Central Marin Sanitation Agency and
Marin Municipal Water District
Direct Potable Reuse Evaluation

Technical Memorandum
DIRECT POTABLE REUSE FEASIBILITY STUDY

FINAL | May 2022

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Abbreviations

%	percent
AACE	Advancement of Cost Engineering International
ADA	average day annual
ADMM	average day maximum month
ADW	average dry weather
ac-ft	acre-feet (foot)
AL	action level
Amp	Amperes
AWPF	advanced water purification facility
AWTO	advanced water treatment operator
BAC	biological activated carbon
BOD	biochemical oxygen demand
°C	degrees Celsius
CBOD	carbonaceous biochemical oxygen demand
CEC	contaminant of emerging concern
CEQA	California Environmental Quality Act
CIP	clean-in-place
CIWQS	California Integrated Water Quality System
CMSA	Central Marin Sanitation Agency
CT	concentration times / contact time
Ct/100 ml	count per 100 milliliter
DBP	disinfection byproduct
DDW	California Division of Drinking Water
DiPRRA	direct potable reuse responsible agency
DOC	dissolved organic carbon
DPR	direct potable reuse
EBCT	empty bed contact time
EC	electrical conductivity
EQ	equalization
ESB	engineered stage buffer
ESCP	Enhanced Source Control Program
ft	feet (foot)
GAC	granular activated carbon
gal	gallon
gfd	gallons per square foot of membrane per day
gpm	gallon per minute
GWR	groundwater replenishment

hp	horsepower
IAP	Independent Advisory Panel
in	inch(es)
IPR	indirect potable reuse
KVA	kilo-volt ampere
KW	kilowatt
LRV	log removal value
MBR	membrane bioreactor
MCC	motor control center
MCL	maximum contaminant level
MF	microfiltration
MG	million gallons
mg/L	milligrams per liter
mgd	million gallons per day
mg-min/L	milligram-minute per liter
mJ/cm2	millijoules per square centimeter
MMWD	Marin Municipal Water District
MOU	memorandum of understanding
MPN/100 mL	most probable number per 100 milliliters
MTL	monitoring trigger levels
NDMA	N-Nitrosodimethylamine
NL	notification level
NPDES	National Pollutant Discharge Elimination System
NTU	nephelometric turbidity units
NWRI	National Water Research Institute
O&M	operations and maintenance
O3	ozone
OOP	Operation Optimization Plan
PDT	pressure decay tests
PHWWF	peak hour wet weather flow
psi	pounds per square inch
Report	CMSA and MMWD DPR Evaluation
RO	reverse osmosis
ROC	reverse osmosis concentrate
RWQCB	Regional Water Quality Control Board
SCADA	supervisory control and data acquisition
SCCWRP	Southern California Coastal Water Research Project
SF Bay	San Francisco Bay
sMCL	secondary maximum contaminant level

SOC	synthetic organic chemical
SWA	surface water augmentation
SWRCB	State Water Resources Control Board
TDH	total dynamic head
TEQ	toxic equivalent quantity
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
TWA	treated water augmentation
UF	ultrafiltration
µg/L	microgram per liter
µhmos/cm	micromhos per centimeter
µm	micrometer
UV	ultraviolet light
UV AOP	ultraviolet light advanced oxidation process
WRA	Water Recycling Agency
WTP	water treatment plant
WWTP	wastewater treatment plant
2016 Study	2016 Recycled Water Feasibility Study

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EXECUTIVE SUMMARY

ES.1 Background

Like many utilities in drought-impacted California, Marin County's largest water services provider, the Marin Municipal Water District (MMWD), and the wastewater services provider for the central Marin region, the Central Marin Sanitation Agency (CMSA), are proactively searching for sustainable measures to secure a safe, reliable, and long-term drinking water supply for their communities.

As part of this effort, CMSA and MMWD are conducting a preliminary evaluation of a potential direct potable reuse (DPR) project. This project, if implemented, would utilize an advanced water purification facility (AWPF) at CMSA's wastewater treatment plant (WWTP) for treated water augmentation (TWA), a process by which highly purified recycled water is added into a potable water distribution system.

This CMSA and MMWD DPR Evaluation builds off previous DPR studies using new draft DPR regulations in California, which are being implemented due to intensifying drought conditions. The goal of this study is to clarify the requirements, costs, challenges, and opportunities associated with delivering a DPR project in Marin County.

This DPR evaluation is an update of MMWD and CMSA's 2016 Recycled Water Feasibility Study, but focuses only on DPR and assesses the feasibility of achieving TWA. It recommends a viable approach to achieve TWA involving the construction of an AWPF at CMSA's WWTP, purifying the secondary effluent that is normally discharged to the San Francisco Bay (SF Bay). Two AWPF production capacities were analyzed: 2 and 4 million gallons per day (mgd). The AWPF would treat the plant's effluent to very stringent drinking water standards. This study analyzed two potential connection points where the purified water could then be introduced into MMWD's drinking water distribution system.

ES.2 Regulatory Summary

Regulations for DPR in California are not yet finalized but are well developed. The draft DPR regulations contain extensive requirements for treatment, monitoring, source control, reporting, and more. The framework remains similar to what has been promulgated for indirect potable reuse (IPR), i.e., groundwater replenishment (GWR) and surface water augmentation (SWA), but many of the requirements have been made more stringent, and new elements have been introduced. The key requirements are summarized in Chapter 2.

ES.3 DPR Source Water Analysis

The water quality of secondary effluent produced by the CMSA WWTP is important for the DPR feasibility evaluation for multiple reasons. First, it informs the identification of appropriate treatment technologies at the AWPF and the development of certain design criteria for the AWPF treatment train to ensure that all regulatory standards can be met. In addition, it informs the analysis of reverse osmosis concentrate (ROC), which would be discharged through the existing outfall and could impact the National Pollutant Discharge Elimination System (NPDES) discharge permit as discussed in Chapter 6. Chapter 3 discusses the water quality of CMSA secondary effluent and the implications for DPR treatment.

In addition to water quality, Chapter 3 also examines the water quantity available to feed a DPR facility. Taking into account historical flow data, peaking factors, and the potential for equalization in the existing 7 million gallon effluent storage basin, the available maximum continuous feed flow for DPR is 5.5 mgd. This feed flow allows for a maximum AWPF production of 3.9 mgd (accounting for unit process recoveries). For unit process sizing, AWPF layouts, and cost estimates, an AWPF production of 4 mgd was assumed.

ES.4 DPR Treatment Facility Analysis

For this project, the available footprint is a key factor in defining treatment capacity. Prior work on AWPFs dictate a space requirement of about 2 mgd per acre. For this effort, we are examining a two-story facility for both the 2 mgd production AWPF and 4 mgd production AWPF. Since it must be capable of meeting the DDW draft standards, the recommended treatment train includes the following key processes:

- Ozone (O_3).
- Biological active carbon (BAC).
- Ultrafiltration (UF).
- Reverse osmosis (RO).
- Ultraviolet light advanced oxidation process (UV AOP) using free chlorine as the oxidant.
- Free chlorination.
- Additional UV disinfection.
- Stabilization and chloramination for distribution.

The treatment train also includes adding several different chemicals to adjust for alkalinity and pH and improve process operation as well as provide any post-treatment necessary to match the resulting product to MMWD's existing drinking water quality. Figure ES.1 shows a process flow diagram of this highly engineered treatment train.

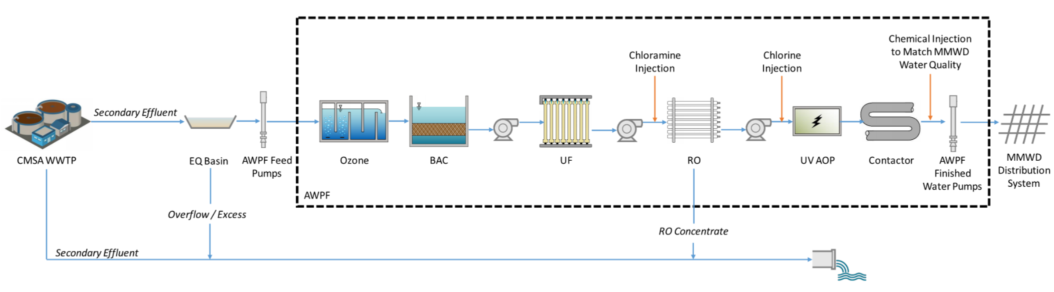

Figure ES.1 Proposed Treatment Train for CMSA DPR Project

AWPF layouts were developed for the 2 mgd and 4 mgd production facilities. For both facilities, a two-story structure was needed to fit all the required components within the available footprint. The layouts include plant feed pump stations, all treatment processes, and ancillary equipment such as chemical storage. Plan views of the two facility sizes are shown in Figures ES.2 and ES.3. The main differences in the layouts are the number of process trains and the location of the ozone generation equipment. An additional train of UF and RO are needed for the 4 mgd facility; placing these trains on the roof means the ozone generator equipment must be moved to its own adjacent structure, which is labeled as the 'Ozone Generation Building' in Figure ES.3. This building increases the overall footprint of the AWPF.

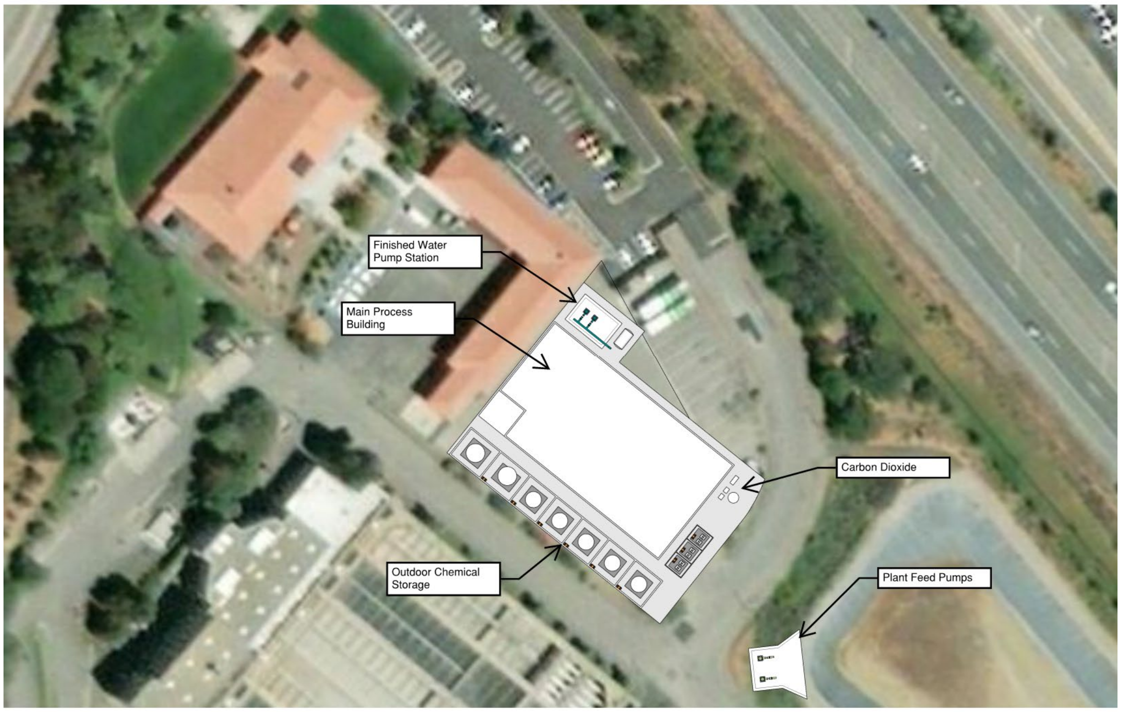

Figure ES.2 Plan View of Two-Story 2 mgd Production AWPF Located at CMSA WWTP

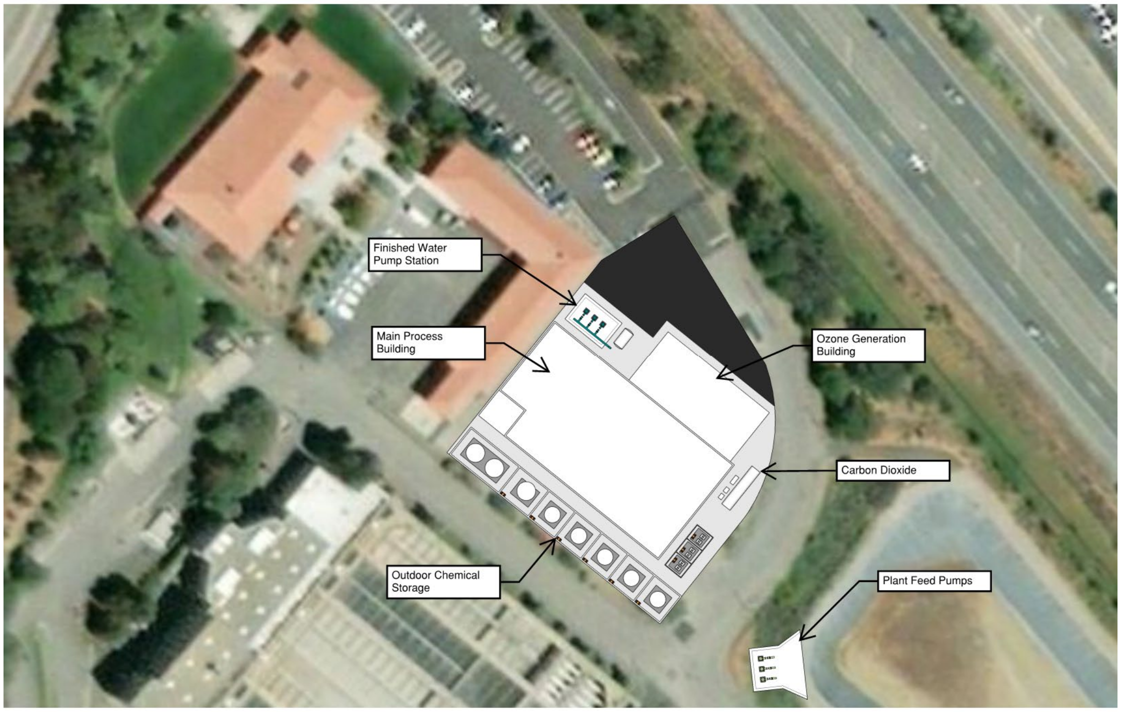

Figure ES.3 Plan View of Two-Story 4 mgd Production AWPF Located at CMSA WWTP

ES.5 Infrastructure Needs to Support DPR

There are a number of infrastructure components needed to integrate the AWPF facility into existing infrastructure. The additional infrastructure components analyzed here are:

- AWPF feed pipeline and pump station.
- AWPF finished water pipeline.
- ROC pipeline.
- Power supply.

The components are shown on Figure ES.4 below. The design criteria and cost estimates for these components are discussed in Chapter 5.

ES.6 Planning Level Cost Estimates

Planning level capital and operation and maintenance (O&M) costs were developed for the two AWPF production capacities as well as the supporting infrastructure required for the AWPF. O&M costs included power consumption, chemical consumption, maintenance, and staffing. A summary of these costs is shown in Table ES.1.

Figure ES.4 Map of Proposed Infrastructure

Table ES.1 Planning Level Cost Estimates

	Planning Level Total Project Cost(1)	
	2 mgd Production	4 mgd Production
Total Project Cost	$91,389,000	$122,357,000
Annualized Construction Cost(2)	$4,970,000	$6,650,000
Annual O&M Cost	$4,467,000	$6,333,000
Unit Cost ($/million gallons [MG])(3)	$12,900	$8,900
Unit Cost ($/acre-foot [ac-ft])(3)	$4,200	$2,900

Notes:
(1) Costs include an estimating contingency, sales tax, general conditions, and contractor overhead and profit. They reflect a March 2022 ENR of 12791 and a San Francisco location factor of 1.298.
(2) Calculated assuming an interest rate of 3.5 percent and annualized over 30 years.
(3) Calculated using the annualized capital cost, annual O&M cost, and assuming the facility is running at capacity 365 days per year.

ES.7 NPDES Discharge Analysis

An analysis was conducted to determine if there are any potential constituents in the RO concentrate (ROC) that could cause an exceedance of the existing NPDES discharge permit. The analysis is intended as a preliminary step that will inform future additional work to evaluate the impacts of ROC discharge.

Based on defined assumptions for RO performance, ROC concentrations were estimated based on 95th percentile secondary effluent data. The results of the analysis show that ammonia is the only constituent that presents a potential issue in the ROC discharge. None of the other constituents are expected to exceed existing or estimated potential NPDES discharge limits.

Additional analysis for ammonia does show that concentrations in the RO concentrate would cause exceedances of the existing NPDES discharge limits. This is not anticipated to be a fatal flaw for a DPR project, and there are strategies presented to mitigate this issue. Additional dilution modeling could be undertaken to demonstrate that although the ammonia concentrations in the discharge are high, the discharge volume is lower and thus additional dilution is being achieved through the outfall. Alternatively, the 7 MG basin could be operated in such a way as to provide additional discharge volume to dilute the ROC to below permit limits. Additional analysis would be needed for each strategy.

ES.8 DPR Implementation Approach

Recent work by the National Water Research Institute (NWRI) provided our industry with a clear vision of the steps and approach necessary to implement DPR[1]. That work, co-authored by Carollo, is titled *DPR Implementation Guide for California Water Utilities* (NWRI Guide). Chapter 8 builds on this work to describe the timeline for DPR implementation, including the ***phases*** of a DPR project, then describe the key ***elements*** for DPR success defined by the NWRI Guide. For each key element, example action items are provided, along with the project phase where they might occur. The timeline to implement a potable reuse project can vary greatly depending on

[1] State Water Resources Control Board (SWRCB) (2016). Evaluation of the Feasibility of Developing Uniform Water Recycling Criteria for Direct Potable Reuse. Prepared by NWRI for the State (of California) Water Resources Control Board.

the urgency and need, the regulatory climate, and the specific project details. The goal of the DPR implementation timeline and approach is to provide perspective on key project elements and how they might fit within an overall project delivery timeline.

The DPR timeline, presented in Figure ES.5, has been divided into four ***phases***: planning, demonstration, implementation, and operations/operator training. Although these phases are ordered generally in sequence, there is overlap between them and some activities continue throughout the life of the project. Throughout the implementation timeline there are elements that can result in schedule days or increased uncertainty; these challenges, such as consensus on the project, water supply need, and public perception, are discussed in further detail in Chapter 7.

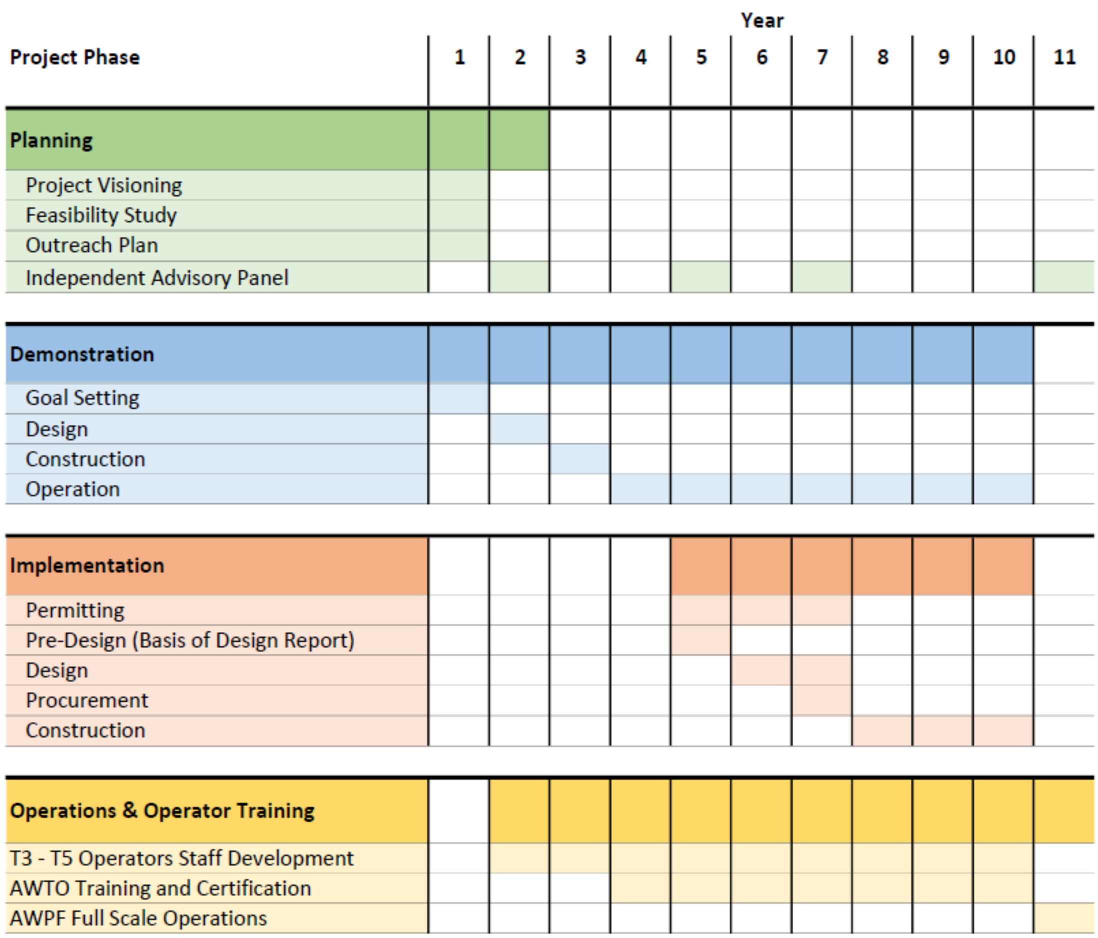

Figure ES.5 Potential DPR Implementation Timeline Based on Four Main Project Phases

The NWRI Guide incorporated perspectives from a state and federal resources, published and ongoing research studies, and a number of California utilities to summarize the essential principles of DPR. The 2021 Guide includes specific elements that are likely to be key for DPR success, including technical, operational, managerial, and regulatory elements. These 13 elements are summarized in Chapter 7 and provide valuable perspective on the necessary components of DPR implementation. The chapter also links the project elements to the main phases of the DPR project timeline to illustrate how these elements fit within the overall project timeline.

Chapter 1

INTRODUCTION

1.1 Background and Purpose

Like many utilities in drought-impacted California, Marin County's water services provider, the Marin Municipal Water District (MMWD), and the wastewater services provider for the central Marin region, the Central Marin Sanitation Agency (CMSA), are proactively searching for sustainable measures to secure a safe, reliable, and long-term drinking water supply for their communities.

As part of this effort, CMSA and MMWD conducted a preliminary evaluation of a potential direct potable reuse (DPR) project. This project, if implemented, would utilize an advanced water purification facility (AWPF) at CMSA's wastewater treatment plant (WWTP) for treated water augmentation (TWA), a process by which highly purified recycled water is added into a potable water distribution system.

This CMSA and MMWD DPR Evaluation (Report) builds off previously evaluated DPR solutions and new draft DPR regulations in California. These new draft DPR regulations were mandated by law to be completed by the end of 2023 due to intensifying drought conditions. The goal of this Report is to clarify the requirements, costs, challenges, and opportunities associated with delivering a robust DPR project in Marin County.

1.2 Project Summary

CMSA and MMWD first began evaluating DPR in the 2016 Recycled Water Feasibility Study (2016 Study), an effort that sought to determine the feasibility of a recycled water system to augment water supplies that serve the county. At the time, how DPR would be regulated in California was speculative, relying on the state's existing indirect potable reuse (IPR) regulations and the progress of DPR projects on a national scale.

Over the last few years, however, two significant developments occurred that merit a re-examination of the 2016 Study's findings: (1) The California Division of Drinking Water (DDW) released a detailed draft of the state's latest DPR regulations; and (2) critical droughts in the Western U.S. are driving DPR implementation at a faster pace than was anticipated five years ago.

This Report builds upon, and updates, the 2016 Study by assessing the feasibility of and recommending the most viable approach to achieve TWA a process in which the purified recycled water is added directly into the drinking water distribution system. The DPR project analyzed here involves the construction of an AWPF at CMSA's WWTP, treating the secondary effluent that is normally discharged to the San Francisco Bay (SF Bay). Two AWPF production capacities were analyzed: 2 and 4 million gallons per day (mgd). The AWPF would treat CMSA's effluent to stringent drinking water standards and to the draft criteria for DPR in California. This Report analyzed two potential connection points where the purified water could be introduced into MMWD's drinking water distribution system.

Since the AWPF finished water must be capable of meeting the DDW draft standards, the recommended treatment train includes the following processes:

- Ozone (O_3).
- Biological active carbon (BAC).
- Ultrafiltration (UF).
- Reverse osmosis (RO).
- Ultraviolet light advanced oxidation process (UV AOP) using free chlorine as the oxidant.
- Free chlorination.
- Additional UV disinfection
- Stabilization and chloramine for distribution.

The treatment train also includes adding several different chemicals to adjust for alkalinity and pH and improve process operation as well as provide any post-treatment necessary to match the resulting product to MMWD's existing drinking water quality. Figure 1.1 shows a preliminary process flow diagram of this highly engineered treatment train.

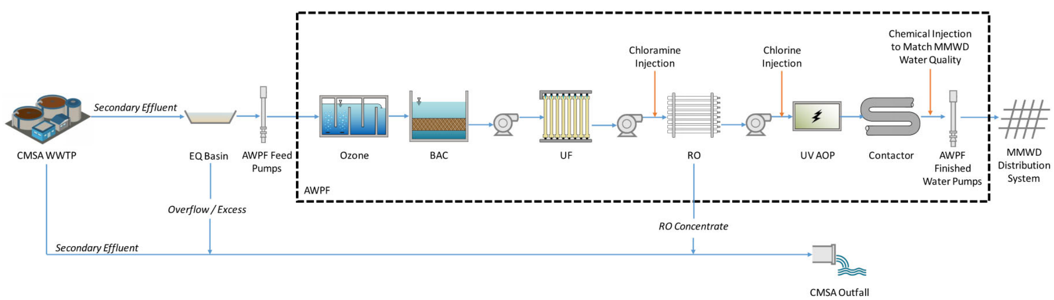

Figure 1.1 Potential Treatment Process Flow Diagram

1.3 Topics Covered in this Report

This Report summarizes the analysis that was done for this DPR evaluation, covering the following topics:

- Regulatory summary:
  - Current potable water reuse regulations.
  - Draft DPR regulations for California.
- Treatment, monitoring, and delivery analysis:
  - Source Water Analysis: Available flows and water quality for an AWPF feed.
  - Treatment Train Analysis: Recommended treatment train, monitoring systems, AWPF facility layouts, and estimated costs.
  - Additional Infrastructure Analysis: Power distribution concepts and delivery methods for DPR into MMWD's water system.
  - Costs: Summary of expected facility capital and operation and maintenance (O&M) costs.

- National Pollutant Discharge Elimination System discharge analysis:
  - Anticipated water quality of the RO Concentrate (ROC).
  - Analysis of CMSA's existing National Pollutant Discharge Elimination System (NPDES) permit and discussion of anticipated compliance challenges associated with the discharge of ROC to the SF Bay.
- Outline of DPR implementation plan:
  - DPR implementation timeline, including identification of four major project phases and potential schedule challenges.
  - Outline of major aspects of a successful potable reuse program using the 2021 DPR Implementation Guide for California Water Utilities.
  - Anticipated technical challenges for DPR implementation.

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Chapter 2

REGULATORY SUMMARY

This chapter provides an overview of the anticipated requirements for DPR as they are laid out in the latest draft regulations, allowing for perspective on the anticipated treatment needs for DPR compared to conventional IPR projects.

