 10-12 times per year or less, membrane elements last at least 4-6 years and the productivity and salt rejection are maintained within the expected ranges.

A number of technologies and process units, which offer the ability to remove the naturally occurring materials that cause fouling, are available for seawater pretreatment. The predominant technologies include:

- Fine Screening
- Coagulation/Flocculation
- Sedimentation
- Dissolved Air Flotation (DAF)
- Chlorination/Dechlorination
- Media Filtration
- Membrane Filtration, such as ultrafiltration (UF)
- Cartridge filters

Since the source waters of the three alternatives have different degrees of fouling potentials and contaminants, each alternative was evaluated for the optimum pretreatment, as discussed in the next few sections. Alternative A, with the highest degree of organics, algae, suspended solids, surface run off contaminants and other potential foulants has a higher degree of pretreatment than other two alternatives.

The physical size of the pretreatment unit processes also varies between alternatives, as shown in Figure 12.

3.6 Contact Tanks

Two existing tanks, as shown in Figure 2, will be rehabilitated and used as contact tanks. These contact tanks will be multi-purpose:

- To provide some degree of equalization of the seawater
- To provide adequate detention time for coagulation chemicals to react with the raw water, typically 20-30 minutes for cold waters
- To provide settling of large particulates and solids which pass through the intake screens

Plate settlers will be installed in the tanks after rehabilitation, to enhance sedimentation and settling.

Coagulant dosing systems is used upstream of the contact tanks to inject chemicals such as Ferric Sulfate or Ferric Chloride into seawater, in order to aid coagulation process and to improve the efficiency of downstream treatment processes such as DAF and Media filtration systems. Provisions will also be made to lower the pH of the seawater for optimum coagulation, when needed. The planned pilot study will determine the optimum coagulation process to be implemented in design.

These tanks have hopper bottoms for solid collection. A mechanical rotating sludge collector will be installed in each tank to remove deposited solids as needed based on a timer control.

All handrails, stairs, piping and valves for both tanks will be replaced.

Table 3.6 Contact Tanks

	Units	Alternative A	Alternative B	Alternative C
Number [1]	EA	2	2	2
Volume, each	Gallons	1,800,000	1,800,000	1,800,000
Detention Time with 1 Out of Service [2]	Minutes	78	86	88

[1] Existing tanks will be rehabilitated and plate settlers will be installed

[2] Additional detention time is available in raw water piping

3.7 Flocculation

Flocculation is the agglomeration of small particles and colloids to form larger settleable and filterable particles (flocs), for removal in subsequent treatment processes. During flocculation, gentle mixing accelerates the rate of particle collision, and the destabilized particles are further aggregated and enmeshed into larger precipitates.

Optimum mixing intensity requires gentle (low-shear) mixing equipment to enhance contact of destabilized particles (typically 20-25 minutes) and to build floc particles of optimum size, density and strength. Optimum floc is usually formed under conditions of gradually reducing energy (tapered flocculation), as achieved in multiple stages, each with variable speed mixers.

A two stage tapered energy flocculation is proposed, as shown in Figure 12, with variable mixer drives which will be automatically adjusted based on seawater temperatures and water quality.

Table 3.7 Flocculation

	Units	Alternative A	Alternative B	Alternative C
Number of Stages	-	2	2	2
Number Per Stage	EA	16	12	12
Number in Service for Sizing	EA	14	10	10
Volume, each Per Stage	Gallons	41,000	41,000	41,000
Detention Time with 2 Out of Service [2]	Minutes	25	20	20

[1] Two stage tapered energy

[2] Each stage

3.8 Dissolved Air Flotation

Dissolved air flotation (DAF) is a water treatment process that is used for removing light weight organics, algae, oil and difficult to settle particulates. DAF is particularly effective when the suspended solids are neutrally or positively buoyant, typical of many surface waters. DAF has been used extensively in seawater desalination facilities to minimize the impacts of harmful algal blooms and other organic matter. Excessive algae dramatically increases suspended solids concentrations in seawater supplies, fouling downstream filters and necessitating rapid backwash cycles or even causing systems to fail. In some cases in the Middle East, desalination systems without DAF had to be taken offline for months while algal blooms persisted.

Removal in DAF is achieved by dissolving air in the water under pressure and then releasing the air at atmospheric pressure in a flotation tank. A portion of the clarified effluent water leaving the DAF tank is pumped to a small pressure vessel (saturator) into which compressed air is also introduced. This results in saturating the pressurized effluent water with air. The tiny bubbles adhere to the suspended matter, causing the suspended matter to float to the surface and form a froth layer, which is then removed by a skimmer.

For the PMLD project, a 10% recycle rate is used. Other DAF design parameters are shown in Table 3.8.

As shown, a lower loading rate is used for Alternative A for the expected lower quality raw water.

A typical schematic of DAF (Xylem's system) is shown below. Figure 12 shows a conceptual layout of the DAF units for the PMLD project.

SCHEMATIC OF A DAF UNIT WITH TWO STAGE FLOCCULATION

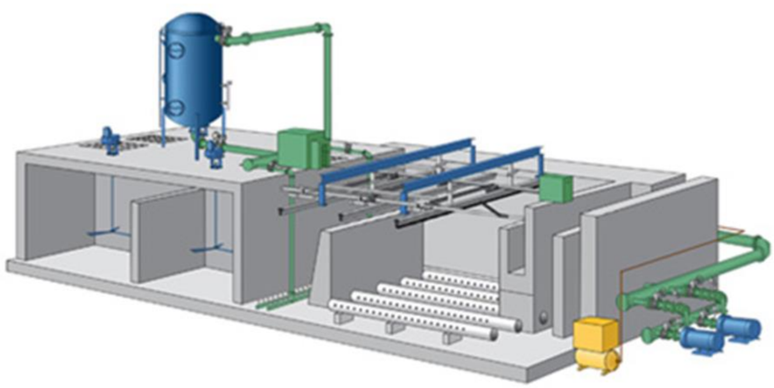


Table 3.8 Dissolved Air Floatation

	Units	Alternative A	Alternative B	Alternative C
Total Number	EA	8	6	6
Number in Service for Sizing	EA	6	4	4
Dimensions, each	Feet	36'x36'	36'x36'	36'x36'
Loading Rate with 2 Out of Service	gpm/SF	2.9	4.0	4.0
Recycle Rate	%	10	10	10

3.9 Media Filtration

In a media filtration, water travels through layers of sand/gravel/anthracite, ranging from fine to coarse grades, in a process known as straining or sieving. Thus, suspended solids are removed from the source water. Two stage media filtration results in a higher degree of clarity of the filtered water because more turbidity particles are trapped throughout the bed. Media Filtration consisting of anthracite-sand multimedia has been successfully utilized in many SWRO plants worldwide with relatively clean ocean waters, referred to as Dual Media Filtration (DMF).

In order to have very low (non-detect) particulates and a Silt Density Index (SDI) of less than 3, which is the goal of this project, two stage media filtration would be required. SDI is a field test, which gives a more accurate determination of pretreatment quality for desalination systems than turbidity measurements. SWRO membrane manufacturers require a maximum SDI of 4, ideally less than 3. With SDI values greater than 5, some SWRO membrane manufacturers will terminate their performance guarantees.

After the water is treated by the first stage filters, it is filtered again through the second stage. This stage of media filtration further reduces the amount of particulates, bacteria, turbidity, and organic levels in the filtered water and acts as a polishing filter. Table 3.9 shows the first and second stage media filtration parameters.

Lower rates are used for Alternative A due to expected lower grade water quality.

Figure 12 shows a conceptual layout of the DMF units for the PMLD project.

Table 3.9 First and Second Stage Media Filtration

		First Stage			Second Stage		
	Units	Alternative A	Alternative B	Alternative C	Alternative A	Alternative B	Alternative C
Total Number	EA	8	6	6	8	6	6
Number in Service for Sizing	EA	6	5	5	6	5	5
Dimensions, each	Feet	18'x56'	18'x56'	18'x56'	18'x56'	18'x56'	18'x56'
Loading Rate with 2 Out of Service	gpm/SF	3.7	4.0	4.0	3.7	4.0	4.0
Wash Water Percent	%	5	4	3	5	3	2

3.10 Ultrafiltration

Ultrafiltration (UF) is becoming increasingly popular in Integrated Membrane Systems (IMS) due to its superior filtrate quality and ability to cope with challenging waters. UF is the most reliable and most consistent form of pretreatment. It produces high grade RO feed water, which is independent of feed water quality, yet more tolerant to feed water changes.

SWRO systems with source waters, which are more biologically active and have the potential for algae blooms and/or the potential for surface or suspended solids from the ocean floor stirred up during storms, would greatly benefit from UF. Due to the concerns with the source water associated with Alternative A, a UF system is proposed downstream of the media filtration for better protection of the SWRO system.

Typical UF flux rates as sole pretreatment range from 25-50 Gallons per square Feet of membranes per Day (GFD). Since the UF system at PMLD facility will be pretreated with two stage media filtration, a higher flux rate (but still conservative) is used as shown in Table 3.10.

Table 3.10 Ultrafiltration

	Units	Alternative A[1]	Alternative B	Alternative C
Total Number	EA	18	N/A	N/A
Number in Service for Sizing	EA	15	-	-
Flux Rate with 2 Out of Service	GFD	50	-	-
Recovery	%	94	-	-

[1] Only required for Alternative A

3.11 Cartridge Filters

For most municipal RO systems, cartridge filters (typically 5 microns) should be considered, even for the optimized pretreated waters. The reason is that sometimes foulants / scalants are not in the source water but are coming from other sources. Examples are: cement lining and corrosion of steel and ductile iron raw water piping, colloidal sulfur from oxidation of Hydrogen sulfide and pretreatment failure or upset. In these occasional, but not unusual cases, the cartridge filter will act as an "insurance policy" for protecting the "asset," the SWRO membranes. Therefore, cartridge filters should not be viewed as a "pretreatment" but as a last defense for protecting SWRO elements.

For the purpose of this report, 5 micron cartridge filters in horizontal special alloy stainless steel housings are used. A conservative loading rate of 3.5 gallons per minute (gpm) per 10-inch equivalent elements is used for this report. After several months of operation, if there is no indication of particulate pass through in the pretreated water, cartridge filters with a larger nominal size of 10 micron could be utilized.

Table 3.11 shows the proposed cartridge filters for the three alternatives.