2.1 Background and Context

The DPR regulations build on the public health protection requirements from IPR and incorporate new elements to account for the loss of an environmental buffer (e.g., a groundwater basin or surface water reservoir), from new information on pathogen concentrations, and due to some level of regulatory uncertainty regarding chemical pollutants. A more detailed regulatory summary, including IPR regulations, is provided in Appendix A.

Water recycling and potable reuse in California fall under the jurisdiction of the State Water Resources Control Board (SWRCB). Within the SWRCB, two departments are responsible for protecting public health and the environment with respect to water: (1) the DDW; and (2) the Regional Water Quality Control Boards (RWQCBs). DDW regulates public drinking water systems and is responsible for developing regulations for recycled water and for reviewing recycled water projects. The RWQCBs, which are divided into regions across the state, develop and enforce water quality objectives and implementation plans to protect the beneficial uses of the state's waters, and write the permits for recycled water projects.

2.2 Draft Regulations for DPR

Based on discussions with the project team, the focus of this effort is TWA. Accordingly, this regulatory summary excludes considerations specific to raw water augmentation, where purified water is added ahead of an existing water treatment plant. Instead, TWA entails the treatment of a secondary or tertiary effluent from a wastewater treatment plant at an AWPF. The purified water produced by the AWPF is discharged directly into an existing drinking water distribution system (see Figure 2.1).

There is currently one operating DPR system in the country in Big Spring, Texas, which sends purified water into a raw water supply ahead of a water treatment plant (WTP) (i.e., raw water augmentation). There is one other DPR project in development in the United States, namely the El Paso TWA project, which will begin construction in 2022. There are currently no operating DPR systems in California, although several are being investigated and planned. At this point, given the novelty of DPR in California, any DPR project proposed will be on the leading edge and need to work closely with DDW.

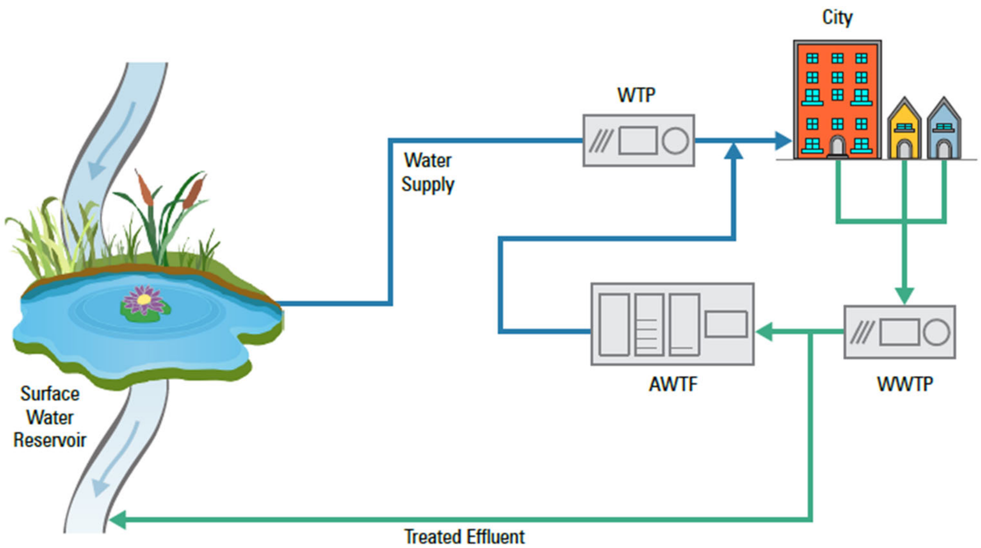

Figure 2.1 Schematic of DPR via Treated Water Augmentation

Regulations for DPR in California are not yet finalized but are well developed. Assembly Bill 574 was signed into law in October 2017 and requires that DDW develop raw water augmentation regulations by 2023. Since then, DDW has published a proposed framework and a second edition framework stating that they intend both raw and treated water augmentation to be regulated under one uniform regulation published in 2023[1]. Most recently, DDW published Addendum version 8-17-2021 to A Framework for Direct Potable Reuse[2], which provides the second draft of regulations as they might be housed within a new Article under the Surface Water Treatment chapter of Title 22 of the California Code of Regulations.

The draft regulations contain extensive requirements for treatment, monitoring, source control, reporting, and more. The framework remains similar to what has been promulgated for IPR, i.e., groundwater replenishment (GWR) and surface water augmentation (SWA), but many of the requirements have been made more stringent, and new elements have been introduced. It is important to note that they are still in draft form, and the final version of the regulations may look different. With that in mind, the key elements of the draft regulations are defined below, with a comparison summary of IPR and draft DPR regulations in Table 2.1.

[1] SWRCB (2019). A Proposed Framework for Regulating Direct Potable Reuse in California, Second Edition. Prepared by the State of California Water Resources Control Board Division of Drinking Water, August 2019.

[2] SWRCB (2021). A Proposed Framework for Regulating Direct Potable Reuse in California, 2nd Edition Addendum: Early Draft of Anticipated Criteria. August 17, 2021.

Table 2.1 Summary Comparison of Key Regulatory Requirements for Groundwater Recharge, Surface Water Augmentation, and Direct Potable Reuse

	Groundwater Recharge	Surface Water Augmentation	Direct Potable Reuse – Treated Water Augmentation
Project Structure & Interagency Coordination	• Main entity is project sponsor	• Involves both a Water Recycling Agency (WRA) and a Public Water System • Joint Plan required	• DiPRRA is the public water agency responsible for project • Joint Plan required
Source Control	• Requires industrial pretreatment and pollutant source control program including: • Assessment of the fate of site-specific chemicals through the wastewater and recycled water treatment systems • Monitoring and investigation of chemical sources • Outreach program to minimize discharge of chemicals into the source water.	• Requires industrial pretreatment and pollutant source control program including: • Assessment of the fate of site-specific chemicals through the wastewater and recycled water treatment systems • Monitoring and investigation of chemical sources • Outreach program to minimize discharge of chemicals into the source water.	• Requires enhanced source control program • All elements of source control as needed for IPR • Quantitative risk assessment for chemicals discharged to collection system • Online monitoring that may indicate a chemical peak resulting from an illicit discharge • Coordination with the pretreatment program for notification of discharges above allowable limits • Monitoring of local surveillance programs to determine when community outbreaks of disease occur • Form a source control committee and institute a continuous improvement process for the program.
Feed Water Monitoring	None	None	• Prior to operation, 24 months of monthly feed water monitoring for regulated contaminants (i.e. those with an MCL), priority pollutants, NLs, a specific list of solvents, DBPs, and DBP precursors.
Pathogen Control	• 12-log enteric virus • 10-log Giardia • 10-log Cryptosporidium	• 12 to 14-log enteric virus • 10 to 12-log Giardia • 10 to 12-log Cryptosporidium	• 20-log enteric virus • 14-log Giardia • 15-log Cryptosporidium

	Groundwater Recharge	Surface Water Augmentation	Direct Potable Reuse – Treated Water Augmentation
Treatment Train	RO + UV/AOP required	RO + UV/AOP required	Ozone/BAC + RO + UV/AOP required
Chemical Control	• Maximum recycled water TOC contribution of 0.5 mg/L • Must meet all current drinking water standards, including MCLs, DBPs, and ALs. Quarterly monitoring.	• Maximum recycled water TOC contribution of 0.5 mg/L • Must meet all current drinking water standards, including MCLs, DBPs, and ALs. Quarterly monitoring.	• Maximum effluent TOC contribution of 0.5 mg/L; additional more stringent TOC thresholds with response actions • Must meet all current drinking water standards, including MCLs, DBPs, and ALs. Quarterly monitoring. • Control of one-hour chemical spike • Continuous monitoring of nitrate and nitrite in RO permeate
Additional Monitoring	• Quarterly sampling in recycled water and downgradient groundwater wells for priority pollutants, unregulated chemicals, and notification levels.	• Quarterly sampling in recycled water for priority pollutants, unregulated chemicals, and notification levels. • 24 months of monthly sampling for sMCLs, TOC, nitrogen, and others at multiple locations in reservoir to be augmented. Additional monthly monitoring for at least first 24 months of operations.	• Monitoring required in feed water, directly after oxidation process, and finished water for: • Weekly: nitrate, nitrite, perchlorate, and lead. • Monthly: All MCLs, sMCLs, NLs, priority toxic pollutants, alert levels, DBPs and DBP precursors, and specified solvents. • Quarterly: chemicals known to cause cancer or reproductive issues for at least three years.
Environmental Buffer	• Minimum aquifer retention time of 2 months	• Initial minimum reservoir hydraulic retention time of 6 months; potential to reduce down to 2 months with additional pathogen control • Initial minimum reservoir dilution of 100:0; potential to reduce down to 10:1 with additional pathogen control	• No environmental buffer

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	Groundwater Recharge	Surface Water Augmentation	Direct Potable Reuse – Treated Water Augmentation
Response Time	None	None	• The system must be designed to meet certain response time requirements to ensure that diversion and/or shutoff can occur in the event of a failure to meet the pathogen and/or chemical control requirements.
Operations	None	None	• Grade 5 AWTO required on site at all times. • All facility operators must be AWTO certified.
Plans	• Operations Optimization Plan	• Joint Plan • Operations Plan • Plan to address impacts to water treatment plant and distribution system	• Joint Plan • Water Safety Plan • Operations Plan • Pathogen and Chemical Control Point Monitoring and Response Plan • Monitoring Plan • Corrosion Control and Stabilization Plan
Reporting	• Annual compliance reporting	• Annual compliance reporting	• Monthly compliance reporting

Abbreviations:
mg/L = milligrams per liter
DiPRRA = direct potable reuse responsible agency
DBP = disinfection byproduct
TOC = total organic carbon
MCL = maximum contaminant level
AL = action level
NL = notification level
AWTO = advanced water treatment operator

2.2.1 Project Structure & Interagency Coordination

Like IPR, DPR projects will require the participation of both water and wastewater agencies. Because DPR projects produce drinking water, the regulations define the direct potable reuse responsible agency (DiPRRA) as a public water agency that is responsible for using municipal wastewater for treatment and provides DPR project water, in this case directly for distribution.

The DiPRRA must prepare a Joint Plan describing all agencies involved in the DPR project, their roles and responsibilities, and procedures to implement the requirements of the DPR regulations. The plan must also describe procedures for corrective actions that may be taken in the event of a failure to meet the requirements, procedures for public notifications, and provisions for backup supply in the event that purified water is not available. If required by the State Board, a DiPRRA must utilize an Independent Advisory Panel (IAP) to conduct reviews of various project elements, including the enhanced source control program, Water Safety Plans, and water quality data.

2.2.2 Enhanced Source Control

The requirements for source control are more extensive than what is required for IPR projects and include the addition of online monitoring in the sewershed as well as coordination with local health surveillance programs. An enhanced source control program must be implemented by the wastewater management agency to limit contaminants in wastewater used in DPR projects. The source control program has several required elements, including investigation and monitoring of State Board-specified chemicals and contaminants and an outreach program to industrial, commercial, and residential dischargers within the service area contributing to the DPR project. In addition, a quantitative risk assessment must be conducted for chemicals that are discharged to the collection system.

A sewershed surveillance program must also be implemented to provide early warning of a potential occurrence that could adversely impact the DPR treatment. It must include online monitoring that may indicate a chemical peak resulting from an illicit discharge, coordination with the pretreatment program for notification of discharges above allowable limits, and monitoring of local surveillance programs to determine when community outbreaks of disease occur.

2.2.3 Feed Water Monitoring

Unlike an IPR project, for a DPR project, there are requirements for monitoring the feed water. Prior to operation, the feed water to a DPR project must be monitored monthly for a minimum of 24 months for regulated contaminants (i.e., those with an MCL), priority pollutants, NLs, a specific list of solvents, DBPs, and DBP precursors. Existing monitoring data meeting certain criteria may be substituted for 12 months of the required data.

2.2.4 Pathogen Control Requirements

DPR projects must address the same three classes of pathogens as IPR, but with higher levels of pathogen reduction required. Treatment and monitoring systems must be designed and validated to attain 20, 14, and 15-log removal values (LRVs) for virus, Giardia, and Cryptosporidium, respectively. The treatment train must consist of at least four separate treatment processes for each pathogen type (a single process can receive credit for multiple pathogens), and each credited process must demonstrate at least 1-log reduction of the target pathogen. For each treatment process that is proposed to receive pathogen reduction credit, a validation study must be conducted, and a report of the results must be submitted to the State Board.

2.2.5 Wastewater Treatment Requirements

The current draft DPR regulations do not specify performance criteria for the WWTP. However, there are some discussions about a potential requirement that the WWTP provides nitrification. The level of nitrification, and the related public health and operational benefits of nitrification, are not defined at this time. Accordingly, for this analysis we are assuming no modifications would be required of the existing WWTP.

2.2.6 Treatment Train Requirements

Additional prescriptions for required treatment have been included in the DPR regulations and are summarized below:

- In addition to RO and an advanced oxidation process, as required for IPR, the treatment train for DPR must include ozone/BAC ahead of RO[3]. It must also include UV disinfection with a dose of at least 300 millijoules per centimeter squared (mJ/cm^2).
- The system must be designed to meet certain response time requirements to ensure that diversion and/or shutoff can occur in the event of a failure to meet the pathogen and/or chemical control requirements. If a failure is identified, the system must divert or shut off before 10 percent of the off-spec water reaches the diversion or shutoff point.

2.2.7 Chemical Control Requirements

Similarly to IPR, DPR product water must meet all existing standards for drinking water, and there is also a limit on effluent TOC. In addition, there are new requirements for additional online monitoring of regulated chemicals, and for control of an undetected one-hour chemical peak. These requirements include:

- Finished water must meet all current drinking water standards, including MCLs, DBPs, and ALs. Monthly monitoring in the product water is required.
- The TOC shall not exceed 0.5 mg/L prior to distribution.
- Nitrate and nitrite must be continuously monitored in the RO permeate. Continuous monitoring of lead and/or perchlorate may also be required if the required weekly grab samples indicate that it is justified. The control system must be designed to automatically divert purified water if there is an exceedance of the TOC limit, the nitrate MCL, and potentially levels for perchlorate and lead.

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[3] The latest version of the draft regulations has included a provision that allows for a treatment train without ozone/BAC, provided that the purified water comprises 10 percent or less of total water supplied on a continuous basis. Partial ozone/BAC treatment is allowable if purified water will comprise up to 50 percent of the total water supplies. For example, if the purified water were going to make up 25 percent of the water supplied, then approximately 75 percent of the purified water would need to be treated through ozone/BAC

- In order to address a potential chemical peak, the system must provide sufficient mixing at some point prior to distribution to attenuate a one-hour elevated concentration of a contaminant by a factor of ten ("10:1 dilution requirement"). This dilution can occur at any point in the treatment and distribution process before the water is consumed. Examples include:
- Blending within a wastewater treatment plant, such as occurs with return activated sludge recycle streams
- Blending in an equalization basin, such as primary equalization or secondary effluent equalization
- Blending within a distribution system, such as blending within a water storage reservoir before distribution to customers

2.2.8 Additional Monitoring Requirements

The additional monitoring requirements for IPR have been expanded for DPR to include additional locations and additional classes of chemicals. In addition, the frequency is increased to weekly or monthly for many chemicals. Extensive chemical monitoring is required on an ongoing basis in the feed water to the DPR project, the effluent from the advanced oxidation process, and the finished water prior to entering distribution[4]. In each location, monthly sampling is required for all MCLs, secondary MCLs (sMCLs), NLs, priority toxic pollutants, alert levels, DBPs and DBP precursors, and specified solvents. Weekly sampling is required for nitrate, nitrite, perchlorate, and lead. In addition, quarterly sampling is required for chemicals known to cause cancer or reproductive issues for at least three years.

The SWRCB last amended its Recycled Water Policy in 2018 with a revised list of contaminants of emerging concern (CECs) recommended for monitoring in potable water reuse projects[5,6]. The amendment contains a revised list of CECs recommended for monitoring in potable water reuse projects. CECs with health-based significance are assigned health based-screening levels, or monitoring trigger levels (MTLs), which are designated for different types of potable reuse. The required monitoring locations for CECs and surrogates are such that health-based CEC monitoring follows treatment, prior to release to the pipeline, while performance-based CEC monitoring is typically at two locations: prior to RO (or AOP if RO does not substantially remove a CEC and allowed by the Regional Board) and following all treatment prior to release to the pipeline.

2.2.9 Operations Requirements

The draft DPR regulations contain new requirements for AWTO. The AWTO certification goes from grade 3 to grade 5. In order to obtain AWTO certification, a grade 3 water or wastewater treatment operator certification is needed. There must be one chief and one shift operator that

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[4] DDW may allow for the finished water sampling location to be used to satisfy the requirement for the post-oxidation sampling point.

[5] SWRCB (2018) Regulations Related to Recycled Water. Sacramento, CA. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/rwregulations.pdf

[6] Updates were based on the 2018 reconvened science advisory panel published Monitoring Strategies for CECs in Recycled water, Recommendations of a Science Advisory Panel (Southern California Coastal Water Research Project [SCCWRP], 2018).

are AWTO grade 5 certified. An AWTO grade 5 must be present on site at all times, except as described below. All operators at the advanced treatment facility must be AWTO certified (can be at any grade). The latest version of the draft regulations does allow for some degree of remote operations. The chief or shift operator must still be able to monitor operations and exert physical control over the treatment facility within a maximum of one hour. There are ongoing discussions which may result in a requirement for 24/7 operations for the first year of operation, which would have a significant impact on Year 1 operating costs.

2.2.10 Plans and Reporting

DPR projects will be required to prepare several plans that are not required for IPR projects. These plans provide extensive documentation of the public health protection elements of the system, and how any issues or failures will be addressed and mitigated. Compliance reporting to the SWRCB will be required on a monthly basis.

There are several plans that must be prepared prior to the operation of a DPR project; these plans must also be updated and maintained over time, and some require periodic review by the Independent Advisory Panel. These include:

- Joint Plan: described previously in this Report.
- Water Safety Plan: requires project proponent to conduct a hazard analysis that considers all steps in the drinking water supply chain from wastewater source to consumer. The plan documents the result and describes risk management controls necessary beyond those outlined in these regulations (e.g., critical limits, monitoring, and corrective actions).
- Operations Plan: describes the operations, maintenance, and monitoring necessary for a DiPRRA to meet the regulatory requirements. The plan must also identify an on-going training program covering several topics related to DPR operations. The plan must be reviewed and approved by the SWRCB.
- Pathogen and Chemical Control Point Monitoring and Response Plan: describes the monitoring and response for each treatment process used to comply with the LRV requirements. Describes online monitoring, control system, alarms and failure response actions, and other items. The plan must be reviewed and approved by the SWRCB.
- Monitoring Plan: describes monitoring conducted for enhanced source control program, treatment process monitoring, chemical monitoring, and any other required monitoring. Also describes follow up actions that will be taken in the event of an MCL or NL exceedance in the purified water. The plan includes schedules, laboratories used, analytical methods, quality assurance procedures, calibration and verification plans, and other items.
- Corrosion Control and Stabilization Plan: describes how the DiPRRA and any other public water systems receiving finished water will address potential impacts resulting from the introduction of advanced treated water into the distribution system.

The DiPRRA must submit monthly compliance reports to the SWRCB including a summary and results of the month's treatment plant compliance monitoring, including treatment performance records, summary of log reduction performance, any excursions outside approved operating limits, calibration records, equipment failures and corrective actions, analytical results of water quality monitoring, and other items.

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Chapter 3

DPR SOURCE WATER ANALYSIS

This chapter discusses the available source water from CMSA in terms of both quality and quantity and the implications for a TWA DPR project.

3.1 Water Quality Characterization

The water quality of secondary effluent produced by the CMSA WWTP is important for the DPR feasibility evaluation for multiple reasons. First, it informs the identification of appropriate treatment technologies at the AWPF and the development of certain design criteria for the AWPF treatment train to ensure that all regulatory standards can be met. In addition, it informs the analysis of ROC, which would be discharged through the existing outfall and could thus impact the NPDES discharge permit as discussed in Chapter 7.

3.1.1 CMSA Effluent Permit

The CMSA WWTP operates under the NPDES Order No. R-2-2018-0003 (NPDES No. CA0038628). Effluent limits included in this permit are shown in Table 3.1. The permit limits for both total suspended solids (TSS) and ammonia are relatively high, resulting in CMSA not needing to nitrify or provide filtration at the WWTP. While sufficient for wastewater treatment, these higher TSS and ammonia limits are of note for pursuing DPR.

Table 3.1 NPDES Effluent Limits in CMSA's 2018 NPDES Permit

Parameter	Units	Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum	Monthly Geometric Mean
Carbonaceous Biochemical Oxygen Demand, 5-day @ 20°C	mg/L	25	40	--	--	--	--
Total Suspended Solids	mg/L	30	45	--	--	--	--
pH	Standard units	--	--	--	6.0	9.0	--
Chlorine, Total Residual	mg/L	--	--	--	--	0.56	--
Enterococcus Bacteria	MPN/ 100 mL	--	--	--	--	--	35
Total Coliform Bacteria	MPN/ 100 mL	--	--	10,000	--	--	240
Copper	µg/L	49		84	--	--	--
Cyanide	µg/L	21		37	--	--	--
Dioxin TEQ	µg/L	$1.4X10^{-8}$		$2.8x10^{-8}$	--	--	--
Total Ammonia	mg/L as N	60		120	--	--	--

Abbreviations:
MPN/100 mL = most probable number per 100 milliliters
µg/L = microgram per liter
TEQ = toxic equivalent quantity

3.1.2 CMSA Effluent Water Quality Data

In October of 2021, CMSA collected samples of secondary effluent for analysis by Alpha Analytical Laboratories, Inc. Table 3.2 shows the results of this testing. As expected from the NPDES permit, secondary effluent ammonia concentrations are high. CMSA also routinely samples recycled water generated and the results of this sampling from November 2020 to November 2021 are shown in Table 3.3.

The data in these two tables provides some important information for the analysis, including:

- Ammonia: average numbers are sufficiently low to allow for RO to reduce ammonia (and total nitrogen) to below regulated values for potable reuse. The ammonia will end up in the ROC and be discharged through the outfall. Additional analysis of strategies to manage this discharge are discussed in Chapter 7.
- Mineral Concentrations: Concentrations of various minerals—primarily silica, calcium, and phosphate—inform the potential for scaling of the RO membranes. In this context, the silica concentrations are fairly low, and scaling with calcium phosphate can be managed by adjusting the pH of RO feedwater. RO scaling is not anticipated to be a significant issue.
- Electrical Conductivity (EC) and Total Dissolved Solids (TDS): Values are reasonably high. These concentrations are not problematic for advanced treatment, but an evaluation of source control may find methods to reduce TDS into the WWTP. Reduction of TDS in the collection system will result in less TDS in the ROC.
- Nitrate: average numbers indicate partial nitrification and are at concentrations sufficiently low so that RO can reduce nitrate to well below drinking water criteria.
- Strontium and Sulfate: If present at sufficiently high concentrations, these could serve as alternative performance surrogates for RO to potentially increase pathogen removal credit. However, observed values are not sufficiently high; other parameters, such as TOC, EC, or sucralose, will be needed for that purpose.
- Nitrite: Nitrite can be found in secondary effluent and can be reduced through optimization of the biological process. Nitrite exerts a large ozone demand, at a ratio of 3.5X. Nitrite values in the WWTP effluent need to be accounted for in the ozone system sizing.
- Total Suspended Solids: TSS levels, on average, are low and are not expected to impact downstream purification. However, high values, such as the maximum, will impact the ozone/BAC process and diversion of flows away from purification during high solids events (measured by turbidity) will be required.
- Total Organic Carbon: TOC was not included in the tables. Assumed high values for TOC of ~10 mg/L will be used until other data is collected.

Table 3.2 CMSA Secondary Effluent Water Quality from October 2021 Testing

Constituent	Unit	Ave	Max	Min	Count
Ammonia (as N)	mg/L	25.3	37	11.2	10
Barium	mg/L	0.054	0.06	0.045	5
Boron	mg/L	0.29	0.4	0.18	10
Bromide	mg/L	1.2	1.6	0.15	10
Calcium	mg/L	57	63	50	10
Chloride	mg/L	390	490	270	10
Conductivity	µmhos/cm	2,056	2,360	1,510	10
Fluoride	mg/L	1.0	1.2	0.79	10
Iron	mg/L	0.33	0.49	0.26	5
Magnesium	mg/L	42	47	32	10
Manganese	mg/L	0.17	0.18	0.16	5
Nitrate (as N)	mg/L	5.9	11	2.6	10
Nitrite (as N)	mg/L	2.4	3.7	1.2	10
Orthophosphate (as PO_4)	mg/L	10	18	1.9	10
Potassium	mg/L	26	28	18	5
Silica (SiO_2)	mg/L	9.3	9.9	8.9	5
Sodium	mg/L	249	290	180	10
Strontium	mg/L	0.46	0.48	0.44	5
Sulfate	mg/L	94	100	86	10
Total Alkalinity	mg/L	240	294	138	10
Total Dissolved Solids	mg/L	960	1262	260	11

Abbreviations:
µmhos/cm = micromhos per centimeter.

Table 3.3 CMSA Recycled Water Quality from November 2020 to November 2021

Constituent	Unit	Ave	Max	Min	Count
Ammonia	mg/L	36	51	5.6	25
Dissolved Oxygen	mg/L	3.0	7.2	2.2	281
E. Coli	Ct/100 ml	3.7	49	ND	117
Nitrate	mg/L	2.3	7.5	0.050	24
Nitrite	mg/L	2.0	5.5	ND	24
Total Coliform	MPN/100ml	18	2,420	ND	293
Total Phosphorous	mg/L	4.9	6.6	2.0	25
Total Sulfides	mg/L	ND	0.20	ND	306
Total Suspended Solids	mg/L	7.5	41	2.0	341

Abbreviations:
Ct/100 ml = count per 100 milliliter.

3.2 Available Water Quantity

Secondary effluent flow data at CMSA was reviewed from 2018 through 2021 to determine how much flow may be available for a DPR project. It is important to note that in 2021 mandatory water use restrictions were in place which may have caused lower wastewater flows during this year. However, 2021 data was not excluded from this analysis as it is likely that if a DPR facility is constructed water use restrictions may be more frequent.

Several steps were taken with the data to determine the available flow and are summarized in the following bullet points. Additional detail for this analysis can be found in Appendix B.

- Step 1: Determine Average Secondary Effluent Flows: Daily flow data from 2018 to 2021 were analyzed to determine the following flow measures: average dry weather, average day annual, and average day max month. These measures for secondary effluent flow are summarized in Table 3.4. These flows are higher than what was observed in the 2016 Study. In discussions with plant staff, flow measurements used for the 2016 Study were artificially low due to issues with the effluent weirs. Thus, the higher flows observed in this Report are more accurate.
- Step 2: Use Peaking Factors to Estimate Peak and Minimum Secondary Effluent Flows: Hourly peaking factors were determined, as these are relevant for understanding how to achieve the required dilution and provide an equalized feed to the AWPF. Hourly secondary effluent flow data were only available from 2021, thus this data was reviewed to determine minimum and peak hourly flows. The peaking factors determined from the 2021 hourly data were applied to previous years' data to estimate likely minimum and peak hourly flows for a more average year. It is notable though that flows in 2021 in general were lower than those observed in previous years. The calculated peak and minimum secondary effluent flows are summarized in Table 3.4.

For 2021, the minimum hourly flow occurred in September. This minimum flow of 2.2 mgd is lower than the minimum hour dry weather flow of 3.3 mgd used in the 2016 Study. The observed peak hour flows in 2021 are also lower than what was seen in the 2016 Study. For additional detail on dry weather diurnal flow patterns, see Appendix B.