PICTURE OF TYPICAL CARTRIDGE FILTER HOUSINGS

Table 3.11 Cartridge Filters				
	Units	Alternative A	Alternative B	Alternative C
Total Number	EA	7	7	7
Number in Service for Sizing	EA	6	6	6
Loading Rate with 1 Out of Service	gpm/10”	3.5	3.5	3.5
Cartridge Filter Rating [1]	micron	5	5	5

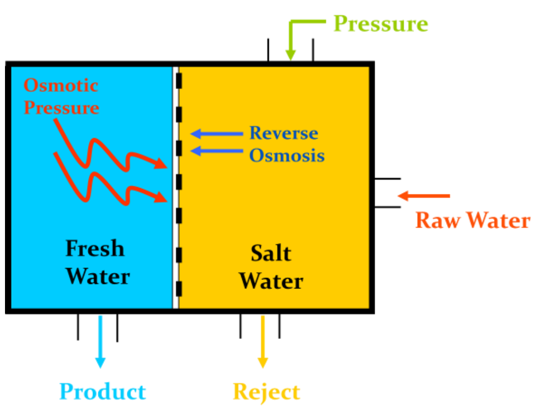
[1] After several months of successful operation, they may be replaced with 10 micron.

3.12 Desalination

3.12.1 First Pass RO

Reverse osmosis (RO) is a physical separation process in which properly pretreated source water is delivered at moderate pressures against a semipermeable membrane. The membrane rejects most solute ions and dissolved compounds, while allowing water of very low mineral content to pass through. The process produces a concentrated reject stream in addition to the purified permeate (i.e. product water).

PRINCIPLE OF REVERSE OSMOSIS (RO)



In an RO system, a higher concentration solution on one side of a semi-permeable membrane is subjected to pressure, exceeding natural Osmotic pressure of the feed water, causing freshwater to diffuse through the membrane, leaving behind a more concentrated solution containing a majority of the dissolved minerals and other contaminants. This process explains the origin of the name, “Reversing the Osmotic Pressure”. The major energy requirement for reverse osmosis is to pressurize the source, or “feed” water. Because the feed water has to pass through very narrow passages in the membrane module, any suspended solids and particulates must be removed during the initial treatment phase (pretreatment).

Recovery in an RO system is defined as the percent of product (Permeate) over the feed water multiplied by 100. The higher the recovery rate, the less by-product (Concentrate) is produced, but with a higher potential for fouling and scaling. A conservative recovery rate of 45% is used for the purposes of this report.

Since the concentrate stream of the SWRO still has significant residual pressure, Energy Recovery

Devices (ERD) will be installed on each SWRO train to recover this energy by reducing the SWRO feed pump pressure. For the purposes of this design report, pressure exchanger type ERD (which are the most efficient available recovery devices) are utilized. SWRO pumps were selected based on coldest expected temperature and a 15% contingency/ fouling factor.

Table 3.12.1 summarizes the conceptual design of the SWRO system for PMLD facility.

Conceptual layout of first pass SWRO with cartridge filters for PMLD project is shown in Figure 13.

PICTURE OF A SWRO PLANT

Table 3.12.1 First Pass Seawater RO

	Units	Alternative A	Alternative B	Alternative C
Total Number of Skids	EA	7	7	7
Number in Service for Sizing	EA	6	6	6
Flux Rate with 1 Out of Service	GFD	8.0	8.0	8.0
Number of Pressure Vessels Per Skid [1]	EA	96	96	96
Number of Elements Per Pressure Vessel	EA	7	7	7
Recovery	%	45	45	45
Membrane Feed Pressure [2]	psi	700-780	700-780	700-780

[1] Space on skid for 108 PVs, or 12% expansion

[2] Varies with seawater temperature

3.12.2 Second Pass RO

The first pass of SWRO results in permeate with a TDS concentration of 200-300mg/L depending on the seawater temperature. In order to meet and surpass the design water quality requirements established for this project as discussed in Section 2.2, the Boron level should be between 0.5mg/L and 1.0mg/L and TDS less than 300mg/L (allowance for additional TDS from post treatment). Computer projections indicate a partial second pass with brackish water RO (BWRO) elements will provide the optimum blend water quality.

As a minimum, 30% of product water needs to come from the second pass. For this report, a conservative 1.4 pass (i.e. 40% from second pass) is used.

Since the second pass feed is the permeate from the first pass RO, there is no concerns with fouling and scaling. Therefore, a higher recovery rate (90-95% can be used in the second pass. A conservative recovery of 90% is used for the PMLD project.

Table 3.12.2 summarizes the conceptual design of the BWRO system for PMLD facility.

PICTURE OF A BWRO PLANT (AS A SECOND PASS)

Table 3.12.2 Second Pass Brackish Water RO

	Units	Alternative A	Alternative B	Alternative C
Percent of Plant Production from Second Pass	%	40	40	40
Total Number of Skids	EA	5	5	5
Number in Service for Sizing	EA	4	4	4
Flux Rate with 1 Out of Service	GFD	16	16	16
Number of Pressure Vessels Per Skid [1]	EA	27	27	27
Number of Elements Per Pressure Vessel	EA	7	7	7
Stages [2]	EA	2	2	2
Recovery	%	90	90	90
Membrane Feed Pressure [3]	psi	240-390	240-390	240-390

[1] Space on skid for 30 PVs, or 11% expansion

[2] Array: 2:1

[3] Varies with seawater temperature

Figure 13 shows conceptual design of the two pass RO system as well as post treatment and auxiliary equipment.

3.13 Remineralization

Based on the quality of the permeate produced from the partial double pass RO system and the product water quality goals set in Section 2.2, Calcium (Ca) must be added to the product water and pH should be adjusted for a LSI greater than zero. The goal is to have calcium greater than 40mg/L as $CaCO_3$ and HCO_3 greater than 40mg/L as $CaCO_3$, as indicated in Section 2.2.

Based on experience with other desalination plants, we have utilized an up-flow limestone contactors polishing with Lime and Caustic. This approach, although has a higher Capital cost, will result in a much more reliable post treatment, consistent water quality and lower turbidity in the finished water.

Another proven, but relatively new method is to not post treat all product water, but only 30-50% and then blend it, allowing for better mixing and control, which is selected method for PMLD.

Typically, the limestone up-flow rate is 3-4 gpm per square feet to minimize media escape. The conceptual design for PMLD consists of 50% of the blended permeate being acidified, then fed to an up-flow limestone bed, which is then blended with the rest of the product, and lime is added to the bypass line. Fine tuning of pH level will be achieved with a small dose of Caustic.

Remineralization conceptual design parameters and layouts are shown in Table 3.13 and Figure 13.

Table 3.13 Calcite Remineralization

	Units	Alternative A	Alternative B	Alternative C
Percent of Product Through Calcite System	%	50	50	50
Total Number of Calcite Beds	EA	7	7	7
Number in Service for Sizing	EA	6	6	6
Dimensions, each	Feet	12’x46’	12’x46’	12’x46’
Loading Rate with 1 Out of Service	gpm/SF	3	3	3
Wash Water Percent After Recovery	%	1	1	1

3.14 Packed Tower Aeration

As discussed in Section 2.1, Alternative A has a high potential for having trace amounts of Volatile Organic Chemicals (VOCs) and Synthetic Organic Chemicals (SOCs) due to surface run offs and current boat activities. Packed towers with air stripping columns are widely used for the treatment and removal of such contaminants.

The process consists of counter-current flow of water and air through a packing material. The packing material provides a high surface area for the transfer of volatile contaminants from the liquid to the gaseous phase. As the water flows down the packed bed, air ascends, essentially "stripping" the contaminants and letting clean water to be collected in the bottom of the towers.

For Alternative A, re-pumping of the product water would be required as shown on Figure 5.

If Alternative A is selected, a portion of post treatment chlorine will be added upstream of the packed tower to prevent bio growth and to keep the tower media sanitized.

The conceptual design of the packed tower aeration is shown in Table 3.14.

Table 3.14 Packed Tower Aeration				
	Units	Alternative A[2]	Alternative B	Alternative C
Type [1]		-	N/A	N/A
Total Number of Towers	EA	4	-	-
Number in Service	EA	3	-	-

[1] Forced draft

[2] Only required for Alternative A

3.15 Disinfection

In post disinfection, chlorine is needed for distribution system protection. On site generation may be considered depending on the bulk chemical costs. The disinfection will meet and surpass the regulatory requirements of the Safe Drinking Water Act and the California Title 22 Code and US Environmental Protection Agency guidelines. Depending on the final pipeline and termination point (such as intermediate chlorine boost stations) Chloramines may be more effective than Chlorination.

3.16 On-Site Finished Water Storage

A 4 million gallon ground storage tank is proposed to be built on site, as shown in Figure 2. The proposed tank will be a pre-stressed concrete tank with dome top and internal columns. For better mixing inside the tank, internal baffles and nozzles on inlet piping are considered.

Table 3.16 On-Site Finished Water Storage				
	Units	Alternative A	Alternative B	Alternative C
Number of Onsite Storage Tanks	EA	1	1	1
Size of Onsite Tank	MG	4	4	4
Diameter	FT	180	180	180
Side Water Depth	FT	22	22	22

3.17 Finished Water Pumping

This on site pump station will pump the product water from the on-site tank to the off-site tanks. The pump station will potentially have two different sets of pump systems, one for the peninsula and one set for the North County.

For the Peninsula distribution and for the purpose of conceptual sizing of this pump station, it is assumed that the pipeline termination will be approximately at elevation 35' above MSL, and the pipeline is 17.5 miles long. Based on the estimated pressure losses due to fittings and pipe losses, a pressure of approximately 100 psi is needed at the desal plant.

The delivery system for North County is still under evaluation, including the number of pipelines required and their required routes. However, preliminary estimates are included for sizing and cost estimates in this report.

Table 3.17 Finished Water Pump Station				
	Units	Alternative A	Alternative B	Alternative C
Total Number of Pumps	EA	6	6	6
Number in Service for Sizing	EA	4	4	4
Pressure	psi	80	80	80

3.18 Finished Water Distribution Pipeline and Terminal Tanks

For all alternatives terminal storage tanks are included in the estimates with adequate size for approximately 24 hours of water storage. Transmission mains are assumed to be Ductile Iron Pipe (DIP) class 300 minimum. All major road crossings and sensitive area crossings such as streams and wetlands are assumed to be installed with trenchless technologies such as jack/bore in a casing.

For the Peninsula distribution, the following are included in the cost estimates:

- 92,400' of 24" water main
- 10 MG storage tank

For the North county distribution, the following are included in the cost estimates:

- 52,800' of 12" water main
- 79,200' of 10" water main
- 26,400' of 8" water main
- Three terminal tanks (0.8MG, 1MG and 2MG)

3.19 Byproducts and Residual Management

The following is a summary of the types and estimated quantities of byproducts and residuals produced at the proposed facility for the three alternatives:

Type 1: Concentrate from the RO system. This stream will essentially have all salts and ions present in the source water but at higher concentration. At the conservative proposed SWRO recovery rate of 45%, the concentration of salts and ions will be 1.8 times that of the seawater. At this recovery rate for all alternatives, the concentrate will contain TDS in the range of 63,000 to 64,000 mg/L depending on the alternative and the seawater temperature. Due to the TDS content, there are no economically feasible reuse opportunities with the SWRO concentrate. The second pass BWRO concentrate will have a TDS of 2,000 mg/L, which is substantially lower than the seawater and therefore will be completely recycled to the feed of the SWRO system as shown in Figures 4, 7 and 10.