- Step 3: Subtract Recycled Water Use to Determine Secondary Effluent Available for DPR: CMSA currently produces Disinfected Secondary-23 recycled water and sends it to Remillard Park pond to provide habitat for an endangered species of turtle. Recycled water is provided during the dry season when requested by the City of Larkspur due to a low water level in the pond.[1] CMSA also uses recycled water for onsite sodium bisulfite dilution, facility irrigation, a recycled water fill station, and plant service water for wash down of tanks, etc. The average flow measures for recycled water use from 2017 through 2021 is shown in Table 3.4. When the current recycled water use is subtracted from secondary effluent flow, the remaining flow is what is available for a DPR facility. This available flow is also shown in Table 3.4.

[1] In a 1988 agreement between CMSA and the City of Larkspur, CMSA agreed to provide recycled water as needed for maintaining the water level in Remillard Park pond. The agreement states that 'a minimum of a two-foot freeboard is to be maintained at all times' in the pond.

Because no hourly recycled water data was available, assumptions were made for peak and minimum flows. For the peak hour wet weather flow, the average day annual value was used. For the peak and minimum hour dry weather values, the average dry weather value was used.

Table 3.4 Summary of Baseline Secondary Effluent, Recycled Water, and Secondary Effluent Available for DPR

Flow, mgd(1)	Baseline Secondary Effluent	Recycled Water	Secondary Effluent for DPR
ADW(2)	6.7	0.9	5.8
ADA(3)	10.2	1.1	9.1
ADMM(4)	23.1	1.2	21.9
Peak Hour Wet Weather Flow(5)	34.3(7)	1.1	33.2
Peak Hour Dry Weather Flow(6)	32.2(7)	0.9	31.3
Minimum Hour Dry Weather Flow(6)	2.4(7)	0.9	1.5

Notes:
(1) Flow data available from 2018 to 2021.
(2) ADW = Average Dry Weather – the average flow occurring during the dry season, defined as the minimum 90-day average flow occurring between the months of May and October.
(3) ADA = Average Day Annual – the average flow occurring over the course of the year.
(4) ADMM = Average Day Max Month – the average daily flow occurring during the maximum flow month of the year. This is calculated as the maximum 30-day average for the year.
(5) Wet weather flow is defined as the flow occurring between the months of October and May.
(6) Dry weather flow is defined as the flow occurring between the months of May and October.
(7) Flows estimated based on peaking factors determined from 2021 hourly flows.

The flow measures summarized in Table 3.4 provide important information about how the system should be configured to provide flow to the AWPF as well as what sized AWPF is reasonable. As described in Chapter 2, the draft DPR regulations require 10:1 dilution of a 1-hour chemical peak at some point prior to distribution of the purified water. For this analysis, it is assumed that this dilution will be achieved in the 7 million gallons (MG) effluent storage basin. Additionally, it is important to understand that advanced purification systems run most efficiently at constant flow (and the invested capital is most efficient for constant flow). This knowledge along with the goal of maximizing new water production and providing a 10:1 dilution mean that dry weather flows must be equalized. The next section looks more closely at the use of the existing effluent storage basin to determine the limits on how much secondary effluent can enter and leave the effluent storage basin to achieve the goals of providing a constant flow to the AWPF and a 10:1 dilution.

3.2.1 Use of Secondary Effluent Equalization

It is our understanding that CMSA's 7 MG storage basin can store disinfected secondary effluent or, during storm events, a blended effluent. Under typical operations, the 7 MG storage basin is not in use. However, during rare high flow events when CMSA needs to blend effluent, the 7 MG storage basin is used to store blended effluent until the blend event is over to minimize the amount of blended wastewater sent to the Bay. Additionally, as needed during dry weather seasons, the 7 MG storage basin is used to store disinfected secondary effluent during plant shutdowns for maintenance, scheduled capital improvement projects, back-up generator failure during power outages, disinfection equipment failures, or other emergencies.

If an AWPF facility is added, the use of this 7 MG storage basin would change, as it would provide necessary dilution of hourly flows by a factor of 10:1, per regulatory requirements. For such a future use, it would be highly preferable to no longer use the basin for storage of secondary effluent during maintenance shutdowns or blended effluent during storms.

If an AWPF is added at CMSA and the 7 MG storage basin is used as the feed water source, this 7 MG storage basin would generally be maintained at a full or partially full level and used for the required 10:1 dilution of a chemical peak. To maintain a 10:1 dilution at the 4 mgd AWPF size, the 7 MG storage basin would need to always contain at least 1.7 MG of disinfected secondary effluent and have no higher than 16.8 mgd[2] fed into it, with flows above that value sent to the outfall. If the storage basin was to receive greated than 16.8 mgd of flow, the advanced purification system would need to cease operation. Furthermore, if an adaptive monitoring approach is used to maintain acceptable concentrations of regulated chemicals in the CMSA outfall, the 7 MG storage basin would need to always contain at least 4 MG of disinfected secondary effluent for use to dilute the RO concentrate[3]. Since this basin holds disinfected secondary effluent, quenching may be needed depending on chlorine residual concentration in the basins prior to AWPF treatment.

Also, it is important to note that for this study, infrastructure improvements, if necessary, to the pond and chlorine contact tanks (e.g. gates, valves, linings, etc.) were not evaluated, but a separate assessment may be needed if this project moves forward.

If needed, it is possible that the 7 MG storage basin could be segregated such that only a portion of the basin is used for AWPF feed water while the remaining portion is used for secondary or blended effluent storage. The capital cost associated with this retrofit, as well as the ongoing cost associated with keeping the 7 MG storage basin full or partially full (e.g. lining maintenance, settling concerns, etc.) would need to be evaluated in a subsequent study as it is currently beyond the scope of this study. It is not anticipated that a new lining would be needed for the proposed basin use.

3.2.2 Continuous Secondary Effluent Flow Available to AWPF

Although the analysis of secondary effluent flows suggested that a minimum of 5.8 mgd are available for DPR (see Table 3.4), additional analysis was needed to determine the maximum feed to the AWPF while maintaining sufficient water in the effluent storage basin to achieve 10:1 dilution. The basin level analysis is shown in Figure 3.1, which simulated the effluent storage basin level under the following conditions:

- Analysis was conducted on an hourly basis. Hourly secondary effluent flows from 2021 were used, with recycled water use subtracted[4].
- Secondary effluent is the only inflow to the basin.
- The outflow from the basin is the feed to the AWPF.

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[2] (700,000 gallons per hour) / (7 MG) $\leq$ 10%. 700,000 gallons per hour is 16.8 mgd.

[3] Dilution studies in the outfall can also be used to justify greater dilution credit and potentially minimize or eliminate the need to use stored effluent for dilution of RO concentrate.

[4] Average day annual recycled water use was converted to an hourly flow assuming constant 24-hour production of recycled water. Although this is likely not completely accurate, the various uses of recycled water suggest that production may occur at times throughout the day (e.g., irrigation water may be used overnight, whereas water for plant uses would be produced during the day).

- The outflow was toggled to maintain a level in the basin above 2 MG. This threshold was identified because during the time when the basin level is drawn down significantly, i.e., the end of the dry season, the hourly flows (for a 4 mgd AWPF production, about 235,000 gal/hr) are such that a level of approximately 2 MG in the basin should be sufficient to provide 10:1 dilution.

Based on this analysis, it was determined that the maximum continuous inflow to the AWPF is 5.5 mgd. Based on the recoveries of the AWPF treatment processes, this results in an AWPF production of 3.9 mgd[5]. Because 2021 was a low flow year, it is possible that at a more average year, the AWPF could pull the 5.7 mgd that would be needed to produce 4 mgd. For the purposes of sizing and costing the AWPF, a production of 4 mgd was used.

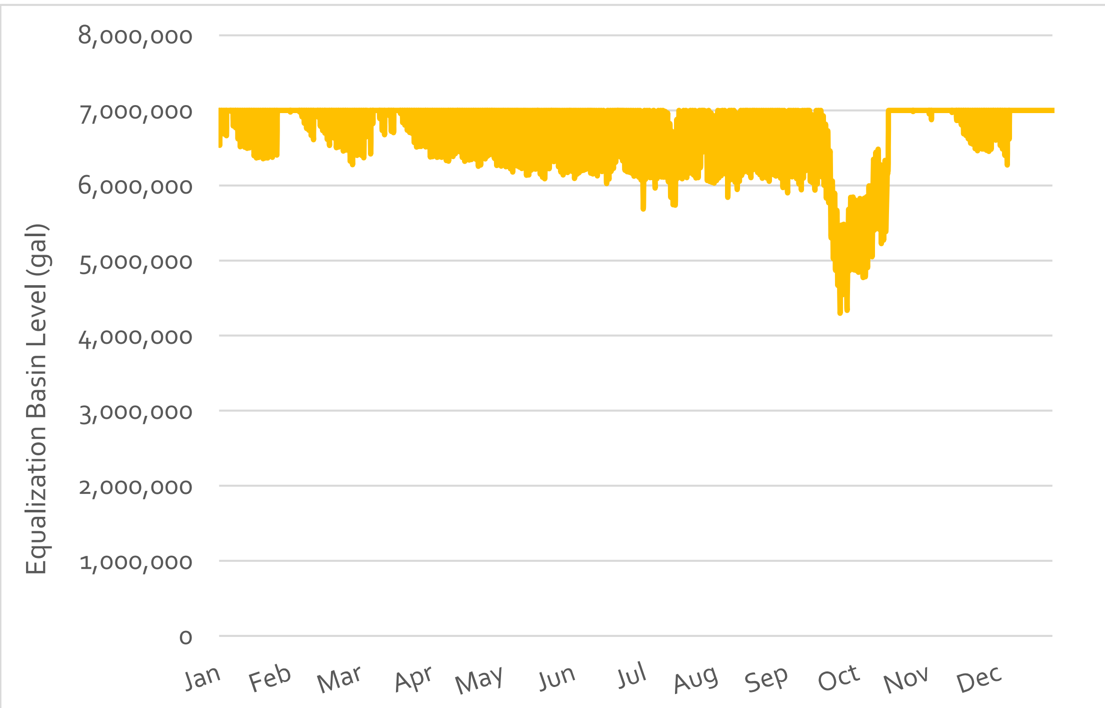

Figure 3.1 Equalization basin level based on hourly secondary effluent inflow from 2021 and constant draw of 5.5 mgd to the AWPF (i.e., 3.9 mgd production scenario)

[5] Although the basin level in Figure 3.2 remains above 4 MG, if the AWPF production were increased from 3.9 mgd to 4 mgd, it causes the basin to drop below 2 MG during the late summer months.

Chapter 4

DPR TREATMENT FACILITY ANALYSIS

4.1 Location

The location of the potential AWPF at CMSA is shown in Figure 4.1. This location was provided by CMSA and is the only potentially available space at the CMSA facility. Two AWPF sizes were considered: 2 mgd production AWPF and 4 mgd production mgd AWPF. For this effort, we are examining a two-story facility for both AWPF sizes, and note that the 4 mgd AWPF utilizes nearly all of the available space. While the 4 mgd size represents the largest facility that is possible at CMSA's site, MMWD has noted that it may struggle to accept more than 3 to 3.5 mgd of finished water. However, if greater production capacity is needed, the following future options exist:

- Intensification: Examine methods to create more available footprint at CMSA, which could include a multiple story parking garage and/or replacement of existing treatment processes with smaller footprint processes (e.g., membrane bioreactor [MBR]).
- Off Site Purification: Look off of the CMSA site for larger land areas for purification. This approach is expected to significantly raise the price of the project, due to the cost of land, and the costs of conveyance to move secondary effluent to the AWPF, ROC to the outfall, and purified water to or from the new site.
- Regional Partnership: Explore a regional or county-wide approach to collecting and treating wastewater for purification. This would entail additional project complexity, with more agencies involved, but could contribute to greater regional reliability.

Figure 4.1 Potential Location of AWPF at CMSA

4.1.1 Process Train

Table 4.1 summarizes the proposed treatment train to produce purified water for DPR, which is also graphically shown in Figure 4.2. Table 4.1 also contains the descriptions and purpose of each treatment process recommended in the DPR treatment train. Table 4.2 lists the pathogen removal credits assigned to each process in the DPR treatment train.

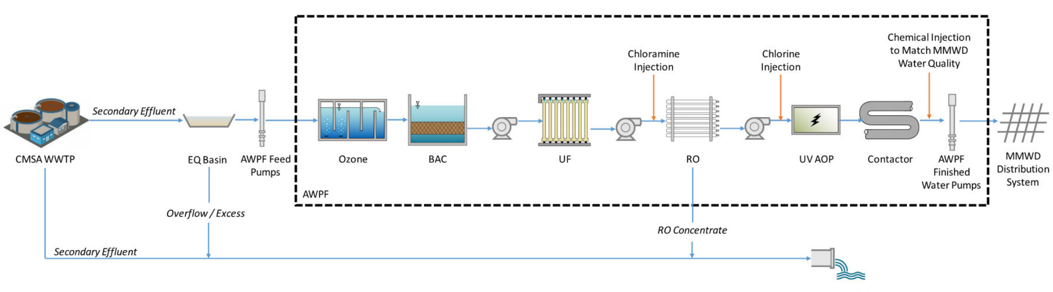

Figure 4.2 AWPF DPR Treatment Train

Table 4.1 Key Treatment Processes Recommended for DPR

Process	Description
Ozone	• Provides pathogen disinfection. • Facilitates biological treatment by breaking down organic carbon for removal by the downstream biological filters. • Reduces concentrations of some chemicals and metals, such as iron and manganese, through chemical oxidation, thereby: – Decreasing toxicity of product water and potentially ROC. – Providing effective pretreatment of water upstream of membranes thereby reducing fouling potential and required level of chloramines.
Biologically Activated Carbon Filtration	• Biological filtration process. • Removes organic carbon, made more bioavailable by the upstream ozone process. • Decreases level of some chemicals, including NDMA. • Reduces turbidity. • Can provide some nitrification
Ultrafiltration	• Membrane filtration process. • Reduces turbidity in BAC filtrate to less than: – 0.2 NTU more than 5 percent of the time within a 24-hour period. – 0.5 NTU at any time. • Removes pathogens via size exclusion through membranes. • Provides necessary pretreatment upstream of RO and UV AOP similar to all existing California potable reuse plants.
Reverse Osmosis	• Reduces total organic carbon. • Reduces TDS. • Decreases level of all chemicals with high molecular weights, and uncharged chemicals with low molecular weights. • Removes pathogens via size exclusion.
Ultraviolet Disinfection/ Advanced Oxidation	• Combination disinfection and chemical oxidation process. • Provides pathogen disinfection. • Achieves oxidation requirement by providing no less than 0.5-log (69 percent) reduction of 1,4-dioxane. • Provides final chemical abatement, including for 1,4-dioxane and NDMA.
Chlorination	• Provides pathogen disinfection.
Stabilization (calcite contactors)	• Provides corrosion control. • Required for water treated by reverse osmosis.
UV Disinfection	• Disinfection process. • Provides final pathogen disinfection to meet full draft DPR pathogen removal requirements.
Blending	• Meets draft DPR blending requirement to reduce a one-hour chemical spike by a factor of 10. • Provides response time if a monitoring alarm were to signal an issue in the upstream treatment.

Abbreviations:
NDMA = N-Nitrosodimethylamine
NTU = nephelometric turbidity units
UV = ultraviolet
TDS = total dissolved solids

Table 4.2 Key Pathogen LRVs per Process

Process	Pathogen Log Removals by Pathogen Category		
	Virus	Giardia	Cryptosporidium
WWTP(1)	0+	0+	0+
O_3/BAC(2)	6	6	1
UF(3)	0	4	4
RO(4)	2	2	2
UV AOP	6	6	6
Stabilization	0	0	0
UV Disinfection(5)	4	6	6
Chlorination(6)	2	0	0
Total	20	24	19
Required	20	14	15

Notes:
(1) Pathogen removal through the WWTP would need to be evaluated and confirmed through a 3 to 12 months study including evaluation of a broad range of pathogens and surrogates.
(2) Based on US Environmental Protection Agency protocols with a CT of 6.24 mg-min/L, the project will result in the credits assigned to Pure Water San Diego, shown here.
(3) Ultrafiltration systems can remove virus (2 to 4+ LRV) but currently are not credited due to the lack of a reliable surrogate to be used daily to verify performance (e.g., pressure decay tests (PDTs) are used daily to verify protozoa removal).
(4) Can receive up to 1 log credit during permitting for electrical conductivity (EC) as a monitoring surrogate; 1.5 log credit for TOC, and 2 for strontium. An additional half log can typically be gained once the facility is operational.
(5) UV Disinfection sized for a dose of 186 mJ/cm2 following US Environmental Protection Agency protocols to result in 4 log reduction of adenovirus and 6 log reduction of protozoa (Giardia and Cryptosporidium).
(6) Chlorination credits based upon the Australian WaterVal analysis, which has been approved by the State of California for up to 6 log reduction of virus. The low LRV shown here is representative of a relatively CT (Value 9 mg-min/L, based upon a t10 contact time of 6 minutes, and a minimum wastewater temperature of 15 degrees C, and a pH of <8.5). Sampling for pH and temperature could allow for lower CT values to meet the target credits. Higher residuals could also be applied to result in increased pathogen credits.

Abbreviations:
UF = ultrafiltration
RO = reverse osmosis

4.2 AWPF Design Criteria

The treatment train was developed to meet California's draft DPR criteria, described in Chapter 2. Table 4.3 summarizes design capacities for each treatment process. The processes are sized to provide the design final product flow, given the recoveries of upstream and downstream processes. Upstream processes must be sized at higher instantaneous flow rates to provide sufficient process effluent for backwashes and other losses. Water used for backwashes would be sent back to the headworks. The backwash water is not anticipated to impact the performance of the existing WWTP. Water lost to ROC would be discharged through the existing CMSA outfall (see Chapter 7 for additional discussion). Detailed treatment process design criteria for each of the alternatives can be found in Appendix C.

Furthermore the proposed treatment train includes the addition of chemicals needed to match MMWD's existing water quality. To do this chloramines, fluoride, and orthophosphate will need to be added in addition to the chemicals needed for the AWPF facility. Since free chlorine is needed for the UV AOP process and ammonia is already located onsite, one ammonia pump is needed to make chloramines from ammonia and free chlorine. Storage for fluoride and orthophosphate will also be needed onsite. It is assumed that the cost for this additional ammonia pump and fluoride and orthophosphate storage will be very small compared to all other costs.

The sections that follow provide more information on each of the AWPF treatment processes.

Table 4.3 Summary of Capacity Criteria for Each Alternative

Process and Criteria	Unit	Alternatives	
		2 mgd Production	4 mgd Production
Ozone + BAC			
Feed Flow	mgd	2.8	5.7
Rated Capacity (Effluent)	mgd	2.6	5.2
Recovery	percent	92	92
UF			
Avg. Feed Flow	mgd	2.6	5.2
Net Filtrate Capacity	mgd	2.5	5.0
Recovery	percent	96	96
RO			
Avg. Feed Flow	mgd	2.5	5.0
Net Permeate Capacity	mgd	2	4
Recovery	percent	80	80
UV AOP			
Rated Capacity (Effluent)	mgd	2	4
Dose	mJ/cm^2	1,000	1,000
Calcite Contactor			
Capacity	mgd	2	4
Chlorination			
Capacity	mgd	2	4
Contact Time	mg-min/L	8.0	8.0
UV (Disinfection)			
Capacity	mgd	2	4
Dose	mJ/cm^2	186	186

Abbreviations:
mJ/cm^2 = millijoules per square centimeter.
mg-min/L = milligram-minute per liter.

4.2.1 Ozone and Biologically Activated Carbon

Ozone is a chemical disinfection process that provides reduction for virus, Cryptosporidium, and Giardia. Ozonation breaks down organic molecules to increase their bioavailability, thereby allowing improved removal via biological degradation through BAC filtration. The BAC process can remove organic matter, including trace constituents and their ozonation byproducts, via the microbial communities that develop on the surface of the media. Ozone/BAC reduces TOC, NDMA, and trace organics. The use of ozone/BAC results in improvements to downstream UF performance, as the BAC filtrate is more biostable and causes less fouling on downstream membranes.

4.2.1.1 Ozone Process

The ozone process involves several components: ozone gas generation, ozone injection into an ozone contactor, and destruction of off-gassed ozone.

To achieve LRVs of 6, 6, and 1 for virus, Giardia, and Cryptosporidium, respectively, the CT method (concentration [C] times contact time [T]) is required. At a temperature of 15°C (a conservative assumption for Marin wastewater in the absence of data), a CT of 6.43 mg-min/L is required for 1 LRV of Cryptosporidium. At that CT, virus, and Giardia LRVs exceed 6, which is the maximum log removal that can be assigned to any one process. Both temperature sampling as well as ozone jar testing must be used to confirm the dose-response curve for ozone. Jar testing can also help determine the ozone transfer efficiency and number of ozone injection points required. Ozone design criteria are summarized in Appendix C.

4.2.1.2 Biologically Activated Carbon Process

The BAC process can be in the form of a gravity or pressurized filter. For this analysis, gravity filters were assumed for space efficiency; however, the type of filter should be refined during final design.

As the filtration run time increases over a period of days, solids and biomass build up on the filter media until a backwash is needed. The backwash process includes draining the filter, agitating the media with air scour, backwashing the media with a fluidized wash, and then refilling the filter and returning it to service. The entire backwash process typically lasts from 30 to 60 minutes.

A key design criterion for BAC is the empty bed contact time (EBCT), or the amount of time that the water resides with the filter media. Higher EBCT results in better biological degradation and TOC removal, but increases capital and operational costs. The optimal EBCT should be selected through piloting; however, EBCTs of between 10 and 30 minutes are typical for wastewater effluents. The filtration systems for the three alternatives are sized to maintain an EBCT of at least 15 minutes at the design flow rates with one filter in backwash.

The BAC filter media typically used is granular activated carbon (GAC), selected to maximize surface area for biological growth and performance. Initially, the GAC will also provide additional treatment of chemicals by adsorbing chemical constituents; however, over time, as the adsorption site are used up, the dominant chemical removal mechanism will become biological. BAC design criteria are summarized in Appendix C.

4.2.2 Ultrafiltration

The UF system is a low-pressure membrane filtration system that removes pathogens and removes particulate matter from BAC filtrate in order to enhance downstream RO membrane performance.

The UF feed tank will store and equalize BAC filtrate, and will also provide storage for BAC backwash water. UF feed pumps will pressurize flow from the UF feed tank through the UF system. Chloramine is added ahead of the UF system to minimize biofouling of the membranes. The UF modules and rack sizing was provided by WesTech based on a design flux of 50 gallons per square foot of membrane per day (gfd); however, following an ozone/BAC process, UF flux may be higher (e.g., 70 gfd). The achievable flux rate should be confirmed through pilot testing.

The UF filtrate/RO feed tank must provide both sufficient backwash volume for the UF system and feed flow for the RO. The UF clean-in-place (CIP) and neutralization tanks are designed to allow adequate water for conducting clean-in-place maintenance on membranes followed by neutralization of cleaned membranes before being put back into use. Design criteria for the UF system are summarized in Appendix C.

4.2.3 Reverse Osmosis

Reverse osmosis is a well-established process used to remove contaminants that remain after the low pressure membrane system. The RO process uses semi-permeable membranes and a driving force of hydraulic pressure to remove dissolved contaminants, making it a physical separation process that can reject constituents as small as 0.0001 micrometer (µm). RO can remove dissolved salts, TDS, hardness, dissolved organic carbon (DOC), synthetic organic chemicals (SOCs), and DBP precursors.

The basic unit of an RO system is the spiral-wound RO element, which consists of several layers of RO membranes wound around a central permeate collection tube and enclosed in a cylindrical housing. The membranes separate the feed flow into treated water (permeate) and a waste stream (concentrate). As feed water flows along the length of the element, permeate passes through the membrane leaving behind most dissolved constituents, resulting in a progressively decreasing flow (concentrate) to carry the same mass of dissolved constituents. The ratio of the permeate production to the feed flow is known as the RO system recovery.

The permeate is composed of low salinity, high quality water. Some salts, neutrally charged chemicals, and gasses will pass through the RO membrane into the permeate. The concentrate stream contains the remaining constituents that were trapped on the feed side. Since the ions being removed are further concentrated as the water passes through the system, there is potential for scaling and foulants to form on the membrane surface that can decrease the efficiency of the system. Scaling is prevented by the addition of sulfuric acid and chemical scale inhibitor upstream of the RO process, which keep scalants in solution.

RO trains are typically designed in stages, the number of which depends on the water supply and the design recovery. In a typical advanced wastewater treatment RO system operating at 75 to 85 percent recovery, a two stage system with RO elements per vessel is typical. In a two stage system, the concentrate from the pressure vessels in the first stage is combined and fed to a smaller number of pressure vessels in a second stage. This approach increases the RO system's recovery.

The RO transfer pump located in the RO feed tank supplies UF filtrate to the RO feed pump, which provides the pressure needed for the RO train, UV reactor, and chlorine contactor. Solids, such as fine sands or organic debris, will result in RO membrane fouling and may cause mechanical damage to the RO membrane elements. Although the UF system will provide exceptionally high-quality water that is free of suspended solids, cartridge filters are still required to protect against membrane damage from suspended material that may be introduced into the RO feed tank, leftover construction debris, or other unexpected solids. Disposable cartridge filters are provided as the final barrier to protect the valuable RO membrane elements against fouling or damage from these particulates. RO design criteria are provided in Appendix C.

4.2.4 Ultraviolet Disinfection/Advanced Oxidation

The ultraviolet disinfection with advanced oxidation system uses UV light coupled with an oxidant—in this case hydrogen peroxide—to break down organics via oxidative reactions and photolysis, and to disinfect pathogens. The UV light alone provides pathogen disinfection and photolysis reactions. Photolysis can lower concentrations of certain chemicals, such as NDMA. The AOP is required to lower concentrations of other chemicals, such as 1,4-dioxane, which serves as an indicator of AOP performance.

The AOP is achieved by introducing an oxidant into the system with UV light, which reacts with the oxidant to produce hydroxyl radicals. Hydroxyl radicals react rapidly with organics and lower the concentrations of a broad range of organic compounds. Appendix C summarizes UV AOP system design criteria.

4.2.5 Stabilization

Water that has undergone RO treatment is exceedingly low in salts and minerals, with a low pH. Without the addition of minerals back into the water, RO permeate water can be aggressive and corrosive and should not be sent directly into a distribution system.

Adding calcium carbonate through calcite contactors is one method to stabilize the water, preparing it for distribution systems. While lime addition can be used in place of calcite contactors, lime can increase the turbidity of the water, which could hinder public perception of the water. Lime addition can also be challenging to operate. The preferred stabilization method should be refined during detailed design. Stabilization criteria are provided in Appendix C.

4.2.6 Ultraviolet Disinfection

UV light disinfects pathogens at a lower dose without providing the additional chemical destruction that occurs with the high UV dose and oxidant addition of a UV AOP system. UV disinfection design criteria are provided in Appendix C.

4.2.7 Purified Water Storage Tank/Chlorine Disinfection

A tank is required for purified water storage to allow for pump station cycling. The tank will also serve as a chlorine contact basin before the purified water is distributed to the MMWD distribution system. Design criteria for the purified water tank are provided in Appendix C.

4.2.8 Chemicals

Chemicals are used throughout the treatment train as described in the previous subsections. A chemical feed station will store the required chemicals and serve as a chemical refill station for chemical deliveries. Storage requirements for each chemical should be determined during final design. Appendix C summarizes the chemicals required and the purpose for each chemical.