Type 2: The backwash water from the Media Filters and UF will be transferred to the backwash collection tanks and pumped to the backwash treatment system consisting of sludge tank and centrifuges. The sludge is collected and sent to sludge treatment facility, while the clear supernatant is mixed with the concentrate and sent to the outfall.

Type 3: Similarly, recovered clean backwash from post treatment will be mixed in the outfall blend tank and sent to outfall. A possible re-use of the stream for spray irrigation, wash water, etc. will be investigated during design.

Table 3.19.1 is a summary and expected quality of the combined outfall. Total Suspended Solids (TSS) and other discharge parameters will meet the future effluent permit requirements. For the purposes of this report, it is assumed that the combined outfall concentrations (with the exception of salts) will be processed to be the same or less than ambient seawater quality after dispersion.

Table 3.19.1 Outfall Water Quality and Quantity

	Alternative A			Alternative B			Alternative C			To
	Flow (MGD)	TDS (mg/L)	TSS (mg/L)	Flow (MGD)	TDS (mg/L)	TSS (mg/L)	Flow (MGD)	TDS (mg/L)	TSS (mg/L)	
Concentrate from RO	15.46	65,000		15.46	65,000		15.46	65,000		Outfall
Recovered and Treated Backwash from Media Filtration	4.78	35,800		1.98	35,800		1.39	35,800		Outfall
Recovered and Treated Backwash from Ultrafiltration	1.76	35,800		-	-	-	-	-	-	Outfall
Recovered and Treated Backwash from Post Treatment	0.06	400		0.06	400		0.06	400		Outfall
Combined Total	**22.05**	**56,200**		**17.5**	**61,500**		**16.91**	**62,300**		

Type 4: All three types of membranes used in PMLD require occasional cleaning, called Clean In Place (CIP). The waste from CIP cannot be recycled, nor can it be sent directly to the sewer due to its basic or acidic nature. Therefore, neutralization systems will be included in the membrane facility with neutralization tank placed under the building floor. The appropriate chemical, typically either sodium bisulfite acid or sodium hydroxide, neutralizes the cleaning chemicals so that the waste can be properly sent to the sanitary sewer. Vertical chemical resistant pumps will serve for mixing the chemicals as well as pumping the neutralized content of the tank gradually to the sewer system.

The CIP events are planned and will be scattered throughout a week or month to reduce peak waste flows.

Type 5: Miscellaneous drains from analyzers, wash-downs, sample panels, etc. will be connected to sanitary sewer system.

Type 6: Bathroom, showers and other building plumbing wastes will be connected to sanitary sewer system.

Table 3.19.2 shows the estimated peak volumes and continuous flows to the sanitary system. A sewage pump station with adequate equalization wet well will be included to pump the sewer to the existing sanitary sewer adjacent to the PMLD site.

This estimated equalized flow was discussed with the Castroville Sanitation District (CSD), who will be taking over the Moss Landing area, and they indicated this volume of discharge can be sent to the gravity sewer at the intersection of Dolan and Highway 1 sewer system manhole.

Table 3.19.2 Other Residuals					
	Total Volume Per Event, all Skids (Gallons)	Frequency	Continuous Flow (gallons per day)	Comment	To
SWRO CIP Cleaning	300,000	Once per Month	50,000	Neutralized	Sanitary Sewer
BWRO CIP Cleaning	80,000	Once every two months	20,000	Neutralized	Sanitary Sewer
UF CIP Cleaning (Alternative A only)	225,000	Once every two months	15,000	Neutralized	Sanitary Sewer
Floor Drains, Analyzers, and Wash Waters	-	Continuous	3,000	-	Sanitary Sewer
Sanitary Sewer from Buildings and Offices	-	Continuous	1,500	-	Sanitary Sewer
Total			**90,000**		

All process solid wastes will be combined and sent to the sludge tanks and sludge treatment facility. The sludge treatment will consist of sludge conditioning, centrifuges, thickeners, belt presses and chemical treatment for production of 30-35% solid content sludge, which will be sent off site by dump trucks.

Table 3.19.3 shows estimated volume of sludge to be hauled off-site for each alternative.

Table 3.19.3 Estimated Sludge Production				
	Units	Alternative A	Alternative B	Alternative C
Dry Sludge Volume (30% Solids)	Gal/Day	5,525	831	407
Weight of Dry Sludge	Pounds/Day	55,250	8,310	4,070
Weight of Dry Sludge	Tons/Day	27.6	4.2	2.0
Number of Hauling Trucks per Week	Number	20	3	< 2

4.0 Building and Site Considerations

4.1 Existing Site

The proposed desalination plant would be located at the Moss Landing Business Park, which is the location of the former Kaiser Refractories Magnesium Extraction and Brick Production Plant that ceased production in February 1999.

Figure 1 shows the overall location of the existing site and the proposed desalination plant in the shaded area. Approximately 16 out of 186 acre site is needed for the desal plant.

Figure 2 shows the proposed desal related facilities south of existing buildings and tanks on site.

The site is ideal for a desalination plant since it has access to a major road for deliveries, is adjacent to a power plant and high voltage grid and is an industrial zoned property.

The site layout focuses on locating permanent structures away from environmentally sensitive areas of the site, such as wetlands and flood plains.

Portions of the proposed structures are located on the deposits from the old Kaiser production plant. A comprehensive geotechnical engineering investigation is budgeted for conducting soil borings and testing to provide recommendations for foundation supports and soil excavation/backfill.

4.2 Existing Infrastructure

The site has significant important infrastructures; some are planned for re-use and utilization with some rehabilitation and upgrades. Examples are:

- Existing Intake structure in the harbor (for Alternative A)
- Twin Intake pipes (for Alternative A)
- Existing outfall for concentrate and treated backwash water discharge (for all Alternatives)
- Portions of the existing intake pipe from the pier to the plant (for Alternatives B and C)
- Several existing tanks
- Existing tunnels and casings under Highway 1

A study was conducted (John Miller, August 2012) on the condition of the existing pipelines, outfall and major tanks on the site. The study generally found the major structures to be structurally adequate and recommended various improvements and rehabilitation such as removal of defective concrete, replacement of affected rebar, and application of epoxy grout and lining to rehabilitate the tanks.

The outfall pipe was videotaped and found to be generally in good condition with some rehabilitation needs. A more detailed investigation will be conducted during design of tanks, buildings and infrastructure to be used in the proposed desal plant. This report has assumed that due to age of the outfall, a new 30” pipe will be inserted into the existing 51” outfall. Similarly, it is assumed that the existing intake from the Bay near the old pier will be used as a conduit for sliplining the new pressure pipe as new intake pipe for Alternatives B and C with limited open excavation and directional drilling under sensitive areas.

This report includes estimated costs for such repairs and an allowance for a higher degree of rehabilitation if required.

4.3 Access and Security

The primary plant access will be from Dolan Road in the vicinity of the existing entrance. The entire desal plant site will be fenced and separated from other current or proposed activities on site as shown in Figure 2. Automated motorized gates with cameras at entrances and other strategically located areas will be installed with split screen monitors in the plant control room for security and safety.

In terms of security of the water system, all final product water systems will be secured by removable access ladders and locks on access hatches. Similarly, the intake pump station will have fencing and security cameras.

4.4 Offices and Process Spaces

Table 4.4 is a summary of the office space requirements. The control room, laboratory and offices are planned to be located in the desal building. The Desal Process Building will also house bulk desal chemicals and have space for parts and storage.

Coagulants and other bulk chemicals will be housed in a building adjacent to the existing contact tanks as shown in Figure 2. All chemicals will be contained in full containment structures and any spill will be completely contained within the building.

For optimum efficiency, the Desal Process Building will also house the central electrical room for shortest distance to the major power users such as SWRO pumps.

Proper safety equipment and emergency eyewash/shower stations will be provided at all chemical storage/feed facilities, meeting code requirements.

Fire extinguishers and fire sprinklers will be installed in the buildings where necessary in order to meet local code requirements.

Table 4.4 Office Space Requirements

Space	Estimated area (SF)
5 Offices	650
Control Room	400
Conference Room	400
Laboratory	350
Records and Archives Room	300
Bathrooms/ Shower	400
Parts Storage and Workshop	1000
Total	**3,500**

4.5 Emergency Power

An independent secondary power supply or emergency stand-by generators will be required to operate the entire facility during power shortages. The emergency generator can run on diesel fuel or natural gas (preferred, if available). The availability of an independent secondary source is being investigated. For the purposes of this report, emergency stand-by generators are included in the cost estimates.

All major plant controls, critical instruments and automation devices will have Uninterruptable Power Supply (UPS) and battery backups.

4.6 Construction Methods

A previous study found the major existing structures to be structurally adequate and recommended various improvements and rehabilitations such as removal of defective concrete, replacement of affected rebar, and application of epoxy grout and lining to rehabilitate the tanks. The recommendations of this study, along with more detailed investigation will be utilized to rehabilitate tanks, which are proposed to be re-used.

The outfall pipe was videotaped and found to be generally in good condition with some rehabilitation needs. A more detailed investigation will be conducted during design to insert the new 36-inch outfall pressure pipe in the existing 51-inch pipe. Similarly a new 32-inch pipe is proposed to be inserted in the existing 36-iinch intake pipe, using Horizontal Directional Drilling (HDD) method, or if needed, Pipe Bursting (PB) method. Both methods are trenchless and will have minimum impact on the environment. However, both methods require access to the pipe, especially near bends, fittings and valves. Several access points exist on these pipelines. These access points and other new access points may need to be constructed for utilizing these technologies. During detail design, every attempt will be made to minimize site disturbances by strategically locating these access points, especially in sensitive areas. Based on review of the pipe plan and profiles and dedicated right-of-ways, it is believed that both outfall and intake can be built in the existing right-of-ways, with limited temporary access and construction easements.

The pipeline from the PMLD property to the bay crosses a portion of Harbor District property and is covered by an easement over that property. The parties are currently negotiating an extension of the easement term for purposes of this project.

The construction of desal facilities will be similar to any industrial construction and will follow industry practices and local codes. Every attempt will be made to minimize construction noise (especially after hours) and project specific plans will be provided to local authorities for approval for soil, sediment and erosion control, storm water management and dust control.