4.3 AWPF Layout

AWPF layouts were developed for the 2 mgd and 4 mgd finished water options. For both options, a two-story structure was needed to fit all the required components within the available footprint. The layouts include plant feed pump stations, all treatment processes, and ancillary equipment such as chemical storage.

Some of the assumptions/decisions that went into these particular layouts are as follows:

- The plant feed pump station (disconnected from the building) provides the feed pressure required through Ozone and BAC into the UF Feed tank.
- The UF Feed tank and RO Feed tanks are stacked (RO Feed on top) to conserve pressure from the UF air gap. An air gap is required after BAC, after UF, after RO, and after UV treatment. Locating the tanks on the first floor would increase the annual operation costs since flow would have to be repumped up to the second floor.
- The chemical equipment was located along the road away from the front of the plant, providing a more visually appealing facility for public tours.
- All chemical tanks are located outside under canopies. This is a conservative cost assumption as CMSA currently has chemical tanks located outside without canopies. This option can be further evaluated during design.
- The current layouts assume that the plant will take full chemical deliveries. The chemical area could be smaller depending on what chemicals are stored on site, and if there is the ability to receive partial chemical deliveries.
- The ozone generation equipment shown are larger, conventional generators. There are some new technologies that may be able to save space in the process area.
- All tanks are located above grade except for the Waste Equalization Tank, which collects the waste flows from each system before pumping them out at a constant rate to the sewer or head of the plant.
- A new, dedicated space for the AWPF's control room, wet lab, and staff area is provided as a conservative assumption. It is possible that these spaces can be combined elsewhere with existing control rooms, labs, and staff areas.

4.3.1 2 mgd Production AWPF

The 2 mgd AWPF layouts are shown in Figures 4.3, 4.4, and 4.5. Because of the rectangular shape of the AWPF, it does extend slightly outside of the space identified above in Figure 4.1.

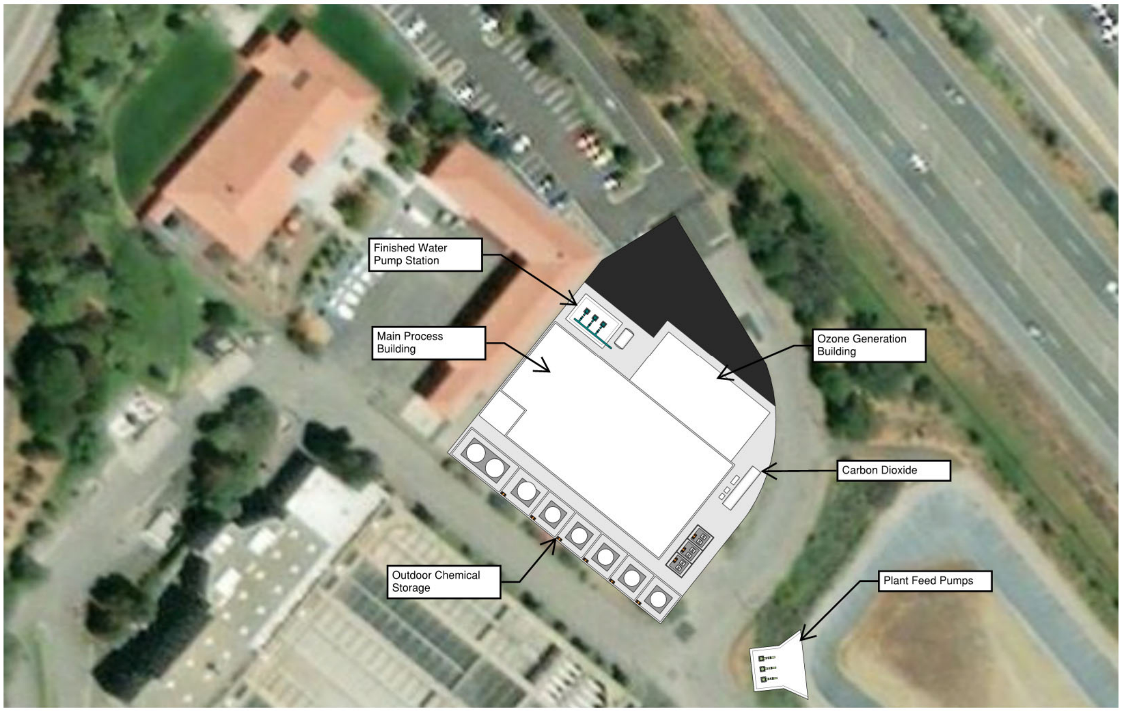

Figure 4.3 Plan view of 2 mgd production AWPF located at CMSA WWTP

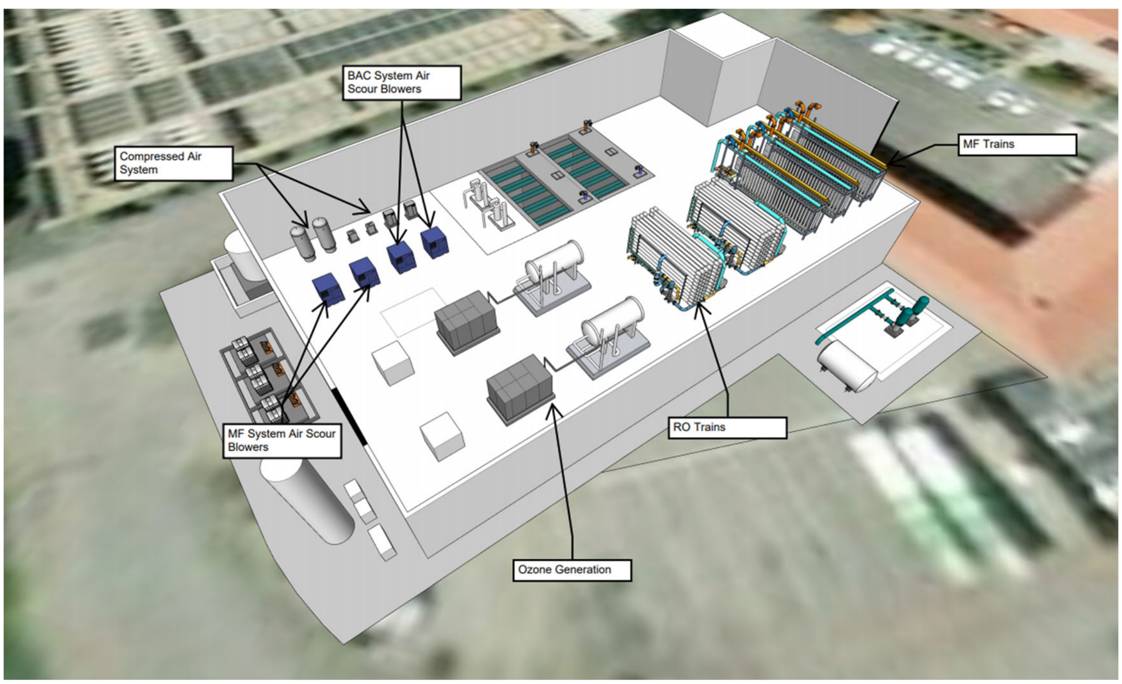

Figure 4.4 Isometric view of two-story 2 mgd production AWPF located at CMSA WWTP

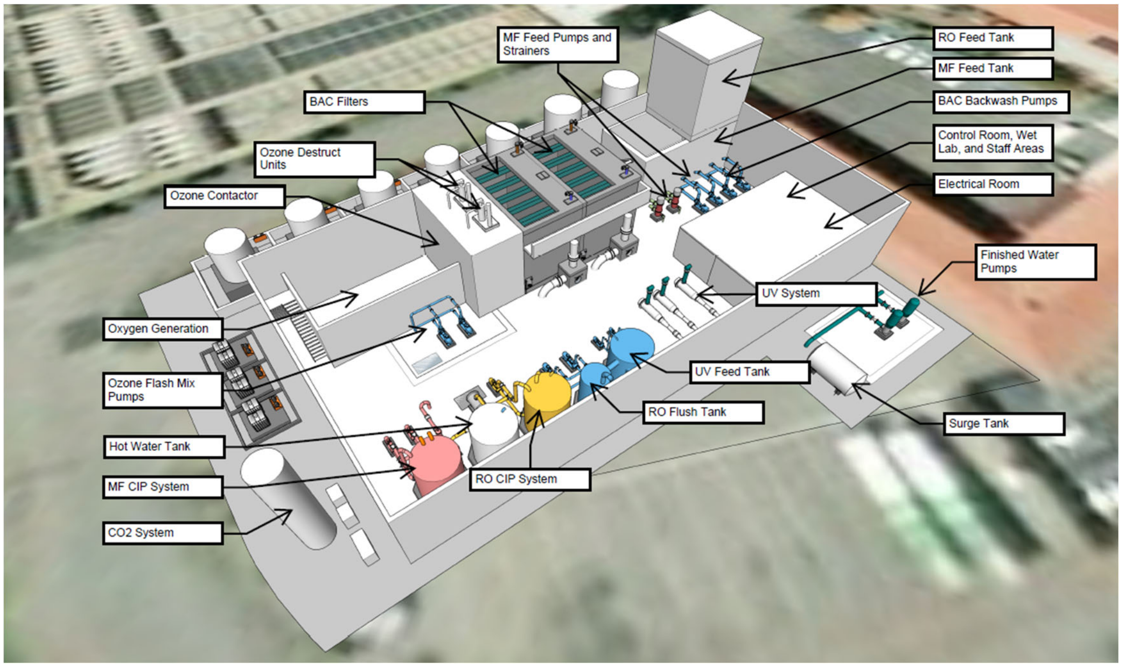

Figure 4.5 Isometric view showing first story of two-story 2 mgd production AWPF located at CMSA WWTP

4.3.2 4 mgd Production AWPF

The 4 mgd AWPF layouts are shown in Figures 4.6, 4.7, and 4.8. The most significant difference introduced in the 4 mgd AWPF layout is that because of the additional UF and RO process trains, the ozone generators do not fit on the second story and were moved to their own structure on the side of the AWPF. This requires additional footprint on the site.

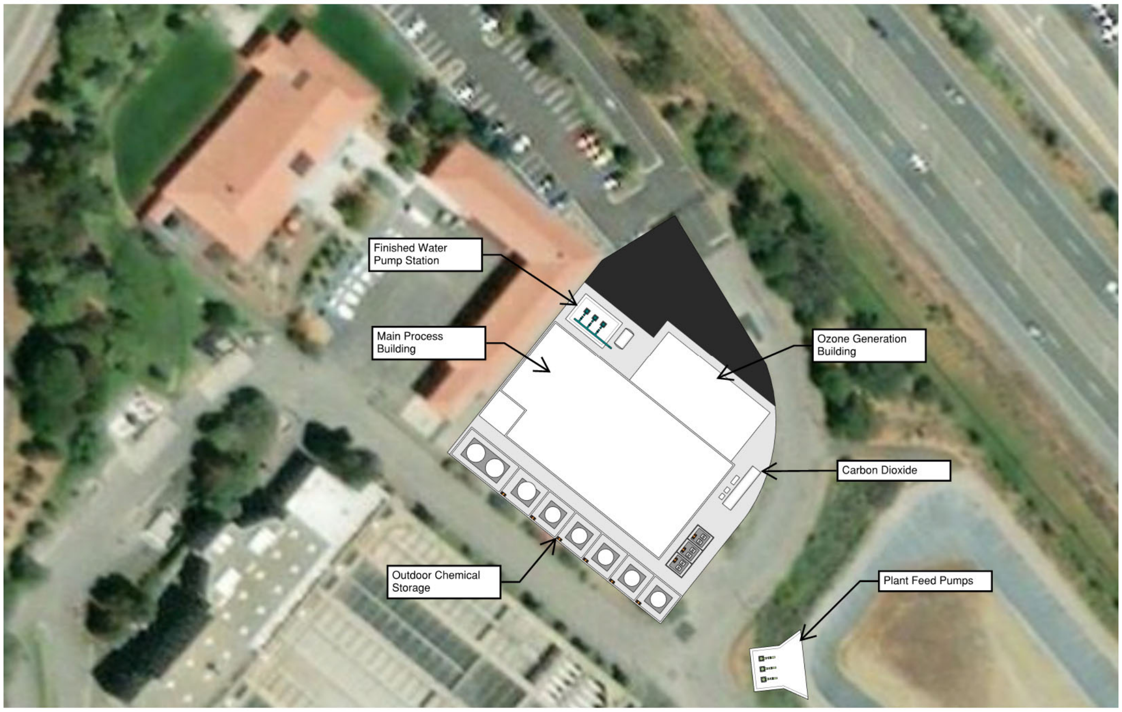

Figure 4.6 Plan view of the 4 mgd production AWPF at CMSA WWTP. Black shaded area represents area that could be paved or landscaped.

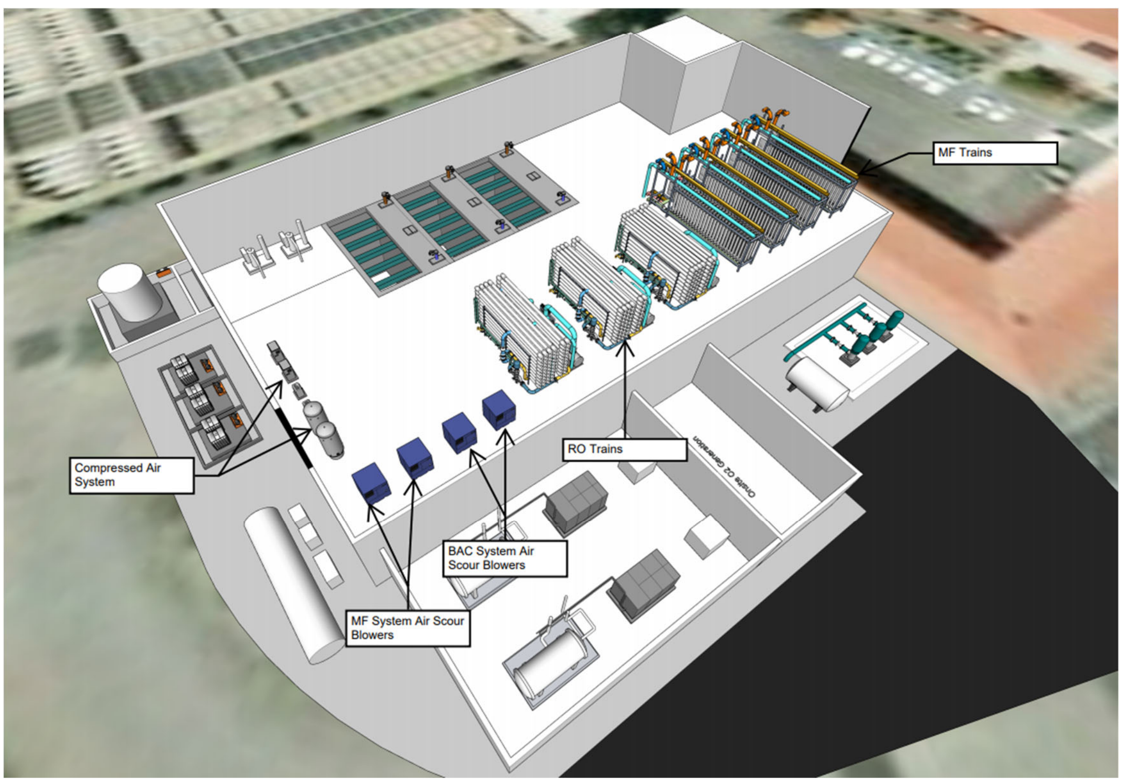

Figure 4.7 Isometric view of two-story 4 mgd production AWPF located at CMSA WWTP. Black shaded area represents area that could be paved or landscaped.

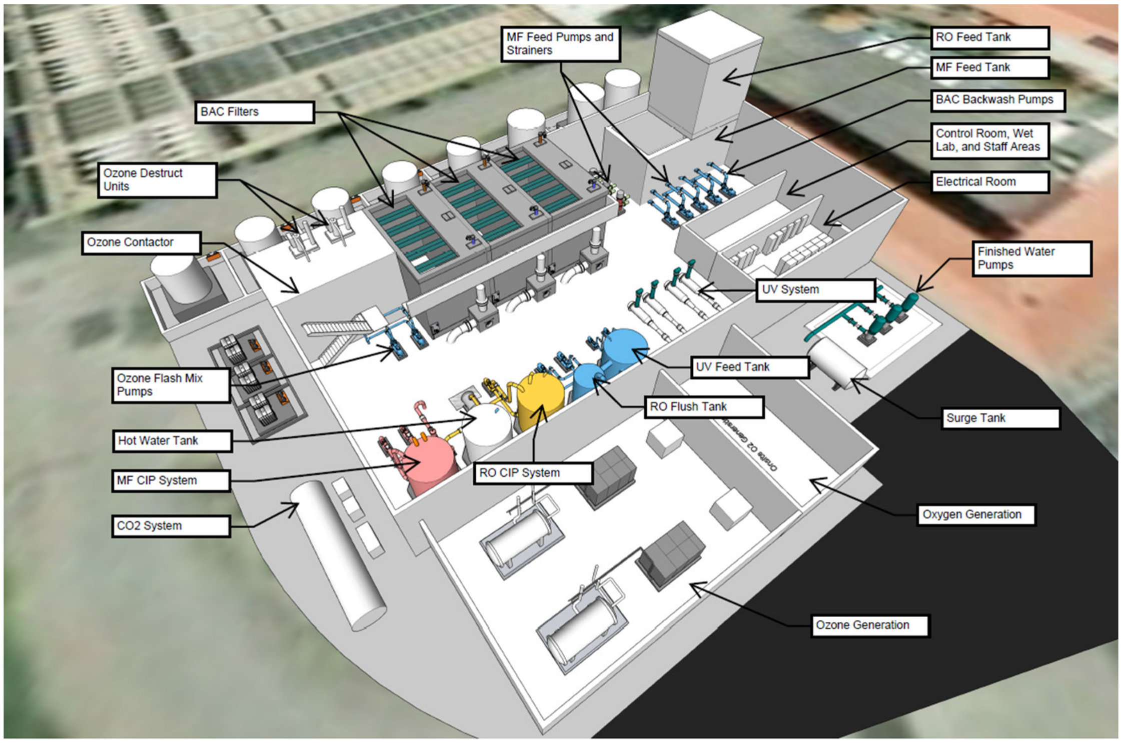

Figure 4.8 Isometric view of first story of the two-story 4 mgd production AWPF located at CMSA WWTP

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Chapter 5

INFRASTRUCTURE NEEDS TO SUPPORT DPR

There are a number of infrastructure components needed to integrate the AWPF facility into existing infrastructure. Namely:

- AWPF feed pipeline and pump station.
- AWPF finished water pipeline.
- ROC pipeline.
- Power supply.

These components are shown in Figure 5.1. Additionally, while a detailed analysis of how the AWPF would be tied into the larger MMWD control system is beyond the scope of this project, costs and staffing were included for monitoring and controlling the system following a Critical Control Point approach. This approach breaks the system down into pathogen and chemical removal components based upon treatment, monitoring, control, and diversion resulting in a "fail safe" system. Additional information about assumptions used and design criteria is discussed further in the sections that follow.

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Figure 5.1 Map of Proposed Infrastructure

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5.1 AWPF Feed Pipeline and Pump Station

As mentioned previously in this report, secondary effluent will be sent to the 7 MG storage basin to provide the minimum 10:1 dilution of peak hour flow. That same water would be pulled from the 7 MG storage basin to feed the AWPF. To transfer water to the AWPF, an effluent pump station and transfer line will be sized for the larger AWPF flow (4 mgd of finished water). A preliminary pipe routing for this feed line is shown in green in Figure 5.1. To move water from the storage basin, it was assumed vertical turbine pumps would be used in a new pump station with a canopy cover constructed where the light green box is shown in Figure 5.2. For the smaller flow alternative, a 1 + 1 pump configuration would be needed. If the facility is expanded to the larger alternative, it was assumed one duty pump of the same size could be added for a 2 + 1 pump configuration.

Design criteria for these pumps are presented in Table 5.1. As shown in this table, the AWPF feed pumps will need to transfer secondary effluent from the storage basin all the way through the Ozone and BAC processes. Thus, the pumps are sized for a total dynamic head (TDH) of 50 feet (ft). Once through the Ozone and BAC processes, interstage pumps will move the water through the remaining purification processes. To construct this feed line from the storage basin, a new basin discharge pipe would need to be installed to feed the new vertical turbine pump wet well.

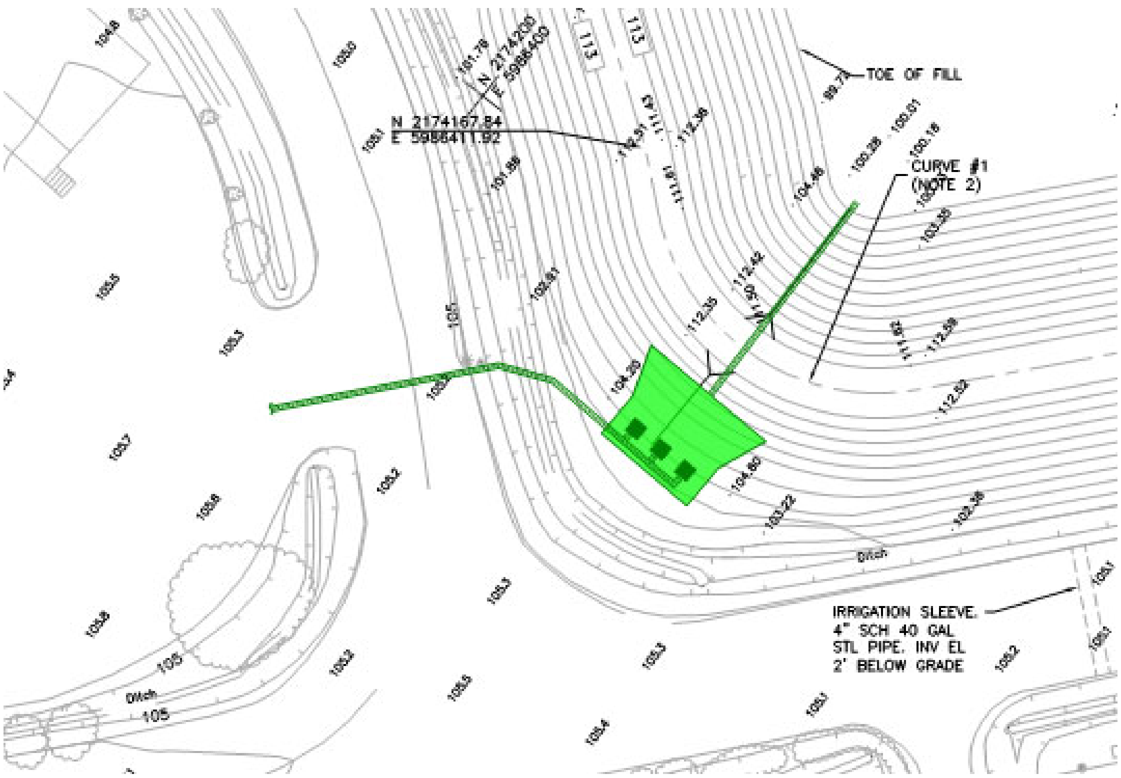

Figure 5.2 Preliminary AWPF Feed Pump Station Configuration

Table 5.1 AWPF Feed Pipeline and Pump Station Design Criteria

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Pipe Diameter	in	14[(1)]	14
Pump Type	-	Vertical Turbine	Vertical Turbine
Pump Number	-	1+1	2+1
Pump Drive	-	VFD	VFD
Pump Capacity, each	gpm	1,800	1,800
Pump Horsepower	hp	60	60
Required TDH			
Headloss in the Pipeline	ft	5	10
Headloss through Ozone and BAC	ft	40	40
Total TDH Required	ft	45	50

Notes:
(1) Oversized for smaller alternative but allows for easy expansion to larger alternative.

Abbreviations:
in = inches
gpm = gallons per minute
hp = horsepower
ft = foot

5.2 AWPF Connection to the Potable Water Distribution System

On the finished water side, the AWPF will need to be connected to the potable water distribution system. Two connection points were considered in this Report and are shown in Figure 5.3. Connection Point 1 operates in a pressure zone with 290 ft of head and Connection Point 2 operates in a pressure zone with 360 ft of head. Proposed routing for these two connection point options is shown above in Figure 5.1 in light blue. For Connection Point 1, the routing is straightforward and will require trenching through CMSA's existing parking lot. For Connection Point 2, a longer pipeline is needed with a number of pipe crossings. The large pipe crossings we are aware of are the storage basin 42-inch (in) inlet, storage basin 54-in outlet, and CMSA's 84-in outfall. Based on the elevations of these pipelines, it was assumed the new 12-in AWPF finished water pipeline would pass over these existing pipelines, which range in depth from 9 to 12 ft to top of pipe. Additionally, the topography at Connection Point 2 goes from flat at the paved area to a steep upward slope at the tree line. The exact location of the MMWD pipeline within that topography has not been pinpointed for this Report. However, it was assumed that the MMWD pipeline lies at the edge of the paved area before the upward slope.

Design criteria for the finished water pipelines to each of these connection points are shown in Table 5.2. As shown in this table, the total pipeline pressure is relatively high, ranging from 140 pounds per square inch (psi) to 180 psi (320 – 410 ft). The AWPF finished water pumps have been sized to handle this required TDH.

Figure 5.3 Proposed Connection Point Options to Existing MMWD Water Distribution System

Table 5.2 AWPF Finished Water Pipeline Design Criteria

Process and Criteria	Unit	Options	
		Connection Point 1	Connection Point 2
Pipe Diameter	in	12(1)	12(1)
Required Pipeline Length	ft	680	1,750
Required TDH			
Headloss in the Pipeline	ft	30	50
MMWD Pipeline Operating Pressure	ft	290	360
Total TDH Required	ft	320	410

Notes:
(1) Oversized for smaller alternative, but allows for easy expansion to larger alternative.

5.3 ROC Pipeline

ROC will be created in the RO process and will need to be routed to CMSA's outfall. Figure 5.1 shows the proposed ROC pipeline routing in yellow. Like the AWPF finished water pipeline to Connection Point 2, the 8-in ROC pipeline will need to cross the storage basin 42-in inlet and storage basin 54-in outlet. It was assumed that this ROC pipeline could also cross over these existing lines which range in depth from 9 to 10 ft to top of pipe.

The existing CMSA effluent pumps are used during high tides to pump treated effluent to the outfall. These pumps were designed with a head of 30 ft. The ROC will leave the RO process at a pressure of 90 psi (208 ft). As shown in Table 5.3, this pressure is sufficient to push water through the new ROC pipeline and existing outfall, even at high tide. Because of this, no ROC pump was assumed.

Table 5.3 ROC Pipeline Design Criteria

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Pipe Diameter	in	8[(1)]	8
Required Pipeline Length	ft	1,050	1,050
Required TDH			
Headloss in the Pipeline	ft	5	15
Required TDH to overcome tide	ft	30[(2)]	30[(2)]
Total TDH Required	ft	35[(3)]	45[(3)]

Notes:
(1) Oversized for smaller alternative but allows for easy expansion to larger alternative.
(2) Based on the maximum head on the existing CMSA effluent pumps.
(3) The available ROC line pressure is 208 ft, well above the required TDH. Thus, no ROC pump was assumed.

5.4 Power

A preliminary evaluation of the electrical capacity of the existing electrical distribution system was also conducted as part of this Report. The goal of this evaluation was to determine if the existing system can support the installation of the new DPR system. The analysis is based on the available information and data provided by CMSA.