Facility design will also include provisions for controlling vibration and noise from desal equipment. The buildings will have sound attenuation. Heavy equipment and large high pressure pipes will be provided with vibration isolation to minimize noise and vibration transmitted to outside buildings.

5.0 Power and Chemical Usage Estimates

5.1 Power Estimates

Detailed power calculations were prepared for each alternative assuming average water temperatures. A summary of power estimates are presented in Table 5.1. These estimates include power for intake pumps, pretreatment, desal, finished water pumping, all other process equipment, as well as estimates for building lighting, exterior lighting, HVAC, ventilation and miscellaneous uses. The estimates also include a 10% contingency. More refined estimates will be provided as the design progresses.

Table 5.1 Power Estimates for Entire Facilities

Process Description	Units	Alternative A	Alternative B	Alternative C
Intake Pumps and Systems	KW	578	608	518
Pretreatment	KW	1610	1030	1029
First Pass SWRO	KW	3919	3924	3918
Second Pass BWRO	KW	722	721	727
Post Treatment Systems	KW	410	225	221
Solids Handling	KW	40	18	9
Finished Water Pumping	KW	472	472	472
Buildings, Lighting and HVAC	KW	574	541	541
Other Miscellaneous	KW	123	41	41
Total Power Estimate	**MW**	**8.4**	**7.6**	**7.5**
KWH/1000 Gallons of Finished Water	**kWh/kGal**	**16.9**	**15.2**	**15.0**

5.2 Chemical Use Estimates

Detailed chemical use estimates were prepared for each alternative and summarized in Table 5.2. The estimates include a 10% contingency and are based on active chemicals. More refined estimates will be provided as the design progresses.

Table 5.2 Chemical Use Estimates

Chemicals	Alternative A			Alternative B			Alternative C		
	mg/L	Flow (MGD)	lb/day	mg/L	Flow (MGD)	lb/day	mg/L	Flow (MGD)	lb/day
Coagulant (Ferric Chloride or Ferric sulfate)	30	33	8,294	20	30	4,987	10	29	2,443
Flocculant/Polymer/filter Aid	3	33	829	2	30	499	2	29	489
Sulfuric Acid	20	33	5,529	15	30	3,740	10	29	2,443
Antifoulant	3	28	703	2	28	469	2	28	469
Lime	20	6	1,004	20	6	1,004	20	6	1,004
Caustic	10	12	1,005	10	12	1,005	10	12	1,005
CO2	5	6	251	5	6	251	5	6	251
Hypochlorite	6	12	603	4	12	402	3	12	301
Ammonia	3	12	301	3	12	301	3	12	301
Sodium Metabisulfite	3	12	300	3	12	300	3	12	300
Total lb/day (All Chemicals)	**18,821**			**12,959**			**9,006**		

6.0 Staffing Requirements

The proposed facility will be fully automated with a central control system with Programmable Logic Controller (PLC) as well as multiple remote PLCs and controllers at each group of controlled equipment. This level of automation is necessary for proper control and optimization of various process units. The facility control will also include various levels of alarms containing outside calling Remote Telemetry Unit (RTU) for safety, water quality and process reliability reasons.

However, despite this level of automation, any plant of this size and complexity must have full time licensed operators at all times during facility operation. In addition, the State of California has mandatory minimum requirements for staffing water treatment facilities.

Based on our experience with other similar desalination plants and complexity of the proposed PMLD facility, we have prepared Table 6.1 for the staffing requirements. This level of staffing and operator licensing requirements meets and exceeds the minimum state requirements.

Each of the off-duty staff will be “on call” to be able to respond to emergencies.

Table 6.1 Staffing Needs

Position	First Shift	Second Shift	Third Shift
Plant Manager	1	-	-
Assistant Plant Manager	1	-	-
Operators	4	2	2
Laboratory Technician	1	-	-
Electrical Technician	1	-	-
Instrument Technician	1	1	-
Maintenance Mechanic	1	1	1
Administrative Assistant	1	-	-
Total Number of Staff	**18**		

7.0 Cost Estimates

7.1 Construction Costs

Costs are based on our experience from other similar projects, price index methods and other industry guidelines. It should be noted that due to the preliminary nature of the estimates, they should be used only for planning purposes. More accurate and detailed cost estimates will be provided as the design progresses. Since we have no control over the cost of labor, materials, or equipment, the contractor's methods of determining prices, or over competitive bidding and market conditions, our opinion of probable cost is on the basis of our experience and qualifications and represents our best judgment as a design professional familiar with the construction industry. All costs were estimated for the first quarter of 2015.

7.2 Indirect Costs

There are three variables that have significant impacts on the cost of water per acre foot: land cost, energy cost, and the interest rate to be paid on bond financing. The cost analysis includes the following assumptions:

Land Cost: Moss Landing Commercial Park owns the land upon which the desalination plant is located, as well as the infrastructure and easements for the intake and outfall pipelines. It is anticipated that the desalination plant, when constructed, will be owned and operated by a public entity. If that public entity wishes to own (rather than lease) the land and easements, it will need to purchase the land and easements following appraisal. This cost analysis assumes an estimated purchase price of $20 million, which includes the already-existing intake and outfall pipes running from the project site, under the harbor, and out to the bay. To allow for future comparison, every $1 million that the purchase price decreases or increases will affect the cost of water production by $5 per acre foot.