5.4.1 Existing Electrical Distribution System

The existing electrical power distribution system is a simple radial system. A one line diagram of the existing system is included in Appendix D. An underground primary service currently supplies the plant's 3000 Amperes (Amp) rated main switchgear via a 1000 kilo-volt ampere (kVA) kVA PG&E pad-mounted transformer. The plant's main switchgear distributes power to the major plant electrical loads via downstream motor control centers (MCCs) and panelboards. The main breaker at the existing switchgear has a 3000 Amp rated frame with a 2000 Amp rated trip unit. Therefore, to support operating loads exceeding 2000 Amp, the main breaker at the switchgear will need to be upgraded to 3000 Amp. The existing main switchgear is connected to the generator switchboard through a 3000 Amp rated breaker with a 2000 Amp rated trip unit.

Based on the most recent electrical study, CMSA's 3000 Amp main switchgear has approximately 3100 Amps (2576KVA or 2061 kilowatt [KW]) of connected load. According to data retrieved from supervisory control and data acquisition (SCADA) by CMSA in 2004, the plant had a peak demand load of approximately 1,424 Amp (1,184 KVA or 947 kW) for 10 minutes, and an average demand load of 1128 Amp (938 KVA or 750 kW). According to the latest data retrieved from SCADA by CMSA, the maximum 5-minute demand load reading for the period between January 1, 2021 and February 28, 2022, was 838KW (1.048KVA or 1.260 Amp).

Using the worst-case peak demand reading of 947KW from 2004, the existing main switchgear is approximately 71 percent loaded relative to the 2000 Amp rating of its main breaker and 48 percent loaded relative to the switchgear's maximum bus size rating of 3,000 Amp. Refer to Table 5.4 for a summary of the existing switchgear's capacity rating based on calculated connected loads from the recent study and measured peak demand loads from 2004.

5.4.2 Electrical System Requirements for DPR

The total anticipated operating load for the new AWPF is 4,233 Amp (3,519 KVA or 2,815 KW). The list of new loads for the AWPF, as well as the electrical load study calculations, are provided in Appendix D. A comparison of the new AWPF electrical load requirement and the available capacity of the existing switchgear is shown in Table 5.4. This comparison indicates that the AWPF's electrical load requirement is almost three times the switchgear's available capacity and seven times the switchgear's main breaker capacity. Therefore, a new service from PG&E, new service switchgear based on PG&E standards, and a new MCC will be required for the AWPF[1].

One line diagrams for the new DPR electrical loads are provided in Appendix D. The new service switchgear is not shown on the one line diagrams since it must be designed in accordance with PG&E standards. The service switchgear can be located outside, close to the new PG&E service transformer.

All required electrical facilities are shown within the footprint of the AWPF facility.

Table 5.4 Electrical System Capacity

Equipment	Rating	Calculated Existing Connected Load	Measured Peak Demand Load (2004 SCADA Reading)	Available Capacity	DPR Electrical Load Requirement (See Appendix D)
Existing Main SWGR	3000 Amp 2494 kVa 1995 kW	3100 Amp 2576 kVA 2061 kW	1424 Amp 1184 kVA 947 kW	1576 Amp 1310 kVA 1048 kW 52 percent	4233 Amp 3519 kVA 2815 kW
Existing Main Breaker	2000 Amp 1663 kVA 1330 kW	3100 Amp 2576 kVA 2061 kW	1424 Amp 1184 kVA 947 kW	576 Amp 479 kVA 383 kW 29 percent	4233 Amp 3519 kVA 2815 kW

Abbreviations:
Amp = amperes
kVA = kilo-volt ampere
kW = kilowatts

[1] The main breaker in the existing switchgear can be modified from 2000Amp to 3000Amp; however, this would still not be sufficient to handle the operating load of the new DPR system.

5.4.3 Providing Standby Power to the AWPF

As indicated on the existing electrical system's one line diagram, the existing 750 KW Waukesha and 995 KW Jenbacher cogeneration units and Cummins 750 KW diesel standby generator distribute power through the 480 V, 2000 A, three-phase, four-wire main generator Zenith switchboard, which is in the Solids Handling Building. Generator power is distributed to CMSA loads via a feeder connection to CMSA's main switchgear breaker 52-GI. A load-shedding scheme is currently in place to drop non-essential loads during utility outage conditions.

Significant upgrades to the existing electrical distribution system would be required if CMSA wants to connect the existing generators to the new AWPF MCC. This is because CMSA is currently commissioning the new 995 KW Jenbacher Cogeneration unit through a new interconnection agreement with PG&E which allows CMSA to operate in ride-through and bumpless transfer modes if PG&E power is lost. As part of the existing Jenbacher controls design included in the new interconnection agreement, Jenbacher's control scheme has been modified and wiring has been added between the Jenbacher engine controls and existing switchgear main breaker to allow the desired ride-through and bumpless transfer operation. Therefore, reconnection of the existing cogeneration units and/or the standby diesel generator to the new DPR MCC would require significant changes to the existing electrical system and equipment. In addition, a new interconnection agreement would need to be submitted to and approved by PG&E. Thus, if standby power is needed for the DPR system, the most uncomplicated approach to provide standby power to the critical loads in the DPR system would be to add a new and separate standby diesel generator to the new DPR MCC. At a Class 5 level total project cost estimate, a new standby diesel generator would cost around $7 million. However, the need for standby power of this potential DPR facility is unknown at this time. If implemented, the DPR system should be part of a broader water supply network where other supplies could be tapped during power outage situations. For this reason, standby power for this potential DPR facility was not included in the cost presented in this report.

Chapter 6

PLANNING LEVEL COSTS

6.1 Planning Level Cost Estimate

The Association for the Advancement of Cost Engineering International (AACE) has suggested levels of accuracy for five estimate classes. These five estimate classes are presented in the AACE International Recommended Practice No. 18R-97 (Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Process Industries). Table 6.1 presents a summary of these five estimate classes and their characteristics, including expected accuracy ranges (AACE, 2020).

Table 6.1 Classes of Cost Estimates

Estimate Class	Maturity Level of Project Definition Deliverables(1)	End Usage(2)	Methodology(3)	Expected Accuracy Range(4)
Class 5	0% to 2%	Concept Screening	Capacity factored, parametric models, judgement, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or Feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or Bid/Tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check Estimate or Bid/Tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Notes:
(1) Expressed as percent of complete definition.
(2) Typical purpose of estimate.
(3) Typical estimating method.
(4) Typical variation in low and high ranges at an 80 percent confidence interval.

The quantity and quality of the information required to prepare an estimate depends on the end use for that estimate. Typically, as a project progresses from the conceptual phase to the study phase, preliminary design and final design, the quantity and quality of information increases, thereby providing data for development of a progressively more accurate cost estimate. A contingency is often used to compensate for lack of detailed engineering data, oversights, anticipated changes, and imperfection in the estimating methods used. As the quantity and quality of data becomes better, smaller contingency allowances are typically utilized. For this project, cost estimates are developed following the AACE International Recommended Practice No. 18R-97 estimate classes 5 and 4.

6.1.1 Capital Costs

6.1.1.1 Basis

Capital costs reflect a March 2022 ENR of 12791 and are based on quantity takeoffs and similar facilities with allowances for civil, mechanical, structural, and electrical improvements, as well as engineering cost.

Construction costs presented typically include an estimating contingency, sales tax, general conditions, and contractor's overhead and profit. The percentages assumed for these factors are shown in Table 6.2.

Total project costs presented typically include a fee for engineering, legal, and administration, as well as an owners reserve for change orders. The percentages assumed for these factors are also shown in Table 6.2.

Table 6.2 Basis for Estimating Capital Costs

Item	Estimated Cost	Estimated Cost of "A"
Equipment / Infrastructure Cost Total	**"A"**	**100%**
Estimating Contingency	40% of "A"	40%
Direct Cost Total	**"B"**	**140%**
Sales Tax	9.25% of 1/2 "B"	6%
General Conditions	15% of "B"	21%
Contractor Overhead and Profit	15% of "B"	21%
Construction Cost Total	**"C"**	**188%**
Engineering, Legal, and Administrative	20% of "C"	38%
Owner's Reserve for Change Orders	5% of "C"	9%
Project Cost Total	**"D"**	**236%**

6.1.1.2 Project Capital Costs

Project capital costs are divided into three key categories:

- Infrastructure costs.
- AWPF costs.
- Electrical upgrade costs.

Infrastructure costs include the cost to transfer secondary effluent from the storage basin to the new AWPF facility, transfer brine to the existing plant outfall, and transfer finished water to the MMWD pipeline. AWPF costs include all costs associated with constructing the treatment needed to create water fit for DPR. Electrical upgrade costs include costs to add the equipment and infrastructure needed to power the new AWPF and infrastructure facilities. A summary of these construction costs is shown in Table 6.3. Annualized costs are shown in Table 6.4. Detailed cost estimates can be found in Appendix E.

Table 6.3 Total Project Cost Estimates

	Total Project Cost	
	2 mgd Production	4 mgd Production
Infrastructure(1)	$9,407,000	$9,566,000
AWPF(2)	$74,780,000	$104,974,000
Electrical	$7,202,000	$7,817,000
Total	**$91,389,000**	**$122,357,000**

Notes:
(1) Costs assume the northern connection point to MMWD's line is used (Option 1). Infrastructure costs for the 4 mgd alternative would increase from $9,566,000 to $13,144,000 if the southern connection point to MMWD's line is used (Option 2).
(2) Facility will most likely need to be supported by piles due to the soft bay mud and risk of settlement. Construction costs associated with piles are included in the estimate.

Table 6.4 Annualized Total Project Cost Estimates

	Annualized Cost	
	2 mgd Production	4 mgd Production
Annualized Total Project Cost(1)	$4,970,000	$6,650,000

Notes:
(1) Calculated assuming an interest rate of 3.5 percent and annualized over 30 years.

6.1.2 O&M Cost

O&M costs were developed for the proposed AWPF facility. These O&M costs include power consumption, chemical consumption, maintenance, and staffing.

A summary of these O&M costs is shown in Table 6.5.

Table 6.5 Project O&M Cost Estimates

	Annual O&M Cost	
	2 mgd Production	4 mgd Production
Infrastructure	$67,000	$133,000
AWPF(1)	$4,400,000	$6,200,000
Electrical	Included in the costs above	
Total	**$4,467,000**	**$6,333,000**

Notes:
(1) Staffing costs have been updated to reflect results of a Carollo survey of IPR operations and extrapolation to DPR requirements. The staffing costs assume that 3 AWTO Grade 5 operators will be needed to provide full staff for 12 hrs/day and skeletal staff for 12 hrs/day, with an AWTO Grade 5 operator on call at all times. Staffing costs also include regulatory and compliance staff, as well as new lab staff to supplement existing lab staff, which would encompass costs associated with compliance with the draft DPR regulations (e.g. preparing plans, water quality sampling).

6.1.3 Unit Cost Basis

Unit costs were developed in $ per MG of finished water produced and $ per ac-ft of finished water produced. These unit costs are shown in Table 6.6.

Table 6.6 Project Unit Cost Estimates

	Unit Cost(1)	
	2 mgd Production	4 mgd Production
$ / MG	$12,900	$8,900
$ / ac-ft	$4,200	$2,900

Notes:
(1) Calculated using the annualized capital cost, annual O&M cost, and assuming the facility is running at capacity 365 days per year.

Chapter 7

NPDES DISCHARGE ANALYSIS

The goal of this analysis was to determine if there are any potential constituents that could cause an exceedance of the existing NPDES discharge permit. The analysis is intended as a preliminary step that will inform future work to evaluate the impacts of ROC discharge. Secondary effluent data to support this analysis were obtained from the California Integrated Water Quality System (CIWQS) system for the period between 2015 and 2022.

7.1 Determination of Relevant Constituents

Constituents analyzed to estimate discharge concentrations were determined as follows:

- Constituents that currently have NPDES discharge limits:
  - Biological constituents, carbonaceous biochemical oxygen demand (CBOD), and TSS: These constituents were not included in the quantitative analysis, as they will be removed through treatment processes prior to the RO[1]. Given the low concentrations that will enter the RO process, the resulting RO brine concentrations will not present an issue for discharge limits.
  - Dioxin TEQ: Data from the CIQWS system indicate that the method detection limit for 2,3,7,4-TCDD, i.e., dioxin, is above the NPDES discharge limit, and this compound was not detected between 2015 and 2022. Therefore, this parameter was not analyzed, as the analysis would show an issue that is an artifact of the method detection limit. Future sampling using a method with a lower detection limit, if available, would be recommended to confirm this constituent is not an issue in the ROC.
  - Copper, cyanide, and ammonia: These constituents were included in the quantitative analysis. Data were obtained from the CIWQS system for the period between 2015 and 2022. 95th percentile concentrations were used for the analysis.
- Other constituents from the NPDES permit Reasonable Potential Analysis:
  - Additional constituents of potential concern were identified from Table F-8 Reasonable Potential Analysis in CMSA's NPDES permit. The RO process results in roughly a 7X concentration of effluent constituents not removed by microfiltration (MF)/UF, which must then be accounted for in this analysis. If the maximum effluent concentration for constituents shown in Table F-8 was within 7 times the governing water quality criterion or objective, the constituent was included in the quantitative analysis.

[1] CBOD will be removed via biodegradation through the ozone/BAF process. TSS will be removed through both ozone/BAC and UF.

- The constituents identified using the method above were cadmium, nickel, silver, and zinc. To estimate a discharge limit, the dilution factor of 10:1[2] was applied to the governing water quality criterion. Although the actual determination of the discharge limit would involve additional factors[3], this simplified estimate is sufficient to determine if these constituents are likely to pose any issue.
- To estimate concentrations in the ROC, it was assumed that the secondary effluent concentrations are the maximum effluent concentrations from Table F-8.

7.2 Anticipated ROC Concentrations

Assumptions made about RO performance are as follows:

- RO recovery was assumed to be 80 percent.
- For constituents analyzed (other than TSS and CBOD as noted above), it was assumed that no removal occurred between secondary effluent and the RO process.
- Removal of all constituents through RO was assumed to be 99 percent, which means that 1 percent of all constituents in the secondary effluent pass through RO and are not entirely captured and transferred to the ROC.
- Based on these assumptions for RO, the estimated ROC concentrations based on 95th percentile secondary effluent data are summarized in Table 7.1. The results of the analysis show that ammonia is the only constituent that presents a potential issue in the ROC discharge. None of the other constituents are expected to exceed existing or estimated potential NPDES discharge limits.

Table 7.1 Summary of Estimated Highest ROC Discharge Concentrations for Constituent of Interest Relative to NPDES Permit Discharge Limits

Constituent	Units	NPDES Discharge Limit	Secondary Effluent Concentration(1)	Estimated ROC Concentration(2)	Likely to Exceed Limit?
Copper Average Monthly	µg/L	49	6.78	33.6	No
Copper Maximum Daily	µg/L	84	9.8	48.6	No
Cyanide Average Monthly	µg/L	21	<0.9	<4.5	No
Cyanide Maximum Daily	µg/L	37	<2.65	<13.1	No
Ammonia Average Monthly	mg/L	60	43.7	216.7	Yes
Ammonia Maximum Daily	mg/L	120	45.3	224.6	Yes

[2] In the current NPDES permit, a dilution of 10:1 was used to develop the water quality-based effluent limits for pollutants determined to have reasonable potential to cause or contribute to exceedances of water quality objectives. The exception is ammonia, for which a 43:1 dilution was used to calculate effluent limits, because it is non-persistent and cumulative toxicity is unlikely.
[3] See Table F-9 of the NPDES permit. Additional factors include site-specific factors and background concentrations.

Constituent	Units	NPDES Discharge Limit	Secondary Effluent Concentration(1)	Estimated ROC Concentration(2)	Likely to Exceed Limit?
Cadmium	µg/L	10(3)	0.78	3.9	No
Nickel	µg/L	130(3)	5.7	28.3	No
Silver	µg/L	22(3)	0.35	1.7	No
Zinc	µg/L	860(3)	45	223.2	No

Notes:
(1) Values are 95th percentile from 2015-2022 CMSA effluent data from CIWQS.
(2) Assumes 80 percent RO recovery and 99 percent constituent removal.
(3) Estimated potential NPDES discharge limit based on governing water quality objective (NPDES permit Table F-8) and 10:1 dilution credit.

7.3 Additional Ammonia Analysis

Additional analysis was conducted for ammonia to further estimate potential discharge concentrations. Per CMSA's existing NPDES permit, daily ammonia concentrations are determined by a 24-hour composite sample. Therefore, for this analysis, it was assumed that a 24-hour composite sample would also be used for future discharges once ROC is included in the blend. This assumption is consistent with the permitting approach pursued by Monterey One Water for their groundwater replenishment project[4]. Average monthly concentrations were also estimated based on calculated daily values.

To better estimate the potential discharge concentrations, the following assumptions about the equalization basin and AWPF operations were used:

- In both AWPF scenarios, it was assumed that operation occurs 24/7, with a constant draw on the equalization basin feeding the AWPF and a constant production and discharge of ROC. The relevant flow rates for the two scenarios are:
  - 2 mgd production: 2.8 mgd AWPF influent flow; 0.5 mgd ROC.
  - 4 mgd production: 5.7 mgd AWPF influent; 1.0 mgd ROC.
- It was assumed that the 7 MG equalization basin is always being used and is operated as follows:
  - Basin is receiving secondary effluent flows from the plant as it is produced, i.e., according to diurnal flow patterns.
  - Flow to the AWPF is constantly being withdrawn from the EQ basin.
  - If secondary effluent flow from the plant is less than AWPF influent flow, the EQ basin level would go down.
  - If secondary effluent flow from plant is greater than AWPF influent flow, the EQ basin would refill until full.
  - If the basin is full and secondary effluent flow from plant is greater than AWPF influent flow, the excess secondary effluent would be available for blending with ROC prior to discharge at the outfall.

[4] Report of Waste Discharge for NPDES Permit Reissuance (NPDES No. CA0048551) – Monterey One Water Regional Wastewater Treatment Plant (2017) https://nmsmontereybay.blob.core.windows.net/montereybay-prod/media/resourcepro/resmanissues/desal_projects/pdf/190329m1w-pwm_fea_app-r.pdf

The results of the anticipated daily maximum and monthly average concentrations presented in Figure 7.1 show that:

- For the 2 mgd AWPF option, the conservatively estimated daily maximum concentrations are below the existing daily maximum limit of 120 mg/L; however, the monthly average concentrations are likely to exceed the monthly average limit of 60 mg/L.
- For the 4 mgd AWPF option, both the daily maximum and monthly average limits are likely to be exceeded during the summer months.

It is important to note that this analysis is conservative because it assumes the 95th percentile concentration of ammonia in secondary effluent at all times. While the 95th percentile concentration will likely not be observed at all times, the periods with the least secondary effluent available for blending, i.e., the summer months, are also the same times at which higher ammonia concentrations are generally observed. A compliance strategy, as noted below, could be needed during these months to avoid exceedances of discharge limits.

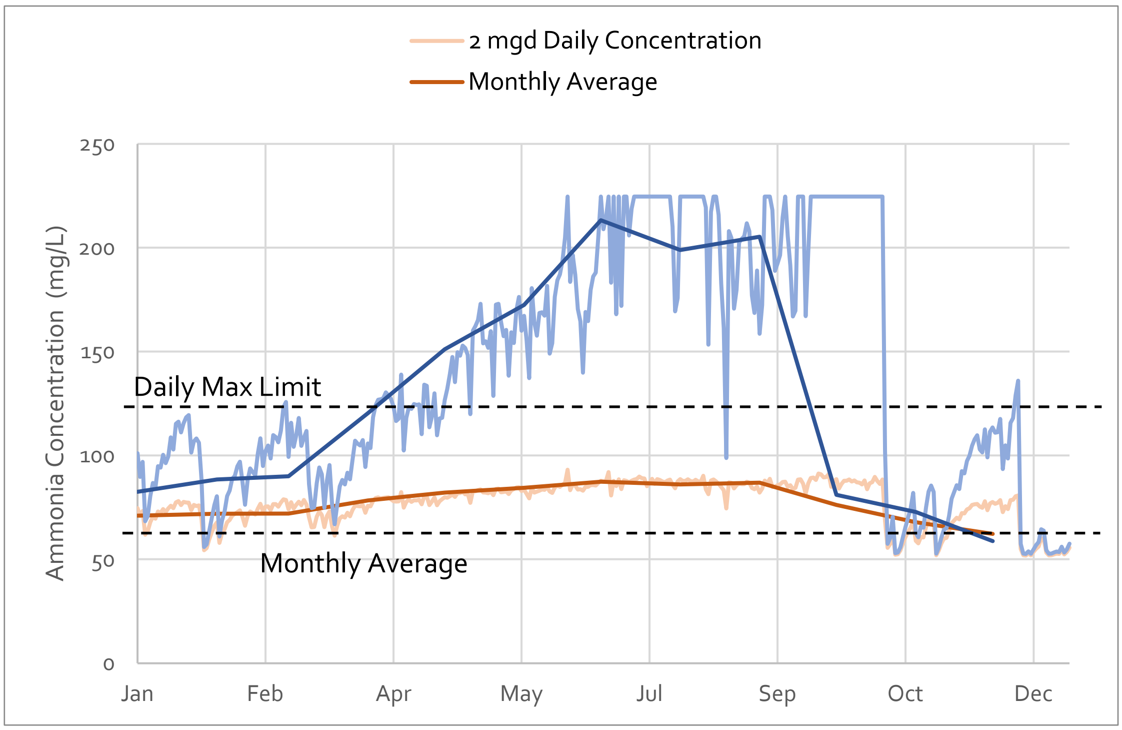

Figure 7.1 Potential worst-case discharge concentrations of ammonia in blended discharge (effluent discharge with ROC) for 2 mgd and 4 mgd AWPF scenarios. Analysis based on hourly secondary effluent flow data from 2021

The concentrations of ammonia in the ROC discharge are not anticipated to be a fatal flaw for a DPR project. There are multiple potential strategies to manage the ammonia in the future ROC discharge. Two such strategies are described below.

7.3.1 Additional Dilution Modeling

Other utilities implementing potable reuse have successfully conducted additional modeling of dilution through their outfall to demonstrate that during periods with high concentration discharge, the flows being discharged are generally much lower than average, and therefore higher levels of dilution and mixing are achieved at the outfall. Different dilution credits can be granted for different flow ranges of secondary effluent to account for the increase in dilution and mixing at lower discharge flows. Monterey One Water received regulatory approval for this approach, and both Morro Bay and Ventura are performing similar modeling and anticipating similar success.

7.3.2 Adaptive Operation of Equalization Basin

If the EQ basin is generally maintained at a full level, it provides substantially more than the required 10:1 dilution of a chemical peak, noting here that this "10:1" is not related to ROC dilution, it is a requirement for chemical dilution within the treatment train. Therefore, there is some room to release secondary effluent from the basin to dilute ROC when effluent flows are low (resulting in higher ammonia concentrations in the effluent). One way to implement such a strategy would be to release secondary effluent from the basin on days with ammonia above a threshold expected to trigger a compliance exceedance. This strategy would potentially require a complex operational paradigm to ensure that the basin is not drawn down below the level at which 10:1 chemical dilution is no longer being provided, while also providing enough dilution to the ROC discharge. It would also require day to day decisions based on the secondary effluent ammonia concentration and basin level. Additional analysis would be needed to fully assess whether this is a viable operational strategy to maintain compliance with existing discharge limits.

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Chapter 8

DPR IMPLEMENTATION APPROACH

8.1 Introduction

DPR is a complex, time-consuming, and costly process. Recent work by the National Water Research Institute (NWRI) provided our industry with a clear vision of the steps and approach necessary to implement DPR. That work, co-authored by Carollo, is titled *DPR Implementation Guide for California Water Utilities* (NWRI Guide). The following sections first describe the timeline for DPR implementation, including the phases of a DPR project, then describe the key elements for DPR success defined by the NWRI Guide. For each key element, example action items are provided, along with the project phase where they might occur.

8.2 DPR Project Timeline

The timeline to implement a potable reuse project can vary greatly depending on the urgency and need, the regulatory climate, and the specific project details. The goal of this DPR implementation timeline and approach is to provide perspective on key project elements and how they might fit within an overall project delivery timeline.

The DPR timeline has been divided into four phases: planning, demonstration, implementation, and operations/operator training. Although these phases are ordered generally in sequence, there is overlap between them and some activities continue throughout the life of the project. For example, projects generally convene an Independent Advisory Panel (IAP) during the planning phase to provide input on project concepts, and the IAP will typically also convene at key points throughout the project. Another example is with operations. Although the actual operation of a purified water facility wouldn't start until the facility is built, advanced planning for plant staffing and operator training would need to start much earlier to ensure that there are sufficient qualified operators once the AWPF comes online.

Some key assumptions and considerations incorporated into the development of the DPR project timeline in Figure 8.1 are as follows.

8.2.1 Overall

The example timeline shown assumes the project sponsor is committed to implementing the project and is actively and consistently working to move the project forward. However, it should be well understood that a decision on whether to move forward with design and construction of a full-scale facility would be made after a demonstration facility has been built and supporting data collected.

8.2.2 Planning Phase

Project visioning is a key component of planning for a DPR project. Visioning starts with clearly laying out and defining the need for the project, i.e., defining the water supply challenge addressed by the project, and quantifying how much water is needed. It is also an opportunity to place the project within the larger planning context and begin to think about coordination with existing or planned projects and availability and sources of funding.

8.2.3 Demonstration Phase

The first step to implementing a demonstration facility is goal setting. In this stage, the project sponsor defines the demonstration goals, which are typically: design, permitting, operations, engagement, innovation. Some examples of demonstration facility goals are:

- Validating the project concept
- Engaging with the public and stakeholders
- Demonstrating the ability to effectively operate advanced water treatment technologies
- Researching issues of emerging concern

Defining the timing for a demonstration facility and committing to funding and building a demonstration facility is the first major action item for a DPR project. The demonstration facility will provide information to support the decision to move forward with a full-scale project.

8.2.4 Implementation Phase

The timeline shown assumes that a demonstration facility would precede a decision about moving forward with a full-scale project. If a project sponsor has full commitment to move forward with a project, the implementation phase could begin sooner, in parallel with the demonstration phase.

Permitting for a potable reuse project includes several elements. Environmental permitting is conducted via the California Environmental Quality Act (CEQA) process. Projects must also be permitted by the Regional Water Quality Control Board, which requires preparation of a Title 22 Engineering Report (with review and approval by the Division of Drinking Water). Projects may also require updates of the relevant NPDES discharge permit to accommodate discharge of ROC.

8.2.5 Operations and Operator Training

The timeline for operator training assumes that all AWTO operations staff will be promoted from within the existing water utility and trained as an AWTO. Given the small number of existing AWTO certified operators, it does not currently make sense to assume these operators can be hired from outside the organization. This also leads to the need to train replacement staff for the operators who transition into the AWTO role.

8.2.6 Schedule Risks

Throughout the implementation timeline there are elements that can result in schedule delays or increased uncertainty. Some examples of challenges faced by utilities working to implement DPR are:

- Consensus on the Project:
  - Internal debate on the project definition, value, and urgency can significantly impact timeline.
- Water Supply Need:
  - Projects have been deferred due to reduction of drought conditions.
  - If other potential new water sources are in play, these may be preferred under certain supply demand scenarios.
- Public Perception:
  - As a utility implements a potable reuse project, community confidence, understanding, acceptance, and support, as well as stakeholder involvement, become essential. However, members of the general public often lack knowledge about their water sources, the systems in place to bring drinking water to their business and homes, and the mechanisms employed to ensure that the quality of their finished water is protective of public health.
  - Issues that commonly come up with the public include no-growth concerns, rate impacts, and general concern over the concept of potable reuse. Project sponsors should work to understand likely concerns in the service area early on so they can be addressed head on.
  - Initiating and maintaining an extensive public engagement campaign is critical.
  - Early understanding of public support or opposition becomes an important part of the decision-making process.
- Inter Utility or Agency Agreements:
  - To implement a successful DPR project, a high degree of interagency coordination is needed. An interagency agreement, such as a memorandum of understanding (MOU), will be needed to define elements of the project, including items such as:
    - Cost sharing.
    - Responsibility for risk and liability.
    - Operational responsibilities.
    - Response to system failure and/or interruption.
    - Meeting regulatory requirements.
  - Developing consensus between multiple agencies, each with their own governing bodies and stakeholders, can be time consuming. This should be a priority early in the project to avoid creating a roadblock when the project is further along.

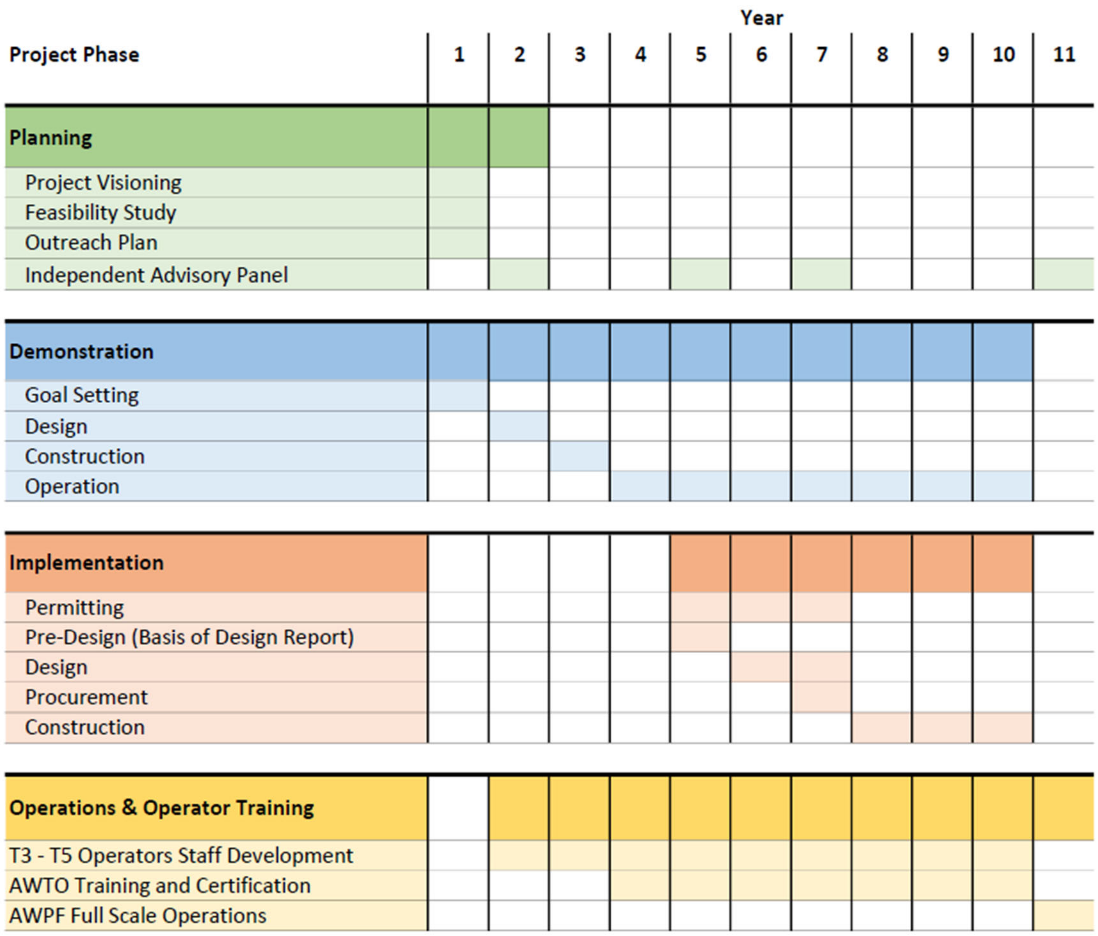

Figure 8.1 Potential DPR Implementation Timeline Based on Four Main Project Phases

8.3 Components of a Successful DPR Program

The NWRI Guide incorporated perspectives from state and federal resources, published and ongoing research studies, and a number of California utilities to summarize the essential principles of DPR. The 2021 Guide includes specific elements that are likely to be key for DPR success, including technical, operational, managerial, and regulatory elements. These 13 elements are summarized in Table 8.1 and provide valuable perspective on the necessary components of DPR implementation. The table also links the project elements to the main phases of the DPR project timeline to illustrate how these elements fit within the overall project timeline.

8.3.1 Technical Challenges

The items below highlight key technical challenges to consider for a potential CMSA/MMWD DPR project.

8.3.1.1 Treatment Train Size and Complexity

As discussed previously, a complex treatment train is needed to meet the requirements for DPR. Each unit process must be validated and operated in such a way as to achieve the necessary pathogen log reduction credits. There will also be a large amount of data that must be collected, analyzed, and synthesized for monthly compliance reporting.

8.3.1.2 Enhanced Source Control Program (ESCP)

An ESCP is an aggressive wastewater source control program, extending beyond local limits and industry-specific monitoring to include regulated and unregulated chemical testing across the AWPF, across the WWTP, and across the collection system.

Potable reuse requires a "water first" mentality. An effective source control program should strive to avoid negatively affecting industries while also aggressively engaging them to fully understand the waste streams they discharge and how those streams can be best handled while reliably producing purified recycled water. The success of a source control program depends on strong interagency cooperation and responsiveness between the WWTP and AWPF. For a project whose agency that administers the source control program differs from the agency that operates the AWPF, entering a memorandum of understanding or other contractual agreement may be required, so that appropriate source control actions can be taken, as necessary, to protect water quality.

8.3.1.3 Advanced Control System

DPR systems must be quickly responsive to any detected issues or failures. Because DPR systems have no environmental buffer, the response time is a key element of public health protection. The inclusion of an engineered storage buffer (ESB) can help provide additional time to respond to issues, but requires space and infrastructure. As a point of reference, the El Paso TWA DPR system will have an ESB with a minimum of 30 minutes of retention time, sufficient for monitoring systems to run through several cycles and for diversion to occur prior to delivering off-spec water. The current AWPF analyzed within this document does not include an ESB, but can be further considered as the project develops.

In the DPR paradigm, the online monitoring and data processing systems are extremely important. This includes maintaining analyzers to a higher degree of accuracy and precision as well as a more complex SCADA system and Dashboards to track safety factors for combined system performance. Current work on such controls and dashboards, which is being implemented at the pilot scale as part of a US Bureau of Reclamation research grant by Carollo (referred to as the OPTICS project), is incorporating machine learning and artificial intelligence to predict issues before they arise and prescribe proactive measures for operations to implement.

8.3.1.4 Achieving the Required Dilution of a One-hour Chemical Peak

California Division of Drinking Water (DDW) has provided minimal guidance on how they envision projects can meet the requirement for dilution of a one-hour chemical peak. The dilution can occur in many different ways, and could be in a primary equalization basin, secondary equalization basin, as part of recirculation of flows within the activated sludge process, or in a finished water tank, as several possible examples. There are also no currently proposed TWA projects with a defined concept to meet this requirement. As discussed above, it is assumed for this analysis that the existing 7 MG effluent storage reservoir would be used to meet this requirement.

8.3.1.5 WWTP Reliability/Performance

The WWTP providing the feed water for a DPR project has a key role to play in providing a stable, high quality feed water. The optimal feed water for a DPR project has low suspended solids and turbidity, low TOC, and low levels of nutrients. Facilities that employ consistent nutrient removal and have tertiary filtration, as one example, will have a more efficiently operating advanced treatment system. Advanced purification can and does happen for potable reuse on secondary effluents without nutrient removal (biochemical oxygen demand [BOD] only) and without tertiary filtration. The current draft regulations for DPR do not require a specific level of wastewater treatment (e.g., does not specify nitrification). However, there are internal conversations underway that are debating if specific levels of wastewater treatment should be required.

8.3.1.6 Resources to Support Ongoing Operation

The regulations require the presence of an AWTO grade 5 certified operator onsite at all times (except with an approved operations plan that allows for some degree of remote operations). At this time, there are only a handful of AWTO grade 5 operators in the state of California; therefore, additional investment in operator certification is needed to ensure sufficient operator capacity in the future.

Specifically, there are several project elements that will require extensive staff resources to develop and maintain, such as:

- Developing and implementing all necessary plans.
- Implementing monitoring program and tracking all water quality data.
- Monthly compliance reporting.
- Implementing and managing the enhanced source control program.

The ongoing operational costs of a DPR project will be significant. The water quality monitoring required may be in excess of $200k annually. DDW will want to see that there are financial resources dedicated to the project on an ongoing basis.

Table 8.1 Implementation steps for DPR from NWRI 2021 guide for California utilities. Key subtasks are linked to the DPR implementation timeline through connection to the four main phases of the timeline: Planning (P), Demonstration (D), Implementation (I), and Operations/Operator Training (O)

No.	Project Element	Details	Key Subtasks			
			Planning	Demonstration	Implementation	Operations/Operator Training
1	Project Definition	• How, what, when, why, where. • Internal buy-in and agreement.	• Define wastewater effluent source, identify advanced water treatment system location, and define delivery mechanism of advanced treated water to distribution system. • Conduct a feasibility study for project concept.			
2	Technical, Managerial, and Financial Capability	• Resources. • Internal culture. • Organizational structure.	• Define governance structure for project, including DiPRRA. • Identify and commit funding sources.			
3	Interagency Agreements	• Are there other agencies that need to be involved?	• Define roles and responsibilities for CMSA and MMWD. • Identify any other agencies with a role to play. • Develop Joint Plan.			
4	Outreach and Education	• Comprehensive, proactive communication plan addressing a range of stakeholders (e.g. agency leadership, community organizations, elected officials, community members).	• Identify potential areas of concern for different stakeholder groups, e.g., contaminants of emerging concern, cost impacts. • Develop communication and outreach plan to educate and address concerns.	• Use demonstration facility as outreach tool to conduct tours and other educational activities.	• Maintain stakeholder outreach and engagement throughout implementation process.	• Continue to inform public and other stakeholders about project success.
5	Wastewater Source Control	• Enhanced source control program required.	• Identify areas of enhancement for existing source control program, including risk assessments for chemicals of concern.	• Use demonstration testing and water quality data to inform needs for ESCP.	• Implement collection system online monitoring.	• Implement continuous improvement procedures for ESCP.
6	Wastewater Treatment	• Reliable, high quality feed water.	• Evaluate whether any modifications are needed to ensure the wastewater produced can reliably meet water quality standards needed at AWPF.	• Use demonstration testing as opportunity to support evaluation of WWTP on AWPF performance.	• Conduct 24 months of sampling in feed water to AWPF.	• Continue WWTP operations consistent with AWPF needs.
7	Multiple Treatment Barriers	• Risk minimization. • Demonstration/pilot testing. • Risk analysis.	• Define treatment barriers, which for DPR must include minimum of O3/BAC + RO + UV AOP.	• Use demonstration facility to verify treatment train effectiveness.		
8	Pathogen Control and Monitoring	• Precise and accurate pathogen reduction. • Diversion. • Demonstration/pilot testing. • Risk analysis.	• Define multi-barrier treatment train to meet pathogen reduction requirements. • Develop control system and diversion capabilities to provide protection at all times.	• Use demonstration facility to verify treatment train effectiveness.		

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Table 8.1 Implementation steps for DPR from NWRI 2021 guide for California utilities. Key subtasks are linked to the DPR implementation timeline through connection to the four main phases of the timeline: Planning (P), Demonstration (D), Implementation (I), and Operations/Operator Training (O) (continued)

No.	Project Element	Details	Key Subtasks			
			Planning	Demonstration	Implementation	Operations/Operator Training
9	Chemical Control and Monitoring	• Precise and accurate chemical reduction. • Demonstration/pilot testing. • Risk analysis.	• Define multi-barrier treatment needed to meet chemical requirements. • Determine strategy for required chemical peak reduction. • Develop and implement schedule for chemical monitoring in multiple locations.	• Use demonstration facility to verify treatment train effectiveness.		
10	Operations	• Operator training and staffing.	• Develop staffing program to develop AWTP operators and replace water operators.	• Use demonstration facility as a training opportunity for operators.	• Begin training operators to become AWTO certified.	• Continue planning for operations staffing to ensure continuity.
11	Water Quality Management	• Finished water quality and corrosion.		• Evaluate impacts of purified water on distribution system stability and corrosion. • Evaluate any potential aesthetic issues from blending purified water into supply.		
12 13	Emerging Issues & Collaboration to Spur Innovation	• Leadership in research on emerging contaminants. • Partnerships with other California agencies doing or planning potable reuse.		• Engage the research community to build credibility with regulators and public.		• Keep up to date with latest research and industry best practices.

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Appendix A

IPR REGULATORY SUMMARY

The first type of potable reuse is GWR, which has been practiced successfully in California since the 1970s. Final regulations have been in place for GWR since 2014[2], although they existed in draft form prior to that for almost 40 years. GWR can take two forms – surface spreading, which entails percolating nitrified tertiary effluent through spreading basins, and direct injection, which entails injecting advanced treated water directly into an aquifer (Figure A.1).

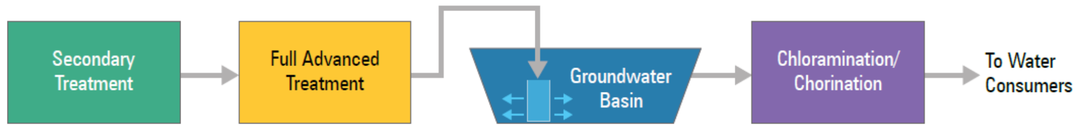

Figure A.1 Schematic of the Stages of Groundwater Recharge via Direct Injection

One of the most successful IPR projects to date is the GWR project of Orange County Water District. The project, originally known as Water Factory 21, came online in 1977. It has since been renamed the Groundwater Replenishment System, and it can now produce up to 100 mgd of advanced treated water that is used to replenish Orange County's groundwater basin[3]. The implementation of early projects helped DDW develop their regulatory framework for IPR, and the long-running success of this and other GWR projects has given regulators confidence that this type of reuse can be done safely.

In 2018, DDW finalized its regulations for IPR via SWA[4]. SWA entails augmenting an existing drinking water reservoir with advanced treated water, and later treating that water at a water treatment plant (WTP) prior to serving it to customers (Figure A.2). SWA regulations contain many of the same elements as GWR, but also include new requirements to account for the lack of experience with this type of project and the complexities introduced by the use of a surface water reservoir. There are currently no operating SWA projects in California; Pure Water San Diego will implement the first SWA project, which is currently under construction. This project has worked very closely with regulators from DDW to ensure that it meets the stringent public health protection requirements.

Figure A.2 Schematic of the Stages Involved in Surface Water Augmentation

Regulations for indirect potable reuse are contained in California Code of Regulations Title 22. Within Title 22, there are regulations for groundwater recharge via both surface spreading and subsurface application/direct injection as well as for SWA. All of the GWR regulations are contained in Title 22, Division 4, Chapter 3 (Water Recycling Criteria). Because SWA involves the

[2] SWRCB (2018) Regulations Related to Recycled Water. Sacramento, CA. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/rwregulations.pdf
[3] https://www.ocwd.com/gwrs/
[4] SWRCB (2018) Regulations Related to Recycled Water. Sacramento, CA. https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/lawbook/rwregulations.pdf

use of an existing drinking water reservoir and water treatment plant, the regulations for SWA are divided between two Chapters of Title 22: Chapter 3 (Water Recycling Criteria) and Chapter 17 (Surface Water Treatment).

Project Structure & Interagency Coordination

Potable reuse projects generally require a single agency to be responsible for obtaining a permit and maintaining compliance with the regulations. As projects become more complex and involve participation of multiple agencies, additional coordination is required.

- GWR: The key entity for GWR projects is the project sponsor, defined as an entity subject to a Regional Board's water recycling requirements for a GWR project. The project sponsor is responsible for applying to the Regional Board for a permit, obtaining a permit, operation of the GWR project, and compliance with all GWR regulations.
- SWA: Because SWA projects involves wastewater treatment, advanced treatment, and then a water treatment plant (which treats the reservoir water), additional coordination is needed. A Joint Plan is required, which establishes who is responsible for the project, describes corrective actions in the event that recycled water has been delivered to a reservoir that fails to meet designated water quality requirements, and describes notification procedures for operational changes that may affect the recycled water quality. The SWA Water Recycling Agency (WRA) must be identified, and is the agency subject to the Regional Board's water recycling requirements. The WRA is analogous to the GWR project sponsor.

Source Control

IPR projects must use treated wastewater from a wastewater management agency that administers an industrial pretreatment and pollutant source control program (Pretreatment Program). The source control program must include several elements, including an assessment of the fate of site-specific chemicals through the wastewater and recycled water treatment systems, monitoring and investigation of chemical sources, and an outreach program to minimize discharge of chemicals into the source water. Because of the higher rigor (and cost) associated with a Pretreatment Program for potable water reuse, a more detailed approach is now implemented for potable water reuse projects, called the ESCP.

Pathogen Control Requirements

The IPR regulations contain specific requirements for control of three types of pathogenic microorganisms: enteric virus, Giardia cysts, and Cryptosporidium oocysts. In addition, there are requirements for how projects must verify that the treatment processes they are using can achieve the required levels of pathogen reduction. The pathogen reduction requirements are based on achieving a pathogen concentration in the treated water that meets an established risk threshold. This threshold is the same for drinking water, IPR, and DPR. The Water Research Foundation has developed several risk-based analyses for potable reuse that target the 1 in 10,000 risk of infection that is associated with the DDW pathogen reduction goals[5].

[5] Trussell, R.R., A. Salveson, S. Snyder, R.S. Trussell, and D. Gerrity (2016) Equivalency of Advanced Treatment Trains for Potable Reuse. Water Environment & Reuse Foundation, Alexandria, VA

- GWR: the treatment must provide 12-log reduction of enteric virus, 10-log reduction of *Giardia* cysts, and 10-log reduction of *Cryptosporidium* oocysts.
- SWA: The baseline required pathogen treatment is the same as that for GWR: a total of 12-log virus, 10-log Giardia, and 10-log Cryptosporidium. For projects with reservoirs providing lower levels of dilution and retention time, the requirements may be up to 2-logs higher for each pathogen type. Because the recycled water put into a reservoir will later be treated through a conventional WTP, the overall system is credited for the minimum 4-log virus, 3-log Giardia, 2-log Cryptosporidium that is required from WTPs per the Surface Water Treatment Rule. This reduces how much credit must be achieved by advanced treatment.
- GWR and SWA: for each treatment process for which pathogen credit is being sought, the process must be validated to demonstrate that it can achieve the proposed log reduction and to demonstrate how on-going monitoring of process performance will be achieved through the use of a microbial, chemical, or physical surrogate parameter.

Treatment Train Requirements

For IPR projects, as a general rule, as less treatment, dilution, and mixing are provided by the environmental buffer (i.e., the aquifer or surface water reservoir), more treatment is required above-ground. This is reflected in the requirements for both GWR and SWA, and as will be discussed later, in the DPR requirements that add even more treatment requirements due to the elimination of the environmental buffer. The regulations do provide for alternative treatment technologies to be used, provided the project can demonstrate an equivalent level of public health protection.

- GWR via surface spreading: surface spreading requires a minimum of tertiary filtration and disinfection prior to application to a spreading basin. As the water percolates through the soil, additional attenuation of contaminants is achieved by soil aquifer treatment (SAT). Any spreading project that provides a minimum retention time in the aquifer of 6 months is credited with 10-log reduction of Giardia and Cryptosporidium. Additionally, 1.0 log of virus credit is granted per month of retention time.
- GWR via direct injection: because recycled water is injected directly into an aquifer, SAT is bypassed in this form of GWR. Therefore, full advanced treatment (FAT) is required prior to injection. FAT requires all flow to go through both RO and an AOP that achieves 0.5-log reduction of 1,4-dioxane. While microfiltration or ultrafiltration are not required for FAT from a pure regulatory standpoint, the protozoa reduction of these membranes is important, as is their role in pretreatment ahead of RO. In addition to these requirements, all Cryptosporidium and Giardia reduction credit must be accomplished prior to injection. Virus credit is granted for retention time in the aquifer.
- SWA: FAT is required.
- Alternatives: Under Title 22, an alternative treatment technology may be used if the proposed alternative meets the following conditions: (1) the alternative provides the same level of protection to public health; (2) the alternative is approved by DDW; and (3) the project sponsor conducts a public hearing. To demonstrate that an alternative provides the same level of protection to public health, an IAP must review the project. The IAP should include an engineer licensed in California with at least three years of experience in wastewater treatment and public drinking water supply, a toxicologist, a

microbiologist, and a chemist. Depending on whether the project is GWR or SWA, either a registered geologist/hydrogeologist or limnologist is required.

Chemical Control Requirements

All IPR projects must meet current drinking water regulatory standards for chemicals. In addition, the regulations impose limits on TOC of wastewater origin, as a bulk mechanism to control chemical pollutants in the treated water.

- GWR and SWA: purified water must meet all current drinking water standards, including MCLs, DBPs, and ALs. These constituents must be monitored quarterly. Constituents with secondary MCLs must be monitored annually.
- GWR: no more than 0.5 mg/L of TOC from the recycled water may be present in the blended groundwater.
  - GWR via surface spreading: diluent water is needed to meet this requirement. The maximum recycled water contribution depends on how much dilution is needed to achieve the maximum TOC of 0.5 mg/L. The initial contribution is limited to 20 percent and can be raised over time.
  - GWR via direct injection: because these projects are required to provide FAT with RO that achieves an effluent TOC below 0.5 mg/L, diluent water is not required. The injected water is generally already in compliance with the maximum TOC requirement of 0.5 mg/L.
- SWA: Although the regulations do not specify a maximum effluent TOC for an SWA project, it is expected that these projects will be treated similarly to GWR, and that they will target an effluent TOC below 0.5 mg/L.

Environmental Buffer Requirements

Requirements for environmental buffers describe the minimum characteristics that these buffers must provide. Smaller environmental buffers (e.g., shorter groundwater travel time) provide less response time, treatment, and/or dilution, which results in an increase in advanced treatment requirements. For both GWR and SWA, there are minimum characteristics that must be met, below which projects would be considered DPR.

- GWR: a minimum aquifer retention time of 2 months is required. The retention time must be verified using a tracer study. As previously mentioned, for GWR via surface spreading (which uses less treatment than injection projects), a minimum of 6 months is required to obtain the full credit for Giardia and Cryptosporidium.
- SWA: For SWA, there are two reservoir parameters with specified requirements. First, a minimum reservoir hydraulic retention time of 6 months is required. Second, a minimum level of dilution of 100:1 of the recycled water in the reservoir is required. The retention time and dilution requirements must be verified by tracer testing and hydrodynamic modeling. The regulations do allow for lower levels of dilution (down to 10:1) and retention time (down to 2 months); however as discussed above, additional pathogen treatment must be provided prior to reservoir augmentation in these scenarios.

Additional Monitoring Requirements

IPR projects require additional monitoring for unregulated contaminants, contaminants of emerging concern, and other items. These requirements, which are listed below, are increased for DPR projects (per the latest draft of the DPR regulations).

- GWR: Quarterly monitoring must be conducted for priority toxic pollutants, a list of site-specific unregulated chemicals to be determined in conjunction with the State Board, and constituents with NLs. Monitoring must be conducted in recycled water and at downgradient groundwater monitoring wells.
- SWA: Quarterly monitoring must be conducted for priority toxic pollutants, a list of site-specific unregulated chemicals to be determined in conjunction with the State Board, and constituents with NLs. Monitoring must be conducted in recycled water prior to reservoir augmentation.
- SWA: Requires data collection for no less than 24 consecutive months from the reservoir that will be augmented. The monitoring must occur at multiple locations and capture multiple horizontal and vertical positions. Required parameters include sMCLs, TOC, nitrogen, E. coli, total coliform, temperature, and dissolved oxygen. This monitoring must also continue for at least the first 24 months of the operation of an SWA project, at which time the project can apply to the State Board for reduced monitoring frequency.

Plans and Reporting

Generally, the number of plans required for IPR projects increases with project complexity. This trend has continued with the draft DPR regulations. IPR projects are also required to conduct annual compliance reporting to the State Board.

- GWR:
  - Operation Optimization Plan (OOP): An OOP must describe the operations and maintenance, analytical methods, and monitoring necessary to comply with the regulations, as well as describe how monitoring results will be reported to DDW and the Regional Board.
  - Annual reporting: is required to DDW and the Regional Board describing the project's compliance with the regulations, any violations and information about corrective actions, any detections of monitored chemicals, descriptions of operational changes, and other items.
- SWA:
  - Operations Plan: An Operations Plan must describe the operations and maintenance, analytical methods, and monitoring necessary to comply with the regulations, as well as describe how monitoring results will be reported to DDW and the Regional Board. The plan must also identify an on-going training program including several topics relevant to SWA projects (e.g., the proper operation of treatment processes).

- Treatment and Distribution Impacts Plan: describes actions the public water system receiving water from an augmented reservoir will take to assess and address potential impacts resulting from the introduction of advanced treated water into its surface water treatment plant and distribution system. The plan must address maintaining chemical and microbial stability in the distribution system and maintaining treatment effectiveness at the WTP and describe how these items will be assessed and reported to the State Board.
- Annual reporting: is required to DDW and the Regional Board describing the project's compliance with the regulations, any violations and information about corrective actions, any detections of monitored chemicals, descriptions of operational changes, and other items.

Appendix B

SECONDARY EFFLUENT ANALYSIS

Secondary effluent flow data at CMSA was reviewed from 2018 through 2021 to determine how much flow may be available for a direct potable reuse (DPR) project. This secondary effluent flow is summarized in Table B.1. These flows are higher than what was observed in the *2016 Recycled Water Feasibility Study* (Carollo). In discussions with plant staff, flow measurements used for the 2016 study were artificially low due to issues with the effluent weirs. Thus, the higher flows observed in this report are more accurate.

Table B.1 Historical Secondary Effluent Flows

Flow, mgd	2018	2019	2020	2021	Overall
ADW(1)	9.79	9.54	8.28	7.35	8.74
ADA(2)	10.28	12.13	8.76	9.47	10.16
ADMM(3)	18.27	23.13	18.54	19.20	23.13

Notes:

(1) ADW = Average Dry Weather – the average flow occurring during the dry season, defined as the minimum 90-day average flow occurring between the months of May and October.

(2) ADA = Average Day Annual – the average flow occurring over the course of the year.

(3) ADMM = Average Day Max Month – the average daily flow occurring during the maximum flow month of the year. This is calculated as the maximum 30-day average for the year.

Additionally, hourly secondary effluent flow data was reviewed for 2021. For 2021, the minimum hourly flow occurred in September. This minimum flow of 2.2 million gallons per day (mgd) is lower than the minimum hour dry weather flow of 3.3 mgd used in the *2016 Recycled Water Feasibility Study* (Carollo), noting that less data was evaluated in the 2016 study and that data was also plant influent flows, compared to secondary effluent flow for this new effort. A diurnal flow graph for each day in September is shown in Figure B.1.

Peak hour flows were also calculated using the hourly 2021 dataset. The observed peak hour flows are lower than what was seen in the *2016 Recycled Water Feasibility* Study (Carollo). These lower peak flows may be due to the fact that flows in 2021 in general were lower than observed in previous years. Table B.2 shows the minimum and peak hour flows for 2021.