Energy Cost: The cost of energy has the largest impact on the annual operating and maintenance costs of the desalination plant. This cost analysis assumes that the project will pay $0.12 per kw/hr for energy. MLCP believes that the public entity owning the project will be able to negotiate a more favorable energy rate with Dynegy (the owner of the adjacent power plant). Nonetheless, a recent cost analysis of a competing desalination project used a $0.12 per kw/hr energy assumption, so that rate has been used in this analysis for an "apples to apples" comparison. To allow for future comparison, every $ 1 cent per KWH decrease in energy costs will decrease the cost of water production by $50 per acre foot.

Bond Financing: The project will likely be financed through municipal bonds, and this cost analysis assumes that the bond interest rate will be 4.3%. Although MLCP believes that a lower interest rate may be obtainable, a recent cost analysis of a competing desalination project used 4.3% bond financing in its analysis, so that rate has been used in this analysis for an "apples to apples" comparison. To allow for future comparison, every 1% decrease in the bond interest rate will decrease the cost of water production by $80 per acre foot.

Other indirect costs are based on a percentage of the direct costs and include the following:

- Engineering, design and construction management assumed to be 10% of construction cost
- Contractor's mobilization, bond and insurance: 5%
- Contractor's overhead and profit: 15%
- Contingencies: 20%

7.3 Operation and Maintenance Costs

The operations and maintenance costs are based on the following factors:

Membrane Replacement – SWRO membrane replacement rate of 20% per year

Membrane Replacement – BWRO membrane replacement rate of 17 % per year

Membrane Replacement – UF membrane replacement rate of 13 % per year

Cartridge Filters Replacement – Every month

7.4 Water Production Cost

The following factors were used in estimating the total water production cost:

- Life Cycle Period: 30 years
- Salvage Value: None

As shown in Table 7.1, the total estimated cost of producing the 13,404 AFY at the proposed facility (without distribution system) ranges from $1500 to $ 1600 per Acre Feet.

The cost for the delivery system (pipelines and tanks) for 9,752 AFY from project site to CalAm's terminal in Seaside and delivery of 3,652 AFY to customers in North Monterey County would be approximately an additional $400 per Acre Feet. Although the delivery system for North County is still under development, including the number of pipelines required and their routes, preliminary costs of pipelines and terminal storage tanks are included in these estimates.

TABLE 7.1: WATER COST FOR DESAL FACILITY WITHOUT DISTRIBUTION SYSTEM			
	ALT A	**ALT B**	**ALT C**
Description			
A: Direct Facility Construction Costs (Including O&P markups & contingency)			
Site and Civil	$1,371,600	$1,227,600	$1,227,600
Structural Concrete and Buildings	$34,007,040	$28,376,640	$26,850,240
Electrical	$16,236,000	$14,616,000	$14,184,000
Process Equipment and piping	$85,880,818	$60,512,338	$64,241,938
Mechanical HVAC	$554,400	$468,000	$468,000
Instrumentation and Controls	$3,931,200	$3,542,400	$3,542,400
Furnishings, supplies and casework	$172,800	$172,800	$172,800
TOTAL DIRECT FACILITY CONSTRUCTION COSTS	**$142,153,858**	**$108,915,778**	**$110,686,978**
Amortized/Annual	**$8,522,822**	**$6,530,036**	**$6,636,228**
Water Cost for this portion ($/AF)	**$636**	**$487**	**$495**
B: Facility Indirect Costs			
Cost of facilities land, easements and existing Infrastructure	$20,000,000	$20,000,000	$20,000,000
Engineering and Construction Management @ 10 % of construction cost	$14,215,386	$10,891,578	$11,068,698
Permitting, Pilot Tests and Mixing Studies	$1,200,000	$1,000,000	$500,000
Commissioning, Testing and training for facilities	$400,000	$350,000	$350,000
TOTAL INDIRECT FACILITY COSTS	**$35,815,386**	**$32,241,578**	**$31,918,698**
Amortized/Annual	**$2,147,308**	**$1,933,041**	**$1,913,683**
Water Cost for this portion ($/AF)	**$160**	**$144**	**$143**
C: Facility O&M Costs			
Power for intake, outfall and desal facility	$8,384,970	$7,471,312	$7,362,426
Chemicals	$2,123,149	$1,398,111	$1,020,889
Labor for facilities	$2,710,000	$2,710,000	$2,710,000
Replacements & Consumables	$1,400,910	$1,073,710	$1,052,210
By-product Handling	$753,180	$140,310	$84,100
General services	$100,000	$90,000	$70,000
TOTAL FACILITY ANNUAL O&M COST	**$15,472,209**	**$12,883,443**	**$12,299,625**
Water Cost for this portion ($/AF)	**$1,154**	**$961**	**$918**
D: Total Water Cost Analysis			
Total Annual Cost including Capital Recovery	$26,142,339	$21,346,520	$20,849,536
Water Cost per 1000 Gallons	**$5.98**	**$4.89**	**$4.77**
Water Cost per AF	**$1,950**	**$1,593**	**$1,555**
E: Assumptions			
Power Cost delivered to site, per KWH	$0.12		
Life Cycle Years/Amortization	30		
Amortization/ Interest Rate, %	4.3%		
Engineering and Construction Management, % of construction cost	10.0%		
Estimates are for year 2015	2,015		
North County Demand, AFY	3,652		
Peninsula Demand, AFY	9,752		
Total Demand, AFY	13,404		
Total Demand, MGD	11.97		
Cost of Land and Easements from MLCP	$20,000,000		
Savage Value	$0		