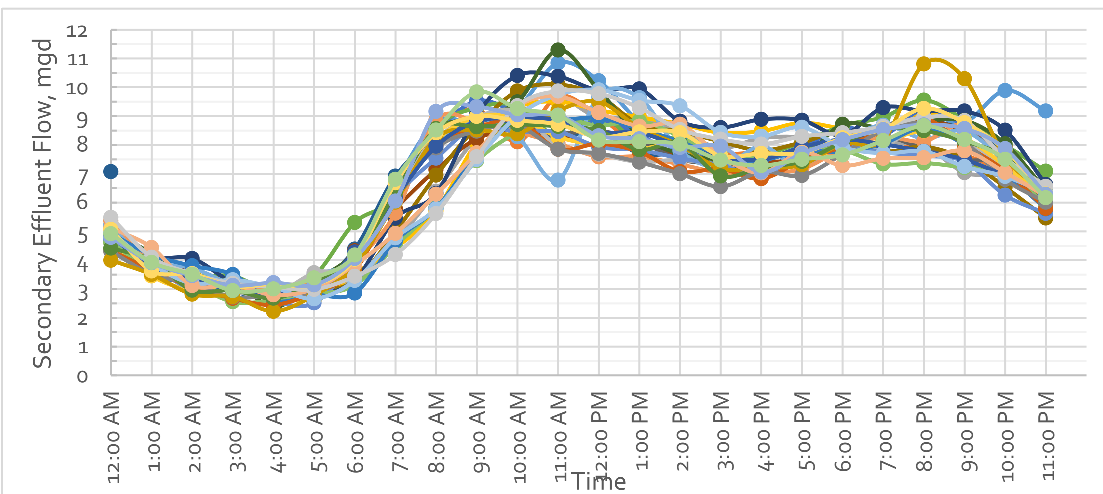

Figure B.1 September 2021 Daily Diurnal Curves

Table B.2 Historical Secondary Effluent Minimum and Peak Hour Flows

Parameter	2021 Flow, mgd	Peaking Factor over ADA
Peak Hour Wet Weather Flow(1)	32.0	3.38
Peak Hour Dry Weather Flow(2)	30.0	3.17
Minimum Hour Dry Weather Flow(2)	2.2	0.24

Notes:
(1) Wet weather flow is defined as the flow occurring between the months of October and May.
(2) Dry weather flow is defined as the flow occurring between the months of May and October.

The peaking factors shown in Table B.2 were used to estimate the peak hour wet weather, peak hour dry weather, and minimum hour dry weather flows for 2018 through 2020, which are shown in Table B.3.

Table B.3 Estimated Secondary Effluent Minimum and Peak Hour Flows

Flow, mgd	2018(3)	2019(3)	2020(3)	2021(4)	Overall(3)
Peak Hour Wet Weather Flow(1)	34.8	41.0	29.6	32.0	34.3
Peak Hour Dry Weather Flow(2)	32.6	38.4	27.8	30.0	32.2
Minimum Hour Dry Weather Flow(2)	2.4	2.9	2.1	2.2	2.4

Notes:
(1) Wet weather flow is defined as the flow occurring between the months of October and May.
(2) Dry weather flow is defined as the flow occurring between the months of May and October.
(3) Flows estimated based on peaking factors determined from 2021 hourly flows.
(4) 2021 flows are based on hourly flow data.

Current Recycled Water Flows

CMSA currently produces Disinfected Secondary-23 recycled water and sends it to Remillard Park pond to provide habitat for an endangered species of turtle. Recycled water is provided during the dry season when requested by the City of Larkspur due to a low water level in the pond. In a 1988 agreement between CMSA and the City of Larkspur, CMSA agreed to provide recycled water as needed for maintaining the water level in Remillard Park pond. The agreement states that 'a minimum of a two-foot freeboard is to be maintained at all times' in the pond.

CMSA also uses recycled water for onsite sodium bisulfite dilution, facility irrigation, a recycled water fill station, and plant service water for wash down of tanks, etc. The total recycled water use from 2017 through 2021 is shown in Table B.4. Furthermore, a graph of these flows compared to secondary effluent production is shown in Figure B.2.

Table B.4 CMSA Recycled Water Use from 217 through 2021

Flow, mgd	2017	2018	2019	2020	2021	Overall
ADW(1)	0.90	1.03	0.99	1.04	0.97	0.90
ADA(2)	0.90	1.11	1.09	1.07	1.07	1.05
ADMM(3)	1.19	1.26	1.26	1.17	1.23	1.26

Notes:
(1) ADW = Average Dry Weather – the average flow occurring during the dry season, defined as the minimum 90-day average flow occurring between the months of May and October.
(2) ADA = Average Day Annual – the average flow occurring over the course of the year.
(3) ADMM = Average Day Max Month – the average daily flow occurring during the maximum flow month of the year. This is calculated as the maximum 30-day average for the year.

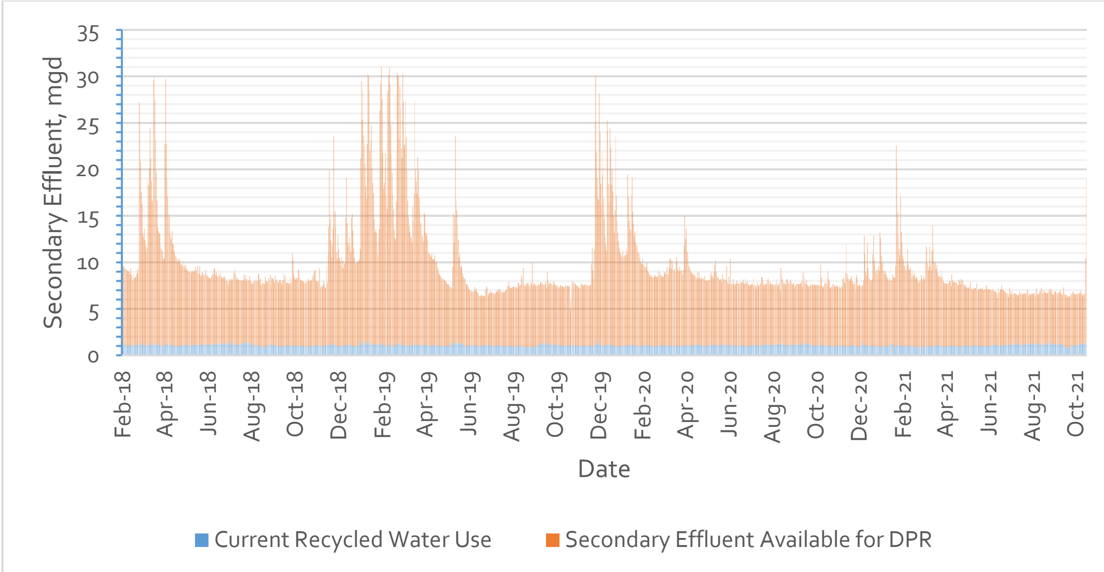

Figure B.1 Historical Secondary Effluent and Recycled Water Flows

Secondary Effluent Available for DPR

When the current recycled water use is subtracted from secondary effluent flow, the remaining flow is what is available for a DPR facility. This available flow is shown in Table B.5. To determine peak hour wet weather flows, the average day annual recycled water flow was subtracted from the peak hour wet weather secondary effluent flows as a conservative assumption. To determine peak hour dry weather and minimum hour dry weather flows, the average dry weather recycled water flow was subtracted from the secondary effluent flows since hourly recycled water use was not available.

Several key conclusions can be made from this data set as to how flow impacts DPR:

- As shown in Table B.5, without equalization the maximum available flow for a continuous production DPR facility is 1.0 mgd.
- With equalization in the existing 7 MG effluent storage basin, which is reviewed in the next section, significantly more flow can be captured for DPR.
- The peak hour wet weather flow (PHWWF) is also an important value, as a DPR project requires a 10:1 dilution of a 60 minute chemical spike. The 7 MG effluent storage basin is intended to be used to provide that dilution, with the review in the next section.

Table B.5 Secondary Effluent Flow Available for DPR from 2018 through 2021

Flow, mgd	2018	2019	2020	2021	Overall
ADW(1)	7.1	6.1	6.7	5.7	5.8
ADA(2)	9.2	11.0	7.7	8.4	9.1
ADMM(3)	17.0	21.9	17.4	18.0	21.9
Peak Hour Wet Weather Flow(4)(6)	33.7	39.9	28.6	31.0	33.3
Peak Hour Dry Weather Flow(5)(7)	31.5	37.4	26.7	9.0	31.3
Minimum Hour Dry Weather Flow(5)(7)	1.4	1.9	1.0	1.3	1.5

Notes:

(1) ADW = Average Dry Weather – the average flow occurring during the dry season, defined as the minimum 90-day average flow occurring between the months of May and October.

(2) ADA = Average Day Annual – the average flow occurring over the course of the year.

(3) ADMM = Average Day Max Month – the average daily flow occurring during the maximum flow month of the year. This is calculated as the maximum 30-day average for the year.

(4) Wet weather flow is defined as the flow occurring between the months of October and May.

(5) Dry weather flow is defined as the flow occurring between the months of May and October.

(6) To determine peak hour wet weather flows, the average day annual recycled water flow was subtracted from the peak hour wet weather secondary effluent flows since hourly recycled water use was not available.

(7) To determine peak hour dry weather and minimum hour dry weather flows, the average dry weather recycled water flow was subtracted from the secondary effluent flows since hourly recycled water use was not available.

Appendix C

DPR DESIGN CRITERIA SUMMARY

The design criteria for each unit process are summarized in the tables below.

Table C.1 Ozone Design Criteria

Process and Criteria	Unit	Alternatives	
		2 mgd Production	4 mgd Production
Feed Flow	mgd	2.8	5.7
Ozone Production			
Ozone applied dose	mg/L	20	20
Ozone MTE	percent	90	90
Ozone Transferred Dose	mg/L	18.0	18.0
Ozone Production	ppd	472	944
Power Consumption	kW	98	197
Ozone wt%	percent	12	12
Ozone contact time	min	10	10
Ozone CT(1)	mg-min/L(1)	6.43	6.43
Oxygen Production	ppd	3,935	7,869

Notes:
(1) Ozone CT required to remove 1 log *Cryptosporidium* at 10 degrees C, according to the equation *Cryptosporidium* LRV = CT*0.0397*(1.09757)^Temperature (EPA 2010). The ability to achieve this CT is dependent on the dose-response curve and must be confirmed through jar testing.

Table C.2 BAC Design Criteria

Process and Criteria	Unit	Alternatives	
		2 mgd Production	4 mgd Production
No. of Filters	No.	2	3
Filter Area	sq ft	456	456
Filter Depth	ft	9	9
Flow per filter			
All Filters Operating	gpm	983	1,310
One Filter in Backwash	gpm	1,966	1,966
Hydraulic Loading			
All Filters Operating	gpm/ft	2.2	2.9
One Filter in Backwash	gpm/ft	4.3	4.3
EBCT			
All Filters Operating	min	31.2	23.4
One Filter in Backwash	min	15.6	15.6

Table C.3 UF Design Criteria

Process and Criteria	Unit	Alternatives	
		2 mgd Production	4 mgd Production
UF Process			
Type	-		
Flow rate	gpm	1,808	3,617
Number of trains in service	No.	2	3
Number of Redundant Trains	No.	1	1
Number of Total Trains	No.	3	4
Installed Modules per Train	No.	72	96
Spare Module Spaces per Train	No.	8	8
Temperature correction			
Peak Capacity Design Temperature	°C	15	15
Reference Temperature	°C	20	20
Temperature Correction Factor	-	1.14	1.14
Pilot Peak Flux Direct (@Reference Temp)	gfd	30	30
Design Peak Flux (@Design Temp)	gfd	26.3	26.3
Flow Criteria			
Average Feed Flowrate	gpm	1,808	3,617
Feed Water Loss	%	2.0	2.0
Gross Filtrate Production	gpm	1772	3544
Filtrate Losses	%	2.0	2.0
Overall Recovery	%	96.0	96.0
System Net Filtrate	gpm	1736	3472
Instantaneous Factor	-	1.15	1.15
Online Factor (1/Instantaneous)	%	87.0	87.0
Instantaneous Filtrate Production	gpm	2,038	4,076
Module Criteria			
Membrane Area per Module	sq ft	775	775
Membrane Area per Train	sq ft	55,800	74,400
Membrane Area Total	sq ft	167,400	297,600
Gross Flux Rate	gfd	22.9	22.9
Instantaneous Flux Rate	gfd	26.3	26.3
Backwash Criteria			
Type		Reverse Flow Followed By Air Scour and Drain	Reverse Flow Followed By Air Scour and Drain

Process and Criteria	Unit	Alternatives	
		2 mgd Production	4 mgd Production
Backwash Interval per Train			
Minimum	min	20	20
Maximum	min	30	30
Filtration Flow	Ratio	1.1	1.1
Backwash Supply Flowrate	gpm	1,121	1,495
Backwash Duration	sec	30	30
Air Scour Flowrate	ACFM	504	672
Air Scour Duration	Sec	30-60	30-60
Forward Flush Flowrate	gpm	1,296	1,728
Forward Flush Duration	sec	20	20

Table C.4 RO Design Criteria

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Design Feed Flowrate	gpm	1,736	3,472
Recovery	%	80	80
Permeate Flowrate	gpm	1,389	2,778
Concentrate Flowrate	gpm	347	694
Feed Flowrate Per Train	gpm	1,736	1,736
Permeate Flowrate per Train	gpm	1,389	1,389
Concentrate Flow per Train	gpm	347	347
Number of RO Trains			
In-Service	No.	1	2
Reliability	No.	1	1
Total	No.	2	3
Staging of RO Trains			
1st Stage			
Pressure Vessels per Train	No.	40	40
Elements per Pressure Vessels	No.	7	7
2nd Stage			
Second Stage	No.	20	20
Elements per Pressure Vessels	No.	7	7
Number of Elements			
Per Train	No.	420	420
Total (In - service)	No.	840	1,260

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Membrane Area			
Per Element	sq ft	400	400
Per Train	sq ft	168,000	168,000
Total (In-service)	sq ft	168,000	336,000
Average Flux Rate	11.7	11.9	11.9

Table C.5 UV AOP Design Criteria

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Number of Vessels			
In-Service	No.	1	1
Reliability	No.	1	1
Total	No.	2	2
Feed Flowrate	mgd	2	4
Feed Flowrate per Reactor	mgd	2	4
Lamp aging and Fouling factor	percent	80	80
Design inlet UVT	percent	96	96
Design outlet UVT	percent	98	98
Design NDMA LRV(1)	LRV	1	1
Design 1,4-dioxane LRV	LRV	0.5	0.5
Hypochlorite dose	mg/L	4.75	4.75

Notes:
(1) Assumed NDMA reduction requirement. Bench scale testing required to confirm NDMA in RO permeate.

Table C.6 Stabilization Design Criteria: Calcite Contactors

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Flowrate	gpm	1,389	2,778
No. of Filters	No.	6	6
Filter Diameter	ft	12	12
Area per Filter	sq ft	113	113
Media Depth	ft	3	3
Flow per filter			
All Filters Operating	gpm	231	463
One Filter in Backwash	gpm	278	556
Hydraulic Loading			
All Filters Operating	gpm/ft	2.0	4.1
One Filter in Backwash	gpm/ft	2.5	4.9

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
EBCT			
All Filters Operating	min	11.0	5.5
One Filter in Backwash	min	9.1	4.6
Calcite Flush Pump Skids	No.	1	1

Table C.7 UV Design Criteria

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Number of Reactors			
In-Service	No.	1	3
Reliability	No.	1	1
Total	No.	2	4
Feed Flow Rate	mgd	2	4
Feed Flow Rate per Reactor	mgd	1	1.33
End of Lamp Life Factor	(-)	0.81	0.81
Sleeve Fouling Factor	(-)	0.95	0.95
Lamp Aging Factor	(-)	0.85	0.85
Design UVT	percent	95	95
Validated Dose	mJ/cm^2	186	186

Table C.8 Product Water Tank/Chlorine Disinfection Design Criteria

Process and Criteria	Unit	Alternative	
		2 mgd Production	4 mgd Production
Flowrate	gpm	3,541	26,596
Baffling Factor	-	0.3	0.3
Virus LRV(1)	-	2	2
pH	-	≤8.5	≤8.5
Turbidity	NTU	≤0.2	≤0.2
Temperature	°C	15	15
CT Value(1)	min mg/L	9	9
Residual Chlorine	mg/L	2	2
Minimum Tank Volume(2)	gal	27,776	55,552

Notes:
(1) The Australian WaterVal Validation protocol published in 2017 was used to determine the CT value. Per Table 1 of WaterVal, assuming a pH of ≤8.5, >15°C, and ≤0.2 NT, the CT required for 2 LRV virus is 9 mg-min/L.
(2) Tank volume is for calculation of CT. This volume does not include operational volume, or the volume required for pumping.

Table C.9 Chemical Storage Design Criteria

Chemical	Purpose
Aluminum Chloride Hydroxide	Pretreatment
Antiscalant	RO Influent
Citric Acid	UF MCs and CIPs
Gypsum	Post-Treatment
Hydrochloric acid	UF MCs, CIPs, and neutralize clean
Sodium Bisulfite	Ozone Quench, neutralize clean
Sodium Hydroxide	UF MC, CIP, and neutralize clean
Sodium Hypochlorite	Pretreatment, UF MC, CIP, and residual disinfectant, UV AOP
Sulfuric Acid	RO influent, calcite contactor influent

Appendix D

ELECTRICAL ANALYSIS SUPPORTING INFORMATION

Table D.1 Electrical Load Summary

Item	# Duty	# Standby	# Total	Output Rating, hp, ea.	Total Connected Load, kW	Drive	Volts
AWPF Feed Pumps	2(1)	1	3	60	90	VFD	480
Oxygen Generators	1	1	2	-	29	-	480
Ozone Generators	1	1	2	-	197	-	480
Ozone Flash Mix System	1	1	2	2.5	2	CS	480
BAF Backwash Pumps	1	1	2	100	75	VFD	480
MF Feed Pumps	2(1)	1	3	100	149	VFD	480
MF Strainers	2(1)	1	3	0.5	1	CS	480
MF Backwash Pumps	1	1	2	50	37	VFD	480
MF Air Scour Blowers	1	1	2	50	37	VFD	480
MF Compressors	2	0	2	10	15	-	480
MF CIP Feed Pumps	1	1	2	75	56	VFD	480
MF CIP Strainers	1	0	1	0.5	0.4	CS	480
MF CIP Drain Pump	1	0	1	2.5	2	CS	480
RO Flash Mix Pumps	1	1	2	2.5	2	CS	480
RO Feed Pumps	2(1)	1	3	200	298	VFD	480
RO Interstage Pumps	2(1)	1	3	50	75	VFD	480
RO CIP Pumps	1	0	1	125	93	VFD	480
RO Flush Pumps	1	1	2	10	7	VFD	480
UV Flash Mix Pumps	1	1	2	2.5	2	CS	480
UV Feed Pumps	2(1)	1	3	50	75	VFD	480
Primary UV System	1	1	2	-	64	-	480
Secondary UV System	3(2)	1	4	-	64	-	480
Calcite Flush Pumps	1	1	2	10	7	VFD	480
Hot Water Transfer Pumps	1	1	2	2	1	CS	480
Immersion Heaters	2	0	2	-	500	-	480
AWPF Finished Water Pumps							
MMWD Connection Point 1	2(1)	1	3	140	209	VFD	480
MMWD Connection Point 2	2(1)	1	3	180	268	VFD	480

Notes:
(1) 1 duty + 1 standby needed for the smaller alternative (2 mgd production).
(2) 2 duty + 1 standby needed for the smaller alternative (2 mgd production).

DPR Electrical Design Standards

Motors will be specified with premium efficiency ratings and a 1.15 service factor. Motor enclosures will be suitable for the environment in which they are installed. All motors driven from VFDs will be inverter-duty rated with a 1.15 service factor.

Motors 25 hp and larger will be provided with integral space heaters to prevent condensation inside the motor. The heaters will be designed to operate on 120V AC power from the associated motor starter.

VFDs will be pulse width modulated type. A harmonic analysis will be specified for the MCC serving the VFDs. The purpose of the analysis is to ensure that the total harmonic voltage and current distortion limits will not exceed those as set forth in IEEE 519. Drives for motors smaller than 50 hp will be 6-pulse and for 50 hp and larger motors will be 18-pulse drives to minimize harmonics.

Power distribution panelboards or power centers will be 480/277V, three phase, four wire type with a main circuit breaker. Lighting panelboards will be 208/120V, three phase, four wire with the main circuit breaker sized to match the lighting transformer capacity. Each panelboard will have a minimum of 20 percent spare breakers and spaces. Panelboards will be fully rated with integral transient voltage surge suppressors where required.

Specific types of raceway will be specified for use in various locations in the facility based on moisture, temperature, and exposure to damage. Underground concrete encased duct banks with PVC schedule 40 conduits will be specified for circuits routed outside buildings on the site. Duct banks will include spare conduits for future use.

Medium voltage power cables, if required, will be stranded copper, 133% 15 kV EPR insulated, shielded conductors. Lighting, power, and control wiring rated 600 volts and below will have use stranded copper conductors with 600V, XHHW insulation. Individual No. 14 AWG conductors will be used for discrete control circuits, unless it is practical to use multi-conductor cables to group control circuits. Twisted-shielded pair cable with No. 16 AWG individual stranded copper conductors, 600V PVC insulation, and an aluminum mylar tape shield around the pair will be used for analog signals.

New electrical duct banks will be specified as steel reinforced concrete ductbanks with minimum 20 percent spare conduits. The minimum conduit size for underground ductbanks will be 2-inch conduit. Conduits will adhere to NEC fill requirements but will not contain more than 40 conductors per conduit when the size of conductor is 10 AWG or smaller. Ductbanks will be installed slopped towards the manholes and pull boxes.

Underground manholes and pull boxes shall be sized to provide ample working space. The minimum size for electrical manholes will be 6’-0”W x 8’-0”L x 7’-0”D. The underground pull boxes will be sized in accordance with NEC guidelines or as indicated on the design drawings. All manholes and pull boxes will be provided with a sump and a drain and will be installed upon a gravel base, 12 inches thick minimum, extending one foot beyond the outer edge of the concrete walls.

LED lighting fixture will be specified with lighting levels in accordance with the Illumination Engineering Society (IES) recommendations and state of California Title 24 requirements. Convenience receptacles for general service will be located on the surface of walls or columns, approximately 18 inches above floors, except convenience receptacles outdoors or in garages, shops, storerooms, or rooms where equipment may be hosed down will be mounted 48 inches above the floor or grade. Weatherproof receptacles will be utilized outdoors, in storage areas, and in wet and damp locations. Receptacles installed outdoors and in restrooms will be provided with ground fault circuit interrupting capability.

The electrical system and equipment will be grounded in compliance with the NFPA 70. Conductors will be No. 4/0 AWG copper, minimum, for ground ring, interconnecting ground rods and for connection to transformers and MCCs. A ground ring will be provided around all new buildings. Electrical equipment, devices, panelboards, and metallic raceways that do not carry current will be connected to the ground conductors. Neutrals of wye-connected transformers will be solidly grounded through a grounding conductor connected to the grounding system. A ground wire will be installed in all raceways that contain power conductors at any voltage.

KEY NOTES:

1. CONNECT "CLOSED" STATUS CONTACT FROM EACH GENERATOR BREAKER IN SERIES WITH THE CLOSING CIRCUIT OF OTHER GENERATOR BREAKERS SUCH THAT THE CIRCUIT BREAKER OF ONLY ONE OF THE THREE GENERATORS CAN BE CLOSED AT ANY TIME.
2. KIRKKEY INTERLOCK BETWEEN 52-U, 52-GI, AND PORTABLE GENERATOR BREAKER LOCATED OUTSIDE OF THE ELECTRICAL BUILDING. PORTABLE GENERATOR BREAKER CAN CLOSE ONLY IF BOTH 52-U AND 52-GI ARE OPEN.
3. HARDWIRE INTERLOCK TO PREVENT THE DIESEL GENERATOR G12.02 TO CONNECT TO THE PLANT SWITCHGEAR WHEN PG&E IS ON LINE AND 52-U IS CLOSED.

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EXISTING ONE LINE DIAGRAM

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SHEET NO.
OF

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Model: Layout1 ColorTable: gshade.ctb DesignScript: Carollo_Std_Pen_v0905.pen PlotScale: 1:1

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DPR MCC ONE LINE DIAGRAM - 2

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OF

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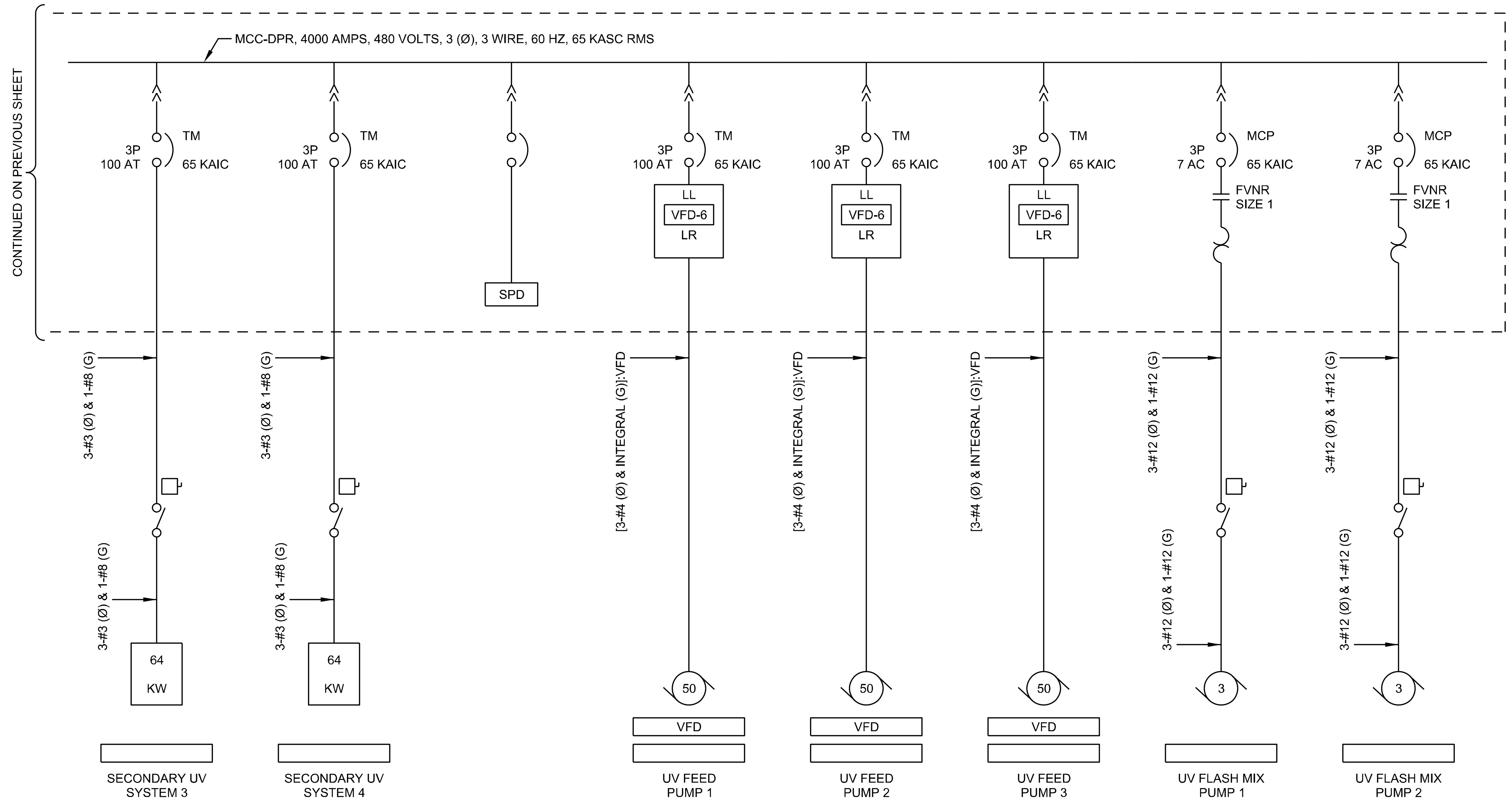

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ELECTRICAL

DPR MCC ONE LINE DIAGRAM - 3

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PROJECT INFORMATION

PROJECT	DPR (DIRECT POTABLE REUSE) DESIGN
CLIENT	CMSA
PROJECT NUMBER	200663
REPORT BY	JAMSHID DORAFSHA
REPORT DATE	3/10/2022 11:12 AM

EQUIPMENT INFORMATION

TAG	MCC-DPR		
DESCRIPTION		PHASE, WIRE, KASC	3PH, 3W, 65 KAIC KASC
LOCATION	DPR	LARGEST MOTOR	200HP
VOLTAGE	480	COMMENTS	
BUS AMPS	4000		

LOAD TOTALS

OPERATING KVA	OPERATING AMPS
3518.8	4232.5

NEC 215 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
4398.5	5290.6

NEC 430 EQUIPMENT SIZING

EQUIPMENT KVA	EQUIPMENT AMPS
3939.2	4738.1

DEFINITIONS

OPERATING = CONTINUOUS + INTERMITTENT

NEC 215 EQUIPMENT SIZING = 1.25 x CONTINUOUS + 1.0 x INTERMITTENT (BASED ON NEC ARTICLE 215)

NEC 430 EQUIPMENT SIZING = 1.25 x LARGEST MOTOR + 1.0 x ALL OTHER MOTORS + 1.25 x CONTINUOUS NON-MOTOR + 1.0 x INTERMITTENT NON-MOTOR (BASED ON NEC ARTICLE 430)

EQUIPMENT SIZING IS BASED ON THE LARGER OF NEC 215 AND NEC 430 CALCULATIONS (LARGER IS HIGHLIGHTED WHEN APPLICABLE)

Note: For 3-phase busses that feed single -phase loads, the amp summation under loads will not match the bus amps due to the difference in voltage.

Note: The values in this report are rounded from higher precision numbers. Manually summing the values shown may yield slightly varied results due to rounding error.

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	OXYGEN GENERATOR 1	29	KW		DUTY / CONTINUOUS	NEW	29.0	34.9	
	OXYGEN GENERATOR 2	29	KW		STANDBY	NEW			
	OZONE GENERATOR 1	197	KW		DUTY / CONTINUOUS	NEW	197.0	237.0	
	OZONE GENERATOR 2	197	KW		STANDBY	NEW			
	OZONE FLASH MIX SYSTEM 1	3	HP	FVNR	DUTY / CONTINUOUS	NEW	4.0	4.8	
	OZONE FLASH MIX SYSTEM 2	3	HP	FVNR	STANDBY	NEW			
	BAF BACKWASH PUMP 1	100	HP	VFD-RH	DUTY / CONTINUOUS	NEW	103.1	124.0	
	BAF BACKWASH PUMP 2	100	HP	VFD-RH	STANDBY	NEW			
	MF FEED PUMP 1	100	HP	VFD-RH	DUTY / CONTINUOUS	NEW	103.1	124.0	
	MF FEED PUMP 2	100	HP	VFD-RH	DUTY / CONTINUOUS	NEW	103.1	124.0	
	MF FEED PUMP 3	100	HP	VFD-RH	STANDBY	NEW			
	MF STRAINER 1	1/2	HP	FVNR	DUTY / CONTINUOUS	NEW	0.9	1.1	
	MF STRAINER 2	1/2	HP	FVNR	DUTY / CONTINUOUS	NEW	0.9	1.1	
	MF STRAINER 3	1/2	HP	FVNR	STANDBY	NEW			

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REPORT BY	JAMSHID DORAFSHA
REPORT DATE	3/10/2022 11:12 AM

EQUIPMENT INFORMATION

TAG	MCC-DPR		
DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 3W, 65 KAIC KASC
LOCATION	DPR	**LARGEST MOTOR**	200HP
VOLTAGE	480	**COMMENTS**	
BUS AMPS	4000		

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	MF BACKWASH PUMP 1	50	HP	VFD-6	DUTY / CONTINUOUS	NEW	54.0	65.0	
	MF BACKWASH PUMP 2	50	HP	VFD-6	STANDBY	NEW			
	MF AIR SCOUR BLOWER 1	50	HP	VFD-6	DUTY / CONTINUOUS	NEW	54.0	65.0	
	MF AIR SCOUR BLOWER 2	50	HP	VFD-6	STANDBY	NEW			
	MF COMPRESSOR 1	10	HP	FVNR	DUTY / CONTINUOUS	NEW	11.6	14.0	
	MF COMPRESSOR 2	10	HP	FVNR	DUTY / CONTINUOUS	NEW	11.6	14.0	
	MF CIP FEED PUMP 1	75	HP	VFD-RH	DUTY / CONTINUOUS	NEW	79.8	96.0	
	MF CIP FEED PUMP 2	75	HP	VFD-RH	STANDBY	NEW			
	MF CIP STRAINER	1/2	HP	FVNR	DUTY / CONTINUOUS	NEW	0.9	1.1	
	MF CIP DRAIN PUMP	3	HP	FVNR	DUTY / CONTINUOUS	NEW	4.0	4.8	
	RO FLASH MIX PUMP 1	3	HP	FVNR	DUTY / CONTINUOUS	NEW	4.0	4.8	
	RO FLASH MIX PUMP 2	3	HP	FVNR	STANDBY	NEW			
	RO FEED PUMP 1	200	HP	VFD-RH	DUTY / CONTINUOUS	NEW	199.5	240.0	
	RO FEED PUMP 2	200	HP	VFD-RH	DUTY / CONTINUOUS	NEW	199.5	240.0	
	RO FEED PUMP 3	200	HP	VFD-RH	STANDBY	NEW			
	RO INTERSTAGE PUMP 1	50	HP	VFD-6	DUTY / CONTINUOUS	NEW	54.0	65.0	
	RO INTERSTAGE PUMP 2	50	HP	VFD-6	DUTY / CONTINUOUS	NEW	54.0	65.0	
	RO INTERSTAGE PUMP 3	50	HP	VFD-6	STANDBY	NEW			
	RO CIP PUMP	125	HP	VFD-RH	DUTY / CONTINUOUS	NEW	129.7	156.0	
	RO FLUSH PUMP 1	10	HP	VFD-6	DUTY / CONTINUOUS	NEW	11.6	14.0	
	RO FLUSH PUMP 2	10	HP	VFD-6	STANDBY	NEW			
	UV FLASH MIX PUMP 1	3	HP	FVNR	DUTY / CONTINUOUS	NEW	4.0	4.8	
	UV FLASH MIX PUMP 2	3	HP	FVNR	STANDBY	NEW			
	UV FEED PUMP 1	50	HP	VFD-6	DUTY / CONTINUOUS	NEW	54.0	65.0	
	UV FEED PUMP 2	50	HP	VFD-6	DUTY / CONTINUOUS	NEW	54.0	65.0	
	UV FEED PUMP 3	50	HP	VFD-6	STANDBY	NEW			
	PRIMARY UV SYSTEM 1	64	KW		DUTY / CONTINUOUS	NEW	64.0	77.0	
	PRIMARY UV SYSTEM 2	64	KW		STANDBY	NEW			
	SECONDARY UV SYSTEM 1	64	KW		DUTY / CONTINUOUS	NEW	64.0	77.0	
	SECONDARY UV SYSTEM 2	64	KW		DUTY / CONTINUOUS	NEW	64.0	77.0	
	SECONDARY UV SYSTEM 3	64	KW		DUTY / CONTINUOUS	NEW	64.0	77.0	
	SECONDARY UV SYSTEM 4	64	KW		STANDBY	NEW			

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CLIENT	CMSA
PROJECT NUMBER	200663
REPORT BY	JAMSHID DORAFSHA
REPORT DATE	3/10/2022 11:12 AM

EQUIPMENT INFORMATION

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DESCRIPTION		**PHASE, WIRE, KASC**	3PH, 3W, 65 KAIC KASC
LOCATION	DPR	**LARGEST MOTOR**	200HP
VOLTAGE	480	**COMMENTS**	
BUS AMPS	4000		

LOADS

TAG	DESCRIPTION	LOAD VALUE	LOAD UNITS	STARTING METHOD	LOAD DESIGNATION	LOAD STATUS	OPERATING KVA	OPERATING AMPS	COMMENTS
	CALCITE FLUSH PUMP 1	10	HP	VFD-6	DUTY / CONTINUOUS	NEW	11.6	14.0	
	CALCITE FLUSH PUMP 2	10	HP	VFD-6	STANDBY	NEW			
	HSPS PUMP 1	200	HP	VFD-RH	DUTY / CONTINUOUS	NEW	199.5	240.0	
	HSPS PUMP 2	200	HP	VFD-RH	STANDBY	NEW			
	HOT WATER TRANSFER PUMP 1	2	HP	FVNR	DUTY / CONTINUOUS	NEW	2.8	3.4	
	HOT WATER TRANSFER PUMP 2	2	HP	FVNR	STANDBY	NEW			
	IMMERSION HEATER 1	500	KW		DUTY / CONTINUOUS	NEW	500.0	601.4	
	IMMERSION HEATER 2	500	KW		DUTY / CONTINUOUS	NEW	500.0	601.4	
	AWPF FEED PUMP 1	60	HP	VFD-RH	DUTY / CONTINUOUS	NEW	64.0	77.0	
	AWPF FEED PUMP 2	60	HP	VFD-RH	DUTY / CONTINUOUS	NEW	64.0	77.0	
	AWPF FEED PUMP 3	60	HP	VFD-RH	STANDBY	NEW			
	AWPF FINISHED WATER PUMP 1	200	HP	VFD-RH	DUTY / CONTINUOUS	NEW	199.5	240.0	
	AWPF FINISHED WATER PUMP 2	200	HP	VFD-RH	DUTY / CONTINUOUS	NEW	199.5	240.0	
	AWPF FINISHED WATER PUMP 3	200	HP	VFD-RH	STANDBY	NEW			
					OPERATING LOAD SUBTOTAL		3518.8	4232.5	

Date/Time displayed in this report reflect time in PST

Appendix E

PLANNING LEVEL COST ESTIMATES

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TASK :	Central Marin Sanitation Agency		
JOB # :	200663	**LOCATION FACTOR :**	1.298
		COST ESTIMATE PREPARATION DATE :	3/15/2022
LOCATION :	San Rafael, CA	**BY :**	EAC
ELEMENT :	AWPF Feed Pipeline and Pump Station - 2 mgd Alternative	**REVIEWED BY:**	RC

DESCRIPTION		QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Pipeline and Pump Station							
	14" Pipeline	100	LF	$2,200	1.30	$285,600	
	Pump Station Structure	1	LS	$838,000	1.30	$1,087,700	
	Vertical Turbine 60 HP Pump	2	EA	$50,000	1.00	$100,000	
	Piping at the Pump Station	1	LS	$70,000	1.30	$90,900	
	Total						$1,564,200
Allowances							
	Electrical	20	%	of Pipeline and Pump Costs		$77,100	
	Instrumentation	15	%	of Pipeline and Pump Costs		$57,800	
	Total						$134,900
	SUBTOTAL						**$1,699,000**
	Estimating Contingency	40	%				$680,000
	ELEMENT DIRECT COST						**$2,379,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$110,000
	SUBTOTAL						**$2,489,000**
	General Conditions	15	%				$357,000
	SUBTOTAL						**$2,846,000**
	Contractor Overhead and Profit	15	%				$357,000
	ELEMENT CONSTRUCTION COST						**$3,203,000**
	Engineering, Legal, and Administrative	20	%				$641,000
	SUBTOTAL						**$3,844,000**
	Owner's Reserve for Change Orders	5	%				$160,000
	TOTAL PROJECT COST						**$4,004,000**

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TASK : Central Marin Sanitation Agency
JOB # : 200663
LOCATION : San Rafael, CA
ELEMENT : AWPF Feed Pipeline and Pump Station - 4 mgd Alternative

LOCATION FACTOR : 1.298
COST ESTIMATE PREPARATION DATE : 3/15/2022
BY : EAC
REVIEWED BY: RC

DESCRIPTION		QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Pipeline and Pump Station							
	14" Pipeline	100	LF	$2,200	1.30	$285,600	
	Pump Station Structure	1	LS	$838,000	1.30	$1,087,700	
	Vertical Turbine 60 HP Pump	3	EA	$50,000	1.00	$150,000	
	Piping at the Pump Station	1	LS	$70,000	1.30	$90,900	
	Total						$1,614,200
Allowances							
	Electrical	20	%	of Pipeline and Pump Costs		$87,100	
	Instrumentation	15	%	of Pipeline and Pump Costs		$65,300	
	Total						$152,400
	SUBTOTAL						**$1,767,000**
	Estimating Contingency	40	%				$707,000
	ELEMENT DIRECT COST						**$2,474,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$114,000
	SUBTOTAL						**$2,588,000**
	General Conditions	15	%				$371,000
	SUBTOTAL						**$2,959,000**
	Contractor Overhead and Profit	15	%				$371,000
	ELEMENT CONSTRUCTION COST						**$3,330,000**
	Engineering, Legal, and Administrative	20	%				$666,000
	SUBTOTAL						**$3,996,000**
	Owner's Reserve for Change Orders	5	%				$167,000
	TOTAL PROJECT COST						**$4,163,000**

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TASK : Central Marin Sanitation Agency
JOB # : 200663

LOCATION : San Rafael, CA
ELEMENT : AWPF Finished Water Pipeline Option 1 (To North of Plant)

LOCATION FACTOR : 1.298
COST ESTIMATE PREPARATION DATE : 3/15/2022
BY : EAC
REVIEWED BY: RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Pipeline							
	12" Pipeline	675	LF	$1,000	1.30	$876,200	
	Allowance to Tie Into Existing Pipeline	1	LS	$15,000	1.30	$19,500	
	Total						$895,700
Allowances							
	Electrical	3	%	of Pipeline Costs		$26,300	
	Instrumentation	3	%	of Pipeline Costs		$26,300	
	Total						$52,600
	SUBTOTAL						**$948,000**
	Estimating Contingency	40	%				$379,000
	ELEMENT DIRECT COST						**$1,327,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$61,000
	SUBTOTAL						**$1,388,000**
	General Conditions	15	%				$199,000
	SUBTOTAL						**$1,587,000**
	Contractor Overhead and Profit	15	%				$199,000
	ELEMENT CONSTRUCTION COST						**$1,786,000**
	Engineering, Legal, and Administrative	20	%				$357,000
	SUBTOTAL						**$2,143,000**
	Owner's Reserve for Change Orders	5	%				$89,000
	TOTAL PROJECT COST						**$2,232,000**

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TASK :	Central Marin Sanitation Agency		
JOB # :	200663	**LOCATION FACTOR :**	1.298
		COST ESTIMATE PREPARATION DATE :	3/15/2022
LOCATION :	San Rafael, CA	**BY :**	EAC
ELEMENT :	AWPF Finished Water Pipeline Option 2 (To South of Plant)	**REVIEWED BY:**	RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Pipeline							
	12" Pipeline	1,750	LF	$1,000	1.30	$2,271,500	
	Allowance to Tie Into Existing Pipeline	1	LS	$15,000	1.30	$19,500	
	Allowance for Crossing Existing Piping	3	EA	$10,000	1.30	$38,900	
	Total						$2,329,900
Allowances							
	Electrical	3	%	of Pipeline Costs		$68,100	
	Instrumentation	3	%	of Pipeline Costs		$68,100	
	Total						$136,200
	SUBTOTAL						**$2,466,000**
	Estimating Contingency	40	%				$986,000
	ELEMENT DIRECT COST						**$3,452,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$160,000
	SUBTOTAL						**$3,612,000**
	General Conditions	15	%				$518,000
	SUBTOTAL						**$4,130,000**
	Contractor Overhead and Profit	15	%				$518,000
	ELEMENT CONSTRUCTION COST						**$4,648,000**
	Engineering, Legal, and Administrative	20	%				$930,000
	SUBTOTAL						**$5,578,000**
	Owner's Reserve for Change Orders	5	%				$232,000
	TOTAL PROJECT COST						**$5,810,000**

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TASK :	Central Marin Sanitation Agency		
JOB # :	200663	**LOCATION FACTOR :**	1.298
		COST ESTIMATE PREPARATION DATE :	3/15/2022
LOCATION :	San Rafael, CA	**BY :**	EAC
ELEMENT :	Brine Pipeline	**REVIEWED BY:**	RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Pipeline							
	8" Pipeline	1,050	LF	$900	1.30	$1,226,600	
	Allowance to Tie Into Existing Pipeline	1	LS	$15,000	1.30	$19,500	
	Allowance for Crossing Existing Piping	2	EA	$10,000	1.30	$26,000	
	Total						$1,272,100
Allowances							
	Electrical	3	%	of Pipeline Costs		$36,800	
	Instrumentation	3	%	of Pipeline Costs		$36,800	
	Total						$73,600
	SUBTOTAL						**$1,346,000**
	Estimating Contingency	40	%				$538,000
	ELEMENT DIRECT COST						**$1,884,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$87,000
	SUBTOTAL						**$1,971,000**
	General Conditions	15	%				$283,000
	SUBTOTAL						**$2,254,000**
	Contractor Overhead and Profit	15	%				$283,000
	ELEMENT CONSTRUCTION COST						**$2,537,000**
	Engineering, Legal, and Administrative	20	%				$507,000
	SUBTOTAL						**$3,044,000**
	Owner's Reserve for Change Orders	5	%				$127,000
	TOTAL PROJECT COST						**$3,171,000**

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TASK :	Central Marin Sanitation Agency		
JOB # :	200663	**LOCATION FACTOR :**	1.298
		COST ESTIMATE PREPARATION DATE :	3/15/2022
LOCATION :	San Rafael, CA	**BY :**	KS
ELEMENT :	AWPF - 2 mgd Alternative	**REVIEWED BY:**	RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Treatment Process Equipment							
	Ozone/BAF and Oxygen Generation	1	LS	$2,710,669	1.30	$3,518,400	
	Ozone Contactor (tank)	1	LS	$47,513	1.30	$61,700	
	Ultrafiltration Process	1	LS	$1,140,478	1.30	$1,480,300	
	Reverse Osmosis Process	1	LS	$1,357,029	1.30	$1,761,400	
	Ultraviolet/Advanced Oxidation Process System	1	LS	$375,082	1.30	$486,900	
	Calcite Contactor	1	LS	$833,859	1.30	$1,082,300	
	Chemical Systems	1	LS	$635,997	1.30	$825,500	
	UV Disinfection	1	LS	$132,229	1.30	$171,600	
	Chlorine and Storage Tank	1	LS	$257,970	1.30	$334,800	
	Break Tanks	1	LS	$71,554	1.30	$92,900	
	AWPF Finished Water Pumping	2	EA	$100,000	1.30	$259,600	
	Total						$10,075,400
AWPF Building							
	Treatment Building	27,000	SF	$ 300	1.30	$10,513,800	
	Piles	27,000	SF	$ 40	1.30	$1,401,800	
	Total						$11,915,600
Allowances							
	Process Equipment Installation, 25% of Unit Process Cost	25	%	of Equipment Costs		$2,518,900	
	Sitework	15	%	of Equipment Costs		$1,511,300	
	Electrical & I/C	25	%	of Equipment Costs		$1,639,300	
	Mechanical	15	%	of Equipment Costs		$974,300	
	Piping and valves	20	%	of Equipment Costs		$3,105,800	
	Total						$9,749,600
	SUBTOTAL						**$31,741,000**
	Estimating Contingency	40	%				$12,696,000
	ELEMENT DIRECT COST						**$44,437,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$2,055,000
	SUBTOTAL						**$46,492,000**
	General Conditions	15	%				$6,666,000
	SUBTOTAL						**$53,158,000**
	Contractor Overhead and Profit	15	%				$6,666,000
	ELEMENT CONSTRUCTION COST						**$59,824,000**
	Engineering, Legal, and Administrative	20	%				$11,965,000
	SUBTOTAL						**$71,789,000**
	Owner's Reserve for Change Orders	5	%				$2,991,000
	TOTAL PROJECT COST						**$74,780,000**

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TASK :	Central Marin Sanitation Agency		
JOB # :	200663	**LOCATION FACTOR :**	1.298
		COST ESTIMATE PREPARATION DATE :	3/15/2022
LOCATION :	San Rafael, CA	**BY :**	KS
ELEMENT :	AWPF - 4 mgd Alternative	**REVIEWED BY:**	RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
Treatment Process Equipment							
	Ozone/BAF and Oxygen Generation	1	LS	$4,716,181	1.30	$6,121,600	
	Ozone Contactor (tank)	1	LS	$93,690	1.30	$121,600	
	Ultrafiltration Process	1	LS	$1,543,128	1.30	$2,003,000	
	Reverse Osmosis Process	1	LS	$2,238,217	1.30	$2,905,200	
	Ultraviolet/Advanced Oxidation Process System	1	LS	$513,298	1.30	$666,300	
	Calcite Contactor	1	LS	$1,196,135	1.30	$1,552,600	
	Chemical Systems	1	LS	$928,552	1.30	$1,205,300	
	UV Disinfection	1	LS	$166,502	1.30	$216,100	
	Chlorine and Storage Tank	1	LS	$515,329	1.30	$668,900	
	Break Tanks	1	LS	$137,947	1.30	$179,100	
	AWPF Finished Water Pumping	3	EA	$100,000	1.30	$389,400	
	Total						$16,029,100
AWPF Building							
	Treatment Building	32,000	SF	$ 300	1.30	$12,460,800	
	Piles	32,000	SF	$ 40	1.30	$1,661,400	
	Total						$14,122,200
Allowances							
	Process Equipment Installation, 25% of Unit Process Cost	25	%	of Equipment Costs		$4,007,300	
	Sitework	15	%	of Equipment Costs		$2,404,400	
	Electrical & I/C	25	%	of Equipment Costs		$2,476,900	
	Mechanical	15	%	of Equipment Costs		$1,467,900	
	Piping and valves	20	%	of Equipment Costs		$4,048,700	
	Total						$14,405,200
	SUBTOTAL						**$44,557,000**
	Estimating Contingency	40	%				$17,823,000
	ELEMENT DIRECT COST						**$62,380,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$2,885,000
	SUBTOTAL						**$65,265,000**
	General Conditions	15	%				$9,357,000
	SUBTOTAL						**$74,622,000**
	Contractor Overhead and Profit	15	%				$9,357,000
	ELEMENT CONSTRUCTION COST						**$83,979,000**
	Engineering, Legal, and Administrative	20	%				$16,796,000
	SUBTOTAL						**$100,775,000**
	Owner's Reserve for Change Orders	5	%				$4,199,000
	TOTAL PROJECT COST						**$104,974,000**

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TASK : Central Marin Sanitation Agency
JOB # : 200663
LOCATION : San Rafael, CA
ELEMENT : Electrical Improvements - 2 mgd Alternative

LOCATION FACTOR : 1.298
COST ESTIMATE PREPARATION DATE : 3/15/2022
BY : JD
REVIEWED BY: RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
CMSA Electrical Improvements							
	New 4000A PG&E Service[(1)]	1	EA	$100,000	1.30	$129,800	
	New 4000A Service Switchgear	1	EA	$400,000	1.30	$519,200	
	10 HP VFD	2	EA	$25,000	1.30	$64,900	
	50 HP VFD	9	EA	$30,000	1.30	$350,500	
	60 HP VFD	2	EA	$35,000	1.30	$90,900	
	75 HP VFD	2	EA	$40,000	1.30	$103,800	
	100 HP VFD	4	EA	$55,000	1.30	$285,600	
	125 HP VFD	1	EA	$65,000	1.30	$84,400	
	200 HP VFD	5	EA	$80,000	1.30	$519,200	
	15 Section MCC	1	EA	$200,000	1.30	$259,600	
	Ductbank	500	LF	$50	1.30	$32,500	
	Conduit	5,000	LF	$25	1.30	$162,300	
	Wires	20,000	LF	$15	1.30	$389,400	
	Total						$2,992,100
Allowances							
	Misc. Allowance (Lignting, Panelboards, etc.)	1	LS	$50,000	1.30	$64,900	
	Total						$64,900
	SUBTOTAL						**$3,057,000**
	Estimating Contingency	40	%				$1,223,000
	ELEMENT DIRECT COST						**$4,280,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$198,000
	SUBTOTAL						**$4,478,000**
	General Conditions	15	%				$642,000
	SUBTOTAL						**$5,120,000**
	Contractor Overhead and Profit	15	%				$642,000
	ELEMENT CONSTRUCTION COST						**$5,762,000**
	Engineering, Legal, and Administrative	20	%				$1,152,000
	SUBTOTAL						**$6,914,000**
	Owner's Reserve for Change Orders	5	%				$288,000
	TOTAL PROJECT COST						**$7,202,000**

Notes:
(1) Cost is dependent on PG&E and actual cost will only be known after a service application is submitted to PG&E. The cost shown assumes PG&E's existing substation and infrastructure are sized adequately for the additional AWPF load.

Engineers...Working Wonders With Water™

TASK : Central Marin Sanitation Agency
JOB # : 200663
LOCATION : San Rafael, CA
ELEMENT : Electrical Improvements - 4 mgd Alternative

LOCATION FACTOR : 1.298
COST ESTIMATE PREPARATION DATE : 3/15/2022
BY : JD
REVIEWED BY: RC

DIVISION	DESCRIPTION	QTY	UNIT	UNIT COST	LOCATION FACTOR	SUBTOTAL	TOTAL
CMSA Electrical Improvements							
	New 4000A PG&E Service(1)	1	EA	$100,000	1.30	$129,800	
	New 4000A Service Switchgear	1	EA	$400,000	1.30	$519,200	
	10 HP VFD	2	EA	$25,000	1.30	$64,900	
	50 HP VFD	10	EA	$30,000	1.30	$389,400	
	60 HP VFD	3	EA	$35,000	1.30	$136,300	
	75 HP VFD	2	EA	$40,000	1.30	$103,800	
	100 HP VFD	5	EA	$55,000	1.30	$357,000	
	125 HP VFD	1	EA	$65,000	1.30	$84,400	
	200 HP VFD	6	EA	$80,000	1.30	$623,000	
	15 Section MCC	1	EA	$200,000	1.30	$259,600	
	Ductbank	500	LF	$50	1.30	$32,500	
	Conduit	5,000	LF	$25	1.30	$162,300	
	Wires	20,000	LF	$15	1.30	$389,400	
	Total						$3,251,600
Allowances							
	Misc. Allowance (Lignting, Panelboards, etc.)	1	LS	$50,000	1.30	$64,900	
	Total						$64,900
	SUBTOTAL						**$3,317,000**
	Estimating Contingency	40	%				$1,327,000
	ELEMENT DIRECT COST						**$4,644,000**
	Sales Tax on 50% of Subtotal Above	9.25	%				$215,000
	SUBTOTAL						**$4,859,000**
	General Conditions	15	%				$697,000
	SUBTOTAL						**$5,556,000**
	Contractor Overhead and Profit	15	%				$697,000
	ELEMENT CONSTRUCTION COST						**$6,253,000**
	Engineering, Legal, and Administrative	20	%				$1,251,000
	SUBTOTAL						**$7,504,000**
	Owner's Reserve for Change Orders	5	%				$313,000
	TOTAL PROJECT COST						**$7,817,000**

Notes:
(1) Cost is dependent on PG&E and actual cost will only be known after a service application is submitted to PG&E. The cost shown assumes PG&E's existing substation and infrastructure are sized adequately for the additional AWPF load.